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PREFACE

Northernmost Canada, consisting of the north shore of the mainland and the Canadian Archipelago, is, in spite of prolonged exploration, still all too little known. Yet there is a growing need to know it because of the accelerated movement of mining and other economic activities into the northern mainland and because the archipelago has such strategic value for the defence of the continent.

It would be impossible to survey such a large area in a detailed way, nevertheless it is often detailed knowledge that is required in order to elucidate problems. The Geographical Branch has, therefore, followed the technique of examining typical samples in detail and using these to interpret the wider scene.

The choice of the sample areas is of first importance. In some cases it depends on the government agency or the economic interest involved. In others it is based on physical criteria, in an attempt to know the land itself. Geologically the region is divided into four belts, although they are not clearly separated but interpenetrate to some extent. There is, first, the belt of Archæan and Proterozoic rocks, forming the northern extension of the Shield; the chief rocks of the mainland, they penetrate north in Melville and Boothia Peninsulas, in northwestern Victoria Island, and through northeastern Baffin Island to the east parts of Devon and Ellesmere Islands. Lying in broad embayments between these prongs of the Shield are rather shallow basins of unfolded Palæozoic rocks, such as are found in central and eastern Victoria Island and in King William Island. They are very similar to those in the Hudson Bay Lowlands. The Palæozoics deepen through a transition belt between the southern and northern archipelagos. They are then caught up in a sinuous zone of folding that constitutes the third belt. The folded belt runs through the centre of the Parry Islands to southwestern and western central Ellesmere. Finally, to the extreme north and west is a broken plain of gently sloping mesozoic and younger rocks, interrupted by piercement domes.

The geographical surveys were planned to include samples typical of each of these belts. In addition, however, the remote north is divided, topographically, into three regions. These are, the southwestern peninsulas and islands, west of Boothia Peninsula; the southeastern peninsulas and islands, east of Boothia; and the northern islands, or High Arctic, north of Lancaster Sound. Samples typical of these divisions were also selected.

The survey of the Alert district provides a sample of the northern islands region, at its extremity, within the fold belt. Its objects were to prepare a ground-photo key of the details of the local site that would enable an interpretation of the general situation to be made. In particular, the relationship of bedrock, land form, surface deposits, drainage, and vegetation under high arctic conditions was studied.

Knowledge of the north would be of little use unless accompanied by knowledge of how to reach it. The Gulf of St. Lawrence, the Ungava railhead, the railheads at Moosonee on James Bay and at Churchill on Hudson Bay, Mackenzie River and the sea route from Vancouver to the Yukon all may in one way or another be considered as leading to the northland. The Geographical Branch is conducting studies of each of these, and the second and third articles of this Bulletin deal with some of the work done. Two of the principal problems are the use of the coasts and the influence of sea ice. Surveys of the geography of the approach to the coast both from land and from sea were made in the James Bay and southern Hudson Bay regions. A general picture of conditions from Moosonee to Churchill was obtained and is here summarized.

The study of the geographical distribution of ice in northern waters was extended to the Gulf of St. Lawrence because of the vital role of the gulf in the sea supply of the Arctic. The results show a considerable range of conditions from year to year, especially with changes in wind direction at the critical seasons. They indicate, none the less, certain more or less regular patterns, owing to the influence of topographic and oceanographic controls. Further studies of this kind should do much to make safer and more effective the link between settled southern Canada and the far-flung North.

J. WREFORD WATSON,
Director, Geographical Branch

THE PHYSIOGRAPHIC SUBDIVISIONS OF THE HUDSON BAY LOWLANDS SOUTH OF 60 DEGREES NORTH

Donald B. Coombs[1]

The continental part[2] of the Hudson Bay Lowlands is a flat, sparsely populated, largely undeveloped, coastal plain located on the west side of James and Hudson Bays from Nottaway River in Quebec to Churchill River in Manitoba. It is situated between 49°58′ and 58°50′ N. and 75°56′ and 95°00′ W. (Figure 1).

Irregular in shape, it has a maximum east-west width of 325 miles and in over-all length, measured from Churchill to the most southerly point on the Harricanaw, is about 800 miles. It is larger than the British Isles, having a total area of some 125,000 square miles, and lies approximately between the same parallels of latitude. Some 100,000 square miles of the area lies in Ontario—one-quarter of that province's entire territory. The remaining 25,000 square miles is found for the most part in Manitoba, with a small southeast corner extending into Quebec.

The region's northern and eastern boundaries are marked by a coastline of over 1,200 miles, where Palæozoic rocks dip gradually under the waters of James and Hudson Bays. The western and southern boundaries are not so sharply delimited, owing to a mantle of boulder clay that covers much of the lowland and parts of the neighbouring Precambrian Shield, against which the region's bedrock abuts.

The southern boundary is marked in part by a low escarpment, which separates the lowland from the clay belt of northern Ontario. This escarpment apparently marks a line of faulting that caused the bedrock of the lowland to be downthrown and is most clearly seen where Mattagami, Opazatika, and Missinaibi Rivers have cut their way across it. On these three rivers the escarpment marks the northern limit of Precambrian rocks in this particular area, beyond which they are succeeded by the Palæozoic. On Abitibi River the escarpment diverges from the true Palæozoic-Precambrian boundary, running southeast towards the Quebec border, whereas the contact runs north towards the mouth of Nottaway River as it empties into the south end of James Bay.

The western limit of the region is in reality more of a transition belt, where arms and inliers of both the Palæozoic and the Precambrian fuse to form a broad belt belonging neither to the Hudson Bay Lowland nor to the Precambrian Shield. However, by linking up observed exposures of Palæozoic bedrock where they first occur along the numerous rivers that tumble into the region from the neighbouring shield, a western border for the area has been determined.

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[1] Donald B. Coombs, B.A., Western Ontario, M.A., McGill. This paper is based on field work carried out by the author during the summers of 1948, 1949, and 1950, while a geographer with the Department of Mines and Technical Surveys.

[2] For the full extent of the physiographic province of the Hudson Bay Lowlands *See* J. Brian Bird: Southampton Island; Geographical Branch, Mem. 1, pp. 40-41 (1953).

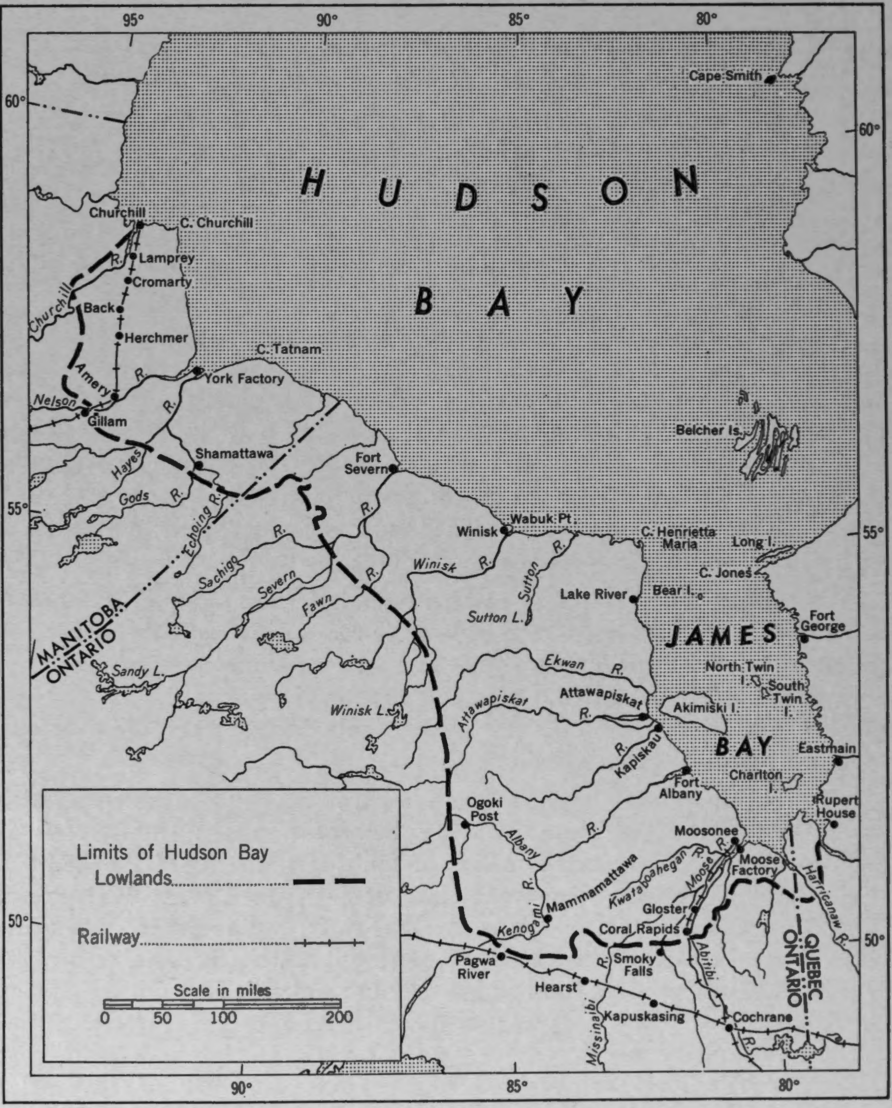

Figure 1. Location map.

The purpose of this paper is to provide descriptive reports of some of the physical aspects of the area, dealing with it from the geographical regional approach.

GENERAL ASPECTS

The general aspect of the Hudson Bay Lowland is that of a flat, swampy plain with a slight downward slope toward its coastal regions along James and Hudson Bays. Over the greater part of its surface there occurs a patchwork of lakes, rivers, and streams, as well as extensive areas of swamp and muskeg, resulting in a watery panorama covering practically the whole of the plain. For the most part, dry land is at a premium, occurring only in the form of moraine or beach ridges, and in the better-drained regions bordering the numerous lakes, rivers, and streams. These moraines and ridges break the monotony of an almost completely flat surface.

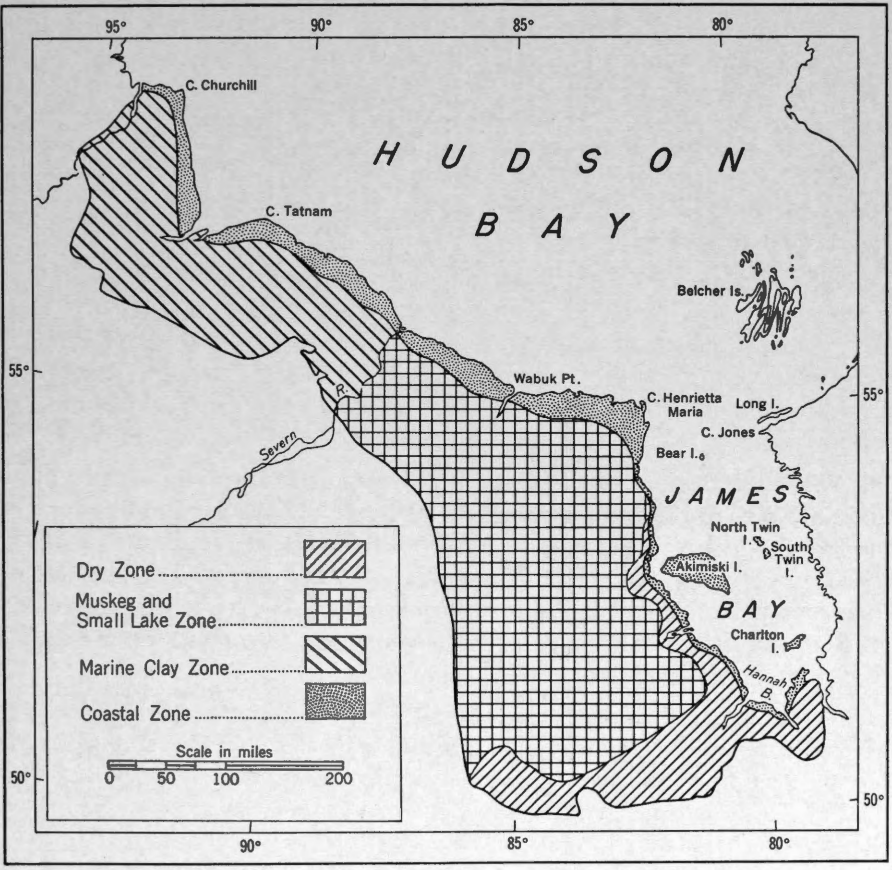

Figure 2. The Physiographic subdivisions of the Hudson Bay Lowlands south of 60 degrees north.

The highest point of elevation in the lowland occurs in the area bordering the Precambrian Shield, where the numerous branches of upper Albany River tumble into the coastal plain. From here, an estimated elevation of 500 feet, the lowland drops gradually to its coastal regions at a gradient of 3·4 feet per mile[1]. Sea-level is reached with such a slight inclination that broad tidal flats extend several miles at low tide.

Although the dominating feature of the lowland is its watery appearance, its surface characteristics are not uniform. Rather, it lends itself to subdivisions based on physical aspects related to the climate, drainage, and

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[1] Kindle, E. M.: Geology of a Portion of the Northern Part of the Moose River Basin, Ontario; Geol. Surv., Canada, Sum. Rept. 1923, pt. C, p. 24.

geological history. Four such subdivisions can be recognized, each having its own characteristic surface appearance, and making possible a more practical discussion of the region and perhaps a better insight into the problems of the area.

The four physiographic subdivisions of the lowland, as shown in Figure 2, are the Dry Zone, Muskeg and Small Lake Zone (Muskeg Zone), Marine Clay Zone, and Coastal Zone. The limits of each were arrived at through a study of aerial photographs and field observations.

DRY ZONE

The Dry Zone is situated below an imaginary line drawn from the mouth of Moose River southward along the Kwataboahegan to Sandbank Lake, then due west to Kenogami River, a branch of the Albany.

The feature that sets this area apart is the greater expanse of dry land, usually heavily wooded, and representing from 40 to 50 per cent of the subdivision's surface. The drier condition is due to a more advanced drainage system than in the other zones. A somewhat milder climate and a longer frost-free period each year also favours the dissipation of excess soil moisture in this zone.

Although comparatively flat, the surface of the zone is slightly more undulating than that of the northern lowland. It has a wave-like type of topography in which the depressions are shallow marsh or muskeg and the crests thickly wooded. Numerous ridges, either former sea beaches or constructed by glacial deposition, occur here and there. On these and other of the better-drained areas adjacent to the rivers and lesser streams grow the better stands of timber.

All the major rivers of the Dry Zone, the Nottaway, Hurricanaw, Moose, Missinaibi, and Kenogami, still are in the youthful stage. Their rapidly flowing waters are continuously undercutting their high, almost vertical banks, from time to time bringing down large trees and leaving others clinging precariously to the new bank edge. These rivers, as well as their numerous tributaries, provide the area with a deeply trenched parallel drainage system, cut into the zone's thick boulder clays.

Though not adequately drained, this zone, as stated earlier, is the driest of the four. A study of its surface from aerial photographs suggests that approximately 30 per cent is covered by muskeg and swamps, 30 per cent by lakes and rivers, and the remaining 40 per cent by comparatively dry land.

The swamp and muskeg areas lie centrally between the parallel draining rivers and streams of the shallow depressions or in areas beyond the limits of drainage. Lakes are not numerous in the southern part of the Dry Zone, but their number increases toward the north, particularly in the transition area that separates it from the Muskeg and Small Lake Zone.

Figure 3. A typical section of the southern part of the Dry Zone at the junction of Missinaibi, Mattagami, and Moose Rivers. (RCAF photo.)

Figure 4. The northern section of the Dry Zone 60 miles northwest of Moosonee. (RCAF photo.)

In appearance the Dry Zone is not unlike the pulp forest areas of the northern Ontario section of the Precambrian Shield, except that the bedrock outcrops are noticeably absent and the angular ruggedness of the shield is replaced by the smooth undulations of the lowland. Figure 3 is typical of the more southern parts of the Dry Zone, where lakes are few, forests fairly good, and the muskeg and swamp areas represented by the lighter shades of the photographs dominate the interfluves. Figure 4, taken in the northern section of the zone, shows numerous lakes, but dry land surface is sufficient to support a considerable area of forest. The transition belt from Dry to Muskeg Zone is represented in Figure 5, the dry areas being less extensive and confined to the river banks and former beach ridges. The muskeg surface of the interfluves is pitted with numerous small waterholes, and lakes are more numerous.

MUSKEG AND SMALL LAKE ZONE

The Muskeg and Small Lake Zone occupies the central part of the Hudson Bay Lowland, with the exception of a small belt of the Coastal Zone along the shores of James and Hudson Bays. Extending from the northern limits of the Dry Zone to a line closely coinciding with the course of Severn River, this second zone covers more than 50 per cent of the total area of the lowland. Its topography is typical of what truly could be called Hudson Bay Lowland country. Indeed, in earlier descriptive reports on this region by such men as Low, Bell, Dowling, and Kindle it was indicated that their observations had been made chiefly in the Muskeg and Small Lake Zone, their journeyings being largely confined to water travel along Albany, Kapiskau, Attawapiskat, Ekwan, Winisk, and Severn Rivers.

The Muskeg and Small Lake Zone might again be subdivided, the first subdivision being the flat muskeg country and the second the small lake regions.

Throughout the muskeg areas the surface water generally is less than 3 per cent of the total area, and the drainage, radial in type, is completely inadequate. Except within a few hundred feet of the banks of rivers and streams, the ground surface is a soggy sphagnum-covered expanse dotted by occasional clumps of sedges or "nigger heads", or a few patches of stunted black spruce. To enter such an area on foot, as the writer learned on numerous occasions, is to sink from several inches to several feet at every step.

Hanson[1] refers to parts of the flat muskeg country as the "Smallpox" Muskeg Zone, this being the area of former lake and pond beds now free of water and characteristically saucer-like in shape. The circular formations are the result of sedimentary filling, following upon the general uplift of the country and the improvement of drainage with the passing of time. The former rims, now supporting narrow but thriving growths of small trees and bushes, showing against the flat muskeg floor, produce the pock-

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[1] Hanson, H. C.: Canada Geese of the Mississippi Flyway; Bull. Ill. Nat. Hist. Surv., vol. 25, art. 3, March 1950, p. 92.

marked effect referred to. It is on these rims and the banks of the rivers and streams, as well as the occasional terrace or former beach ridge, that the only land dry enough to support tree growth of any size in these areas is found; such areas form less than 10 per cent of the total surface.

The muskeg country is extremely flat, with very little appreciable relief of any kind. The only breaks in the landscape are the occasional short lines of trees located on some low ridge or along the edge of a small lake, pond, or stream. The rivers and streams flowing through the area have no real valleys, but, like those of the Dry Zone, occupy trenches having almost vertical slopes: they are, however, not so deeply incised. They are fed by numerous small tributaries that branch off at right angles, losing themselves in the muskeg within a few hundred feet.

The second of the subdivisions of the Muskeg and Small Lake Zone comprises those areas in which lakes and irregular-shaped pools cover anything from 10 to 50 per cent of the surface area. Hanson[1] terms these regions the "Pothole" Muskeg, where myriad ponds and small lakes are often so closely grouped that only narrow strips of land separate one from the other. However, his use of the term muskeg, which pertains more to the actual mechanical condition of the soils of an area rather than the over-all nature of the surface (which he apparently implies), is perhaps somewhat misleading.

As in the purely muskeg sections, it is difficult to traverse the lake-dotted regions except after freeze-up. This, undoubtedly, accounts for the fact that a number of large lakes, such as those a few miles north of Ekwan River about 50 miles from its mouth, have never been mapped, although the Ekwan has been travelled for several hundred years.

Most of the lakes of this zone are encircled by a thin growth of trees that cling to a small, narrow ridge of high land that ice and wave action have built up around the water's edge with sediments from the lake bottom. In the tundra areas of Canada, such as western Southampton Island, where small lakes and soggy muskeg are also prevalent, such ridges provide some of the few good walking stretches to be found in such country. This would be true of the lowland also, were it not that a lush vegetative growth, principally of willow and black spruce, forms an almost impenetrable barrier. While on the shore of one of these lakes, the writer and his companion were forced to erect their tent on a mat of willows spread on the muskeg adjacent to the narrow tree band, as the narrowness of the ridge on which the trees grew, even if cleared, would not have afforded sufficient room to pitch a tent.

Figure 6 is typical of the exclusively muskeg areas of the Muskeg and Small Lake Zone, displaying the "Smallpox" surface features Hanson speaks of. The Small Lake areas are represented in Figure 7, where the myriads of small lakes separated by narrow strips of land are surprisingly reminiscent of rice paddies. In the latter photograph the extreme flatness of the region is also apparent.

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[1] Hanson: op. cit., p. 92.

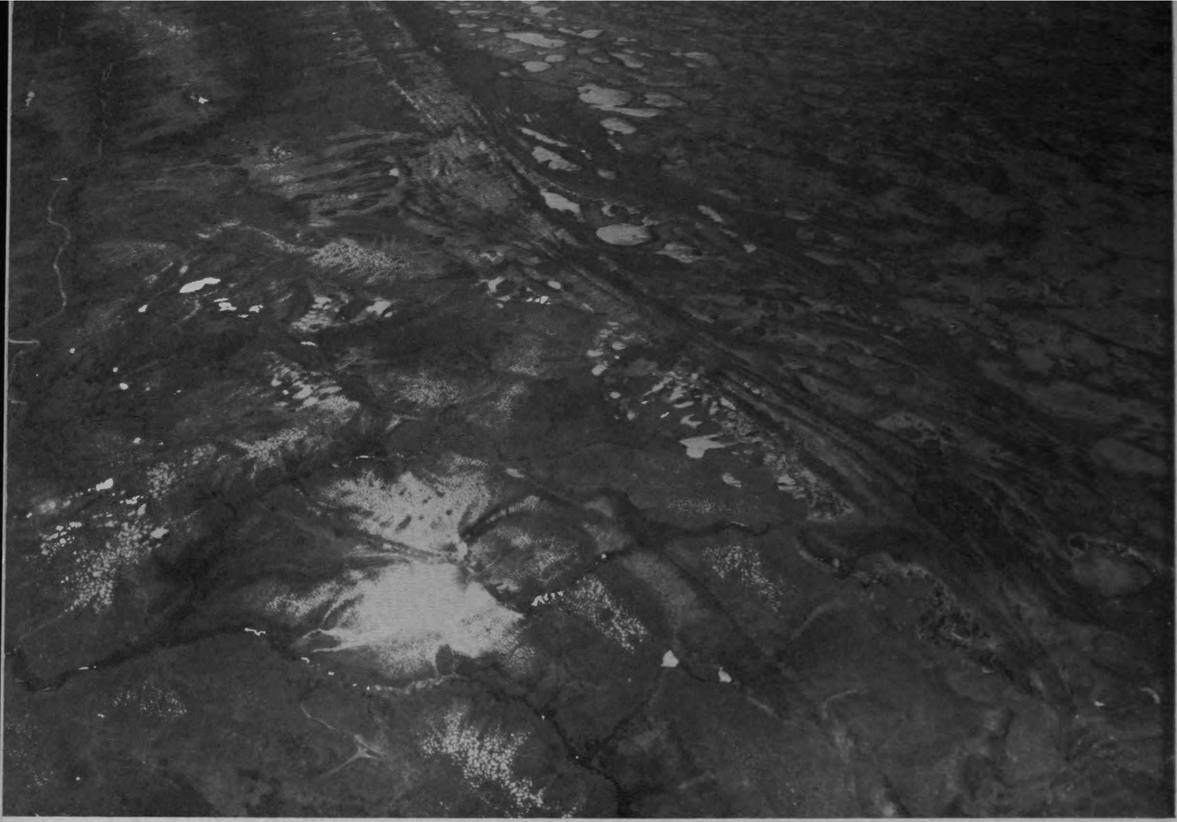
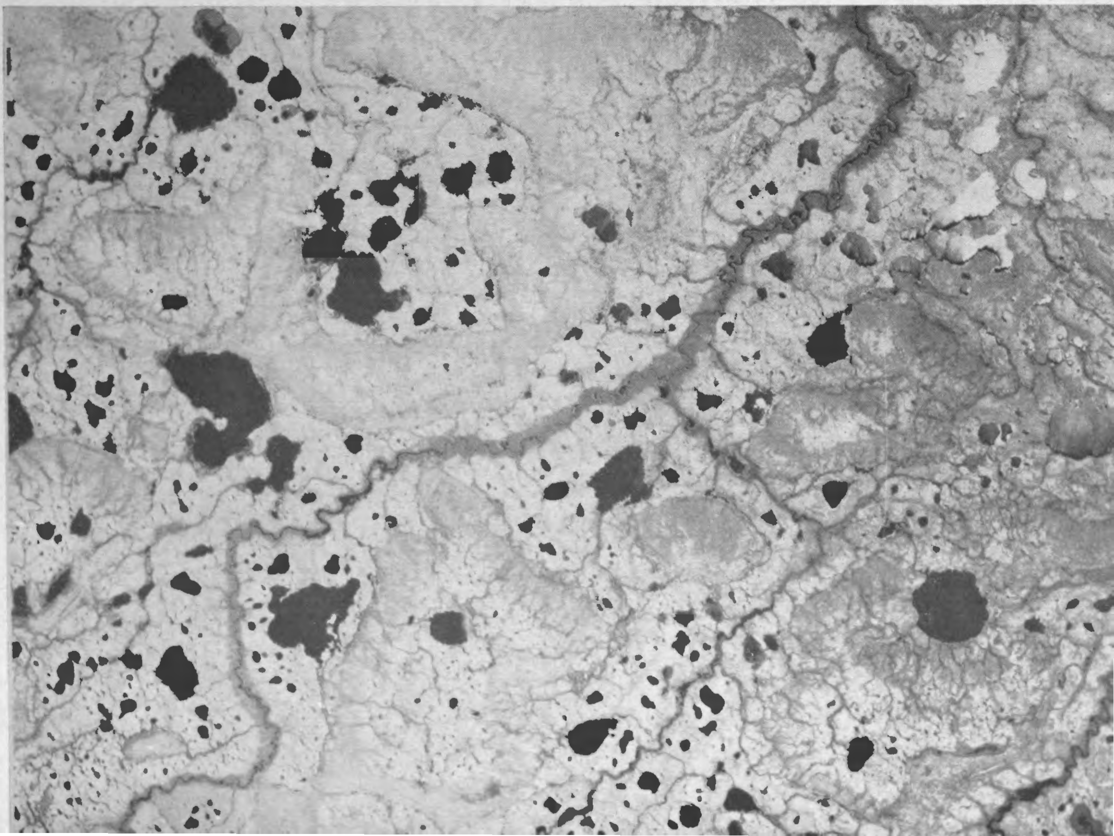


Figure 5. Transition belt between Dry Zone and Muskeg and Small Lake Zone, looking west. Note moraine, or possibly a former marine beach ridge, running southwest to northeast. (RCAF photo.)

Figure 6. "Smallpox" Muskeg, about 15 miles north of Attawapiskat River. (Photo: H. C. Hanson.)

Figure 7. Muskeg and Small Lake Zone.

Figure 8. Marine Clay Zone 60 miles south of Churchill. (RCAF photo.)



It is the considered opinion of many that in the event of an aircraft being forced down in this region or in the Marine Clay Zone to the north, rescue operations would be virtually impossible before freeze-up, unless helicopters were available. Although such a view may be slightly exaggerated, it will serve to stress the difficulty of surface travel over this country during the frost-free period.

MARINE CLAY ZONE

The Marine Clay Zone, the third of the lowland's subdivisions, extends over the remaining part of the region lying north of Severn River and landward beyond a narrow stretch of coastal terrain. This zone is so named because of the widespread mantle of marine clay deposited during the post-glacial submergence of the lowland.

Owing to its more northerly position, it was possibly the last of the lowland area to be deglaciated, and also, with the exception of the present coastal region, the last to emerge from the post-glacial seas.

Because of these factors, and a freeze-up of almost 9 months, the zone's surface, as shown in Figure 8, has a more immature appearance than areas of the Dry and Muskeg and Small Lake Zones farther south. The wide presence of permafrost, not general in the more southern zones, also would be an inhibiting factor in the development of more mature surface features.

The Marine Clay Zone, like the rest of the lowland, is very flat. This is particularly apparent in the spring, when the melt water from the previous winter's ice and snow covers the surface in a broad sheet. Poor drainage, the imperviousness of the soils, and the frozen condition of the sub-soils, prevent downward seepage, hinder run-off of surface water, and turn the area for a time into an expanse of shallow lake.

Much of the zone is covered with a complex network of sluggish dendritic streams, which, however, eventually link up with some main drainage channel leading to the sea. There are areas, however, that are almost completely undrained, the water merely overflowing in periods of thaw or rain from one water-hole to the next until some stream is reached. Such areas are covered by extensive peat bogs, for the most part barren of tree growth of any kind.

Patterns worked out by erosive action of water and ice in the clay surface are varied. In all cases it is pitted with small indentations, particularly in the undrained regions. Some of these depressions are dry, but usually they are filled with stagnant water. From the air, and as observed in aerial photographs, much of the zone is reminiscent of the bark of a tree with its pattern of ridges and hollows.

As in the other zones of the lowland, the flat monotony of the landscape is occasionally broken by former beach ridges or long moraine terraces at varying distances inland, parallel with the Hudson Bay coast-line. The

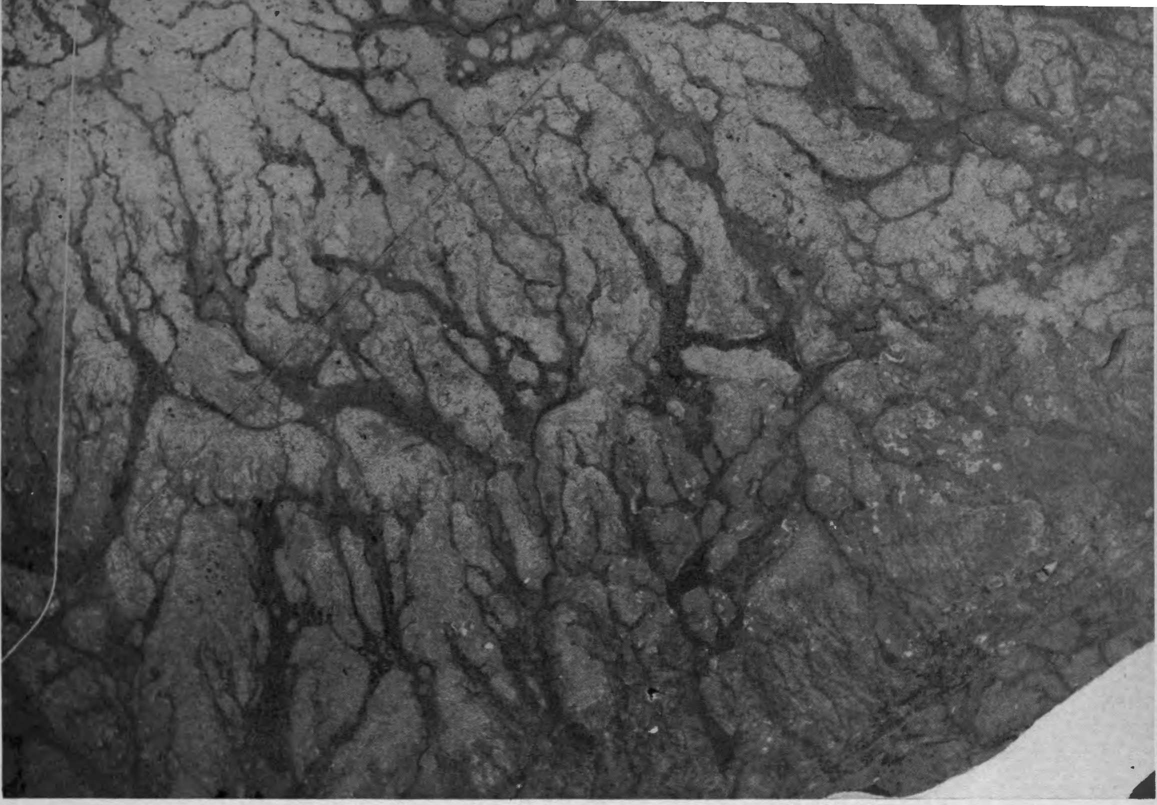


Figure 9. Marine Clay Zone in the Nelson River area, showing the old railway bed to Port Nelson. Note the bark-like appearance of the surface. (RCAF photo.)

Figure 10. Marine Clay Zone just north of Nelson River. (RCAF photo.)

most pronounced of these is the broad, elevated terrace that runs northwest from Nelson River about 30 miles from the coast, to form what Alcock[1] calls the "Terminal Moraine of the Seal-Churchill Divide".

Figure 9, showing the former railway bed to Port Nelson and the present cutoff at Amery to Churchill, is an example of the bark-like appearance of much of the surface of the Marine Clay Zone. Figure 10 is a lower altitude photograph of a similar area.

In areas where the Marine Clay Zone borders on the Precambrian, the landscape takes on an appearance closely resembling the zones to the south. The transition belt separating typically Marine Clay areas from those of the Precambrian Shield is not very wide, resulting in a sudden and very marked change in surface features when seen from the air. The change from the grey shades of the Precambrian to the browns of the Marine Clay also is very noticeable, the latter tints arising out of the colour of the surface clays.

COASTAL ZONE

The fourth and smallest of the subdivisions, the Coastal Zone, is the area of the lowland that immediately comes to mind for those knowing the region, when the subject of the country along the west coast of James and Hudson Bays comes up for discussion. For it is along this coast-line that are found the broad tidal flats extending for miles seaward from high-water mark. Anyone who has ever travelled by small boat or canoe along this coast has had the experience of spending more than a few hours stranded during low water.

The Coastal Zone in southern James Bay, from Hannah Bay at the mouth of Moose River north to the Ekwan, varies in width from a few hundred yards to several miles. North of the Ekwan as it rounds Cape Henrietta Maria the zone broadens, extending inland up to 10 miles. In general, from Cape Henrietta Maria to Churchill, it averages about 5 miles in width, closely following the line that on some maps of the area indicates the limit of tree growth.

From the sea the shoreline of the Coastal Zone presents a very monotonous picture to the coast-wise traveller. The land is almost entirely without relief and any shallow bays that do occur in the coast-line make little or no appeal to the eye. From a canoe at high tide one gets the impression of voyaging over the surface of a huge saucer filled to the point of overflowing.

When the sea retreats at low tide, anywhere from ½ mile to 6 miles, the broad intertidal zone that is laid bare is extremely flat. It is floored by well-rippled, greyish blue clay and silt, studded here and there with glacial boulders. Long, slimy, pale green fucus attached to small stones and fine green sea grass represent the visible plant life of the mud flats.

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[1] Alcock, F. J.: The Terminal Moraine of the Seal-Churchill Divide; Geol. Surv., Canada, Sum. Rept. 1920, pt. C, pp. 13-18.

Along the landward margin of the tidal belt runs a neutral zone that belongs neither to the land nor the tidal flats for any extended period. Shallow pools of salt or brackish water cover this neutral belt.

Although a considerable part of the Coastal Zone's shoreline is marked by wide gravel or shale beaches, at some points, such as between the mouth of Moose and Attawapiskat Rivers, there is no proper beach. In these latter areas neap tides will leave 200 to 400 yards of mud or muddy gravel uncovered, whereas high spring tides pushed by strong north winds may cover the short grass that forms a 200-yard band along the coast. In both cases high tide is marked by a line of driftwood partly covered by a rotting brown mass of seaweed (fucus).

Low ridges are another feature of the lowland's shoreline. These are principally located in the coastal areas, where the gravel and shale beaches occur. They may be several hundred feet or more above high tide, may be 3 to as much as 10 feet high, and may extend along the coast from several hundred yards to half a mile.

The ridges appear to develop from offshore bars. By repeated wave action, aided by apparent continued crustal uplift in the region and a gentle slope of the sea floor—1 foot in 200 or 300 yards—these bars are slowly pushed toward the shore.

During the occasional severe autumn storm, bringing strong gales from the north or northeast, and coinciding with the maximum tides, intensified wave action increases the height of these bars as well as forcing them farther landwards. Repeated storm action over a period of years continues to drive them inshore, and crustal uplift helps to raise them well out of the water, until they are only just reached by high tide. At this point the bars take on the nature of storm beaches, acting as barriers against raging waters rolling inland during high seas.

Throughout this period of transition from offshore bars to storm beaches the process begins to repeat itself, with other bars going through the formative stage, moving inshore, and eventually coming to rest a hundred feet or more directly in front of the previous bars. This process, repeated over and over again, is responsible for the large number of ridges that parallel much of the lowland coast-line, as shown in Figure 11, taken in the Cape Henrietta Maria area.

Such a series of ridge lines distinguishes the coastal zone from Lake River north to Churchill River. Between these former beaches are flat salt areas and numerous shallow, elongated lakes, normally filled with brackish water. In the neighbourhood of the coast the ridges are either bare or covered with short, coarse grass, and inland willows and scrub spruce begin to make an appearance.

South of Lake River, following the shoreline to Rupert House, the character of the coastal zone changes. The ridges become less numerous and the area just beyond the neutral belt is largely marsh, supporting a

Figure 11. Coastal Zone beach ridges, from 2,000 feet.

Figure 12. Coastal Zone: Cape Tatnam area. (RCAF photo.)

growth of salt grasses increasing in height and density inland. It is difficult to cross these marshes without getting wet, even when knee-length rubber boots are worn.

Inside the grassland, or natural hay land, a strip of very wet alder and willow, 2 to 4 feet in height, precedes the first dwarf spruce and tamarack, marking the seaward edge of the coastal forest belt. The width of the salt marshes, willow, and the coastal tree belt, as shown in Figure 12, vary considerably; in some instances they may be only a few hundred feet, whereas in others they may reach a mile or more in width.

These physical characteristics of the Coastal Zone can also in general be related to a number of the islands of James Bay. Those islands that can be identified with the Coastal Zone are the sedimentary group lying west of an imaginary line running from Cape Henrietta Maria to Rupert House. Included in this group are Akimiski, Charlton, Lord Weston, North and South Twins, Trodley, and Grey Goose. East of the line, islands such as Bear and Solomons Temple are rock outcrops of Precambrian or pre-Palæozoic formations.

The most conspicuous topographic features of importance on any of the Coastal Zone islands are the 50- to 60-foot bluffs that run north to south on the Twin and Lord Weston Islands. These appear to be part of what may have been a large terminal moraine, as they, like the rest of the islands, are dotted with large glacial erratics. As in the case of the coastal areas of the mainland, series of elevated beaches or shale ridges are also a marked feature of these Coastal Zone islands.

Physically the Coastal Zone holds no more appeal to man than do the other zones. Together the various zones represent an area that, if it were not for fur-bearing animals that inhabit the region, and the resulting fur trade, could well be considered Canada's Water Desert.

RÉSUMÉ

La partie continentale des basses-terres de la baie d'Hudson est une plaine côtière uniforme d'environ 125,000 milles carrés, s'étendant du côté ouest des baies James et d'Hudson. Quoique l'aspect général soit celui d'une plaine basse, marécageuse, couverte de lacs, rivières et ruisseaux, il y a quand même assez de variété dans le climat, le drainage et l'évolution géologique pour se permettre de subdiviser cette région en quatre zones.

La première, la zone aride, est située dans la partie sud-est des basses-terres et est caractérisée par une superficie de 40 à 50 p. 100 de terre aride, toutefois assez bien boisée. On trouve ailleurs des savanes et des marécages de toutes sortes.

La deuxième est une zone de savanes (muskeg) et de petits lacs qui occupe la partie centrale des basses-terres; elle est la plus représentative de la topographie de la région. Des marécages de dimensions diverses sont couverts de sphaignes détrempées, incluant des groupes de carex et d'épinettes noires chétives. Les lacs occupent jusqu'à 50 p. 100 de la superficie dans une autre partie de la zone.

La troisième, la zone d'argile marine, est située au nord de la rivière Severn et est ainsi nommée à cause de son manteau d'argile déposé à l'époque de la submersion post-glaciaire des basses-terres. L'écoulement des eaux est retardé par un drainage inadéquat et la présence, en tout lieu, de permafrost et de sols imperméables.

La quatrième, la zone côtière, frange la côte sur une largeur de plusieurs milles; elle est située en grande partie au nord de la limite septentrionale de la forêt. Le principal caractère physique de cette zone consiste en plages qui s'étendent sur quelques milles dans la baie, à marée basse.

Ces différentes zones forment donc une région qui, si elle ne servait pas de refuge pour les animaux à fourrures et de territoire de chasse pour l'homme, mériterait bien le nom de "désert aquatique canadien".

ESQUISSE GÉOGRAPHIQUE DE LA RÉGION DE FLOEBERG BEACH, NORD DE L'ÎLE ELLESMERE

Pierre Gadbois et Camille Laverdière[1]

Cette synthèse de géographie régionale est basée sur une série d'observations effectuées sur le terrain pendant une partie de l'année 1952. La région de Floeberg Beach se situe à l'intérieur des latitudes boréales 82° 25′ et 82° 35′, et des longitudes 61° 30′ et 63° 30′.

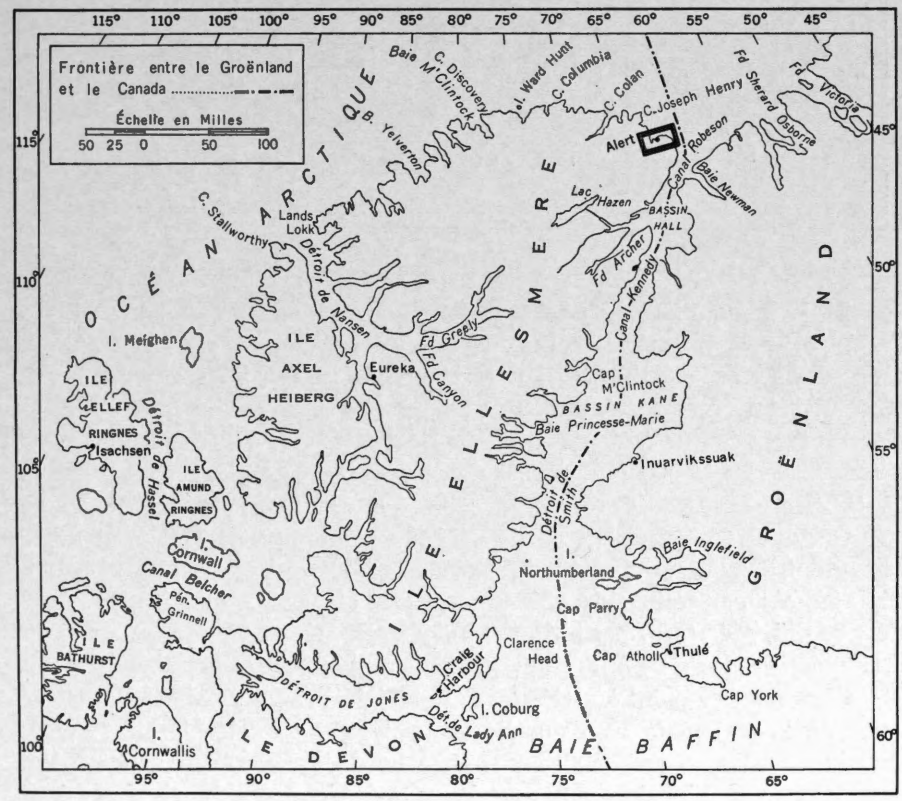

Figure 1. Carte de localisation.

APERÇU HISTORIQUE

La seule atteinte du pôle nord géographique tourmenta longtemps plus d'un explorateur. Les côtes septentionales de l'île Ellesmere s'offrirent enfin avec succès, il y a 45 ans, comme le dernier tremplin sur la terre ferme, avant la marche sur la banquise polaire, qui permit de pousser jusqu'au faîte du globe terrestre. Car au préalable les côtes du Groenland, quoique projetées davantage vers le nord, s'avérèrent impraticables

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[1] Pierre Gadbois, B.A., M.A., Université de Montréal, et Camille Laverdière, B.Sc., Université Laval, M.A., Université de Montréal, sont géographes à la Division de la géographie, Ministère des Mines et des Relevés techniques, Ottawa. Tous deux étaient membres d'une expédition dirigée par M. Gadbois qui prépara les chapitres sur le climat et les glaces; quant aux autres chapitres, on les doit à M. Laverdière.

après une expérience de Peary en 1900[1]; le choix du Svalbard (Spitzberg) fut également la cause d'essais infructueux au début du siècle dernier.

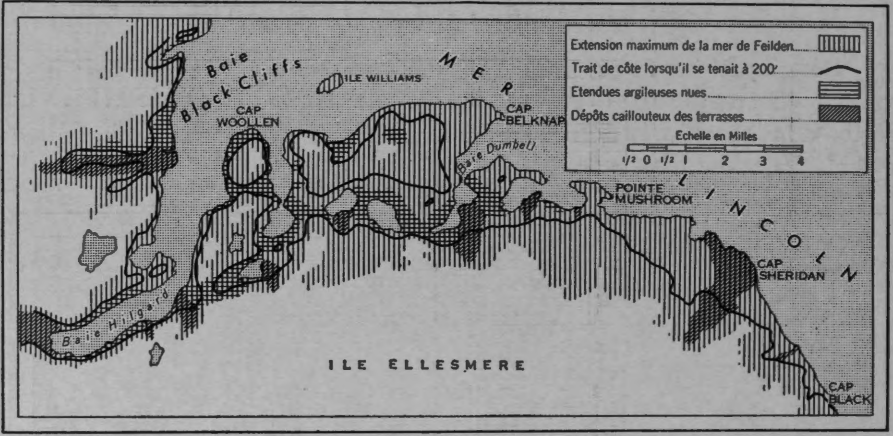

Figure 2. L'invasion marine post-glaciaire dans la région de Floeberg Beach.

Mais la première grande tentative pour atteindre le pôle nord, par l'archipel arctique américain, fut vouée à un échec complet; A. H. Markham[2] dirigeait ce raid sous l'expédition de Nares, en 1876. Pourtant, cette voie d'accès, l'*American Route* comme on l'appelait (par suite des essais antérieurs entrepris surtout par des américains tels Kane, Hayes, Hall et Greely), devait être la plus favorable de toutes, comme le croyaient C. R. Markham[3] et Nares[4] lui-même, et comme le démontra finalement Peary[5] en atteignant ce but ultime si convoité, au printemps de 1909. Il fallait cependant acquérir une méthode de voyage appropriée à la région, soit le déplacement par traîneau à chiens emprunté en l'occurrence à l'indigène[6]; c'est ce qui, plus tard, permit aussi à des explorateurs comme Rasmussen, Stefansson et Koch, de faire connaître plus rapidement le domaine arctique.

C'est donc ce point à atteindre qui précipita, simultanément, la découverte de la région de Floeberg Beach, puisqu'elle se situait alors sur le chemin du pôle. Ainsi, Hall en 1871, à bord du *Polaris*, navigua même dans la mer de Lincoln avant que la poussée des glaces ne le force à se retirer presqu'aussitôt[7]. Mais la région à l'étude n'est vraiment connue que depuis 1875, grâce au navigateur Nares qui, ne pouvant pousser plus avant son navire bloqué par le pack boréal, fut forcé d'hiverner au nord de

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[1] "*. . .the result of the journey was to eliminate this route as a desirable or practicable one by which to reach the Pole. The broken character of the ice, the large amount of open water, and the comparatively rapid motion of the ice, as it swung round the northern coast into the southerly setting East Greenland current, were very unfavourable features,*" R. E. Peary: *Nearest the Pole*, Hutchison & Co., London, 1907, p. 333.

Voir également R. E. Peary: *Four Years Arctic Exploration 1898-1902* dans *Geog. Jour.*, vol. 22, 1903, p. 656; puis le rapport de R. E. Peary: *Work Done in the Arctic in 1898-1902* dans *Bull. Amer. Geog. Soc.*, vol. 35, 1903, p. 518.

[2] A. H. Markham: *The Great Frozen Sea*, Daldy, Isbister & Co., London, 1878, pages 308-368. Voir aussi A. H. Markham: *On Sledge Travelling* dans *Proc. Geog. Soc.*, vol. 21, 1877, pages 110-119.

[3] C. R. Markham: *The Arctic Expedition of 1875-76* dans *Proc. Geog. Soc.*, vol. 21, 1877, p. 553.

[4] G. S. Nares: *On the Navigation of Smith Sound, as a Route to the Polar Sea*, dans *Proc. Roy. Geog. Soc.*, vol. 21, 1877, pages 274-281. Voir aussi G. S. Nares: *On the North Circumpolar Sea* dans *Proc. Roy. Geog. Soc.*, vol. 21, 1877, pages 96-106.

[5] R. E. Peary: *The North Pole*, Hodder & Stoughton, London, 1910, p. 257.

[6] R. E. Peary: *The Secrets of Polar Travel*, The Century Co., New York, 1917, IX + 313 pages.

[7] C. H. Davis, ed.: *Narrative of the North Polar Expedition*, Gov. Print. Office, Washington, 1876, p. 84.

l'île Ellesmere; c'était la première fois qu'une expédition mettait pied en ces lieux.[1] On organisa par la suite des équipes de cartographie, dont celle d'Aldrich délimita le littoral nord de l'île. Puis Pavy, médecin de l'expédition de Greely établie à Fort Conger lors de la première année polaire en 1882, n'effectua qu'un rapide passage à Floeberg Beach.[2] Finalement, Peary hiverna à deux reprises à Floeberg Beach, soit en 1905-1906 et 1908-1909, presqu'au même emplacement où se trouvait Nares quelques décennies auparavant.[3]

Figure 3. Floeberg Beach, sur les rivages de l'océan Arctique, là où Nares et Peary hivernèrent. Les blocs de glace, continuellement ancrés sur l'avant-côte, suggérèrent le nom pour cette localité. La banquise polaire, poussée par des vents de l'intérieur des terres, se tient présentement au large de la côte.

De nos jours, dans ces solitudes de l'Arctique, quelques cairns rappellent le séjour de Nares et de Peary, comme de quelques-uns de leurs hommes qui y laissèrent leur vie. De plus, des cercles de tentes, posées en bordure des eaux à Floeberg Beach, témoignent d'une résidence temporaire des Esquimaux du district de Thulé, au Groenland; ils accompagnaient Peary à chacune de ses expéditions. Malgré un gibier relativement abondant, on n'a pas encore trouvé de preuves d'une colonisation ancienne de la région par les Esquimaux, ou du moins du passage de leur périodique parti de chasse. Ils ont dû certes s'aventurer un jour dans la région de Floeberg

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[1] G. S. Nares: *Journals and Proceedings of the Arctic Expedition*, 1875-76, Harrison & Sons, London, 1877, p. 14. Voir aussi G. S. Nares: *Capt. Nares' Report* dans *Nature*, vol. 15, 1877, p. 32. Enfin, G. S. Nares: *Narrative of a Voyage to the Polar Sea during 1875-76 in H.M. Ships* "Alert" *and* "Discovery", Low *et al.*, London, 1878, vol. 1, pages 129-130.

Voir, de plus, E. L. Moss: *Shores of the Polar Sea; a Narrative of the Arctic Expedition of 1875-6*, Ward & Co., London, 1878, 83 pages.

[2] A. W. Greely: *Three Years of Arctic Service*, Bentley & Son, London, 1886, vol. 1, p. 111.

Voir également J. Rouch: "Le record français de latitude" dans *La Géographie*, t. 50, 1939, pages 1-12.

[3] Peary: *Nearest the Pole*, *op. cit.*, et Peary: *The North Pole*, *op. cit.*

Beach, car on sait qu'ils peuplèrent jadis une grande partie de l'île Ellesmere, venant par vagues successives de migration, à la poursuite de l'ours blanc et du bœuf musqué. Les indigènes passèrent ensuite de l'île Ellesmere au Groenland en franchissant le détroit de Smith et les canaux Kennedy et Robeson. Ainsi, à moins de 50 milles au sud de Floeberg Beach, au cap Beechy, on décela des vestiges de leurs anciennes pérégrinations,[1] et même à mi-chemin, soit à la baie Lincoln, au dire de Peary.[2]

Les secteurs plus méridionaux de l'île, d'ailleurs plus faciles d'accès, furent visités assez régulièrement par les blancs, dont des membres de la Gendarmerie royale du Canada. Jusqu'à ces derniers temps, les *Esquimaux polaires* du Groenland allaient s'y approvisionner en fourrures chaque printemps. Les expéditions arctiques internationales n'étant plus possibles depuis le dernier conflit mondial, on s'est alors intéressé à une nouvelle organisation de ces territoires éloignés, en établissant surtout des postes météorologiques; celui d'Alert est compris à l'intérieur de la région à l'étude.[3]

LE RELIEF ET LA STRUCTURE

Le site de la région de Floeberg Beach occupe une unité géographique cohérente, bornée par la mer sur la moitié de ses façades et par des crêtes osées et rugueuses sur l'autre moitié. En effet, le territoire concerné se perd sous les eaux de l'océan Arctique, lorsque des falaises déclives bordent le canal Robeson; à l'intérieur des terres, la contrée inégale, menant au lac Hazen, et la chaîne United States finissent de le circonscrire. En gros, c'est un plateau vaguement ondulé qui gagne d'une façon plus ou moins douce le niveau des eaux. Ces hautes-terres de roches calcareuses, incisées en véritables traits de scie par de nombreux ravins, atteignent des altitudes de 700 et même 1,000 pieds; quelques croupes plus résistantes d'argilite percent au dessus de cette surface.

Le littoral est frangé de quelques baies, vestiges d'un relief ennoyé qui n'a pas encore retrouvé sa position pré-glaciaire; la baie Hilgard est en réalité un fjord. La présence de lacs ainsi que des étangs Hill et White en un tel territoire est le résultat de surcreusements différentiels de la part des appareils glaciaires. En d'autres occasions, une sédimentation marine fait office de barrage une fois lacs et bouchons portés en position terrestre: des exemples de masses d'eau retenues en amont de telles accumulations nous sont donnés par les lacs Lower- et Upper-Dumbell; toutefois, une solifluction d'inégale ampleur joue le même rôle en certains cas. D'autre part, les cours d'eau, coulant brusquement durant une très courte partie de l'année, ont entaillé en canyon la roche en place: à leur embouchure s'étagent des deltas de matériaux grossiers qu'une solifluction n'a pas réussi à perturber, à cause de la nature des roches constituantes. Sur ces vastes platières sans déclivité, les cours d'eau s'étalent subitement mais en se canalisant toutefois en plusieurs chenaux.

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[1] H. W. Feilden: *On the Mammalia of North Greenland and Grinnell Land* dans *The Zoologist*, 3e sér., vol. 1, 1877, p. 315. Voir aussi H. W. Feilden: *Ethnology* dans Nares, 1878, *op. cit.*, p. 190. Finalement, E. L. Moss: *A Fragment of Human Skeleton from North Latitude 81° 42'* dans *Sc., Proc. Roy. Dublin Soc.* (nouv. sér.), vol. 1, 1877, pages 68-69.

[2] Peary: *Geog. Jour.*, 1903, *op. cit.*, p. 667.

[3] R. W. Rae: *Joint Arctic Weather Project* dans *Arctic*, vol. 4, 1951, pages 21-22.

LE SOUBASSEMENT ROCHEUX, SA PHYSIONOMIE

Si la région fut autrefois fortement perturbée, puis nivelée en une surface plus ou moins plane par divers agents, on discerne dans le détail le résultat d'un agencement entre la structure des couches et leur composition. D'une part, à travers toute la contrée règnent des assises sédimentaires redressées presqu'à la verticale;[1] d'autre part, une monotone interstratification de calcaire dur et de schiste argileux tendre compose la texture des différents lits peut-être d'âge huronien d'après Feilden et De Rance,[2] mais de l'ère suivante (ou paléozoïque) pour Troelsen.[3] L'érosion sélective à donc pu s'opérer merveilleusement en un tel milieu; elle se manifeste par l'alternance d'un relief en creux et d'un relief en bosses orienté suivant la direction des strates, soit OSO-ENE. Des assises d'argilite plus résistantes que les roches avoisinantes s'identifient avec les témoins d'érosion que sont les monts Dean et Pullen, ainsi que dans cette série de collines qui se poursuivent vers le sud-ouest; la portion centrale surbaissée de l'une de ces collines s'explique par l'intercalation d'un calcaire plus tendre. Quelques raides falaises ébouleuses de la rive droite du fond de la baie Hilgard doivent également leur aspect à l'argilite, roche légèrement métamorphique.

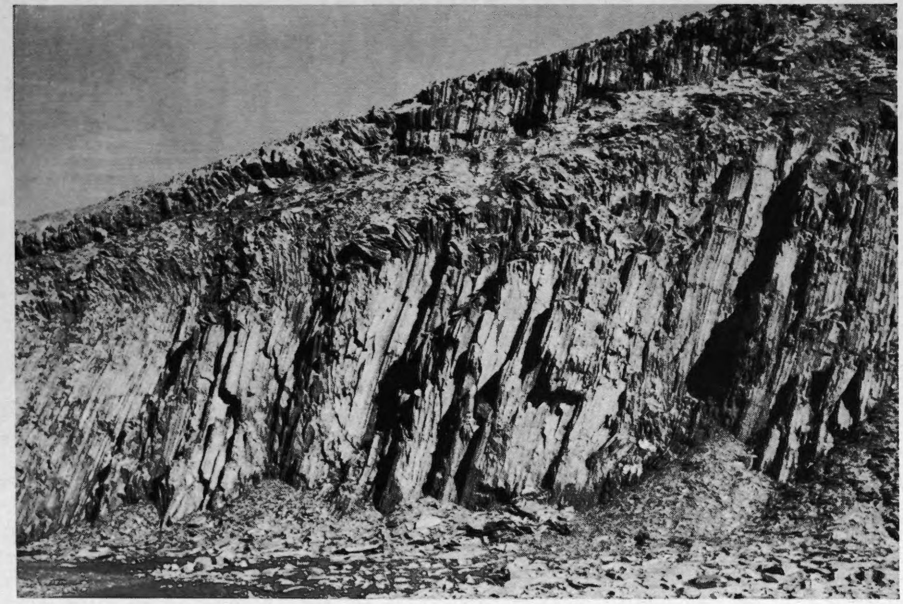

Figure 4. Roche en place représentée par des interstratifications de calcaire et de schiste argileux dont les lits sont redressés presqu'à la verticale; à remarquer un glissement par faille à la partie supérieure de l'affleurement rocheux.

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[1] J. P. Johnson: *Information Collected About the Dumbbell Bay and North Ellesmere Island Regions of the Canadian Arctic Archipelago*, thèse M.A., Darmouth College, Hanover, N.H. (sans date; 1951), pages 23-24.

[2] H. W. Feilden et C. E. De Rance: *Geology of the Coasts of the Arctic Lands* dans *Quart. Jour*. Geol. Soc. London, vol. 34, 1878, pages 556-557. Voir aussi C. E. De Rance et H. W. Feilden: *On the Geological Structure of the Coasts of Grinnell Land and Hall Basin* (dans Nares, *op. cit.*, 1878), p. 328.

[3] J. C. Trœlsen: *Contribution to the Geology of Northwest Greenland, Ellesmere Island and Axel Heiberg Island* dans *Medd. om Grønland*, Bd. 149, Nr. 7, 1950, p. 64.

Le paysage, dans l'ensemble, se présente donc comme une vaste surface aux lignes molles et ondulées, peut-être gauchie de l'intérieur des terres vers la mer; seules quelques buttes résistèrent assez efficacement aux processus de dénudation de l'érosion péri-glaciaire. L'allure de ce relief tabulaire se retrouve inchangée de chaque côté de la vallée de la rivière Hilgard, puisqu'elle n'occupe qu'une auge glaciaire remarquablement burinée à même le plateau. De rares plissements anticlinaux et synclinaux apparaissent dans les coupes toujours fraîches des berges des ravins; le pendage est généralement très accusé et uniforme, à l'exception des lits très plissotés aux environs de la rivière Hilgard. Des failles nombreuses, mais impuissantes à déterminer les grands traits du relief—quoique l'ample vallée Winchester pourrait fort bien être le résultat d'un effondrement local—accompagnèrent sans doute de tels plissements des couches géologiques.

Ainsi, on voit de nombreux plans de friction le long du premier mille du ravin Parr, dont le tracé rectiligne fut déterminé par une ligne de faille; on remarque même un déplacement vers l'aval, de la rive droite par rapport à la rive opposée, d'environ 75 pieds.

L'ENGLACIATION CONTINENTALE

Le secteur étudié de l'île Ellesmere, tout aussi bien que la terre de Peary au Groenland, occupe les plus hautes latitudes boréales de tous les continents. On s'explique alors mal que ces régions soient présentement dépourvues de neige pérenne caractérisant pourtant les étendues circonvoisines; mais il faut croire sans doute que la fonte estivale vient à bout des accumulations. Toutefois, à l'époque de la dernière grande activité glaciaire (Wisconsin), l'île Ellesmere, y compris sa partie nordique, subit un râclage glaciaire ne laissant, à son départ du plateau de Floeberg Beach, qu'un sol parsemé tout au plus de débris erratiques. Pour Koch,[1] le Groenland septentrional au contraire fut de tous temps préservé d'un recouvrement par les glaces.

Malgré l'intempérisme accusé s'attaquant au soubassement rocheux, deux séries différentes de stries glaciaires bien conservées (OSO-ENE et SSE-NNE) furent observées dans la péninsule Kirk et du côté opposé de la baie Colan, Johnson[2] dit en avoir également identifié. Toutefois, la première série sus-mentionnée, se tenant à une basse altitude, peut être due à l'action des glaces de mer serties de pierres et poussées sur le rivage. D'une façon générale, le paysage côtier d'Ellesmere devait être autrefois occupé par un glacier de barrière, à l'origine de ces îlots de glace flottant à la dérive avec le pack de l'océan arctique.[3]

L'INGRESSION MARINE

Le retrait généralisé de la calotte inlandaisienne amena des rajustements isostatiques, sans doute accompagnés, d'autre part, de manifesta-

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[1] L. Koch: II—*Contributions to the Glaciology of North Greenland* dans *Medd. om Grønland*, Bd. 65, Nr. 15, 1928, p. 380.

[2] J. P. Johnson: *op. cit.*, pages 30-31.

[3] G. Hattersley-Smith: *Comments on the Origin of the Ice Islands* dans *Arctic*, vol. 5, 1952, p. 96.

tions eustatiques. Dans l'intervalle, la transgression marine qui s'ensuivit dépassa quelque peu la cote actuelle de 400 pieds, que nous n'avons pu malheureusement déterminer avec précision.

Schei[1], pour le district situé au sud, et Koch[2], pour la terre de Peary, rapportèrent des valeurs plus fortes; mais nous attendons surtout, pour objet de corrélation, les résultats des dernières missions danoises[3] et françaises[4], car au dire de Knuth[5], Koch n'avait pas toujours la tâche facile. Ainsi en fut-il pour Feilden[6], quand on se rend compte de ses données de près du triple; car on s'aperçoit aisément, pour avoir inventorié géographiquement le même territoire, que ces différences ne sont dues qu'à des méprises ou à certaines évaluations spéculatives. On ne pouvait dès lors fonder nos connaissances sur de telles données pour établir la partie de la carte glaciologique de cette contrée[7].

Sur la marge de cette étendue d'eau post-glaciaire, que nous appellerons désormais la mer de Feilden—on sait que Feilden, attaché en tant que naturaliste à l'équipe de Nares, fut le premier à s'occuper de morphologie dans la région—les appareils fluviatiles sédimentèrent leurs tributs divers; l'exondation précitée les porta en position terrestre. On retrouve rarement ces alluvions sur le littoral immédiat des eaux arctiques, à l'exemple des dépôts caillouteux rattachés à la pointe Sheridan, vu leur redistribution par le formidable pack polaire; ils persistent au contraire s'ils occupent un inlet ou une baie, en d'autres mots un rentrant quelconque hors de la poussée des glaces.

S'il est vrai que les cours d'eau responsables de ces transports sont gelés sur place durant dix mois, que la durée de la fonte s'étire languissante sur ceux qui restent, il arrive toutefois quelques brèves mais puissantes périodes où le tracé fluvial se change en un véritable torrent capable de rouler des boulders fort respectables. On n'est dès lors aucunement surpris de rencontrer, lié à l'embouchure de ces ravins, un matériel grossier, allant de sablons à des cailloux de plusieurs pouces de diamètre, accumulé en deltas étagés; au cours du soulèvement épéirogénique, le ruisseau s'enfonçait d'une façon concomitante dans ses propres alluvions. Mais au cours de cette progression régulière vers l'aval, ces débris torrentiels surmon-

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[1] P. Schei: *Summary of Geological Results* dans *Geog. Jour.*, vol. 22, 1903, p. 64. Voir aussi O. Holtedahl: *Summary of Geological Results* dans *Report of the Second Norwegian Arctic Expedition in the* "Fram", *1898-1902*, nº 36, The Society of Arts and Sciences of Kristiania, 1917, pages 22 et 24.

[2] *Op. cit.*, p. 381. Voir également L. Koch: *The Physiography of North Greenland* dans *Greenland, the Discovery of Greenland, Exploration and Nature of the Country*, vol. I, Reitzel, Copenhagen; Milford, London, 1928, p. 517.

[3] J. C. Troelsen: (dans P. C. Winther: *A Preliminary Account of the Danish Pearyland Expedition*, 1948-49), dans *Arctic* ,vol. 3, 1950, p. 7.

Mais déjà en 1947, aux abords du fjord de Brønlund, un relevé géologique d'une période de deux semaines ne fit reconnaître à J. C. Troelsen: *Contributions to the Geology of the Area Round Jørgen Brønlunds Fjord, Peary Land, North Greenland* dans *Medd. om Grønland*, Bd. 149, 1949, p. 20, qu'une altitude de 113 mètres. (115 mètres dans B. Fristrup: *Perry Land* dans *Can. Def. Sc. Ser.*, 1953, p. 4, traduit de *Naturens Verden*, vol. 35, 1951.)

[4] J. Malaurie: "Une expédition géographique dans le nord du Groenland" dans *Rev. Géog.*, Lyon, vol. 27, 1952, p. 296.

[5] C. E. Knuth: *The Northermost Country in the World* dans *Geog. Mag.*, vol. 24, 1951, p. 218. Voir également C. E. Knuth: *The Danish Expedition to Peary Land, 1947-49* dans *Geog. Jour.*, vol. 118, 1re partie, 1952, p. 1 .

[6] H. W. Feilden: *The Post-Tertiary Beds of Grinnell Land and North Greenland* dans *Ann. and Mag. Nat. Hist.*, London, 4e sér., vol. 20 ,1877, p. 485. Voir aussi H. W. Feilden: *Arctic Molluscan Fauna* dans *The Zoologist*, 3e sér., vol. I, 1877, p. 438. Puis H. W. Feilden et C. E. De Rance, *op. cit.*, p. 566. Finalement, C. E. De Rance et H. W. Feilden, *op. cit.*, p. 343.

[7] R. F. Flint *et al.*: *Glacial Map of North America* dans Geol. Soc. of America, *Spec. Paper 60*, 1re partie, 1949. Aussi la carte en pochette de A. L. Washburn: *Reconnaissance Geology of Portions of Victoria Island and Adjacent Regions. Arctic Canada* dans Geol. Soc. Amer., *Mem. 22*, 1947.

tèrent finalement le limon antérieurement accumulé au large, puisque les particules étaient tenues plus longtemps en suspension; le mobile de ce comportement réside dans l'abaissement de niveau du bassin de réception.

LES TERRASSES ET LES CAILLOUTIS

Si la terrasse prise comme unité représente un relief originel, leur ensemble cependant se qualifie de composite. Il y a distinction en effet entre les premières qui se sont formées, donc occupant les niveaux supérieurs, et les dernières naturellement situées aux basses altitudes ou encore toujours en présente formation.

Au début, la déversée du matériel caillouteux s'effectuait sur les bords d'un bassin profond, le colmatage prenant avant tout de l'importance suivant la verticale: voilà pourquoi les talus occupent-ils le trait dominant. Mais plus les eaux de la mer de Feilden se faisaient rares, parallèlement à leur régression, plus la charge devait se déposer sur un fond sans profondeur. Ainsi donc les replats se déployaient à leur tour pour n'être plus occupés que partiellement par le réseau hydrographique à chenaux digités qui, ne pouvant s'accaparer en entier de l'énorme platière deltaïque, laissait à la mer le soin de façonner maintenant, au-delà de l'estran, une terrasse d'érosion. Cette dernière particularité ne fut acquise que depuis les temps récents; voilà pourquoi la terrasse présentement en formation se différencie de la terrasse d'accumulation maintenant exhaussée.

La submersion post-glaciaire s'effectua non pas par saccades suivies de repos consécutifs, mais par une simple élévation continentale plus ou moins lente: retenons qu'il n'y a aucune solution de continuité dans l'altitude d'un replat de terrasse à un autre.

Les processus de mise en place des cailloutis à leur entrée dans la mer demeurent assez bien connus. De plus, le débit des tributaires contribue suffisamment à une déchloruration des eaux bordières, avec pour résultat d'exclure le développement de toute vie marine. Si de nos jours quelques rares spécimens fossiles se rencontrent à la surface de ces assises, il faut y voir le jeu d'un simple transport par les eaux de ruissellement au départ de strates argileuses fossilifères reposant plus haut, ou encore d'atterrissages postérieurs suivant divers procédés, au delà du trait de côte mais à l'écart des embouchures du réseau à chenaux multiples.

LES ARGILES FOSSILIFÈRES

Des dépôts alluvionnaires argileux d'origine marine ne pouvaient se former qu'en retrait des éventails deltaïques construits en eaux troubles. Une fois portés hors des eaux, ces sols meubles sont ravinés à l'extrême par des rigolets d'érosion dans lesquels s'engage un véritable fleuve de boue qui finalement s'accapare de tout le paysage.

L'argile culmine rarement à l'altitude atteinte par les replats caillouteux des terrasses, car lorsque l'édification de ces dernières se poursuivait, les boues étaient déjà sédimentées au large et bien en contrebas; on ne peut s'en servir pour mesurer la limite maximum atteinte par la transgression post-glaciaire. Des lambeaux résiduels, étudiés avec précaution, pourraient toutefois faire office de témoins précieux.

Les boues sont excessivement riches en carbonate de calcium, mais peu plastiques et peu susceptibles de porter un sol réticulé quand elles ne sont pas dérangées par la solifluction. L'eau circulant dans le sol *per ascensum* dépose lors de son évaporation, une fois la surface libre atteinte, une carapace plus ou moins blanche de sel; ces surfaces, une fois asséchées, confèrent au paysage une coloration très pâle tranchant avec le reste du sol terne et brunâtre. L'argile, par sa fine texture, est plus apte à porter le pâturage à bœufs musqués,[1] cette association de carex et de graminées hydrophiles formant un tapis continu.

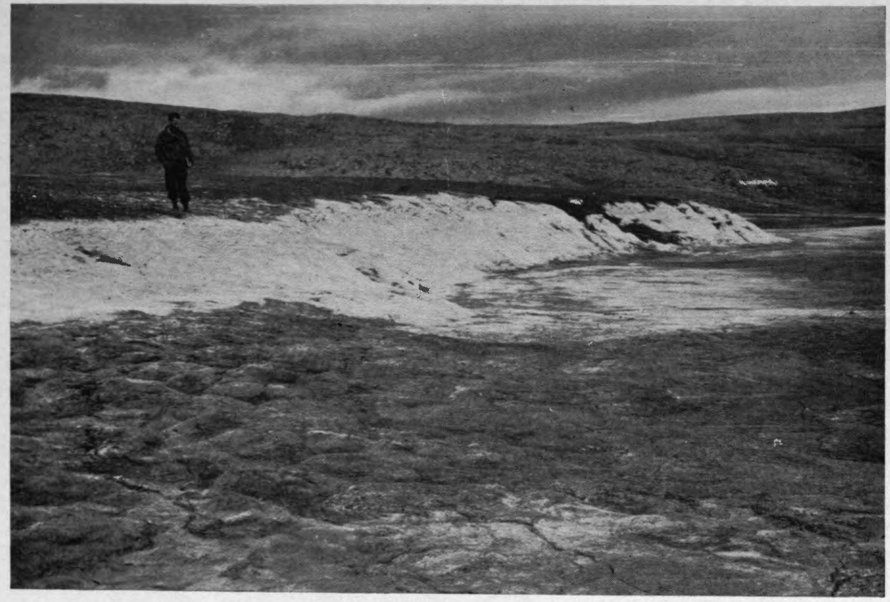

Figure 5. Argile coquillère d'origine marine, à la tête de la baie Colan, et mince couverture de sels de carbonate de calcium à sa surface.

Une faune marine prodigieuse quant aux individus, mais monotone à l'excès quant aux espèces, s'est développée au sein de ce matériel approprié reposant jadis sous les eaux salées. Poussés à l'extérieur du sol par les alternances de gel et de dégel, des bancs entiers de coquillages enduits de rouille caractérisent les étendues d'argile marine, le plus souvent vides de peuplement végétal, quoique la prairie à monocotyles puisse envahir les parties soliflués. Mais à l'intérieur de ces millions de pélécypodes à coquilles bien développées, on ne reconnaît qu'une faune crustacéenne vraiment médiocre, quelques espèces tout au plus. Ainsi, *Astarte borealis*

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[1] A ce sujet, voir C. Laverdière: "Les pâturages à bœufs musqués du nord de l'île d'Ellesmere, archipel arctique canadien" dans *Rev. Géog. Alpine* (sous presse).

et *Saxicava arctica* sont les spécimens les plus communs; nous avons trouvé, de plus, *Astarte striata*, *Mya truncata* beaucoup plus rare et enfin *Macoma balthica* mais en un seul endroit.[1] Toutefois, Feilden[2] eut l'opportunité de déceler quelques gîtes fossilifères plus riches en espèces.

De plus, nous avons trouvé, parmi de tels gîtes, un crâne de bœuf musqué (*Ovibos moschatus*) et des parties bien conservées d'arbres flottés; on sait que Feilden[3] rencontra d'autres mammifères de la faune du pays ainsi fossilisés.

LES SOLS POLAIRES

LA SOLIFLUCTION

Il s'en faut que les dépôts marins antérieurement décrits occupent tout l'espace compris entre le niveau de la mer et la plus haute limite atteinte par celle-ci à la disparition des glaciers du pléistocène. De grands placages furent laissés complètement à nu sur lesquels prit naissance un matériel non consolidé que la solifluction transporta ensuite au bas des pentes. Mais les sols meubles formés *in situ* règnent avant tout sur le plateau; ils portent sans exception un magnifique réseau polygonal.

L'Arctique est un paysage en marche: la solifluction s'accapare en effet de tout le terrain qu'elle tend à réduire à un même niveau. Les cours d'eau, ont une moins grande participation dans ces aplanissements, quoiqu'à la fonte des neiges, l'écoulement en nappe aide déjà considérablement à réduire le relief. La moindre dénivellation favorise un écoulement du matériel meuble devenu plastique, puisque gorgé d'eau, avec le dégel estival; à la cessation de cette courte activité saisonnière, le permafrost n'est encore qu'à deux ou trois pieds de la surface du sol.

Le sous-sol de la région de Floeberg Beach est donc gelé en permanence, même si la partie sus-jacente hausse sa température au-dessus de 32° Fahrenheit durant environ deux mois. Tout le territoire témoigne de l'activité intense causée par la solifluction: le sol coule comme un sirop plus ou moins figé que l'on aurait versé sur une série d'aspérités; les coulées pierreuses et les trains de boulders cheminent à travers la contrée; les sols réticulés s'allongent suivant le sens des pentes; les bourrelets soliflués, au contraire, épousent les courbes de niveau, tandis qu'au pied des déclivités, avec la terminaison des raideurs, un chevauchement du matériel ne peut que s'ensuivre.

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[1] Ces mollusques fossiles furent obligeamment identifiés par M. Aurèle La Rocque de l'Ohio State University.

[2] H. W. Feilden: *The Post-Tertiary...op. cit.*, p. 485. Aussi dans H. W. Feilden: *Arctic Mulloscan... op. cit.*, p. 438; H. W. Feilden et C. E. De Rance, *op. cit.*, p. 566; C. E. De Rance et H. W. Feilden, *op. cit.*, pages 342-343.

On conférera de plus aux travaux suivants: J. G. Jeffreys: *The Post-Tertiary Fossils Procured in the Late Arctic Expedition* dans *Ann. and Mag. Nat. Hist.*, London, 4e sér., vol. 20, 1877, pages 232-237; puis J. G. Jeffreys: *Note* dans *Ann. Mag. Nat. Hist.*, 4e sér., vol. 20, 1877, pages 489-491; R. P. Whitfield: *Notes and Observations on Carboniferous Fossils and Semi-fossil Shells* dans *Amer. Mus. Nat. Hist.*, vol. 24, art. 2, 1908, pages 57-58; enfin, J. P. Johnson, *op. cit.*, p. 29.

Quant à certains mollusques vivant de nos jours dans la région de Floeberg Beach, pour fins de comparaison, voir E. A. Smith: *On the Mollusca Collected during the Arctic Expedition of 1875-76* dans *Ann. Mag. Nat. Hist.*, 4e sér., vol. 20, 1877, pages 136-144; et E. A. Smith: *Mollusca* (dans Nares, 1878, vol. II, *op. cit.*), pages 227-231.

[3] H. W. Feilden: *The Post-Tertiary...op. cit.*, pages 487-488; *On the Mammalia ...op. cit.*, pages 316-317; *Mammalia* (dans Nares, vol. 2, *op. cit.*), p. 195; enfin De Rance et Feilden, *op. cit.*, p. 344 et Fielden et De Rance, *op. cit.*, p. 566.

La désagrégation première du substratum rocheux, par éclatement des pierres dû au gel et au dégel, donne tout d'abord un relief spécial de blocailles bouleversées et désordonnées. La mise en marche de ces pavages de blocaux, posés sans ordre déterminé sur le terrain, les oriente suivant leur longueur dans la direction de l'écoulement. D'autre part, elle en fait redresser plusieurs si un obstacle quelconque situé à l'aval, éperon de roche en place ou pierre libre, empêche la progression d'une dalle pierreuse; cette dernière se redresse alors sous la poussée continue. On aura alors autant de "pierres tombales" posées debout dans le paysage. Sur ces débris qui s'amenuisent de plus en plus, un sol meuble, tout en s'approfondissant, donnera naissance aux sols réticulés.

Figure 6. Paysage de blocailles bouleversées résultant de l'attaque première du substratum rocheux par les divers agents d'érosion, en région d'assises de calcaire.

LES SOLS RÉTICULÉS

Il n'est aucunement question ici d'étudier le mécanisme à l'origine de ces sols polaires; nous donnerons simplement le résultat auquel en est arrivé une étude plus poussée de ce type de terrain.[1] Il s'agira de s'attarder quelque peu sur le sol polygonal typique du plateau, puis de passer à la description des autres types génétiques dont la classification fut basée sur la nature du substratum qui conditionne, avant tout, telle ou telle forme.

Le Groupe Majeur. En plein domaine du terrain réticulé, en pays uni ou doucement vallonné, chaque polygonne atteint un diamètre d'un peu plus

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[1] C. Laverdière,: "Les terrains réticulés de la région de Floeberg Beach, nord de l'île d'Ellesmere, archipel arctique canadien"; Division de la géographie, Ministère des Mines et des Relevés techniques, Ottawa, 1952 (manuscrit non publié).

de deux pieds, fort bombé; de plus, l'hexagone ou pentagone est ceint par une dépression dont la profondeur, sous le sommet du renflement, est d'environ 6 à 8 pouces. Le fond de la cavité s'élargit avec l'âge: au début, une simple fissure se dessine, mais les angles du polygone s'émoussant, celui-ci prend alors des formes curvilignes si bien que dans un tracé en plan, chaque dos apparaît comme un cercle. Parallèlement à ce phénomène, le bombement s'accuse jusqu'à offrir un dos d'allure par trop pointue, en bosse de chameau. Au lieu de se dégrader en vieillissant, le polygone prend au contraire de l'ampleur puisqu'il tend incessamment à la calotte sphérique en surface, à la sphère si nous poussons l'extension en profondeur.

Figure 7. Sol réticulé typique du plateau de la région de Floeberg Beach; topographie également bien représentative avec ses longues surfaces ondulées et ses buttes-témoins, à l'arrière-plan par exemple.

Le sol non consolidé du plateau, provenant de la désintégration de la roche en place, contient donc encore des cailloux plus ou moins morcelés. Dans un sol soumis au gel et au dégel, les pierres libres sont rejetées à sa surface, leur uniforme distribution caractérisant le premier stage. Mais elles prennent le chemin du fond de la tranchée par microsolifluction, éboulement dû à la gravité, entraînement par les eaux de fonte ou pluviales, déplacement par le vent, le gel et le dégel, etc. A ces emplacements, sur sols mûrs, on constate une prédominance marquée en éléments caillouteux, plus fins et menus que ceux de dos du polygone. Puisqu'ils sont plus mûrs, la fragmentation eut temps d'être poussée plus loin; leur diamètre varie de fractions de pouce à quelques pouces. On rencontre toute la gamme de distribution, depuis le sol jeune et donc à cailloux uniformément répartis à sa surface, jusqu'aux sols rendus à maturité dont le contraste est bien apparent entre sommets et dépressions.

Les polygones se dessinent aussi nettement sur schiste argileux que sur calcaire, quoique ceux-ci s'accompagnent, de plus, d'une dissémination de boulders à leur surface. S'il n'en est pas ainsi pour certains secteurs, il faut s'en remettre à la jeunesse du produit non consolidé: par exemple, une assise de schiste argileux, c'est-à-dire un matériel très tendre et très vulnérable aux effets de l'intempérisme, portera un sol polygonal alors que la strate voisine, de calcaire, n'aura fourni encore qu'un produit de désintégration très superficiel. Ainsi on voit apparaître dans le paysage de longues successions de pavages grossiers et de sols fins, évidence d'une même alternance sous-jacente de strates molles et dures, le schiste argileux et le calcaire. L'argilite, étant une roche résistant aux divers effets de l'érosion, se présente donc en buttes-témoins dans le relief. Les talus d'éboulis, qui n'ont pu être déplacés, flanquent dès lors ces collines de tous côtés, protégeant le noyau central contre les attaques futures de l'érosion subaérienne; la formation d'un réseau réticulé n'est aucunement possible sur de telles déclivités. Toutefois, des ébauches de tels sols peuvent apparaître si le terrain devient plat.

La grande caractéristique qui frappe l'observateur est cette régularité soutenue offerte par le réseau polygonal, indépendamment de l'épaisseur du matériel meuble et de la topographie—à condition de demeurer à l'intérieur de limites raisonnables, soit du terrain plan à des pentes de quelques degrés. Confirmant plusieurs de nos prédécesseurs, nous croyons que la fissuration du sol est conséquente du dégel. Le matériel tend par la suite, en se déprimant au droit des fissures pour se refouler au sommet des polygones, à se concentrer uniformément tout autour d'un point central; ainsi se rassemblent les gouttes d'eau ou d'huile tombées sur une surface cirée. L'emplacement de la fissure et l'apparition graduelle du bombement se déterminent simultanément. Le facteur à l'origine de la formation d'un réseau premier ne peut être déterminé que par la cohésion du matériel meuble vis-à-vis des centres de contraction puis d'appel, également distribués les uns par rapport aux autres.

Les Groupes Mineurs. Une argile marine non perturbée ne porte généralement pas de sols polygonaux formés par rajustement interne du sol: tout au plus se fissure-t-elle très superficiellement par dessiccation, alors que de grandes superficies limitrophes demeurent inchangées. Toutefois, sous l'action d'une solifluction, l'argile peut se morceler en polygones par décollement, comme par les rejeux internes si elle est saturée d'eau. Enfin, des résurgences de boue localisées viendront percer à la surface du sol, que celle-ci soit ou non recouverte d'une mince pellicule de cailloutis.

Des hexagones quasi parfaits se rencontrent sur limon d'origine lacustre, que celui-ci soit noyé ou non sous les eaux; ce sont des sols remarquablement bien fissurés. Les limons lacustres proviennent d'un matériel entraîné par les eaux courantes, puis sédimenté au droit de mares sans profondeur qui s'assècheront ou se vidangeront partiellement avec la fuite de l'été.

Les sols caillouteux des terrasses fluvio-marines, parce que bien égouttés mais surtout à cause de la grosseur des particules constituantes, ne portent généralement pas un tel réseau; toutefois, une ébauche de sols polygonaux peut exceptionnellement prendre pied en un tel milieu. De longues fissures linéaires, apparentées aux polygones de géant, parcourent irrégulièrement les replats des terrasses. Les polygones de géant, dont la genèse est mal connue, sont des unités majeures atteignant même des diamètres de 150 pieds et à l'intérieur desquelles se sont normalement développés les fins polygones antérieurement décrits.

Figure 8. Sol à tertres des pâturages à bœufs musqués; le faible recouvrement végétal est ici représenté par des mousses et des saules arctiques.

De symétriques et minuscules polygones naîtront s'ils se forment sur une mince couche de terre qui repose sur un substratum étranger et solide, une dalle pierreusse en l'occurrence. Telles sont les conditions à l'origine des polygones miniatures de dessiccation formés sur limon d'entraînement.

Rien de plus frappant que le sol à tertres du pâturage: il varie plutôt d'un tapis gazonneux sur plancher plat mais fort raboteux, toujours gorgé d'eau, à une succession de buttes très arrondies et presque nues sur pentes déclives, si bien que l'on croirait à l'accolement des pains du boulanger avant la fournée. Un sol très réticulé débitera en mottes ces emplacements qui suintent d'une eau provenant de la fonte des neiges, des précipitations pluviales et de l'abaissement du plan du permafrost.

Un autre type de terrain réticulé se revêt de polygones du groupe majeur déjà décrit, puis l'ensemble se met à solifluer aux endroits les plus déprimés, contournant ainsi les buttes qui ne participent pas encore à l'écoulement. Si une traînée de pierres vient ensuite à s'engager en chicane entre les dos des polygones, elle fait conséquemment office de constituant des fissures. On pourrait également croire à une poussée d'origine interne crevant à la surface du sol et refoulant en position marginale les pierres ainsi en marche; il nous coûte d'admettre ce procédé par suite du caractère trop manifeste du fluage; toutefois, il se peut que l'action concomitante des deux s'exerce.

Ainsi donc, le modelé de la région de Floeberg Beach fut surtout déterminé par les processus d'érosion péri-glaciaire, avant tout la solifluction.

LE CLIMAT

L'établissement d'une station météorologique dans la région à l'étude ne date que de 1950. Les statistiques sont donc encore insuffisantes pour nous permettre une étude systématique du climat local. C'est plutôt une idée du caractère climatique que nous présentons ici en donnant d'abord quelques considérations générales, et en soulignant ensuite les caractéristiques de chaque saison.

Le soleil apparaît pour la première fois vers le 1er mars et restera continuellement au-dessus de l'horizon trente-huit jours plus tard. Une altitude maximum de 31° au-dessus de l'horizon, atteinte au midi du 21 juin, marque le début de la régression du soleil.

A Floeberg Beach, pendant les mois de novembre à avril inclusivement, le mercure ne monte qu'exceptionnellement au-dessus du zéro degré Fahrenheit. La neige recouvre le sol dès la fin d'août et ne disparaît qu'à la fin de juin. L'hiver donc s'étend sur une période de neuf mois chaque année et le printemps, l'été et l'automne doivent se partager les trois autres mois. Il faut noter pourtant que ces courtes saisons, régies par la présence ou l'absence de neige sur le sol, ne sont que des saisons apparentes alors que les saisons réelles, climatiques, sont considérablement plus longues. On remarque, par exemple, un grand écart entre la moyenne des températures d'avril et celles de mai; cet écart marque bien le début du printemps astronomique et, si ce n'était de la haute latitude et des basses températures prédominant encore, la fonte s'ensuivrait, mais cette différence de quelque vingt-cinq degrés n'est pas suffisante pour atteindre le point de fonte. En principe, nous sommes donc au printemps dès le mois de mai, mais en pratique, l'hiver se poursuit jusqu'au mois de juin alors que la fonte des neiges marque le début de la saison apparente. Cette disparité est moins grande à l'automne alors qu'août et septembre marquent un écart de plus d'une vingtaine de degrés coïncidant à peu près aux premières chutes de neige. On peut dire que juin, juillet et août sont respectivement le printemps, l'été et l'automne apparents de cette région. En effet, la fonte des neiges survient en juin alors que juillet, le mois le plus chaud de l'année, en est presque complètement exempt et que les premières chutes qui demeureront sur le sol tombent en août. Ces trois mois ne varient entre eux que par quelques degrés, conservant une moyenne de près de trente degrés.

L'HIVER

Septembre marque généralement le début de l'hiver alors que les températures baissent considérablement et que le sol est déjà couvert par plusieurs pouces de neige. La plus grande partie de la neige annuelle tombe en août, septembre et octobre; le reste est distribué plus ou moins également sur les neuf autres mois. Cette distribution diffère de celles des postes plus méridionaux de l'archipel arctique où les premières chutes de neige abondantes surviennent ordinairement plus tard.

Le tableau des moyennes mensuelles et annuelles des précipitations neigeuses permettra de comparer les divers postes de l'archipel arctique avec celui d'Alert:

TABLEAU 1

Moyennes (en pouces) des précipitations neigeuses mensuelles et annuelles[1]

Station	Années d'observation	J	F	M	A	M	J	J	A	S	O	N	D	Annuel
Arctic Bay	12	3·1	1·8	2·9	2·4	2·8	2·3	0·1	0·3	6·6	7·0	3·1	2·3	34·7
Bache Peninsula	4	1·7	4·6	1·1	1·0	....	....	0·0	0·0	4·5	7·5	7·2	0·5	......
Cambridge Bay	11	2·8	1·8	2·2	1·4	2·1	0·9	0·2	0·0	3·0	6·4	5·2	3·0	29·0
Clyde River	8	3·5	3·3	2·4	2·4	4·3	3·1	1·2	0·5	6·0	12·9	11·3	2·1	43·0
Coral Harbour	8	2·9	3·2	3·7	4·6	3·8	1·3	0·0	0·2	2·9	8·1	6·9	4·2	41.3
Craig Harbour	8	7·2	3·2	4·6	7·1	6·2	3·5	0·3	0·4	5·4	17·2	7·0	2·8	64·9
Dundas Harbour	9	3·2	3·6	2·1	3·0	4·4	3·7	0·3	1·3	8·1	9·3	4·5	4·3	47·8
Eureka	4	1·0	0·6	1·0	0·1	0·2	0·1	0·0	0·4	5·9	1·1	1·4	0·7	12·5
Fort Ross	13	6·7	3·0	3·9	3·3	4·4	5·3	0·4	0·6	11·5	12·3	9·0	3·2	63.6
Frobisher	9	3·0	5·8	4·6	4·0	5·7	1·8	t	t	5·4	8·2	9·0	4·0	51·5
Holman Island	11	2·3	3·5	3·9	3·3	4·1	1·2	0·0	2·2	2·8	7·1	3·5	2·2	36·1
Isachsen	3	0·7	0·6	0·6	0·5	3·2	1·4	2·9	1·3	7·4	1·4	2·0	0·5	21·5
Lake Harbour	18	9·7	10·0	8·2	10·7	6·5	2·0	t	0·4	2·2	13·5	19·7	12·1	95·0
Mould Bay	3	0·4	0·5	1·2	0·2	1·5	2·2	1·5	1·4	4·2	0·8	0·8	0·3	15·0
Nottingham Island	23	4·8	5·3	6·1	9·0	5·7	3·6	0·8	0·4	3·6	9·9	15·6	7·8	72·6
Pangnirtung	13	9·9	12·4	9·4	15·1	4·3	1·9	t	t	2·0	14·2	19·3	12·2	100·7
Pond Inlet	24	2·1	1·8	1·9	2·9	1·6	1·5	0·0	0·5	4·0	7·2	4·4	3·0	30·9
Resolute	4	0·7	1·4	2·0	1·3	6·2	3·0	0·5	3·1	7·9	5·7	2·7	1·0	35·5
Resolution Island	22	10·6	10·2	9·8	9·4	8·2	3·3	t	0·3	1·2	8·1	12·3	13·5	86·9
Alert[2]	1950	....	....	....	....	....	....	0·6	0·5	4·7	9·6	2·8	2·0	....
	1951	0·5	2·4	2·1	2·3	3·6	6·5	5·1	19·8	13·5	7·1	2·2	6·5	71·6
	1952	2·9	2·9	3·8	3·6	5·9	5·0	3·9	9·5	6·9	6·1	2·8	3·6	54·9

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[1] R. W. Rae: *Climate of the Canadian Arctic Archipelago*, Div. de la Météorologie, min. des Transports (Canada), 1951, p. 57.

[2] Données obtenues de la Division de la Météorologie, min. des Transports, Ottawa.

Les neiges antérieures à celles du mois de septembre semble être un phénomène normal de la région. En effet, Nares rapporte que "*the late snowfall* (31 août 1875) *had completely covered the land to a depth of from six to twelve inches*"[1]. Durant notre séjour dans la région de Floeberg Beach, la neige tenait sur le sol dès le 13 août; l'année précédente, en 1951, l'hiver est survenu le 14 août[2]. Les données statistiques indiquent qu'il est tombé pendant ce mois un total de 19·8 pouces de neige alors qu'en 1950, les précipitations neigeuses n'étaient que de 0·5 pouce et de 9·5 pouces en 1952.

A la fin de septembre, les plus fortes chutes de neige sont donc déjà tombées, recouvrant tout le relief jusqu'au moment où le vent viendra à nouveau dénuder les sommets. Ce sera la tempête polaire, le blizzard, qui soulève la neige poudreuse en tourbillons, l'enlevant des plateaux et des plaines pour l'accumuler dans les ravins ou autour des obstacles qui peuvent se présenter. Un bâtiment solitaire est parfois complètement enseveli sous le *drift* (rafale ou mieux une poudreuse) alors que, vingt-cinq pieds plus loin, le sol est complètement dénudé. Nares[3] mentionne qu'en 1875-1876, les sommets de la région du cap Sheridan furent dénudés à l'automne et demeurèrent ainsi jusqu'au début de juin alors qu'il est tombé plusieurs pouces de neige qui à nouveau recouvrirent tout. La banquise était si dénudée, dit-il,[4] que son équipage dut transporter la neige de la côte en guise d'isolant pour le bateau. Il souligne aussi le grand calme hivernal de ces régions, disant que le peu de vent venait ordinairement de l'ouest.[5]

Pendant l'hivernage de l'*Alert* à Floeberg Beach, on a observé une température minimum de 73·7° sous zéro, en mars 1876, et une moyenne pour treize jours de −58·9 et de −66·29° pour une période de quatre jours et neuf heures[6]. Ces chiffres sont évidemment des extrêmes et ils ne peuvent servir qu'à donner une indication des froids intenses. Les moyennes mensuelles sont cependant considérablement plus élevées.

TABLEAU 2

Température moyenne mensuelle à Alert, T. du N-O., en 1950-1952[7]

Année	Jan.	Fév.	Mars	Avril	Mai	Juin	Juil.	Août	Sept.	Oct.	Nov.	Déc.	Moyenne annuelle
1950....	......	......	......	......	......	......	36·3	29·6	7·0	−14·6	−24·6	−34·1	....
1951....	−40·9	−37·7	−30·0	−20·3	6·3	28·2	30·5	27·2	13·0	−12·6	−21·1	−34·7	−7·7
1952....	−35·1	−34·0	−35·9	−20·0	14·0	26·4	32·7	27·4	6·7	−2·6	−15·4	−13·5	−4·1

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[1] **Nares, 1878, vol. I, *op. cit.*, p. 131.**
[2] **Communication (*verbatim*) de Bruggemann.**
[3] **Nares, 1878, vol. I, *op. cit.*, p. 220-221 et p. 329.**
[4] **Nares, 1878, vol. I, *op. cit.*, p. 177.**
[5] ***Ibid.***
[6] **G. S. Nares: *Captain Nares' Report* dans *Nature*, vol. 15, 1877, p. 32.**
[7] **Données obtenues de la Division de la Météorologie, min. des Transports, Ottawa.**

Le ciel d'hiver, dans la région de Floeberg Beach, est le moins nébuleux de l'année. Ceci est dû en partie à l'évaporation presque nulle sur des milliers de milles carrés qui ne peut surcharger l'air d'humidité, et aussi au fait que les vents doivent passer au-dessus d'immenses superficies froides où ils laissent tomber leur humidité avant d'atteindre ce point. La nébulosité mensuelle du mois d'octobre au mois de mai n'atteint pas 50 p. 100.

LE PRINTEMPS

Déjà, le mois de mai est plus chaud que le précédent par quelque trente degrés et on constate un écart marqué entre les températures du midi et celles des heures noctures.

La disparition de la neige superficielle, au début de juin, s'effectue par sublimation plutôt que par le procédé de la fonte. La température ne demeure pas au-dessus de 32°F. assez longtemps pour faire fondre la neige, mais le vent plus chaud en dispose en la faisant passer directement de l'état solide à l'état gazeux. Ce phénomène s'effectue à la fois sur toute la superficie neigeuse qui diminue alors uniformément.

La fonte survient d'abord sur les versants faisant face au soleil, puis sur toute la région côtière jusqu'à une distance de cinq ou six milles du rivage. Le procédé est très rapide à cause de l'insolation continuelle résultant en un dégel sans interruption. Les températures, dès le milieu de juin, atteignent un niveau qui se rapproche de celui de juillet et des deux premières semaines d'août. Mais la neige ne disparaît pas au sud d'une ligne qui relierait la tête de la baie Hilgard au mont Pullen avant le milieu de juillet, alors que dans la région côtière les plantes sont déjà en fleurs. Cette zone à la fonte tardive est très bien délimitée par sa bordure neigeuse, presque rectiligne, à une altitude variant entre 600 et 700 pieds au-dessus du niveau de la mer. Le fait s'explique donc par l'élévation des lieux d'une part, et par de plus fortes précipitations dans ce secteur d'autre part, car nous remarquions que le brouillard se tenait plus fréquenment au-dessus de cette région.

Nous avons mentionné un grand calme et une faible nébulosité d'hiver, mais dès le début du printemps, ces conditions changent du tout au tout. Coïncidant avec le grand écart de température du mois de mai, l'air saturé d'humidité, au-dessus de la banquise et des chenaux d'eau libre, est ensuite poussé vers la côte par les vents du nord. Ces brouillards viennent généralement voiler le soleil du soir, à Floeberg Beach, pour ensuite se dissiper le lendemain matin. A la mi-juillet, cependant, les côtes et les baies se libèrent de glace, et la brume, formée localement, peut obscurcir le ciel pendant plusieurs jours consécutifs; il en est ainsi jusqu'à l'hiver suivant et la reprise des glaces. On peut s'éloigner d'un endroit par un temps radieux et, en dedans d'une demi-heure, être surpris par une brume assez épaisse pour ne pas permettre de retrouver son chemin.

L'ÉTÉ

Avec la venue de l'été, on note de plus hautes températures, un asséchement du sol boueux lors de la fonte des neiges, des précipitations pluvieuses, etc.

La transition entre le printemps et l'été est très graduelle. La fonte débute près de la côte, dans la région des lacs Dumbbell et des baies Colan et Hilgard, pour ensuite pousser vers le sud. Cette première région est dénudée dès le 1er juillet mais on observera encore, quinze jours plus tard, de grandes étendues couvertes de neige sur le plateau au sud de ce secteur. Les cours d'eau les plus importants, de régime surtout nival, ont un débit maximum très tardif.

Tous les cours d'eau commencent à fonctionner légèrement à la mi-juin et ils peuvent facilement être traversés à pied jusqu'au début de juillet. Entre le 10 et le 15 de ce mois, il survient quelques journées très chaudes suivies d'une grande fonte. L'eau se met à couler en nappes sur les surfaces inclinées, et les ruisseaux et rivières se transforment en torrents. On verra des ruisseaux se déblayer un large lit dans une vallée bloquée par une accumulation de neige poudrée et durcie d'une hauteur atteignant plus de cinquante pieds. Un affluent d'occasion dévallera une pente de quelque 30° pour rejoindre le cours principal au contact duquel il construira un cône de déjection. Au début de la fonte, les eaux coulent naturellement à la surface de la neige qui recouvre les lits des cours d'eau. Ces quelques jours auront toutefois été suffisants pour nous faire comprendre la génèse des platières deltaïques qui semblent disproportionnées par rapport aux cours d'eau, pour nous montrer l'origine des cônes de déjection au pied de fortes pentes, et enfin, pour nous expliquer comment des systèmes fluviaux apparemment de débit très faible peuvent s'encaisser aussi profondément qu'ils le sont dans un matériel si dur.

Ici, il faut accepter le beau temps et la chaleur comme un privilège transitoire pouvant disparaître en quelques heures ou en quelques minutes pour faire place à une brume épaisse ou à une pluie fine et glacée. Aussi, parfois des chutes de neige assez abondantes recouvrent pendant quelques jours en juillet, tout le relief.

L'AUTOMNE

Avec le mois d'août survient la menace constante d'un hiver hâtif. Le soleil de minuit descend de plus en plus sur l'horizon et il en résulte une différence progressive entre les températures diurnes et nocturnes. Les premières chutes de neige disparaîtront partiellement. Dès la mi-août cependant, l'influence de l'été ne pourra plus résister et le relief sera recouvert une fois de plus pour la durée du long hiver. Avec la disparition nocturne du soleil au tout début de septembre, et enfin, avec son extinction complète en octobre, le froid, la neige et les glaces redeviennent sans aucune opposition maîtres de cette région arctique.

LES GLACES

Les glaces constituent un élément important et permanent du paysage. En tout temps de l'année on verra, du rivage, l'immense étendue de glace rugueuse recouvrant presqu'entièrement l'océan Arctique ainsi que les baies plus ou moins profondes de son littoral. On aperçoit, du haut des sommets, par la réflection du soleil sur les étendues de glace cristalline qui les recouvrent, les nombreux lacs et étangs de l'intérieur de la contrée.

Toutes les surfaces lacustres de la région sont naturellement gelées pendant la durée de l'hiver, c'est-à-dire de septembre à juin. Ces étendues d'eau douce conservent, en gelant, une surface unie et la neige ne s'y accumule que très peu. Dans certains endroits, bien exposés aux vents, les lacs et étangs se présentent comme de belles patinoires de glace vive, de couleur variant du bleu au vert, donnant l'impression à distance qu'ils ne sont pas gelés. Ailleurs, lorsqu'ils sont couverts de neige, il serait parfois difficile, si ce n'était de leur grande régularité, de déterminer si on est sur la terre ferme ou sur la glace, par suite du peu de relief du sol.

L'eau des lacs gèle profondément. Au début de mai 1876, l'équipage de Nares mesurait 91¼ pouces de glace dans les lacs Dumbbell[1]. Ces lacs servent de source d'eau potable pour le personnel du poste météorologique d'Alert.

Les étangs peu profonds se débarrassent de leur glace pendant le court été, mais les lacs ne s'en libèrent pas complètement tous les ans. La glace disparaît d'abord à leur bordure, vers la fin de juin, et progresse ensuite de la périphérie vers le centre de la surface gelée. En juillet, alors que toute la glace est à flot, les vents la poussent d'un côté à l'autre des lacs, selon leur direction et leur intensité. A la fin de juillet, toute la surface glacée prend une forme cristalline, translucide, et se brise dans un plan vertical, toujours à sa périphérie, formant une myriade de petits glaçons qui brillent à la surface avant de redevenir à l'état liquide. Avec le retour des nuits froides du mois d'août, une mince couche de glace couvrira les lacs pour disparaître le lendemain. Plus ou moins tard en août, les eaux se solidifieront suffisamment pour ensuite supporter le poids d'un homme au début du mois suivant.

Le régime des glaces dans les baies est plus complexe et moins régulier parce qu'il dépend non seulement du climat mais d'un nombre de facteurs isolés, propres à chacune de ces baies, comme la marée, les courants marins, la provenance des vents, etc. L'orientation et l'exposition aux vents, la profondeur, les accidents des côtes, sont autant d'agents qui empêchent, retardent ou réduisent l'entrée ou la sortie des glaces dans les baies.

L'apparence hivernale des baies Hilgard, Colan, Dumbbell, Parr et Ravine dépend de la condition dans laquelle elles se présentaient immédiatement avant leur congélation. Si, à ce moment, il y avait absence presque totale de floebergs, les baies présenteront de belles surfaces uniformes quoique quelque peu raboteuses; on verra ordinairement une telle régularité

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[1] Nares, 1878, Vol. 1, *op. cit.*, p. 314.

pour les glaces de l'inlet Parr, de la baie Ravine, et des parties sud des baies Colan et Hilgard, toutes protégées de l'entrée des floebergs par un étranglement les séparant des influences directes du pack polaire. Ailleurs, les conditions sont plus variables et les floebergs vont et viennent à l'automne, selon la fantaisie du vent; à la venue de l'hiver ces glaces flottantes seront immobilisées là où elles auront été surprises par le gel. Dans les baies intérieures, relativement bien protégées des vents, les accumulations de neige poudrée sont plutôt restreintes et ne constituent pas d'obstacles sérieux au déplacement en traîneau ou en raquettes.

Le procédé de fonte dans les baies est similaire à celui des lacs, sauf peut-être que le décollement marginal est facilité par l'action des marées qui ont une amplitude d'un pied et demi à trois pieds.[1]

C'est au début du mois d'août, avant la reprise du froid, que les eaux libres atteignent leur extension maximum. La baie Hilgard est alors couverte par une banquise brisée et mobile qui joue dans ses cadres au gré du vent. On voit dans sa partie septentrionale, plus ouverte sur la mer, des floebergs de toutes dimensions entrer et sortir selon le caprice des courants marins et se dégager temporairement de la banquise. La tête de cette baie, pédiforme et plus étroite, conserve un couvert de glaces discontinu, sali et rongé, dépassant à peine la surface des eaux. Similairement, la section au nord de l'étranglement de la baie Colan se libérera complètement de ses glaces alors que la partie sud, plus fermée, suivra à peu près le régime des lacs. Il en est ainsi de la Baie Dumbbell et de son étranglement, l'inlet Parr. La baie Ravine, orientée dans la direction des vents dominants, subira une permutation de son couvert de glace du côté oriental au côté occidental, et vice versa.

A la venue de l'automne et du gel, la mobilité des glaces diminue progressivement jusqu'à ce que tout à nouveau soit pris d'un bloc qui sera craquelé, fissuré et tordu sous l'effort des vents et de la marée.

Au delà des baies commence la banquise ou pack polaire. Le déplacement du pack polaire fut remis en éveil récemment par l'intérêt suscité par les îles de glaces appelées communément T-1, T-2 et T-3, dont le parcours erratique fut étudié ces dernières années. Ce déplacement, dû aux grands courants marins surtout, détermine la conformation des glaces d'hiver en marge de l'île Ellesmere: la banquise peut-être saisie par le gel et fixée à quelques centaines de pieds du rivage aussi bien qu'à plusieurs milliers de pieds où elle aurait été repoussée par les vents venant de l'intérieur des terres. Dans les deux cas, elle est reliée à la côte par une bordure de glace qui conserve une surface relativement uniforme à moins que le pack ne vienne la fracasser ou y chevaucher sur plusieurs pieds de hauteur.

Une banquette de glace (*ice-foot*) se forme avec plus de facilité si la côte offre des pentes douces, d'où la glace peut facilement prendre pied. Cependant, Nares mentionne que dans le canal Robeson, exception faite des endroits où la côte est trop abrupte pour permettre la formation d'une

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[1] S. Haughton: *Abstract of Results obtained from Tidal Observations* dans Nares, 1878, Vol.2, *op. cit.*, p. 361.

banquette, le rivage est bordé à quelques pieds de distance par un mur presque continu, formé par la pression de la banquise qui accumule ses glaces sur des hauteurs variant entre quinze et trente-cinq pieds.[1] Au nord de ce canal, là où la côte s'oriente vers le nord-ouest et perd son caractère abrupt, la dense banquise devient ancrée à environ cent ou deux cents verges du rivage, dans des profondeurs de huit à douze brasses, et y forme une bordure discontinue de vingt à plus de soixante pieds de hauteur.[2]

Au delà de la banquette, c'est le pack polaire, la banquise à la surface craquelée et fissurée, rugueuse et impénétrable à cause de ses multiples aspérités atteignant des hauteurs de quarante à cinquante pieds. Certaines de ces aspérités sont des floebergs qui ont pu profiter de la formation d'un chenal d'eau libre (*lead* ou "polynie") pour se soustraire temporairement à la banquise et être par la suite englobés dans un pack plus jeune, résultant dans cette disparité des sommets; d'autres, moins volumineux, ont simplement été bousculés par des pressions latérales ou par un relâchement estival des glaces liant ensemble les divers éléments de la banquise. Lorsque ces floebergs sont suffisamment émergés, on observe une stratification nette marquée par une différente coloration des nombreuses couches de glace et la présence d'impuretés terreuses.

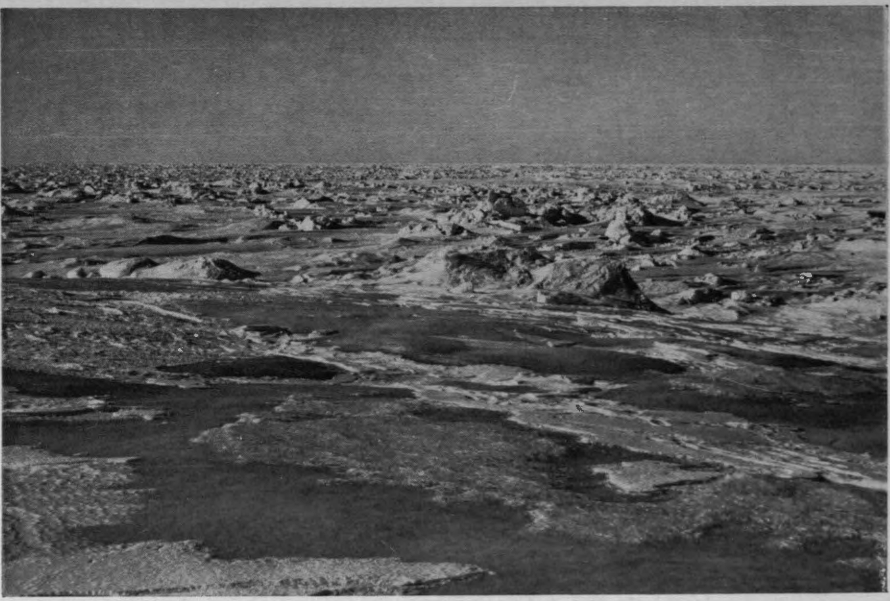

Figure 9. Aspect cahotique et désordonné de la surface de la banquise polaire, le long de la côte de la mer de Lincoln.

On voit donc en hiver une superficie ou surface plus ou moins large au delà de laquelle se présente une grande lisière de glaces bousculées, de hummocks et de floebergs de tous âges pris dans un bloc solide formant

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[1] Nares, 1878, Vol. 1, *op. cit.*, p. 128.
[2] Nares, 1878, Vol. 1, *op. cit.*, p. 129.

partie intégrale de la banquise. On reconnaît cependant que c'est une banquise saisonnière, qui se brisera et s'éparpillera au cours de l'été, contrairement à la banquise polaire, située loin au delà et ne subissant pas ces changement saisonniers sauf peut-être pour la formation de quelques chenaux d'eau libre.

Les mouvements de la banquise en hiver sont imperceptibles du rivage, alors qu'au delà de l'horizon l'influence des vents et des pressions latérales remanie constamment la surface glacée; mais que vienne un vent de l'intérieur des terres pendant l'été et cette banquise qui semblait à jamais figée quitte momentanément le littoral où elle se colle à nouveau aussitôt la bourrasque terminée. Dès que le gel d'automne survient, à la fin d'août, la banquise, surprise dans son jeu oscillatoire, devient fixée sur place pour la longue saison hivernale.

LA VÉGÉTATION ET LA FAUNE

Il est intéressant de noter que plus d'une soixantaine de plantes fleurissent annuellement dans la région de Floeberg Beach; que le bœuf musqué, le caribou, le loup, le renard, le lièvre, l'hermine, le lemming, représentent la faune mammifère terrestre; qu'une quinzaine d'espèces d'oiseaux y nichent annuellement, etc. Mais au géographe, il importe avant tout d'apprendre que déjà à la fin de mai, la saxifrage fleurit et que des peuplements végétaux s'assemblent pour former même la prairie. Il lui importe de pouvoir dire qu'au cours d'une journée sur le terrain, il verra quelques oiseaux, ou peut-être quelques voiliers et que, soudainement, il se trouvera face à face avec un troupeau de bœufs musqués; que les insectes, s'il n'en trouve pas quelques-uns sous les pierres, ne lui causeront aucun trouble.

Il y aurait matière à toute une étude détaillée que d'analyser le comportement de ces associations remarquables, établies en un milieu excentrique, le plus souvent hostile et ingrat; l'adaptation seule des espèces peut triompher de conditions physiques si particulières.

LES PLANTES

Sous une telle latitude, rien de surprenant de voir que le sol se présente nu et qu'il règne ainsi sur la majeure partie du territoire à l'étude. Néanmoins, des plantes minuscules, d'un à trois pouces de hauteur, s'accaparent des moindres replis de terrain, se terrent au droit des fissures des sols réticulés, occupent en un mot toutes dépressions à micro-climat qui leur sont favorables. Elles croissent de plus sur un sol fortement alcalin, de pH supérieur à 8,[1] et à texture variant des argiles aux cailloutis. En un tel habitat à végétation si clairsemée, le coloris des fleurs ne peut pas nous laisser indifférents: on y voit des jaunes, s'offrant comme couleur dominante, puis des blancs et des violets.

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[1] La concentration en ions d'hydrogène des échantillons de sol prélevées à Floeberg Beach, fut déterminée par M. F. F. Bishop du ministère de l'Agriculture, Ottawa.

La saxifrage (*Saxifraga oppositifolia*)[1] est incontestablement la plante la plus commune du nord de l'Arctique. Cette petite fleur purpurine se rencontre sur toute la superficie du plateau de Floeberg Beach, en endroits secs comme humides, même à l'intérieur d'étendues herbeuses gorgées d'eau, en un mot partout où existe une cavité quelconque. A la levée des neiges, la saxifrage entre encore la première à la vie.

Des plantes comme le pavot jaune arctique (*Papaver radicatum*) abondent également avec le seul arbre de ces lieux, le saule polaire (*Salix arctica*); c'est toutefois une espèce dendrologique naine, bien chétive et bien rabougrie, qui rampe contre le sol, empruntant les plus petites dépressions pour se tapir. D'autres plantes des terrains secs et de distribution générale sont représentées par un pâturin (*Pao abbreviata*) croissant en touffes contre les pierres puis une puccinellie (*Puccinellia Langeana*), une polygonacée (*Oxyria digyna*) des lieux ouverts, une céraiste (*Cerastium alpinum* var. *glutinoso-lanatum*) à fleurs blanches et étoilées, une potentille (*Potentilla pulchella*), une drave (*Draba Bellii*) et finalement une dryas (*Dryas integrifolia*). Quelques spécimens, peu communs toutefois, se rencontrent encore en milieux secs: c'est une lychnis (*Lychnis furcata*), une stellaire (*Stellaria monantha*), un pissenlit (*Taraxacum phymatocarpum*) et deux saxifrages boréales (*Saxifraga cernua* et *S. cespitosa* var. *uniflora*).

Deux graminées, la pâturin des prés (*Poa pratensis* f. *prolifera*) et la puccinellie de Vahl (*Puccinellia Vahliana*), et une lychnis (*Lychnis apetala*) représentent les éléments les plus communs des endroits humides: telles sont les surfaces occupées par la prairie arctique, les endroits déclives où constamment résurge une eau de fonte et souvent à l'emplacement même des larges éventails fluvio-deltaïques. De plus, on pourra parfois renconter une renoncule couleur safran (*Ranunculus sulphureus*), une saxifrage (*Saxifraga flagellaris*), une pédiculaire laineuse (*Pedicularis Langsdorfii* var. *arctica*) et trois minuscules crucifères (*Braya purpurascens*, *Cochlearia officinalis* var. *groenlandica* et *Draba fladnizensis*).

On peut mentionner comme plantes franchement aquatiques, ou croissant en territoires marécageux, une deschampsie (*Deschampsia pumila*), un obscur carex (*Carex aquatilis* var. *stans*), deux linaigrettes à houppes duveteuses (*Eriophorum angustifolium* var. *triste* et *E. Scheuchzeri*) et une rare renoncule (*Ranunculus hyperboreus*) à feuilles surnageant sur les eaux.

Nous avons vu qu'un sol minéral s'accapare de la majeure partie du territoire; les quelques étendues herbeuses, au contraire, se présentent sans solution de continuité pour former la prairie qu'on peut, par opposition, qualifier de luxuriante. Cette prairie est formée par l'association de graminées et de carex hydrophiles et établis sur un versant ou au pied d'une pente, c'est-à-dire partout où des eaux de résurgence entretiendront une humidité essentielle à la croissance des plantes. Ainsi, on remarque le plus souvent un vulpin (*Alopecurus alpinus*) une arctagrostide (*Arctagrostis latifolia*), une deschampsie (*Deschampsia brevifolia*) et un carex (*Carex*

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[1] Tous ces spécimens botaniques furent obligeamment identifiés par M. Marcel Raymond du Jardin botanique de la ville de Montréal.

misandra). A cette floristique s'associent les individus déjà mentionnés pour les milieux humides, dont la renouée *(Polygonum viviparum)* est la plus commune.

Telles sont les plantes vasculaires qui se présentent sans difficulté au géographe dans ses cheminements sur le terrain; telles sont donc les plantes qui donnent la note dominante au paysage biologique. Quant à une documentation botanique poussée de la région de Floeberg Beach, on aura qu'à consulter le résultat des récoltes effectuées sous les expéditions de Nares[1] et de Peary[2]. Polunin[3] a su faire la synthèse de toutes les découvertes botaniques antérieures de l'est de l'Arctique canadien, et de présenter[4] un exposé écologique de cette flore. Enfin, Bruggemann[5] herborisait en 1951 dans la région de Floeberg Beach.[6]

LES ANIMAUX

S'il était donné de rencontrer des terres près du pôle boréal, occupé de nos jours par l'océan Arctique, rien ne nous empêcherait de croire que des plantes s'y introduiraient, que des oiseaux y couveraient annuellement et que des mammifères en feraient un lieu d'élection. L'accaparation de ces territoires par tout un monde organique serait avant tout fonction des moyens de communication, offerts surtout par les grands ponts continentaux. A moins de 500 milles au sud du pôle, la région de Floeberg Beach réalise déjà pleinement cet agencement ordonné de la communauté biotype. Elle réunit merveilleusement les éléments de cette vie animée: dans les eaux, dans les airs, sur le sol, de sorte que chaque milieu possède ses représentants bien organisés et ses associations remarquables.

Des oiseaux ont fait de ce coin perdu de la terre leur endroit de couvaison. Ainsi, l'oiseau le plus commun, avec le diminutif bruant ou plectrophane des neiges, est le labbe à longue queue, puisqu'il remorque deux longues plumes à sa suite. Il est des journées où les oiseaux semblent ne plus être, d'autres où quelques sternes arctiques, quelques goélands bourgmestres vous survolent par curiosité; où quelques oiseaux de rivage, tel le sanderling, le tourne-pierre commun et la maubèche à poitrine rousse, pataugent dans la boue; où les bernaches de Brent, les cacaouis, les eiders

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[1] J. D. Hooker: *Botany* dans Nares, 1878, vol. II, *op. cit.*, pages 301-326; voir aussi H. C. Hart: *On the Botany of the British Polar Expedition of 1875-6* dans *Journ. Bot.* (nouv. sér.), vol. 19, 1880, p. 52 et suiv.

[2] P. A. Rydberg: *List of Plants Collected on the Peary Arctic Expedition of 1905-6 and 1908-9 With a General Description of the Flora of Northern Greenland and Ellesmere Land* dans *Torreya*, vol. 11, 1911, pages 249-259; vol. 22, 1912, pages 1-11.

[3] N. Polunin: *Botany of the Canadian Eastern Arctic*, 1re partie, *Pteridophyta and Spermatophyta*, Canada, Nat. Museum, Bull. 92, 1940.

[4] N. Polunin: *Botany of the Canadian Eastern Arctic*, 3^{e} partie, *Vegetation and Ecology*, Canada, Nat. Museum, Bull. 104, 1948, pages 9-33.

[5] P. E. Bruggemann et J. A. Calder: *Botanical Investigations in Northeast Ellesmere Island, 1951* dans *Can. Field-Nat.*, 1953, vol. 67, pages 157-174. Voir aussi S. D. MacDonald: *Report on Biological Investigations at Alert, N.W.T.* dans *Ann. Rep. Nat. Mus. Can.*, 1951-52, Bull. No. 128, 1953, pages 255-256.

[6] Quant aux végétaux de moindre importance pour le géographe (à moins qu'il n'entreprenne une étude de détail), il pourrait consulter la bibliographie suivante: M. J. Berkeley: *Enumeration of the Fungi collected during the Arctic Expedition, 1875-76* dans *Journ. Linn. Soc. Bot.*, vol. 17, 1880, pages 13-17. P. T. Cleve: *On the Diatoms collected during the Arctic Expedition of Sir George Nares* dans *Journ. Linn. Soc., Bot.*, vol. 20, 1884, pages 313-317. G. Dickie: *On the Algae found during the Arctic Expedition* dans *Journ. Linn. Soc., Bot.*, vol. 17, 1880, pages 6-12. T. M. Fries: *On the Lichens collected during the English Polar Expedition of 1875-76* dans *Journ. Linn. Soc., Bot.*, vol. XVII, 1880, pages 346-370. R. S. Williams: *Some Farthest North Lichens and Mosses of the Peary Arctic Expedition to Grand Land in 1906* dans *Torreya*, vol. 18, 1918, pages 210-211. Mais qu'on se réfère surtout à l'ouvrage édité par N. Polunin: *Botany of the Canadian Eastern Arctic*, 2^{e} partie, *Thallophyta and Bryophyta*, Canada, Nat. Museum, Bull. 97, 1947; voir également Hooker, *op. cit.*, pages 313-326.

ou moyacs remarquables, les huarts à gorge rouge s'ébrouent dans les eaux des mares et des étangs. Il y a de plus de rares harfangs ou hiboux des neiges, et quelques ptarmigans à queue blanche ou perdrix arctiques. Enfin, quelques autres oiseaux de secteurs plus méridionaux pourront accomplir de simples tournées au-dessus de la région.[1]

Nous avons vu que les étendues d'eau lacustres ne dégèlent pas entièrement l'été venu, sinon sur le pourtour, et naturellement encore moins les eaux du bassin arctique. Néanmoins, un poisson d'eau salée et un autre d'eau douce, un saumon arctique atteignant un pied de longueur, sont connus pour ce milieu particulier[2]. Dans les eaux encore, de rares phoques puants s'aventurent dans l'océan Glacial arctique[3], profitant des chenaux d'eau libre entre les glaces pour venir respirer à la surface; à la fonte des glaces littorales, quelques-uns pourront être aperçus à Floeberg Beach. Rien de surprenant dès lors si quelques ours blancs sont rencontrés un jour au droit même du territoire à l'étude: Peary[4] dit que les Esquimaux qui l'accompagnaient en tuèrent un dans les parages et un second dans l'inlet Markham[5]; il vit lui-même leurs traces sur la neige recouvrant la banquise polaire, à

Figure 10. Troupeau de bœufs musqués constitué de deux femelles et de quatre jeunes (probablement deux paires de jumeaux).

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[1] Voir également les observations de H. W. Feilden: *Ornithology* dans Nares, 1878, vol. II, *op. cit.*, pages 206-217, parues aussi dans *The Ibis*, 1877, pages 401-412, et de MacDonald, 1953, *op. cit.*, pages 247-251. Enfin W. E. Godfrey: *Notes on Ellesmere Island Birds* dans *Can. Field-Nat.*, vol. 67, 1953, pages 89-93.

[2] A. Gunther: *Account of the Fishes collected by Capt. Feilden between 70° and 83' N. Lat.* dans *Proc. Zool. Soc.* (London), 1877, pages 293-295, ainsi qu'un second article paru dans Nares, 1878, vol. II, *op. cit.*, vol. I, p. 329 et vol. II, pages 70-71. Enfin MacDonald, 1953, *op. cit.*, pages 251-253.

[3] Peary, 1907, *op. cit.*, p. 133; 1910, *op. cit.*, p. 224.

[4] Peary, 1910, *op. cit.*, p. 126.

Peary, 1910, *op. cit.*, p. 140.

quelques centaines de milles au large des côtes.[1] Quelques troupeaux de narvals enfin pourront remonter par le canal Robeson jusqu'à Floeberg Beach, à cause du caractère disloqué du pack dans ce passage étroit soumis à de forts courants; un tel animal fut tué au cap Union.[2]

L'île est habitée par de nombreux renards arctiques, aucunement apeurés par l'homme, et naturellement d'un grand nombre de lemmings dont ils se nourrissent. Quelques rares hermines et lièvres polaires, quelques loups solitaires et de petits troupeaux de caribous de Peary pourront être également aperçus. Mais l'individu le plus remarquable de la contrée est sans aucun doute le bœuf musqué, animal d'instinct grégaire qui se tient donc en troupeaux contenant parfois quelques dizaines de bêtes[3]. L'ovibos ou bœuf musqué possède une aire de distribution confinée à certaines îles de l'archipel arctique canadien ainsi qu'aux secteurs côtiers et inhabités du Groenland; mais quelques troupeaux épargnés errent encore dans les terres stériles du Mackenzie-Keewatin.

CONCLUSION

Tels sont les résultats préliminaires de nos observations et recherches faites à propos de la région de Floeberg Beach, la plus septentrionale du Canada. Ces résultats ont été incorporés avec la description et l'explication, lorsque c'était le cas, des principales caractéristiques du relief et de sa structure, des sols polaires, du climat et des glaces, enfin de la végétation et de la faune.

SUMMARY

During the summer of 1952 the authors visited the Floeberg Beach region, the most northerly part of the Canadian Arctic archipelago, located near latitude 82 degrees north on Ellesmere Island. This article outlines the main characteristics of the area studied.

The area was first visited in 1875-76 by a British expedition led by Nares. Peary spent the winters of 1905-06 and 1908-09 there, and it was during the second winter that he succeeded in his attempt to reach the North Pole. In 1950 a meteorological station was established at Alert.

Near the Arctic coast the surface is undulating. Towards the interior it rises gradually to a deeply incised plateau of limestone and argillaceous shale. A general elevation of 1,000 feet is attained, above which some rock summits stand out.

During the Pleistocene glacial invasion the ice-cap covering the interior of Ellesmere Island discharged towards the Floeberg Beach area, stripping it of its superficial materials. From the ice-cap a series of fringing glaciers developed, and some of these still exist to the west. After the

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[1] Peary, 1910, *op. cit.*, pages 226 et 280.

[2] Peary, 1910, *op. cit.*, pl. à la p. 301. Pour une étude de la vie animale dans le bassin Polaire, voir K. Rodahl: *North, the Nature and Drama of the Polar World*, Harper & Brothers, New York, 1953, chap. 5.

[3] Voir également le travail de H. W. Feilden: *Mammalia* dans *The Zoologist*, 3^e série, vol. 1, 1877, pages 313-321 et pages 353-361. Et H. W. Feilden: *Mammalia* dans Nares, 1878, vol. II, *op. cit.*, pages 192-205. Voir aussi MacDonald, *op. cit.*, pages 243-246.

retreat of the glaciers a marine transgression reached an elevation above the 400-foot level. Isostatic readjustment later elevated and exposed the materials deposited in this sea, among them fossiliferous clays and fluviomarine gravels.

Solifluction is the dominant process tending to reduce the surface to sea-level, as stream erosion plays only a small part in levelling the land. On the shallow soils formed in situ, at elevations above 400 feet, a remarkable polygonal pattern has developed.

The climate at Floeberg Beach is severe and unique. Its annual precipitation of about 10 inches falls mainly as snow at the beginning of autumn. Its mean monthly temperatures are the lowest on the North American continent. The region is not greatly affected by winds, but in winter, nevertheless, over large areas the surface is blown clear of snow.

Ice persists on the lakes the year around, and sometimes attains a thickness of 8 feet; even greater thicknesses are reached by the sea ice. The polar pack-ice is always present and close to the shore, but a strong wind from the interior may temporarily move it offshore.

Over most of the Floeberg Beach region the ground appears bare of vegetation. However, small plants, the most common of which is saxifrage, grow in the fissures that pattern the ground, and some extensive grassy areas occur.

About fifteen species of birds nest annually in the region, the snow bunting being especially common. The land mammals include lemmings, ermine, hares, foxes, wolves, caribou, and several herds of musk-ox.

ICE DISTRIBUTION IN THE GULF OF ST. LAWRENCE DURING THE BREAK-UP SEASON

C. N. Forward[1]

The purpose of this paper is to present the results of a study of ice distribution and its behaviour in the Gulf of St. Lawrence during March, April, and May—a period of utmost importance to navigation and shipping. The relative influences on the ice of the physical factors of the environment are investigated.

The area studied here is that part of the gulf south of a line from Heath Point (Anticosti Island) to the Bay of Islands (island of Newfoundland). Other approximate limits are shown in Figure 1. Ice conditions in the northern part of the area, including the Strait of Belle Isle, and in harbours, are not treated in detail because the available ice reports refer chiefly to the open areas of the gulf[2]. Several of the terms used have a special meaning that may not apply to their use elsewhere. *Gulf* is an abbreviated form for the Gulf of St. Lawrence, and it is applied here mainly to the area shown in Figure 6; when it applies to the whole Gulf of St. Lawrence, the context makes that apparent. *Break-up* is used in a wide sense, meaning not only the actual breaking up of the ice-sheets but also the clearing of ice from the area. *Ice season* is the period from November to May when ice is present. *Light ice conditions* indicates that the ice is less extensive than in other areas and under 2 feet thick. *Heavy ice conditions* means that the ice is relatively extensive and thicker than 2 feet.

PHYSICAL SETTING

SUBAERIAL AND SUBMARINE MORPHOLOGY

The Gulf of St. Lawrence lies between two physiographic provinces. In the north is the Canadian Shield, composed of Precambrian rocks, and in the west, south, and east is the Appalachian system, composed of greatly folded and faulted Palæozoic rocks. The Appalachian system is divided into two main ranges, the fold mountains of Gaspe, which curve southeastward before disappearing below the waters of the gulf, and the highlands of Nova Scotia, which, maintaining a northeast-southwest trend, continue as the Long Range of Newfoundland. These two main ranges enclose the gulf.

The gulf is much deeper north of a line from Cape Gaspe to St. Paul Island than south of it (Figure 1). A submarine canyon, whose depth ranges from 150 to 300 fathoms below the surface of the water, traverses the gulf and extends from the estuary of the St. Lawrence River, north of the Magdalen Islands, through Cabot Strait and southwestward to the

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[1] C. N. Forward, B.A., M.A., British Columbia. This paper is based on a larger study carried out by the author, a geographer with the Geographical Branch, Department of Mines and Technical Surveys.

[2] The aerial ice survey inaugurated in 1940 by the Department of Transport has provided a wealth of information, upon which this analysis is primarily based.

edge of the continental shelf, where it separates Bank St. Pierre from Banquereau Bank. Branches of this canyon extend toward the Strait of Belle Isle and for some distance between Anticosti Island and the mainland. These steep-walled canyons are 40 to 100 miles broad and occupy much of the northern and eastern sections of the gulf. On the other hand, the bottom of the area south of the transverse canyon between Cape Gaspe and Cape Breton Island lies less than 50 fathoms below the surface. Ice is more likely to form in such shallow areas, because of the relatively small amount of water that must be cooled before freezing can take place.

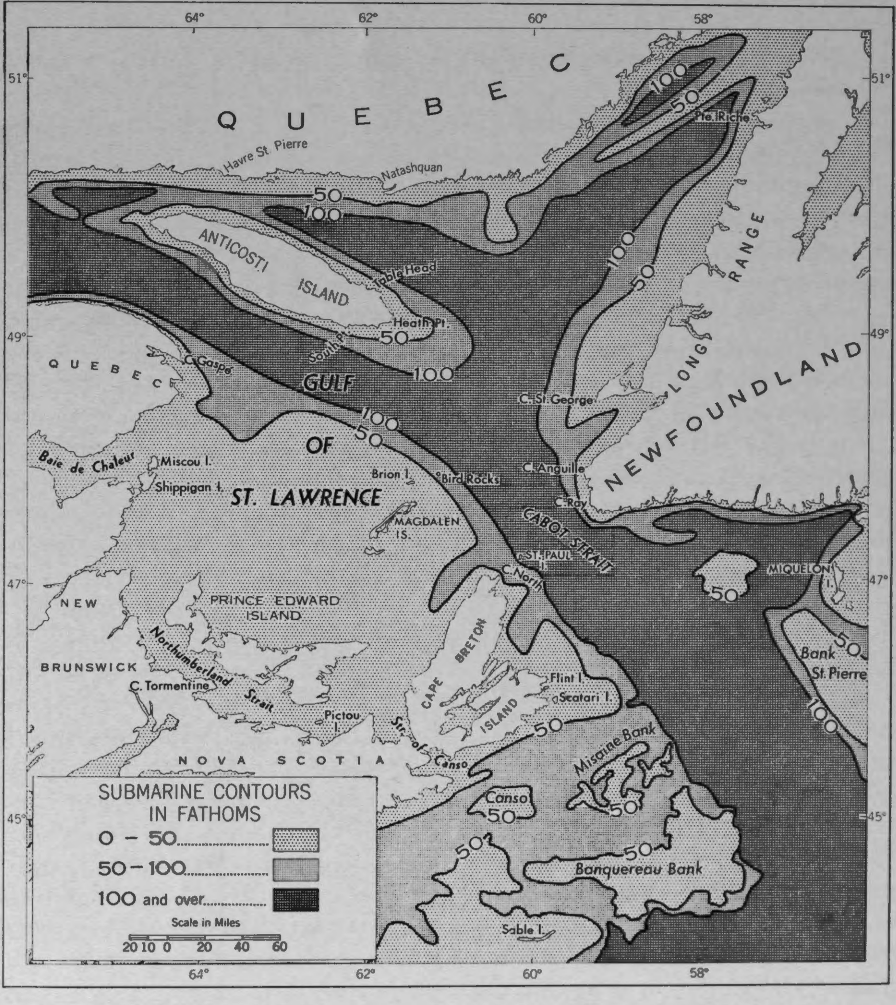

Figure 1. Bathymetric map of the Gulf of St. Lawrence.

Of the three straits connecting the gulf with the Atlantic, Cabot Strait is the widest. It is apparent that a greater volume of ice will leave through this strait during the break-up season than through either the Strait of

Belle Isle or the Strait of Canso. Because the Strait of Canso is very narrow, the southern part of the gulf is more confined than the central section, and ice movement is restricted. Moreover, the causeway now being built across the strait will, upon completion, further restrict the movement of drifting ice. The northeast arm is also confined, but the Strait of Belle Isle provides a wider link with the open ocean. Anticosti Island, the Magdalen Islands, and Prince Edward Island tend to hinder the free movement of ice.

The shorelines of the gulf and the islands within it are characterized throughout by indentations that conform essentially to the alinement and the nature of the rock structure.[1] It is notable that the western and southern shorelines have numerous broad, shallow embayments, in contrast with the Precambrian shoreline on the north, where the bays are small and the water is deep offshore. The broad, shallow bays provide great areas of protected water surface where ice forms more readily and where the break-up is slower than in unprotected regions. The delay in movement of the ice during the break-up season is particularly noticeable in Baie de Chaleur, where the mouth of the bay is narrowed by Miscou and Shippigan Islands. On the other hand, the smooth north coast of Gaspe does not hinder the free drift of ice during the break-up.

WATER MOVEMENTS

Water movements naturally affect the behaviour of floating ice. Among the factors that cause movement are tides, tidal currents, and ocean currents. The tidal undulation enters the gulf mainly through Cabot Strait, and progresses in a counter-clockwise direction around a central point west of the Magdalen Islands. The tidal action hinders the formation of large sheets of ice and aids in the breaking up of sheets already formed. This shattering action is more effective where the tidal ranges are high. Tidal ranges in the gulf are not great, as a rule, but are higher toward the estuary of the St. Lawrence River and in Northumberland Strait than elsewhere (Figure 2). In these areas, tidal shattering is most pronounced.

The velocities of the tidal currents are generally less than 1 knot in open areas, but in the Strait of Canso they are decidedly stronger. In Northumberland Strait the tidal currents meet in the middle off Cape Tormentine, and their strengths are approximately 1 knot to 1·5 knots. The Strait of Belle Isle has currents that are tidal in character, but there is also a dominant flow in one direction or the other for periods of a week or more. The velocities in the strait range between 0·5 knot and over 2 knots. In most other sections of the gulf the tidal currents are weak and ill-defined. Winds are effective in checking or increasing the velocities of these currents.

Superimposed upon the system of tides and tidal currents is a system of constant ocean currents characterized by a counter-clockwise circulation (Figure 2). Water from the ocean pours in around Cape Ray, curves to

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[1] Johnson, Douglas W.: The New England-Acadian Shoreline; New York, 1952, pp. 20-23.

the right, and flows northeastward along the west coast of Newfoundland as far as Point Riche. At Cape Ray the current, a belt near shore 10 to 15 miles in width, has a velocity of a little less than 1 knot. From Cape St. George to the Bay of Islands the movement of the water is hardly appreciable, but northward of this point it is constant at about 1 knot, stronger near land than offshore[1]. The current has the beneficial effect of keeping the southwest and west coasts of Newfoundland free of ice later than other areas within the gulf. Much of the water in this current departs from the stream and spreads out northwestward, heading across in a weak movement towards Anticosti Island. In fact, the greater part of the flow in this whole northern area to a considerable depth is toward the St. Lawrence estuary, although the velocities are low and the direction of movement is readily affected by the wind. Nevertheless, a great quantity of ice is carried southward and westward from the Strait of Belle Isle area. The currents in the strait itself are tidal in character.

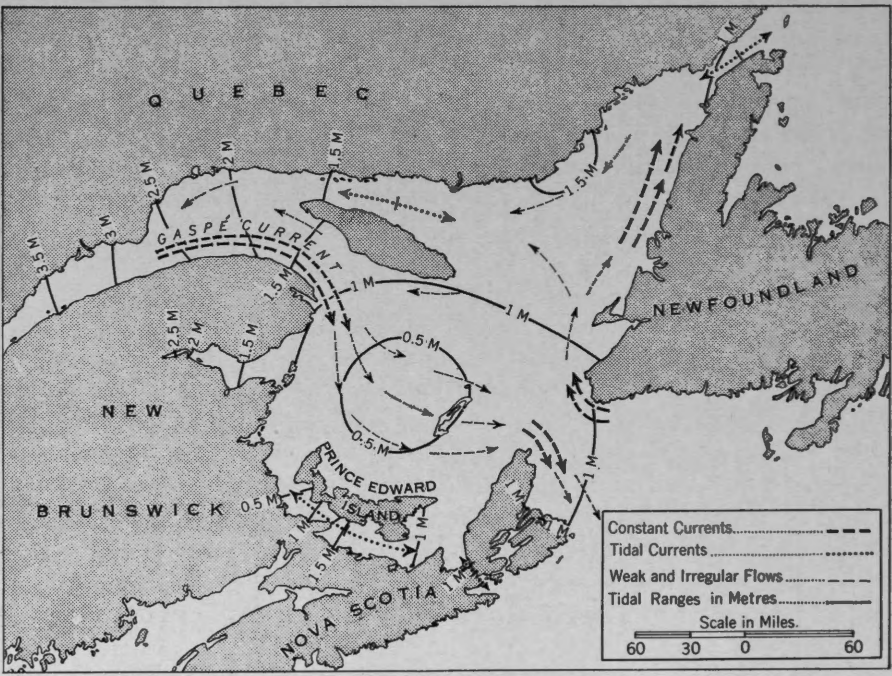

Figure 2. Ocean currents and tidal ranges in the Gulf of St. Lawrence.

At the mouth of the St. Lawrence River, water from the northern part of the gulf combines with that from the river to generate the Gaspe current. This current, about 12 miles wide, begins at Cap Chat and hugs the Gaspe coast as it flows eastward with an average velocity of 2 knots. A large amount of ice formed in the St. Lawrence River and estuary is

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[1] Gulf of St. Lawrence Pilot; 3rd edition, Canada, Dept. of Mines and Resources, Ottawa, 1946, p. LVI.

carried into the gulf by this current. Leaving Cape Gaspe, the current flows southeastward, but the velocity is reduced by $\frac{1}{2}$ to 1 knot and it spreads over a wide area, filling up the central part of the gulf. The predominant trend in this central section is eastward across to the Magdalen Islands and Cape Breton[1]. In the southern part, particularly in Northumberland Strait, the currents are tidal in character. The lack of constant currents in this section permits the accumulation and stagnation of ice on some occasions.

The speed of the Gaspe current is much increased when it meets the constriction of Cabot Strait. An 18-mile wide current, comparable in constancy with the Gaspe current, flows along the Cape Breton coast a few miles off Cape North. Fed chiefly by a dominant flow of water southeastward from the northern end of the Magdalen Islands to Cape North, its velocity at times reaches 2 knots[2]. This current is of great importance in transporting ice from the gulf, especially during the break-up.

Most of the rivers flowing into the gulf, except the St. Lawrence, are too small to give rise to significant currents. Their effect on the clearing of ice is almost negligible, because the bulk of the ice discharges through Cabot Strait before the rivers break up.

CLIMATE

The climate of the Gulf of St. Lawrence region is not as marine in character as might be expected, considering its location. Lying in the belt of westerly winds, the area is mainly under the influence of air that moves from land to sea. The path of the most frequent cyclonic storms passes directly across the central part. The continental air is modified to a certain extent, resulting in more moderate conditions than those that are experienced inland.

During the winter the isotherms tend to run northeast-southwest across the gulf. The Cabot Strait region experiences temperatures about 10 degrees Fahrenheit higher than those of the Quebec north shore because of the moderating influence of the open Atlantic. This difference in temperature is reflected in the dates of closing of harbour navigation in the region (Figure 4). The harbours in the southeastern part freeze later than those in the northwestern. Table I indicates that average monthly temperatures throughout the gulf drop below the freezing point in December and remain there until April. The air temperature is low enough to give rise to ice formation even on salt water if other factors combine to make it possible, and to preserve ice that may have formed elsewhere and drifted into the area. Temperatures are still near freezing during April, when the break-up is well advanced. The variability of ice season temperatures is high. In a given year the difference from average of the mean monthly temperature might be 5 or 10 degrees at many stations in the gulf area.

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[1] The Currents in the Gulf of St. Lawrence; Canada, Dept. of Naval Service, Ottawa, 1913, p. 11.

[2] Gulf of St. Lawrence Pilot; loc. cit.

Frequently, several consecutive months in one season experience temperatures somewhat higher or lower than average. The severity of ice conditions is largely dependent on these year to year fluctuations of temperature. In the examination of ice conditions during a 13-year period, it is desirable to relate the results to the observed temperatures of each year as well as to the average temperatures.

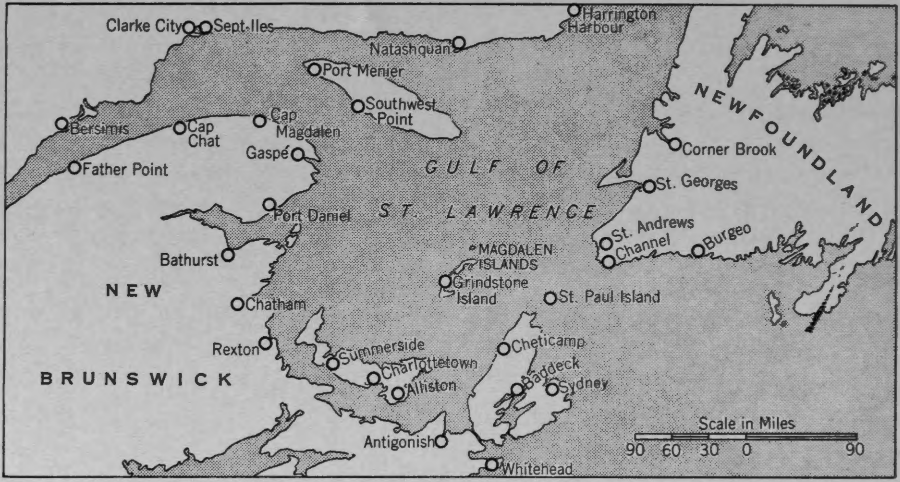

Figure 3. Locations of meteorological stations.

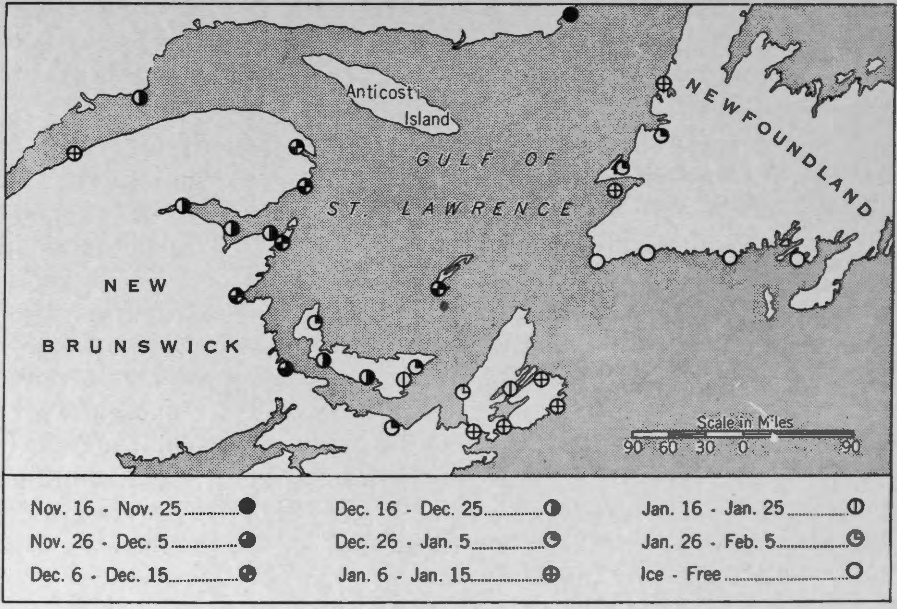

Figure 4. Average dates of closing of harbour navigation.

Abundant precipitation evenly distributed throughout the year is characteristic of the area. Most stations receive more than 40 inches a year. There is a slight summer maximum in the more continental northwestern part of the gulf and a winter maximum in the more maritime southeastern part. Snowfall is fairly high, ranging from 60 to over 200 inches. The higher totals are recorded along the north shore and the lower totals in the southeastern section. The effect of precipitation on ice formation and break-up in the gulf is minor compared with that of temperature or wind.

TABLE I

Monthly Averages of Daily Mean Temperature, Gulf of St. Lawrence

Meteorological station	November	December	January	February	March	April
Bersimis	27	14	2	8	20	33
Father Point	29	17	9	11	22	34
Clarke City	26	11	2	6	18	31
Natashquan	27	13	6	6	17	30
Harrington Harbour	28	13	8	9	20	30
Cap Chat	32	19	13	15	22	35
Cap Magdalen	31	18	11	14	21	32
Ellis Bay	30	18	13	12	20	31
Anticosti (SW. Pt.)	30	20	12	12	21	31
Gaspe	30	17	10	11	22	33
Port Daniel	31	19	12	12	27	34
Bathurst	32	18	10	11	24	36
Chatham	33	19	12	12	25	37
Rexton	36	30	15	14	25	33
Summerside	36	24	18	18	26	37
Charlottetown	36	25	18	17	26	36
Alliston	38	26	20	20	28	37
Antigonish	38	27	20	18	28	37
Cheticamp	39	29	22	20	27	36
Baddeck	38	27	27	20	26	37
Sydney	38	29	29	20	27	36
Grindstone Island	36	25	19	16	23	32
St. Paul Island	37	27	27	18	25	32
Burgeo	35	29	23	21	26	33
Channel	36	28	22	21	25	33
St. Georges	35	28	21	16	24	33
Corner Brook	34	25	18	18	25	35

Source: Department of Transport, Meteorological Division, Monthly Record (Monthly Statistics Series), Toronto, 1940-1950.

The wind roses (Figure 5) illustrate the percentage frequencies of wind by direction for January and April, the months representing the period when ice is found in the Gulf of St. Lawrence. Winds of a westerly trend prevail for most of the year, although in spring and summer they are less noticeable. At this latter time of year the winds are more variable in direction and easterly winds occur more frequently than at other seasons. Changes in direction, even complete reversals, may be expected within very short periods of time, owing to the movement of mid-latitude depressions across the area in an almost constant procession in winter. Indeed, it is this feature that is responsible for the highly variable weather conditions of the gulf region. The wind is effective in continually shifting the pack-ice that covers most of the gulf in winter. Owing to the rotation of the earth, the drift of floating pack-ice in the northern hemisphere is about 30 degrees to the right of the wind direction. In general terms, however, the prevailing westerly winds carry the ice eastward toward Cabot Strait, whereas northerly winds tend to pack the ice in the southern part of the gulf. Southerly winds usually accelerate the clearing of ice, but easterly winds hold the ice in the gulf. The sudden changes of wind direction cause local changes in the position of pack-ice, such as the opening or closing of leads and pools.

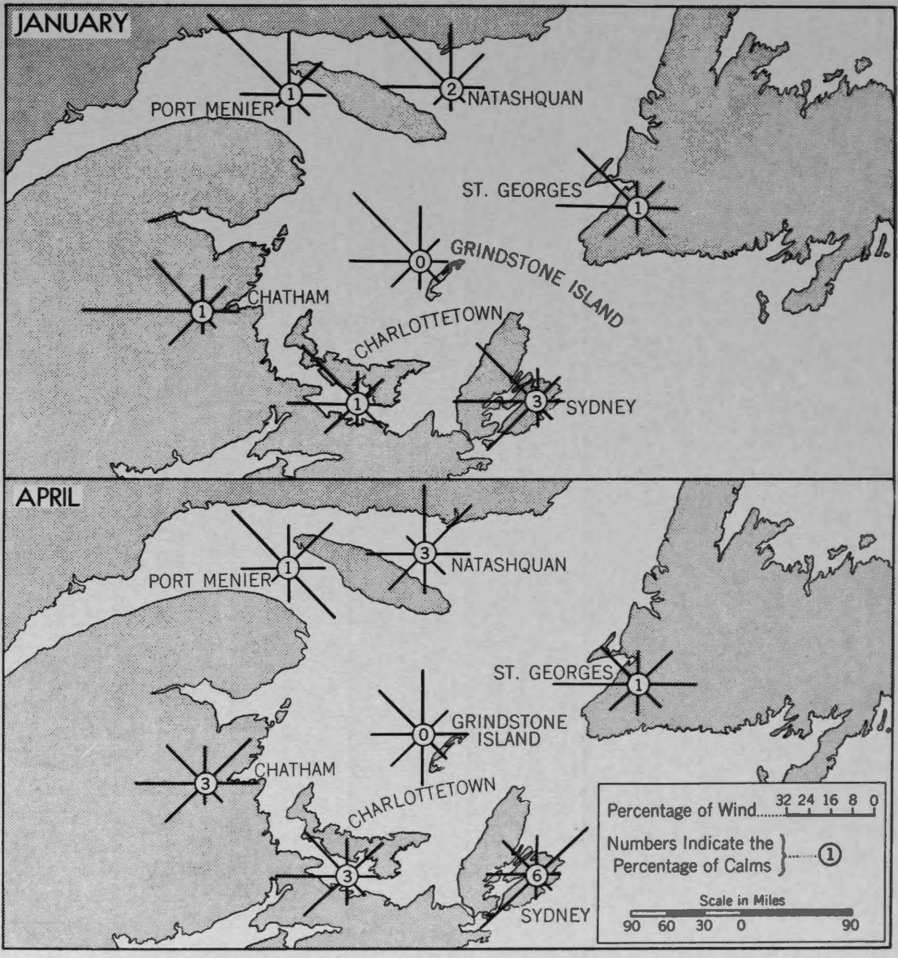

Figure 5. Wind frequencies in the Gulf of St. Lawrence.

WINTER ICE CONDITIONS

Data on the distribution of ice in the Gulf of St. Lawrence during the months from November to March are far from complete, and much of what is available refers to very limited areas. Conditions, of course, vary greatly from year to year, and the following is merely intended to depict average conditions.

The island of Newfoundland acts as a barrier separating the Gulf of St. Lawrence ice from the Arctic ice, although the Strait of Belle Isle admits a quantity of ice sufficient to fill the northeast arm. Most of this pack-ice originated as landfast ice along the coast of Labrador. Icebergs seldom gain entrance to the gulf; they drift southward in the main stream of the Labrador current. Pack-ice constitutes the bulk of the gulf ice.

Winter navigation in the area is restricted. One steamship company operates a winter service with ice-breaking vessels from Tadoussac to Sept Iles and sometimes as far east as Havre St.Pierre, which is made possible by the fact that frequent northwest winds push the ice offshore. In Northumberland Strait an ice-breaking ferry connects Prince Edward Island with the mainland, and a ferry operates between Cape Breton Island and the island of Newfoundland. In addition to these regular services, navigation is carried on by two or three Canadian Government ice-breakers, which assist those ships attempting navigation and cross the gulf occasionally while en route from the Cape Breton area to the St. Lawrence River, and by small sealing vessels.

On the whole, commercial navigation ceases in most sections of the gulf by about the middle of December. In keeping with the characteristics of climate, it is apparent that the harbours nearest the open Atlantic freeze later than those that are more removed from the marine influence (Figure 4).

ICE CONDITIONS IN DECEMBER

When the surface-water temperatures in the northern part of the gulf drop below freezing point during late November, ice begins to form in the northeast arm, especially in the shallow bays and confined stretches of water. This ice is very light and no appreciable amount forms until December. In addition to ice produced by local freezing, heavy pack-ice begins to enter the gulf through the Strait of Belle Isle late in December. In spite of the fact that ice conditions are not serious in the Strait of Belle Isle throughout most of this month, navigation generally ceases about December 1.

Ice forms fairly early in the lower St. Lawrence River and estuary along the north shore, because these areas are removed from the moderating influence of the open Atlantic, but large sheets of ice seldom develop until January. Such factors as winds, tides, and currents churn the water, breaking up the young ice before it has grown to a thickness that will resist these attacks. A large quantity of ice, broken by tidal action in the St.

Lawrence estuary, is carried into the gulf by the Gaspe current in late December, after the upper reaches of the river have already contributed ice to the gulf.

Corresponding closely with the advent of low air temperatures throughout the gulf, the freezing of harbours occurs later in the southern and southeastern areas; here navigation is customary until the end of the first week in December. Although the Baie de Chaleur does not freeze until the latter half of the month, owing to the great size of the body of water, the smaller bays and harbours along the western side of the gulf freeze before December 15. Ice originating in the St. Lawrence River is carried into the gulf by the Gaspe current and by westerly winds and spreads out in southern areas where constant currents are lacking, filling Northumberland Strait by the middle of January.

The route through the Strait of Canso is closed to navigation about January 1, owing to the blocking of the northern entrance by ice, although the section south of Mulgrave remains open. Many of the harbours situated along the Nova Scotia and Prince Edward Island coasts do not freeze until late December, or in some cases until late January. Cabot Strait remains clear throughout December.

ICE CONDITIONS IN JANUARY

By January the water temperatures have been lowered sufficiently to give rise to a large-scale production of ice. Pack-ice formed in the gulf usually attains a thickness of 2 to 4 feet, but because of lower temperatures and a longer ice season Labrador pack-ice is thicker, sometimes up to 7 feet. The growlers[1] that enter the area may be considerably larger. Occasionally, a sheet of ice is buckled into ridges as a result of pressure, caused mainly by strong winds. Several thicknesses of ice may be piled one above the other, forming a mass as thick as 12 or 15 feet. Such ridges occur most frequently in the vicinity of headlands.

Large sheets form in the Strait of Belle Isle and the northeast arm of the gulf and, together with heavy ice that enters the strait from the Labrador coast, choke up the whole area. The amount of ice that drifts in through the strait is largely controlled by the tidal currents. When the dominant flow is inward for a few days, more ice enters than at other times, but the actual amount is far less than it would be if there were a constant inward current. Some of this pack-ice drifts southward in the weak flow to other sections of the area where it may be incorporated into a large ice-field or shifted about by wind and wave throughout the winter. Frequent northerly winds aid in driving the ice southward. A few small icebergs and growlers that have strayed from the Labrador current may find their way into the gulf through the strait before it becomes blocked by pack-ice. The west coast of Newfoundland receives the full benefit of the moderating influence of the Gulf of St. Lawrence; the harbours along this

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[1] A small piece of glacier ice, barely showing above the water.

coast do not freeze until January. St. Georges Bay fills with river ice; this seldom becomes cemented into a field and the floes remain in motion all winter. Offshore, the northward-flowing current is effective in defending the coastal area against the invasion of ice from the north until February. The north shore of the gulf is fairly clear of pack-ice throughout the winter, because of the prevailing northwest winds that continually push the ice offshore, and limited navigation is possible.

The central part of the area is covered with pack-ice that shifts about constantly. Leads are readily discovered between the floes, but few ships other than ice-breakers attempt navigation. The general movement of the ice in the central part is from west to east, under the influence of the prevailing winds and water currents, and conditions are never static because the St. Lawrence River continues to discharge ice into the gulf and new ice is forming in many areas.

The ice is more closely packed in the southern part of the area, because of the decreased current and the confinement of the basin by the land. By the middle of January, Northumberland Strait and George Bay are usually filled with close pack-ice, and the Strait of Canso is blocked at the northern entrance. Such a volume of ice is swept toward the constriction of the strait that it packs solid and freezes into a compact mass that constitutes a "bridge", as it is commonly called. The effect of this bridge is to prevent the ice in George Bay from drifting into the strait. This results in ice-free conditions south of Balache Point and navigation in this stretch is possible throughout most of the winter.

Pack-ice begins to emerge through Cabot Strait about the middle of January, but it is usually light and scattered. In a year of severe conditions ice may be found as far east as Miquelon Island in January, as was the case in 1943. Conversely, in a year of favourable conditions, such as 1945, there may be no ice in the Cabot Strait area. On the average, Cabot Strait is partly covered with ice streaming out of the gulf, but it is never frozen over from shore to shore. Rarely does the ice extend southward of Flint Island along the east coast of Cape Breton Island.

The harbours along the Cape Breton east and south coasts freeze during the second week in January, whereas those along the south coast of Newfoundland, and that of Halifax, are usually ice-free throughout the year. These ice-free harbours are protected by their locations from the invasion of gulf ice and are climatically favoured in the retardation of local ice formation.

ICE CONDITIONS IN FEBRUARY

The main exodus of gulf ice begins in February. Ice from the central section, between Anticosti Island and Cabot Strait, is the first to move out. While ice is passing through Cabot Strait, heavy ice in the northeast arm continues to drift southward, eventually closing on the west coast of Newfoundland as far south as the Bay of Islands. Some of this ice makes its way westward along the north shore. In addition, the St. Lawrence estuary adds ice to the supply. Consequently, the Cabot Strait outflow is partly compensated by inflows in other areas and by local freezing, but the net result is a loss of ice.

Generally, Cabot Strait is partly covered with ice closely packed on the Cape Breton side and fairly open or scattered on the Newfoundland side. In some years, as occurred in 1943, the ice closes in on the Newfoundland coast, owing to sustained southerly winds, but this is not the usual condition. Eastward of the strait the ice is more open and lighter, and scattered strings of ice frequently extend eastward to the 58th meridian and southward to the 46th parallel. Occasionally, northeast winds cause the ice to move southwestward along the south coast of Nova Scotia, blocking the harbours.

The southern part of the gulf remains packed with ice, much of it shifting, but little departing from the area to stream through Cabot Strait. The bays, including the Baie de Chaleur and George Bay, are frozen over completely, or are filled with closely packed ice that has been cemented into large sheets, presenting a mosaic appearance. Other areas are covered with ice of a comparable description, except that there are wide leads between the sheets, particularly in Northumberland Strait.

As early as February, therefore, the movement of ice from the gulf begins on a large scale. This is the normal result of winds and currents, and does not indicate that the ice is melting or breaking up owing to mild weather.

ICE DISTRIBUTION IN THE BREAK-UP SEASONS, 1940-1952

The description of actual ice distribution in the break-up season in March and April of the years 1940 to 1952, inclusive, is based on information obtained by aerial observation. The data employed were incomplete for March but were detailed for April. This detailed information in April enabled the determination of limits of the main ice areas at specified dates, and these limits are shown on the accompanying maps (Figures 6-18). The main ice areas do not include regions of widely scattered strings and small patches of ice.

The graphs accompanying the maps are intended to show the temperature characterictics of the ice seasons. Statistics for the difference from average of the mean monthly temperature were used to prepare these graphs[1]. In the case of the years 1940 to 1950, inclusive, figures from twenty-seven meteorological stations were used in construction of the graphs, but in the other two cases, 1951 and 1952, only eighteen stations were used[2]. Because the graphs are intended to show the general temperature characteristics of the season over the water area of the gulf, stations situated on the coast near sea-level were chosen as most representative.

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[1] Monthly Record (Monthly Statistics Series); Canada, Department of Transport, Meteorological Division, Toronto, 1940-1952.

[2] The reduction in number of stations in these years was necessitated because the Monthly Record had not reached the publication stage when this manuscript was being prepared. The abbreviated list published in the Monthly Weather Map was used instead of that in the Monthly Record for these 2 years.

As many stations as possible were included in order that deviations from average due to local causes might be minimized. In view of the nature of the ice data available, a breakdown of temperatures in various parts of the gulf was deemed unwarranted; consequently, the stations lose their local identity and represent points in the Gulf of St. Lawrence area as a whole.

The horizontal axis, zero, is symbolic of the average temperature of every station in the gulf region, although the averages may differ. The difference from average at each station in whole degrees Fahrenheit is found along the vertical axis. Each station recording an average monthly temperature above its all-time average is located above the zero line, whereas each one recording a below average temperature is found below the line.

THE NATURE OF THE BREAK-UP

PATTERNS AND RATES OF BREAK-UP

The pattern and rate of break-up varies considerably from year to year. There is, however, a regular drift of the ice from west to east, with Cabot Strait constituting the main outlet.

In most years there are certain areas that become free of ice before others. A triangular region off the south coast of the island of Newfoundland, with the apex at Cape Ray, is generally ice-free throughout the year and a passage around Cape Ray and Cape Anguille is open most of the time. The central part of the gulf northwest of Cabot Strait discharges ice in January or February, but it continues to receive more from other sections and, as a result, it is rarely the first area to become clear, although it clears before the southern part. The stretch south of Anticosti Island appears to open first, then the western section and the steamer route, and finally the southeastern sector and the dispersal region. Although ice remains in the Baie de Chaleur after the area outside is clear, it is usually confined to the southern side. Northumberland Strait clears from west to east, and the east coast of Prince Edward Island tends to open earlier than its surroundings. Similarly, the area immediately east of the Magdalen Islands frequently opens early. Chedabucto Bay and the south coast of Cape Breton are encroached upon by ice only occasionally. Although these general features of the break-up are characteristic of most seasons, it is possible to differentiate the seasons on the basis of several recurrent patterns and rates of withdrawal.

The thirteen seasons may be divided roughly into two categories, with two exceptions.

The first group comprises the years 1940, 1941, 1945, 1947, 1948, and 1949. During these seasons, the ice drifted from west to east and vacated the southern part of the gulf in a normal course of withdrawal. Baie de Chaleur, Northumberland Strait, George Bay, and the Strait of Canso were clear before the dispersal region, and open water appeared off the coast of Prince Edward Island at an early date. Generally, the steamer track

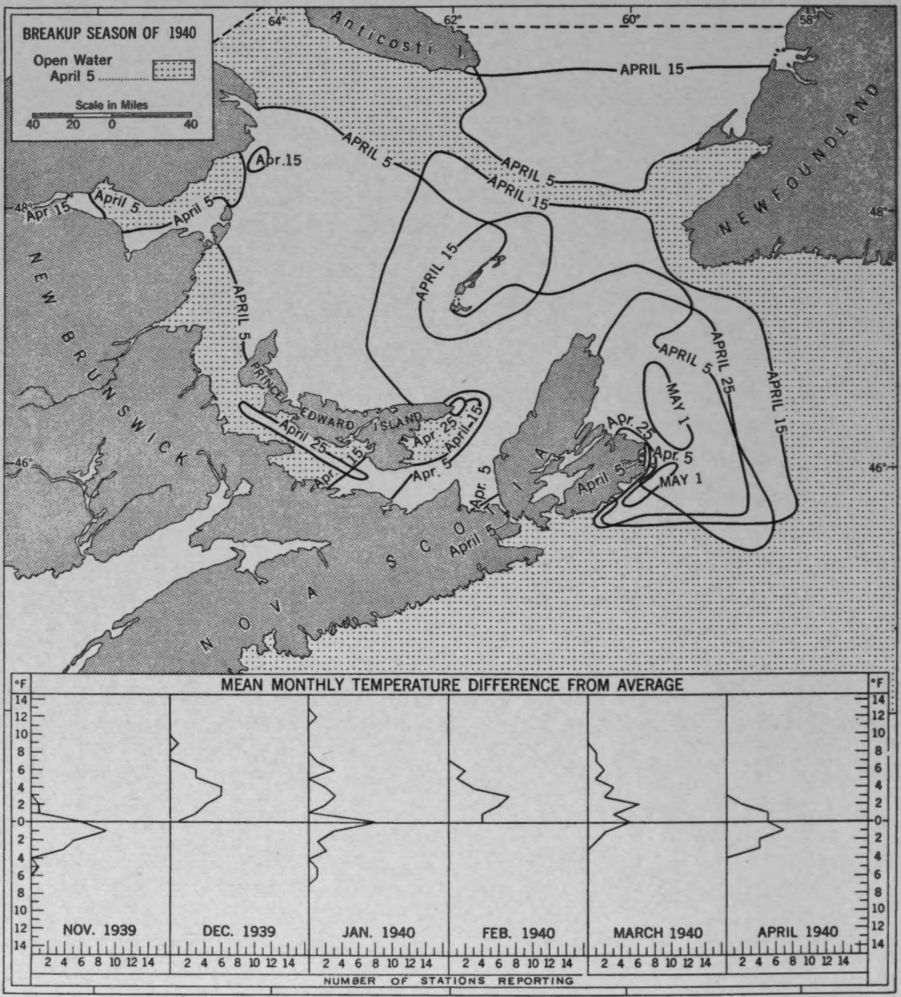

Figure 6. Season of 1940. There was a considerable area of open water in the gulf during March, particularly in the central section along the steamer track. By early April ice was melting and breaking up in the western part of the gulf. Clearing proceeded from west to east. The remaining ice was found off the Cape Breton east coast.

The graph indicates that the season was warmer than average, in spite of the fact that November and April were below normal. March was near the average.

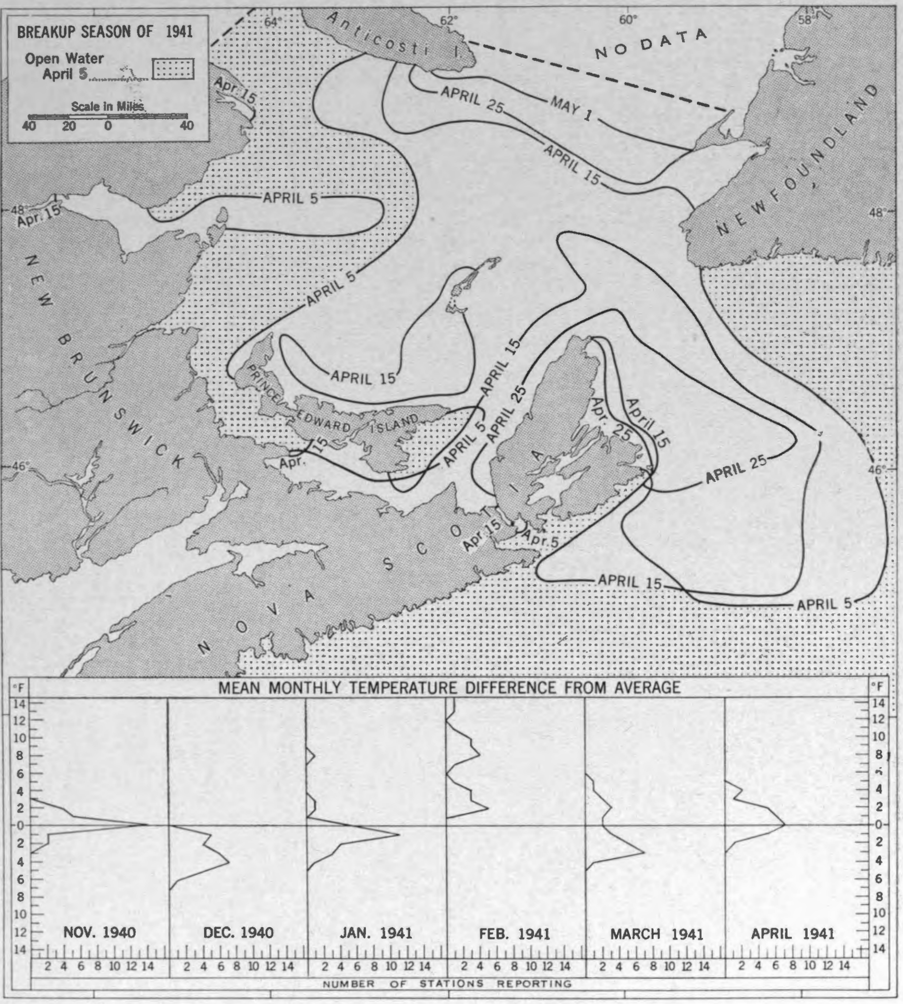

Figure 7. Season of 1941. The break-up was well advanced by the end of the first week of April. The whole area was clear by May 1. There was a greater quantity of ice than in 1940. The break-up was swift and normal, making its way from west to east through Cabot Strait. Cabot Strait and the steamer track were ice-covered until a later date and a greater volume of ice was spread over a wider area beyond the strait.

Temperatures were near average in November, below average in December and January, above average in February, normal in March and April. Lower temperatures in December and January were probably the cause of heavier ice than in 1940.

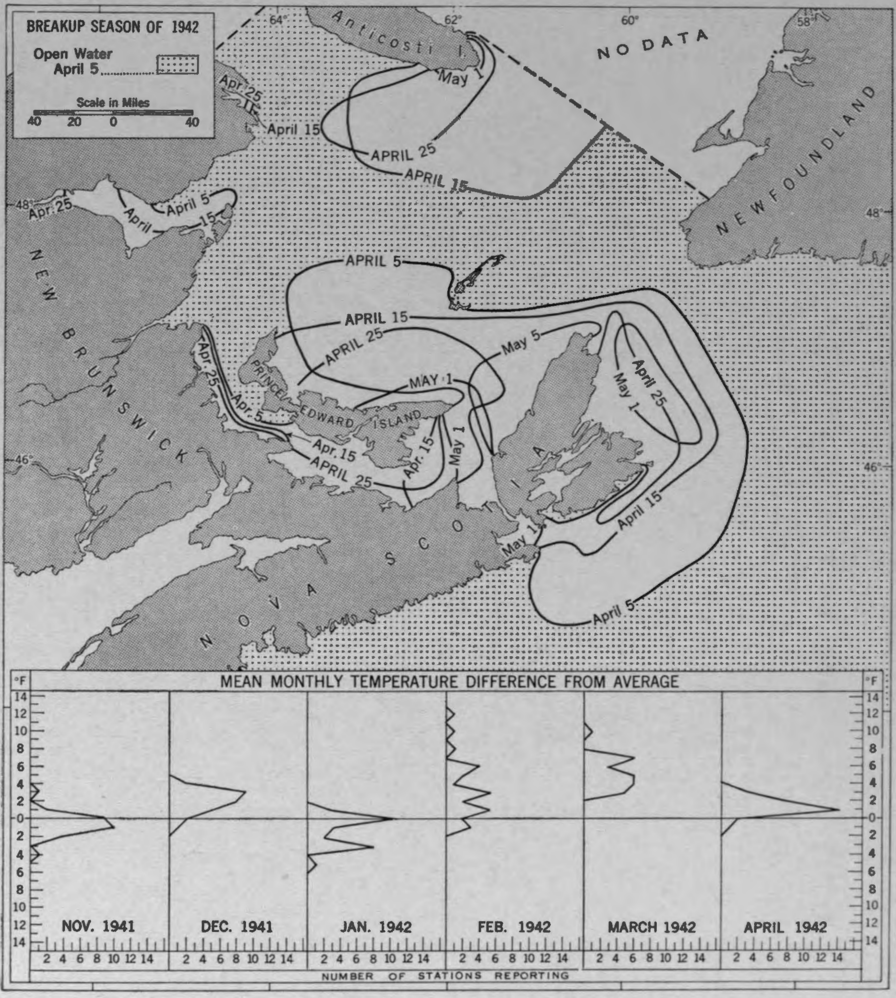

Figure 8. Season of 1942. The break-up indicated an early opening of all navigation routes. Much of the gulf was open at the beginning of April; ice was confined to the southern section and loosely distributed over a wide area. The flow of ice through Cabot Strait was restricted by northerly winds, and ice accumulated along the west coast of Cape Breton. A large field of ice encroached on the steamer track south of Anticosti Island and dispersed very slowly. Ice stagnated in the southern section and clogged the George Bay-Strait of Canso area until May.

Temperatures in November and January were below average; other months were warmer than normal.

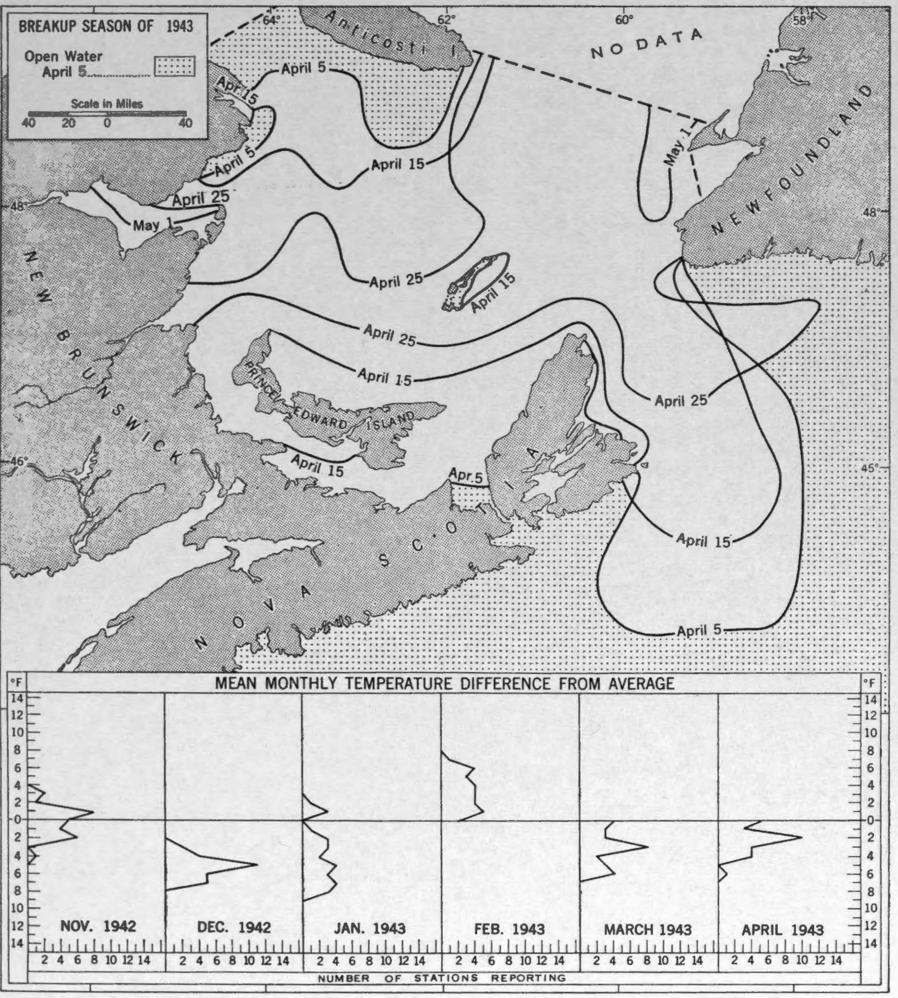

Figure 9. Season of 1943. Ice in the main body of the gulf was more abundant. It cleared first in the area east of Gaspe Peninsula, then in the southeastern part of the gulf, and finally in the central section along the steamer track. Southerly winds occurred frequently.

Concerning temperatures, below-normal conditions prevailed in every month except November and February. Ice was heavy and widespread, but much of it was closely packed.

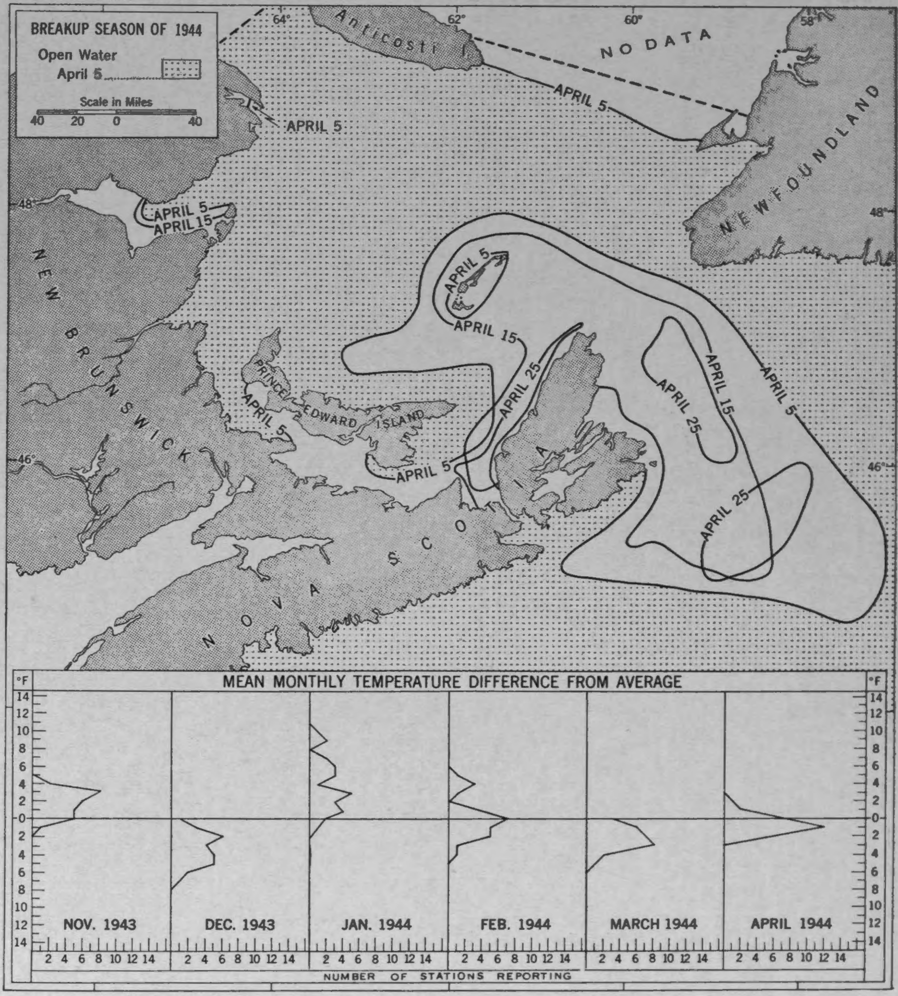

Figure 10. Season of 1944. At the beginning of April there was a wide area of open water. The break-up as a whole was similar to that of 1942.

Temperatures in December and January were below average, near normal in February, and below average again in March and April.

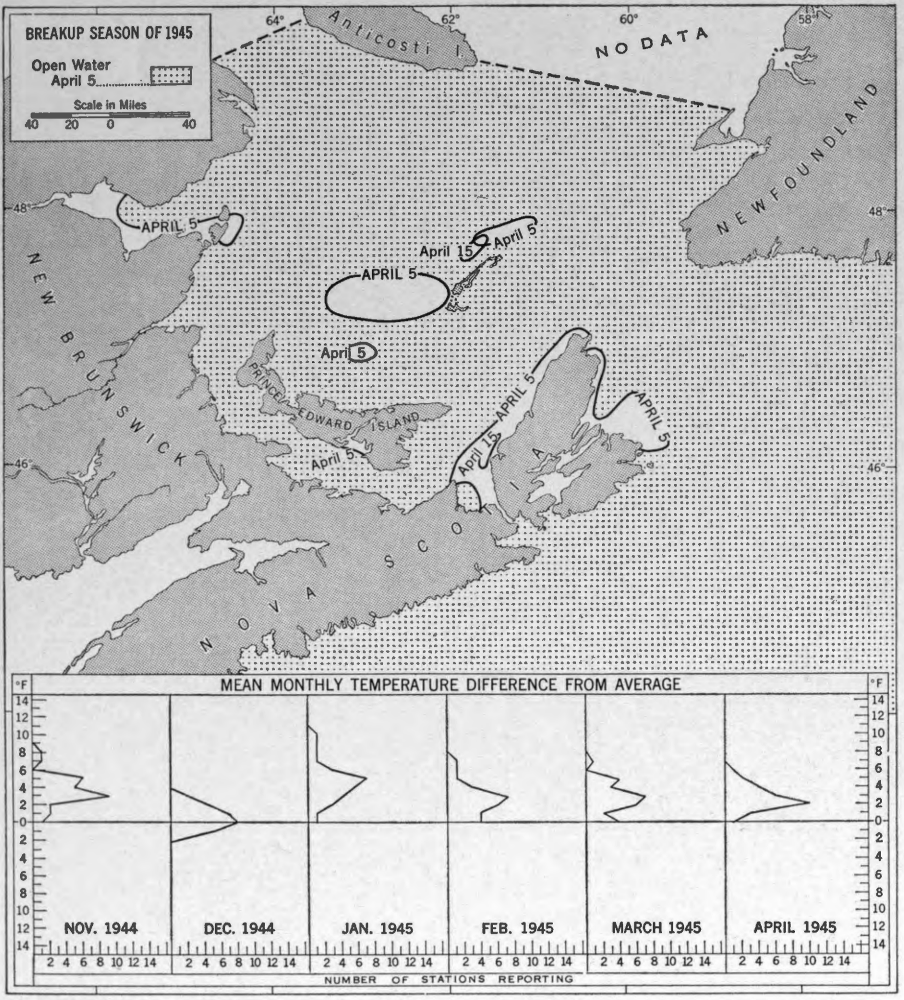

Figure 11. Season of 1945. The break-up and final clearing occurred early. The pattern of break-up was similar to that of 1944. Ice departed from the gulf via a route lying on the southern side of Cabot Strait, but lingered a little longer in Baie de Chaleur, the vicinity of Magdalen Islands, and the George Bay region.

High temperatures prevailed throughout the season.

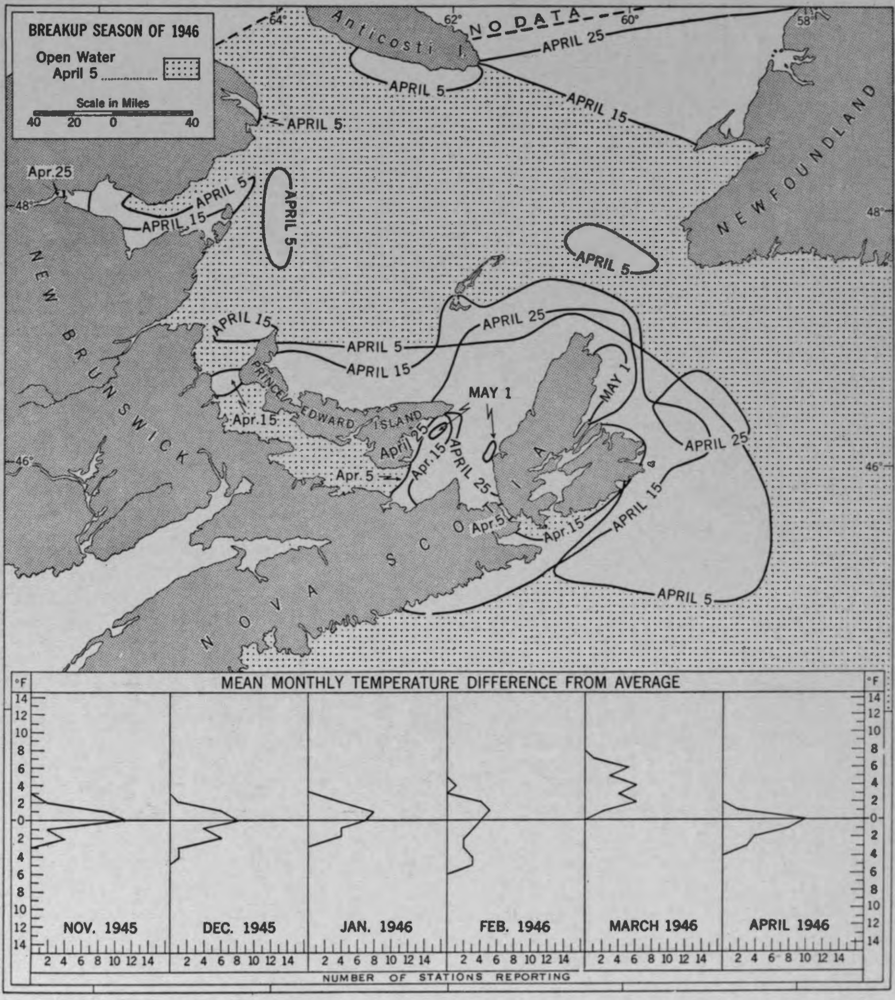

Figure 12. Season of 1946. Prevailing northwest winds in March led to the removal of a considerable quantity of ice through Cabot Strait. The steamer track was almost clear at the end of the month. During April, prevailing winds drove the ice southward and tended to discourage its free movement through Cabot Strait.

Temperatures were near the average from December until March. March temperatures were higher than normal, but April temperatures were slightly lower.

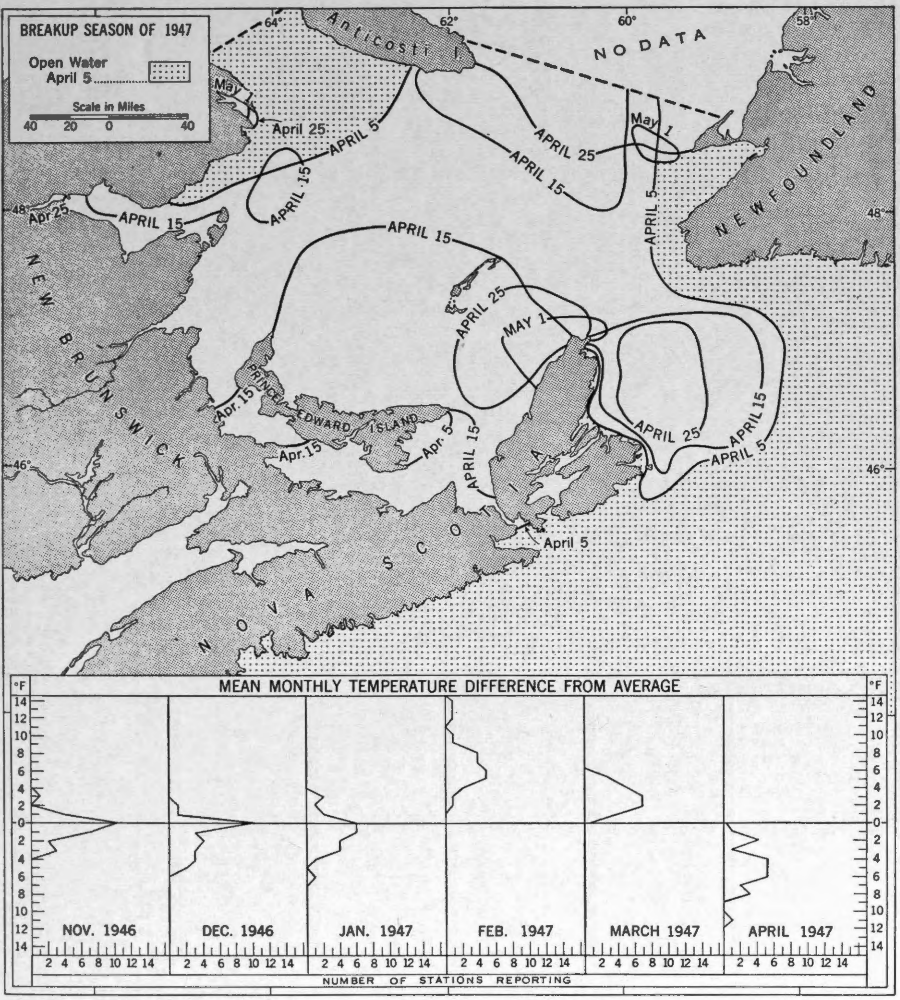

Figure 13. Season of 1947. The pattern of break-up was similar to that of 1941. Ice cleared first in the western part of the gulf, along the steamer route, and in Northumberland Strait and George Bay, then in the central area, and finally along the west coast of Cape Breton, north of the steamer track, and in the dispersal region.

Temperatures were below average in November, December, and January, above average in February and March, and again below average in April. The ice was fairly extensive.

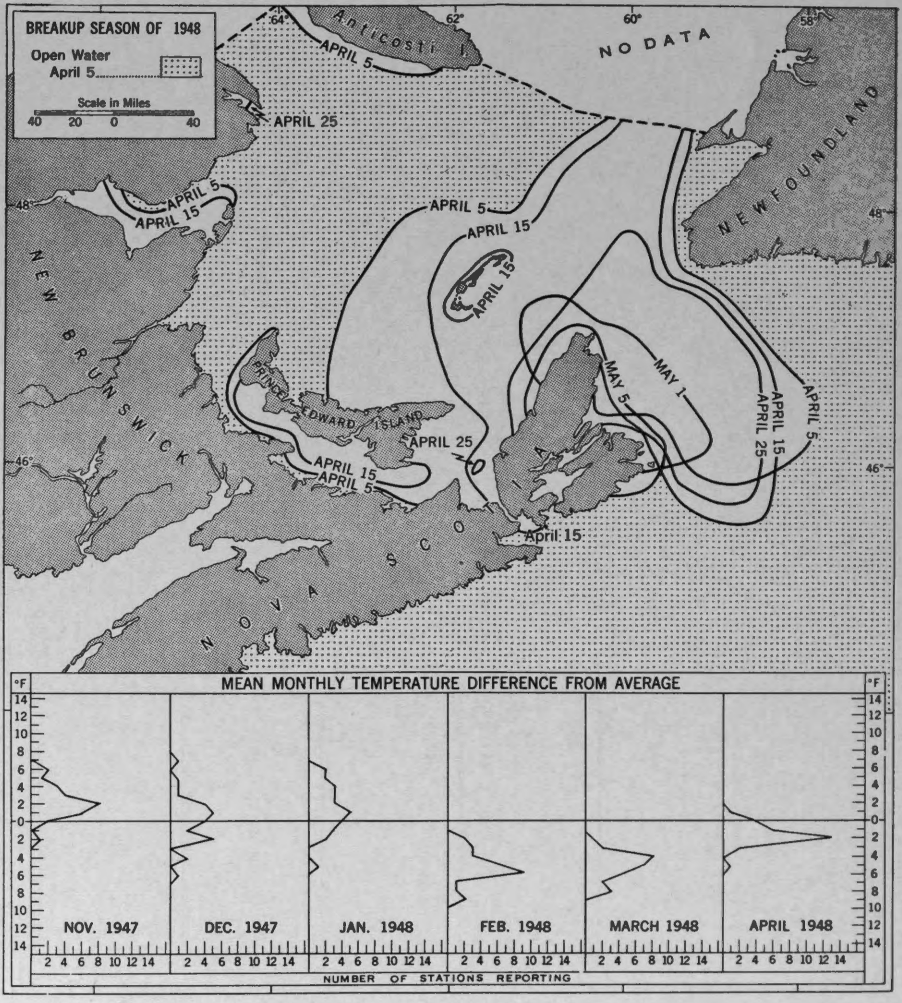

Figure 14. Season of 1948. The large quantity of ice in the gulf early in the break-up season cleared rapidly, gaining exit through Cabot Strait. The ice withdrew from west to east and vacated the George Bay area before the Cape Breton north and east coastal areas. The break-up resembled that of 1941, except that the Cape Breton region was encased by ice until an exceptionally late date.

Temperatures were above average in November and January, near average in December, and below average in February, March, and April.

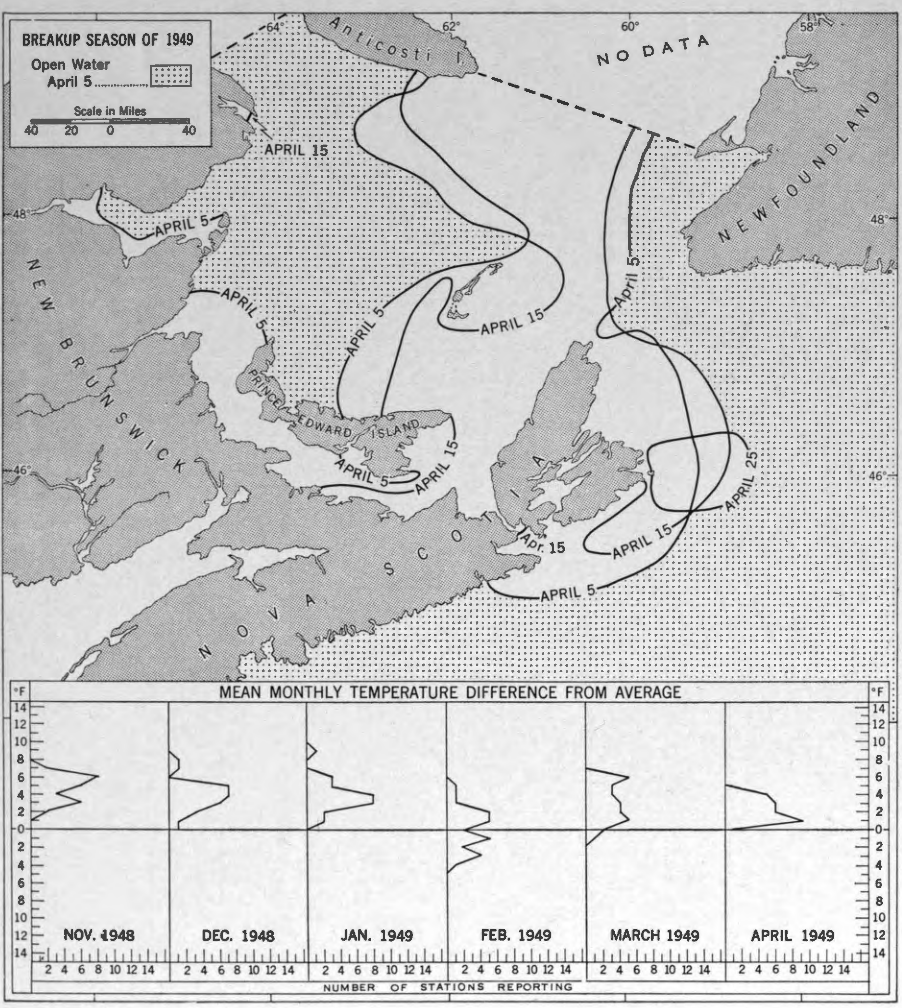

Figure 15. Season of 1949. The ice was lighter than the year before but covered a wide area. Clearing from west to east, the ice left the gulf through Cabot Strait. This season may be compared with that of 1940, when the break-up followed a similar pattern.

Owing to high temperatures, however, the ice was lighter than in 1940. All months, except February, which had near average temperatures, were 4 or 5 degrees above average at many stations.

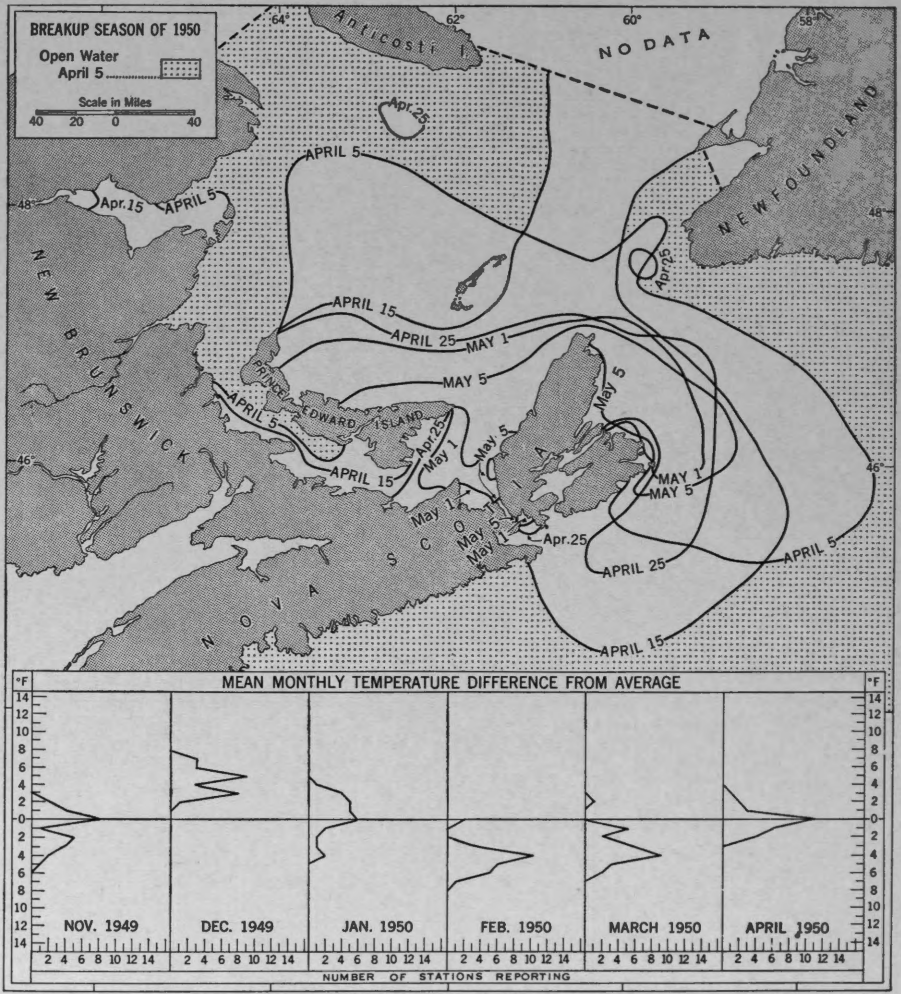

Figure 16. Season of 1950. The ice was extensive and heavy in this season and moved more from north to south than from west to east. Northerly winds were responsible for the accumulation of ice in the southeastern part of the gulf. Conditions resembled those of 1942, when the ice stagnated in this area, but the ice was more abundant in 1950, and the final clearing was postponed even longer.

December and January were the only months with temperatures warmer than average; February and March were colder than usual.

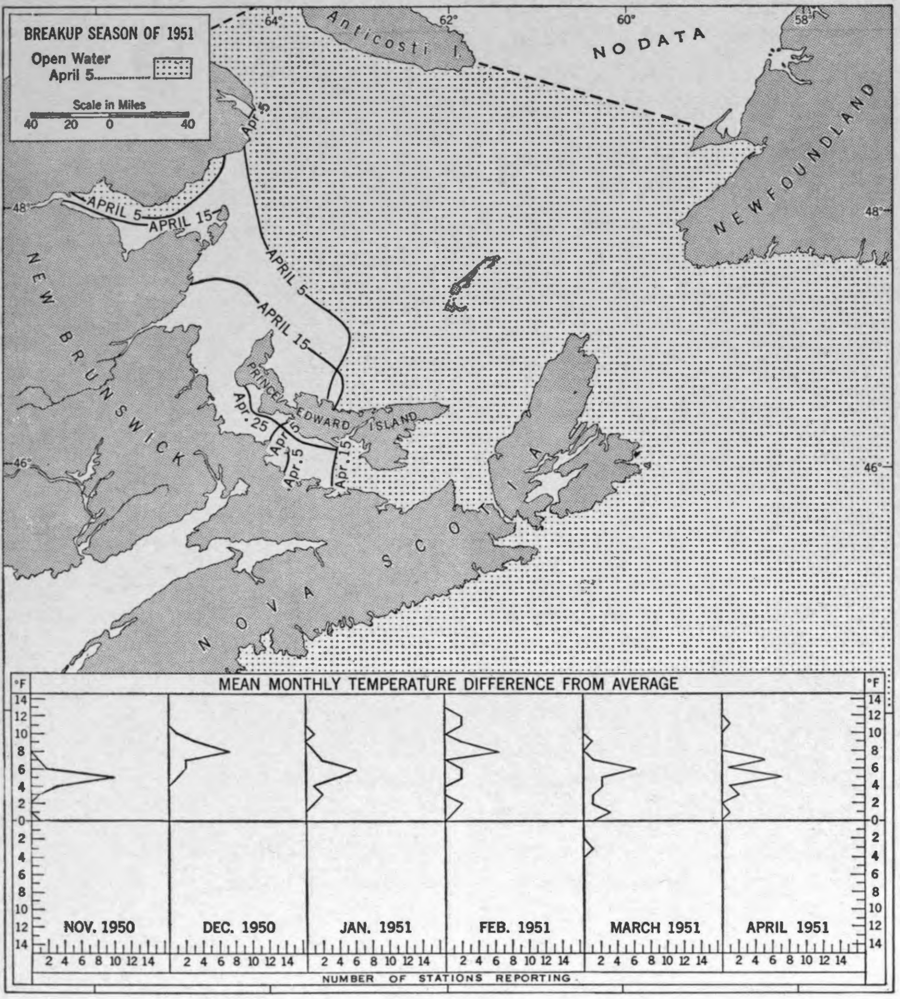

Figure 17. Season of 1951. The pattern of break-up was unparalleled. Ice conditions were light. The ice was packed along the New Brunswick coast by strong and sustained easterly winds that retarded the break-up in Baie de Chaleur. When the ice dispersed, it scattered widely without hindering navigation in other areas.

Temperatures were several degrees above average in every month. A great part of the gulf was ice-free throughout the season and ice was exceptionally light.

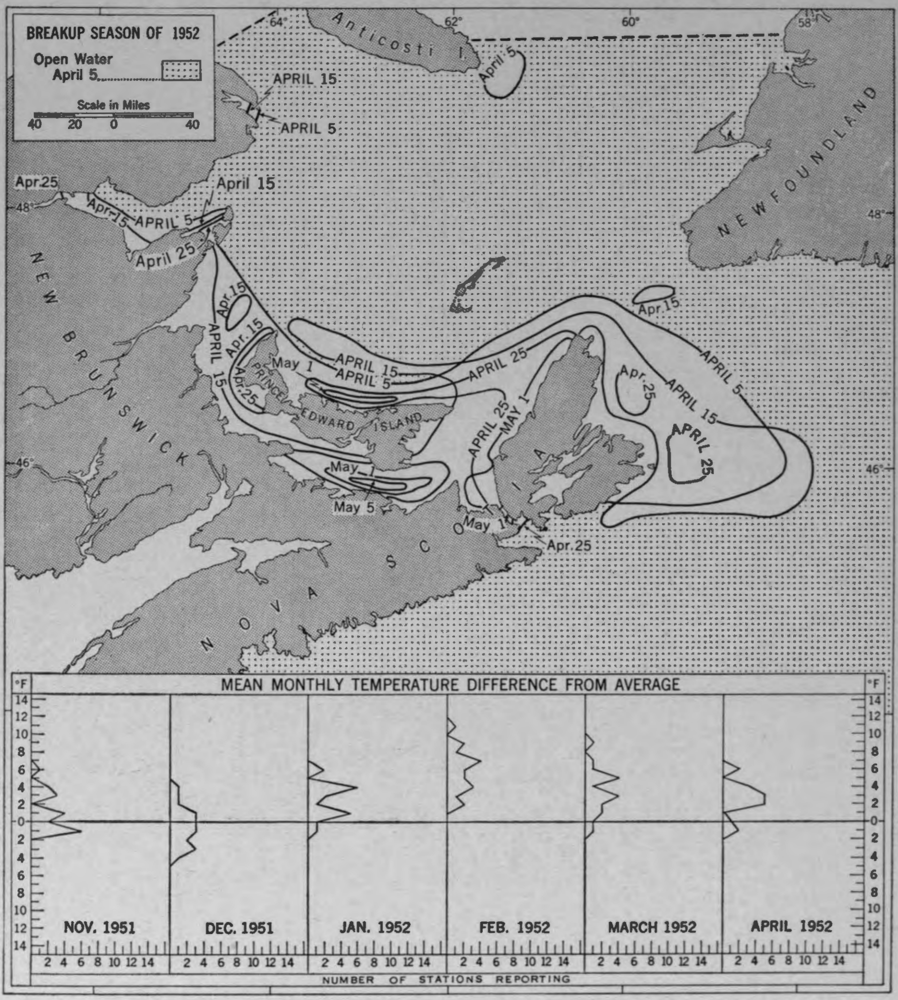

Figure 18. Season of 1952. Clearing of the ice began at an early date, but it remained in the southern sections until early May, blocking the Strait of Canso. The retarding of the break-up was due primarily to northerly winds that packed the ice in the south, and to the lack of sustained periods of southerly or westerly winds. The break-up was similar to that of 1942.

Temperatures in November and December were near average, and during the other months of the season they were above average. The ice was more extensive than in 1951.

was not clear much in advance of the southern regions. In all but the two seasons of 1940 and 1949, some ice along the west coast of Cape Breton was slow in rounding Cape North, but the delay was not lengthy. Also, in the case of 1941 and 1947, the ice lingered unduly late in the region north of the steamer track, otherwise the break-ups followed a reasonably consistent pattern. The rate of clearing was fairly rapid throughout both March and April during these seasons. The amount of ice present was a deciding factor in determining the date of its complete disappearance. For example, in 1945 the gulf was practically clear by the first of April, whereas in 1947 it was not clear until early in May; in spite of this, the actual rates of break-up were comparable. The break-up of 1948 differed slightly from the rest in that it progressed rapidly until the end of April, then the ice lingered on the west coast of Cape Breton. The movement of the ice in these years was reasonably direct and at a rapid pace, without stagnating in the southern part of the gulf.

The second group includes the ice seasons of 1942, 1944, 1946, 1950, and 1952, which witnessed such stagnation as failed to occur in the years discussed previously. Ice remained along the west coast of Cape Breton until exceptionally late dates. In most cases, the clearing progressed until all but the southeastern section of the gulf was free of ice, then the process of clearing slowed and the ice appeared to stagnate. Although the steamer track was frequently clear in advance of the southern areas, ice from the north was thrust southward across the route in 1942 and 1950, hindering navigation until after the middle of April. As a rule, the flow of ice through Cabot Strait was restricted in April, leaving the strait partly open. Usually, Northumberland Strait opened before George Bay, but in 1952 it was the last place to clear. The east coast of Prince Edward Island generally cleared before the Cape Breton side of the strait, but in 1946 it was blocked late in April after being clear most of the month. The north coast of the island was slow in clearing, except in 1944. This season displayed some of the characteristics of the first group; it differed from them, however, in its rate of break-up. In respect to rates of break-up, the ice in these years became sluggish toward the end of the season. Rapid clearing during March followed by gradual withdrawal in April was experienced in the seasons of 1944 and 1946. A similar rate of clearing prevailed in 1942 and in 1950, except that the rate was not so swift in March. The 1952 season differed in that the withdrawal was slow in both months. The ice seasons in this second group, therefore, were characterized by an early spurt of clearing followed by a period of stagnation and accumulation of the ice in the southeastern section of the gulf. The route via the Strait of Canso and George Bay was blocked until long after the steamer track was open.

The 2 years not included in either of these groups, 1943 and 1951, follow quite different break-up patterns.

In 1943, the ice began clearing in George Bay at the south and off Anticosti Island in the north. The ice in the western part of the gulf retreated from both the north and south to accumulate in the central area. Likewise, around Cape Breton it shifted offshore. During much of April the ice streamed through Cabot Strait, filling it from shore to shore. As a result, the steamer track was blocked until late in April, but the Strait of Canso route was open remarkably early. Baie de Chaleur was late in clearing. On the whole, however, the rate of break-up was swift throughout the season, especially in view of the great quantity of ice that lay in the gulf that winter.

The other exceptional year was 1951. In many parts of the gulf that are usually ice-covered during the spring there was virtually no ice. Accumulation had occurred in the western part of the gulf. Dispersal took place on the outer fringes of the fields, leading to their contraction, but the main body of the ice remained as if pinned against the western side. During the first half of April the ice moved south and finally disintegrated before the end of the month. Because the clearing proceeded gradually, the eastern areas were not invaded by large fields dangerous to navigation, but, rather, remained open throughout the break-up. The rate of clearing was slow during both March and April. These 1951 conditions were definitely remarkable, if not unique.

DETERMINING FACTORS OF THE BREAK-UP

The behaviour of the ice in all phases of its formation and break-up is controlled by the physical factors of the environment. Many of these factors were indicated previously, but it is necessary to re-examine them in order to determine the relative influence of each factor on ice distribution. Some factors are non-variable, such as the subaerial and submarine morphology, the tides and tidal currents, and the ocean currents; the variable factors are temperature, precipitation, and wind. Other factors, such as the physical properties of the water and the surface water temperatures, are not considered here. The influence of salinity and density is probably slight and the surface temperature is essentially controlled by air temperature.

Subaerial and Submarine Morphology

Because ice forms more readily where the water is shallow, it is more likely to originate in the southern part of the gulf than elsewhere. Whether or not ice forms in great quantity in the open gulf is not known, although it is suspected that it does not. The bays and harbours throughout the gulf do freeze over during the winter, if only for a short time. Where the bays are broad and shallow, as in this southern region, a great quantity of ice is produced. Among the bays that freeze are Baie de Chaleur, Miramichi Bay, and Gaspe Bay. In the wide-mouthed bays, such as George Bay, it is possible that some ice formed in other areas finds its way into the bays and is cemented into a solid sheet before local ice covers them. Other regions of local ice formation are the shallows in Northumberland Strait and around the Magdalen Islands.

The gulf is so shaped that the southern part acts as a basin of accumulation into which ice is diverted as it moves from west to east. If Cape Breton Island was removed, the gulf would become ice-free much earlier than it does, because the relative narrowness of the outlet retards the clearing. The ice tends to pile up along the west coast of Cape Breton and little can escape through the constricted Strait of Canso. The Strait of Belle Isle is also narrow and, in addition, other forces discourage the mass movement of ice toward this opening. On the other hand, conditions would be far worse if Cabot Strait was as narrow as either the Strait of Belle Isle or the Strait of Canso. Its existence makes possible the movement of most of the ice to the open Atlantic; otherwise, the ice would remain in the gulf until it melted.

Within the main southern basin are smaller bays and bights that tend to detain the ice. There is the bight of the north coast of Prince Edward Island where the ice is cradled throughout the winter. There is George Bay, which serves as an overflow basin for ice in Northumberland Strait even after the bay has cleared. In turn, George Bay often funnels ice into the Strait of Canso. And, finally, there is Baie de Chaleur, which always clears first along the northern side, mainly because the mouth on the southern side is obstructed by Shippigan and Miscou Islands.

The Magdalen Islands, the Bird Rocks, and Brion Island constitute obstacles in the path of ice movement by splitting the larger sheets of ice that move toward Cabot Strait. Anticosti Island serves as a barrier separating the ice that originates in the St. Lawernce River from that which comes from the northeast arm. Most of this river ice drifts unchecked along the smooth Gaspe coast to the gulf. During seasons when the ice moves southward, Prince Edward Island protects Northumberland Strait, with the result that it opens earlier than other southern regions.

The controlling influence of the land obviously determines the boundaries within which the ice may move, and governs the routes by which the ice may leave. It provides a frame that is non-variable in its function, but within which other forces affect the movement of the ice.

Tides and Tidal Currents

The disturbance of the water is the most important influence exerted by the tidal undulation; the tidal currents shift the ice back and forth and are responsible for a certain amount of mass movement.

Landfast ice that forms along shores and over shoals is frequently shattered by the tidal swell and is carried offshore by tidal currents or by winds as pack-ice. This occurs commonly in the early winter, especially where the range of tide is great. The St. Lawrence estuary, with its high range of tide, must be the source of large quantities of ice, because the tides and currents detach and carry away the ice as fast as it is formed. This effect is not so pronounced in the vicinity of the Magdalen Islands, owing to the small range of tide there.

In Northumberland Strait the tidal currents are reasonably strong and the range of tide is higher than in most sections of the gulf. These forces are successful in preventing the formation of a continuous sheet of ice. Nevertheless, here and elsewhere in the area, narrow strips of landfast ice form along the shores. Outside the strips the ice is kept in motion. In the bays that do freeze over, the ice-sheet, once consolidated, is not affected by the tidal swell. During the spring, when the ice is decaying, however, the swell plays its normal part in breaking up these ice-sheets. In the Strait of Canso, tidal currents prevent the formation of an ice-sheet.

Transportation of great quantities of ice is effected by tidal currents. When the wind blows in the same direction as the current flows, ice may be carried along at a comparatively high velocity, but if the wind continues in the same direction when the current is reversed, the velocity may be reduced and only part of the ice will return to its original position. This type of movement occurs frequently in Northumberland Strait, the Strait of Canso, and other areas where tidal currents are reasonably strong. Considerable ice is both brought into the gulf and moved out of it by the tidal currents in the Strait of Belle Isle, because there appears to be a dominant flow one way or the other for extended periods of time. Although the whole northeast arm of the gulf becomes choked with ice, the strait does not freeze over completely.

The effect of tides and tidal currents is chiefly to break up the ice-sheets into pack-ice and to keep the pack moving. This process often results in the formation of great quantities of ice in favourable areas, thereby increasing the total amount of ice. On the other hand, through movement of the water, the tides tend to retard the formation of ice and to prevent widespread consolidation of sheet ice.

Ocean Currents

The system of constant currents in the gulf is definitely a major factor in the movement of ice. An immense volume of ice is carried into the gulf from the St. Lawrence River by the Gaspe current. When the velocity of the current is reduced off the mouth of Baie de Chaleur, the ice spreads out in the southern part of the area. A slower drift still prevails, which carries some ice toward the Magdalen Islands and Cabot Strait. In spite of this cross-gulf flow, much of the ice finds its way into the southern basin, which eventually fills up.

A constant current off Cape North carries ice from the gulf, but its carrying capacity is little utilized during the early winter because ice does not reach it in any great quantity until that from the west reaches Cabot Strait. If there were a current of comparable velocity joining the Gaspe and Cape Breton currents, the ice from the river would be conducted directly into the Atlantic, but such is not the case. On the Newfoundland side of Cabot Strait the current flows into the gulf (Figure 2). The general westward drift along the south coast of Newfoundland and the inward flow around Cape Ray tend to repel the invasion of ice from the north and west. As a result, these areas are frequently clear throughout the season. Similarly, the northward drift and current along the west coast of Newfoundland keep that coast open later in the autumn and clear it earlier in the spring than the area offshore. In the northern part of the gulf the currents are ill-defined and of low velocity, although there appears to be a general westward movement. This drift aids the spreading of ice from the northeast arm.

Within the physiographic framework of the gulf the constant currents and general movements further define the directions in which the ice may move and indicate the areas where the ice may stagnate.

CLIMATIC FACTORS

These are the main causes of annual variation in ice conditions. The effects of sunshine, cloudiness, frequency of depressions, or other air-mass phenomena were not investigated, the aim of the study being the establishment of a general relationship between ice conditions in the break-up season and the main features of weather, namely, temperature, precipitation, and wind. The study was based on published statistics, except in the case of the examination of synoptic charts to determine wind direction and force.

Temperature. On the basis of their temperature characteristics, four main types of break-up seasons can be isolated. The first type, noted in the years 1940, 1945, 1949, 1951, and 1952, is characterized by above-average temperatures in the ice season. In the second type, the first 3 months, essentially, are colder than the last 3; this type is found in the years 1941, 1942, 1946, and 1947. The third type is just the opposite, in that the first 3 months are warmer than the last 3; the years that have this feature in common are 1944, 1948, and 1950. Finally, the fourth type is represented by 1 year only, 1943, when the temperatures of the ice season were below average. Within these main types there are subdivisions that indicate more specifically the differences between the years; these are shown in Table II.

The pattern of break-up is reasonably independent of the ice season temperatures. Although there are two cases where the pattern of break-up is similar in 2 years of like temperature conditions, namely, groups 2A and 2B, there is no instance in the first three main groups where all the years of one group witnessed the same pattern of break-up, nor does the rate of break-up seem to be controlled by temperatures in the ice season. There does not appear to be any consistent relation even within sub-groups, although, again, in group 2B the same rate of break-up prevailed in each year. On the other hand, group 1B is characterized by two opposite rates of break-up.

TABLE II

Relationships Between Temperature, Wind, and Ice Conditions in the Gulf of St. Lawrence

Group		Temperatures	Year	Winds	Pattern of break-up	Rate of break-up	Time of final clearing	Quantity and extent of ice
1 above average temperatures	A	every month well above average	1945	strong westerly	west to east, direct withdrawal	rapid in March and April	early April	light
			1951	strong easterly and northerly	west side accumulation	slow in March and April	late April	light
	B	most months well above average	1949	northerly and westerly	west to east, direct withdrawal	rapid in March and April	late April	moderate to light
			1952	strong northerly and light, variable	stagnation in south	slow in March and April	early May	moderate to light
	C	most months above average or near average	1940	(insufficient data)	west to east, direct withdrawal	moderate in March, rapid in April	early May	moderate to light
2 first 3 months colder than last 3	A	first 3 months near average, last 3 months higher than average	1942	strong northerly	stagnation in south	moderate in March, slow in April	early May	moderate to light
			1946	strong westerly followed by northerly and easterly	stagnation in south	rapid in March, slow in April	early May	moderate
	B	first 3 months lower than average, last 3 months higher than average	1941	(insufficient data)	west to east, direct withdrawal	rapid in March and April	late April	moderate to heavy
			1947	westerly and southerly	west to east, direct withdrawal	rapid in March and April	early May	moderate to heavy

3 first 3 months warmer than last 3	A	first 3 months above average, last 3 months below average	1948	strong westerly followed by strong northerly and easterly	west to east, direct withdrawal	rapid in March and April	middle of May	heavy
			1950	strong northerly	stagnation in south	moderate in March, slow in April	middle of May	heavy
	B	2 of first 3 months above average, last 3 below average	1944	strong westerly and northerly	stagnation in south	rapid in March, slow in April	late April	moderate to heavy
4 below average temperatures		4 months well below average	1943	strong southerly and westerly	south to north, direct withdrawal	rapid in March and April	early May	heavy

The time of final clearing, that is the time when all the ice, except for scattered strings and patches that do not constitute a hindrance to navigation, has melted or left the gulf, can only be roughly estimated, because the information available will not permit the determination of actual dates (Table II). The relationship with temperature is closer than in the case of either the pattern or the rate of break-up, but it is not close enough to establish temperature as the main control in this respect. In spite of the fact that the year of earliest clearing, 1945, had unusually high temperatures, the year 1951 was later in clearing, yet it had even higher temperatures. However, two of the colder than average seasons, 1948 and 1950, were the latest in clearing. Low late winter and early spring temperatures appear to retard the clearing more than low autumn and early winter temperatures.

Although the break-up of bays and harbours may be accelerated by spring thaws, the clearing of the gulf as a whole may or may not respond to this impetus. In 1943, low spring temperatures may have retarded the opening of Baie de Chaleur, but did not affect the speedy withdrawal of the ice from the gulf. In 1951 and 1952, high spring temperatures did not bring about early withdrawal. George Bay, which generally freezes over completely, is subject to invasions of ice long after its original ice-sheet has disappeared. In 1943, however, George Bay was clear more than a month before Baie de Chaleur, in spite of the low spring temperatures. The smaller bays and harbours in the area were not investigated.

The primary effect of spring thaws as applied to the conditions in the Gulf of St. Lawerence is in bringing about the decay and break-up of ice-sheets and in contributing to the clearing process. As a factor in clearing, however, spring thaws are not a major influence outside the small bays. On the other hand, the winter temperatures do influence the break-up, being partly responsible for the quantity and extent of ice to be cleared away.

A close relationship exists between the temperatures of the ice season and the quantity and extent of ice.[1] Owing to the lack of reliable data concerning winter ice conditions, this estimate of the severity of each season is based primarily on the conditions existing in March (Table II). The terms used to describe these conditions are relative only, for instance, the term "light" indicates that the ice was less extensive and appeared in smaller quantities than in the other years; "heavy" is taken to represent a more extensive and abundant occurrence of ice. The other terms define intermediate conditions. Each of the thirteen seasons is compared with the rest. The seasons of high temperatures coincide with those of light ice conditions and the seasons of low temperatures with those of heavy ice conditions; between these extremes the other years fit the pattern reasonably well. It may appear that lower temperatures in the last 3 months cause more severe ice conditions than lower temperatures in the first 3,

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[1] By "quantity" is meant the total volume of ice and by "extent" is meant the area that is ice-covered.

as in the case of 1948 and 1950. However, the lower temperatures may have retarded early spring clearing, which led to a misjudgment of the severity of the ice conditions.

The air temperature is definitely of fundamental importance in respect to ice conditions. It is the cooling of the atmosphere, which in turn cools the water, that produces ice in the first place. As a whole, mean monthly temperatures are below freezing for 4 months of the year, providing a suitable climate for ice formation. Air temperature is such a variable factor that the temperatures of one ice season may be quite different from those of another. These differences are reflected primarily in the amount and the extent of ice that exists in the gulf during a given season. When monthly temperatures are above average the ice is less abundant and covers a smaller area than when they are below average. In spring, the higher temperatures cause melting of ice and the breaking up of large ice-sheets into pack-ice. Temperature, however, does not appear to be the most important factor determining the movement of the ice, the rate of withdrawal, or the time of final clearing.

Precipitation.[1] The main effect of precipitation seems to be the retardation of freezing by providing snow cover. A heavy blanket of snow lying on the ice throughout the winter months helps to retain heat. It limits the thickness of the ice because it is chiefly through conduction of heat upward that the ice-sheet is able to build downward on the under side. When the ice was heavy, as in 1943, 1948, and 1950, the tendency was toward lower than average snowfalls; when the ice was lighter, as in 1945 and 1946, the tendency was toward higher than average snowfalls. The correlation is by no means close, however. Heavy snowfall is responsible for the formation of slush ice. When low temperatures follow a snowfall the slush frequently provides a mortar that aids in cementing pack-ice into large sheets. During the break-up the effect of precipitation is relatively insignificant. Taking the ice season as a whole, it is likely that precipitation performs a minor role in determining the ice conditions in the gulf.

Winds. Wind is definitely the most important factor causing a deviation from the pattern and rate of withdrawal of the ice determined by the non-variable factors. As was indicated by the wind roses (Figure 5), prevailing winds throughout the winter and spring have a westerly component, but in spring this trend is less pronounced. Although the drift of floating ice is approximately 30 degrees to the right of the wind direction, owing to the earth's rotation, it varies according to the closeness of the pack. In any case, it is possible to deal with the effect of wind in the general terms, northerly, easterly, southerly, and westerly without specifying actual directions. There is no doubt that westerly winds combined with currents are a potent factor in causing the ice to move toward Cabot Strait.

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[1] In this investigation the same stations were used as in the case of temperature. Statistical data are based on Monthly Record (Monthly Statistics Series), op. cit.

In order to discover the influence on the ice of the annual variation of the wind, the statistics for the total mileage of wind by directions were examined at twelve stations. These figures indicate the prevailing direction for each month as determined by the aggregate velocities of the prevailing winds, rather than by the total hours of wind. In addition, daily synoptic charts for the months of March and April were scanned for the years 1944, 1945, 1948, 1951, and 1952. These observations proved that the winds during February, March, and April are the primary control of the pattern and rate of break-up, as well as the time of final clearing.

A short period of strong wind from one direction tends to have a greater effect on ice movement than a long period of light wind. Therefore, gales exert an influence quite out of proportion to the length of time they last. Strong winds may occasionally move ice against a current. Only the constant currents in the gulf are never checked by the wind; the weak flows and tidal currents are all susceptible to the effect of wind, especially when loose ice is present. Not only may the wind either speed up or slow down the normal current flow, but it may also generate currents that continue to flow for some time even after the wind has ceased.

A period of several days with sustained strong wind from one direction can redistribute tremendous quantities of pack-ice in the gulf. The frequency of such periods of wind from the same direction during February, March, and April is of utmost importance. For example, in 1952, strong northerly winds prevailed for several periods of a week or more in February and March, resulting in accumulation of the ice in the southern part of the area. The same process occurred in 1951, except that the winds were more easterly and continued until the middle of April, driving the ice toward the western section. In 1943, sustained southerly winds were responsible for pushing the ice northward, where it found its way out of the gulf readily. These cases are extreme; the normal situation is the cancelling of the effect of one period by that of another; e.g., if the winds are strong easterly for a few days, they may be strong westerly in the next period. Often the periods are short and cause only minor diversions of the ice. A period of very light variable winds may result in stagnation of the ice, as in late April 1952.

These influences of the wind are reflected in the pattern of break-up. Those years in which the ice tended to stagnate in the southern part of the gulf were characterized either by excessively strong northerly winds at some time during the season, or by lack of sufficient southerly winds. In some cases there was an actual accumulation of ice in the south, as in 1952, and in others the ice present simply did not withdraw readily, as in 1944. The season of 1952 serves as an example of stagnation throughout April, owing to weak and variable winds, as well as of southern accumulation. On the other hand, the years in which the ice withdrew more readily from west to east experienced a favourable combination of wind throughout the spring season. Short periods of southerly winds followed by longer periods of westerly appear to assure the withdrawal of the ice from the south. If strong winds occur frequently, as in 1945, the exodus is accelerated. The other patterns, that of 1943, when the ice moved northward during April, and that of 1951, when the ice lingered in the western part of the gulf, were caused by southerly and easterly winds respectively.

The influence of the wind on the rate of break-up is a vital factor in moving the ice. Should the wind combine forces with the water currents in driving ice through Cabot Strait and in feeding this stream with ice from the bays and bights of the more confined sections of the gulf, clearing would progress rapidly, but should the wind oppose the water currents and other forces tending to clear the area, the process would be retarded. This adverse effect occurs most severely with northeast winds, which, considering the deviation in the drift of the ice, drive the ice southward, as in 1952. Of course, the rate of break-up may be rapid through part of the season and then be slowed by northerly or easterly winds for a short period of time. The season of 1948 was subject to north and northeast winds of a high velocity towards the end of April, which forced the ice onshore along the east coast of Cape Breton, although it had been offshore throughout most of the month. The time of final clearing is mainly determined by the wind. In retarding the withdrawal of ice by causing stagnation in the southern section, the wind is directly responsible for ice remaining unduly late in the gulf. In several instances when there was a direct withdrawal, the ice was held onshore along the eastern coast of Cape Breton Island by easterly winds.

The quantity and extent of ice also are affected by the wind. When ice formation is in progress, the wind aids the tides and tidal currents in disengaging ice from the land and from shoals in the producing areas and in carrying it away to add to the shifting pack. The extent of ice may be reduced materially by accumulation in one particular area as a result of wind. In this manner the wind is often responsible for the closeness of pack-ice. Most of the shifting in position of pack-ice is caused directly by the wind. Northerly winds brought ice southward, blocking the steamer track in mid-April, in the seasons of 1942 and 1950. In 1948, southerly winds pushed the ice to the north side of Northumberland Strait about the middle of April and kept the ice off the Cape Breton east coast. Likewise, in 1952, the ice was shifted from one side of the strait to the other around April 25. Westerly winds generally clear southeast coastal areas quickly. This effect may be noticed along the north side of Baie de Chaleur, the southeast coasts of Prince Edward Island, the Magdalen Islands, and Cape Breton Island. The northward movement of ice in 1943, occasioned by southerly winds, effectively blocked the mouth of Baie de Chaleur and greatly retarded its clearing.

On the average, the prevailing westerly winds during the ice season ensure that most of the ice will eventually depart from the gulf through Cabot Strait. Lack of prevailing westerly winds for varying periods of time results in a different pattern of ice movement. Periods of sustained northerly or easterly winds cause accumulation of ice in the southern part of the area and slow the rate of clearing. Westerly and southerly winds in combination lead to a rapid movement of ice through Cabot Strait. Thus wind is the major factor in determining the pattern and rate of break-up, as well as the time of final clearing, and is responsible for many of the minor changes in position of the pack-ice.

CONCLUSION

The investigation of the distribution of ice in the Gulf of St. Lawrence during thirteen break-up seasons shows that the behaviour of the ice, although extremely variable, follows certain patterns. Examination of environmental factors that exert an influence on the ice reveals a direct relationship with the behaviour of the ice. These factors, both non-variable and variable in function, act in combination to determine the ice behaviour, but it is the variable factors, mainly meteorological, that are chiefly responsible for the year to year differences. In view of the variable behaviour of the ice owing to these factors, the determination of average conditions is rendered difficult. The 13-year period examined is hardly long enough to provide valid averages. Many of these years were distinctly above average in respect to temperature, whereas few were below average. This fact serves to indicate that the ice conditions of this period, as a whole, were less severe than those that might be expected in a future period. Nevertheless, certain generalizations can reasonably be made.

The Gulf of St. Lawerence is never completely ice-covered; there are always areas of open water, because much of the ice is shifting pack-ice, especially in the central part. The southern section is an area of accumulation and considerable close pack-ice and large ice-sheets may usually be found in this region. In most parts of the gulf, the ice does not remain until it melts in the spring, but rather drifts into the open Atlantic, mainly through Cabot Strait.

The discharge of ice is commonly in progress during February, and is accelerated in March. Cabot Strait is seldom completely blocked for more than a few days at a time. The ice-field in the dispersal region generally extends eastward past 58 degrees west and southward past 45 degrees north. Occasionally, the ice moves onshore along the south coast of Cape Breton under the influence of easterly winds, but rarely encroaches on the area off the south coast of Newfoundland. Most of the ice that first leaves the gulf comes from the central area between Anticosti Island and Cabot Strait. However, this central region may continue to be ice-covered until late in March or early in April, owing to invasions of ice from other areas. Ice in the lower estuary of the St. Lawrence River finds its way into the gulf by the middle of March, leaving the stretch below Pointe des Monts clear of ice. Toward the end of March, the steamer route opens and allows navigation to commence. Frequently, the passage north of

Anticosti Island clears before that south of it. The steamer track is sometimes blocked by ice during April, when northerly winds drive ice from the northeast arm across it. Ordinarily, however, the ice north of a line from Cape St. George to Natashquan is not discharged through Cabot Strait, but tends to drift northward, where it disintegrates and melts.

Early in April the ice withdraws from the western part of the gulf, leaving ice in Baie de Chaleur, although the bay is clearing along the northern side. Throughout the southern section the larger ice-sheets are breaking up, rendering the ice more mobile. In the meantime, the stream of ice through Cabot Strait continues, with the bulk of ice moving along the Cape Breton side. The field of ice beyond the strait, formed by ice emerging from the gulf, has receded from its position of greatest extent in March. As the month progresses the ice moves toward Cabot Strait. The region around the Magdalen Islands clears before the southern area and the belt of ice in Cabot Strait becomes narrower. Most of the ice has departed from Baie de Chaleur by the end of the third week in April. Northumberland Strait clears from its western entrance eastward and the last ice to withdraw from the gulf, in late April or early May, is that in the southeastern sector along the west coast of Cape Breton. Sometimes the Strait of Canso clears in early April, but this is dependent on the clearing of George Bay, and the ice may remain there until the end of the month. Likewise, ice is found in the dispersal region off the Cape Breton east coast until the end of April.

The ice-fields are constantly shifting position. Some areas may be clear at certain times and ice-covered at others, mainly according to the direction of the wind. Such fluctuations are especially noticeable along the east and south coasts of Cape Breton, where the ice may be driven alternately onshore and offshore by the wind. As a result of these encroachments, Louisburg Harbour is sometimes blocked for a few days in April, but usually there exists a shore lead inside the ice-field. The east coast is more susceptible to these invasions, because the ice does not clear from this area until the end of April or early May. Sydney Harbour may be blocked for longer periods and until a later date than Louisburg.

The variability of the ice conditions in the break-up season is well illustrated by the 13 years examined. With the gulf essentially open by the end of March, the year 1945 probably witnessed one of the earliest clearings that might be expected. On the other hand, the year 1950 saw ice remain in the gulf until May 15. The unusual patterns of break-up that characterized the years 1943 and 1951 may not occur frequently, but it is possible that other patterns, equally distinctive, but not represented among the years studied, may yet occur. On the basis of the 13 years, it appears that most often the ice will either withdraw directly from west to east, passing through Cabot Strait readily, or will tend to stagnate in the southern part of the gulf toward the end of the season.

RÉSUMÉ

Le golfe Saint-Laurent est fermé aux navires marchands pendant près de cinq mois, chaque année, par la glace qui s'y accumule. Afin d'allonger la saison de navigation, une meilleure connaissance de l'état des glaces s'imposait. A cette fin, l'on inaugurait en 1940 des reconnaissances que l'on a poursuivi au cours des treize dernières années.

D'après les renseignements obtenus dans ces relevés, on a préparé une série de cartes qui indiquent la limite des zones de glace au moment de la débâcle durant ces dernières années. Si ces cartes révèlent les phases successives de la débâcle et les formes variées qu'elle prend, elles nous indiquent aussi que le comportement des glaces est extrêmement variable. On a également étudié les facteurs qui influencent l'état de la glace comme les marées, les courants marins, la température et le vent afin de déterminer la part qu'ils jouent dans la débâcle. Ce sont surtout ces facteurs météorologiques, en particulier la température et le vent, qui apparaissent comme agents responsables des variations annuelles.

Malgré ces variations, il a été possible de déterminer certaines constantes dans le déplacement des glaces au cours d'une saison. Le golfe Saint-Laurent n'en est jamais complètement couvert; au contraire, on y trouve presque toujours des canaux d'eau libre entre des champs de glace en mouvement. La glace s'accumule dans la partie sud du golfe, qui commence à s'en libérer lentement en janvier et en février et plus rapidement en mars et en avril. Généralement la masse de glace en mouvement se déplace de l'ouest à l'est vers le détroit de Cabot, pour se retirer dans l'Atlantique. Quelquefois, cependant, la glace reste dans la partie sud du golfe et fond sur place. Vers le 1er mai, le golfe est enfin libre et la navigation reprend son cours normal.

MAP NOTES

SELECTED CANADIAN MAPS

British Columbia 1953. 1:2,000,000 (approx.).

Fifth British Columbia Natural Resources Conference. Dept. of Lands and Forests, Victoria, B.C. Price $1.

This full-colour map of British Columbia indicates pipe-lines, airports, roads, and railroads. It was designed primarily for British Columbia school children to acquaint them with the physical features of their province, hence the main features are exaggerated to make them conspicuous.

[L.H.]

Mineral Map of the province of Ontario. 1:1,267,200 (20 miles to 1 inch).

Ontario, Dept. of Mines, Toronto, 1953.

This map shows the principal mines and mining occurrences by coloured symbols and names as well as the Mesozoic, Palæozoic, and Precambrian formations by yellow, pink, and green colours. Gas fields, principal pipe-lines, and boundaries of mining divisions are indicated.

Seven insets, one of which shows *Metallurgical Works in Ontario*, provide useful information, completed by tables of the value and growth of mineral production, and a list, compiled by mining divisions, of the principal mines and mineral occurrences.

[L.H.]

Southwestern Ontario—Principal Oil and Natural Gas Fields. 1:380,160.

Canada, Dept. of Mines and Technical Surveys, Geol. Surv., Canada, Ottawa, 1953.

The geological formations are shown in different tints of blue and grey; oil fields, natural gas fields, gas pipe-lines, and compressor stations are indicated by different coloured symbols.

Seven insets showing different gas and oil fields on a larger scale give the location of gas and oil wells of different formations, with the lot and concession numbers.

[L.H.]

Province de Québec, carte officielle. 16 milles au pouce.

Québec, Ministère des Terres et Forêts, Québec, 1951 (4 feuillets). Prix $2.

Cette carte montre les districts électoraux en différentes couleurs, les limites des cantons ou des seigneuries, les parcs et les réserves. Les chemins de fer et quelques routes sont aussi indiqués.

Le Labrador (Terre-Neuve) est désigné par la même couleur que le Nouveau-Québec et le tracé du nouveau chemin de fer qui va de Sept-Îles au Lac Knob est indiqué par un symbol spécial.

Une liste alphabétique des districts électoraux provinciaux est donnée sur le feuillet sud-ouest.

(Cette carte est aussi publiée à 32 milles au pouce sur une seule feuille. Prix 50c.).

[L.H.]

Province de Québec. Producteurs de Textiles primaires 1953. (App. 1:800,000).

Québec, Ministère de l'Industrie et du Commerce, Service de la Cartographie économique, Québec, 1953.

Sur une base en blanc et noir indiquant les comtés, différents signes conventionnels en couleurs localisent les producteurs de lainage, de cotonnade, de textiles synthétiques, de soie, de tricots et de différents tissus. La région de Montréal est indiquée en carton à l'échelle d'environ 1:450,000.

[L.H.]

Réserve de Chasse et de Pêche de Kipawa. Deux milles au pouce.

Québec, Ministère des Terres et Forêts, Québec, 1951. Prix 50c.

Les frontières de la réserve sont délimitées par une ligne verte, alors que la réserve elle-même est indiquée en jaune. Les subdivisions des cantons, les rangs et les lots sont numérotés dans les régions habitées des environs de la réserve. Les lignes directrices des levés d'arpentage sont indiquées en noir.

[L.H.]

Parc de La Vérendrye. Trois milles au pouce.

Québec, Ministère des Terres et Forêts, Québec, 1952. Prix 50c.

La carte comprend partiellement les districts électoraux d'Abitibi-Est, Gatineau, Pontiac, Rouyn-Noranda et Témiscamingue. Une teinte de brun représente le parc et un trait rouge les routes. En certains endroits, les lots et les rangs sont numérotés.

[L.H.]

Parc national de la Gaspésie et Réserve de Chasse et de Pêche des Chics-Chocs. Deux milles au pouce.

Québec, Ministère des Terres et Forêts, Québec, 1952. Prix 50c.

La carte comprend les districts électoraux de Gaspé-Nord et de Matane dans lesquels sont situés le Parc national de la Gaspésie et la Réserve des Chics-Chocs.

Un large trait vert marque les limites du Parc tandis qu'un large trait rouge indique la Réserve des Chics-Chocs. Les routes sont représentées par un trait rouge mais les cantons, les seigneuries et les rangs sont seulement délimités en noir.

[L.H.]

General Reference Map—South Saskatchewan River Project. 1:720,000 (approx.).

Report of the Royal Commission on the South Saskatchewan River Project, Ottawa, 1952. Queen's Printer, Ottawa, Price 50 cents.

Colour symbols indicate irrigable areas, dams, reservoirs, roads, and railroads. The ranges and the townships of the development area are indicated. Areas of the relief are shown by a brown tint, and contours define regions over 2,000 and 2,500 feet.

[L.H.]

BOOK NOTES

RECENT GOVERNMENT PUBLICATIONS OF GEOGRAPHICAL INTEREST

THE CANADIAN SNOW SURVEY 1947-1950. By D. C. Pearce and L. W. Gold. Union Géodésique et Géophysique Internationale. Association Internationale d'Hydrologie Scientifique. Assemblée Générale de Bruxelles, 1951. Pub. 32, vol. 1, 28 pp., map, diags., tbls., illus., biblio.

This report presents a summary of the studies (initiated by the Associate Committee on Soil and Snow Mechanics of the National Research Council) on the physical characteristics of snow cover for the 4-year period 1947-1950. The paper describes and compares observations made at some thirteen stations scattered throughout Canada that are participating in the survey. As a result, the general information on the characteristics of snow cover in exposed areas has been expanded, and research into the physical characteristics of snow cover in sheltered areas has been initiated.

[W.A.B.]

ECONOMIC ZONING OF CANADA AND THE D.D.P. GEOGRAPHIC CODE. Canada, Dept. of Defence Production, Econ. and Stat. Br., Ottawa, 1953, pp. 1-93, map.

This publication is intended to present the "meaningful framework within which economic data can be effectively organized and interpreted". Its general discussions and approach are, of course, not new, particularly to the geographer. The general theme is, however, that the "zone" should be a practical substitute for the theoretical "region" and a zone is, therefore, defined as "a spatial unit which has a distinctive matrix of structural and functional factors with regard to both its production and marketing patterns, and for which statistical data on these factors can be derived".

[N.L.N.]

NEWFOUNDLAND PILOT (CANADIAN EDITION). Canada, Dept. of Mines and Tech. Surv., Surv. and Mapping Br., Ottawa, 1952, 484 pp., map. Price $2.50.

Information is contained in this first Canadian edition for all the coastal waters of the island of Newfoundland as well as for St. Pierre and Miquelon. A brief account of the history, economy, and physical features precedes a more complete outline of the climatic and meteorological conditions. Sailing directions are given for all the harbours and anchorages on the islands, together with information on navigation lights, buoys, fog alarms, and radio direction stations. Details are given on conditions in many of the navigable coastal passages. Navigation directions, depths of water, and the location and depth of dangerous shoals and reefs are noted. Reference is made, wherever possible, to published Admiralty and Canadian Hydrographic charts. Some information is also available on the size and function of coastal towns, communications between towns, and the marine services available in them.

[V.W.S.]

HYDROGRAPHICAL FEATURES OF THE WATERS OF THE BAY OF ISLANDS, NEWFOUNDLAND, IN THE AUTUMN. By Louis Lauzier. Joint Committee on Oceanography, St. Andrews, N.B., 1953, 20 pp., maps, graphs, charts.

Using information obtained between the years 1945 and 1949 by the Atlantic Herring Investigation Committee, this report presents a summary of the temperature-salinity relationships that exist in the Bay of Islands, Newfoundland. Because it is a fiord, the Bay of Islands has a shallow threshold that separates the bay from the waters of the Gulf of St. Lawrence, and the surface water has different characteristics in each area. Seasonal and diurnal changes in temperature are discussed, and variations in the salinity of the bay are noted. Mention is made of the counter-clockwise water circulation.

[V.W.S.]

CERTAIN ASPECTS OF OCEANOGRAPHY IN THE COASTAL WATERS OF LABRADOR. By David C. Nutt. Jour. Fisheries Research Bd. of Canada, vol. 10, No. 4, June 1953, pp. 177-186, maps, tables, graphs, biblio.

This is a report of one phase of the oceanographic work carried out by the schooner "Blue Dolphin" during the 3 summers 1949-1951. The influence of the Labrador current upon the water of six inlets along the Labrador coast is discussed with the aid of temperature-salinity polygons and tables. Consideration is given to the water-exchange relationships that exist between Lake Melville and Hamilton Inlet. Brief mention is made of the marine life to be found in the waters of the Labrador coast. The possible relationship between general climatic amelioration and marine environment is noted.

[V.W.S.]

THE SLOPE WATER OFF THE SCOTIAN SHELF. By H. J. McLellan, L. Lauzier, and W. B. Bailey. Jour. Fisheries Research Bd. of Canada, vol. 10, No. 4, June 1953, pp. 155-176, maps, graphs, biblio.

The band of water between the edge of the continental shelf and the Gulf Stream off the coast of Nova Scotia is discussed in this article. It is pointed out that in temperature and salinity the surface layers of the slope water are intermediate between the coastal waters and the Gulf Stream. The origin of alternate warm and cold bands in the slope water is discussed with the aid of charts showing vertical temperature distributions. Temperature-salinity relationships are used to show the several component types of water present.

[V.W.S.]

THE WIND CURRENTS AND DOMINANT SURFACE FLOW AT SAMBRO LIGHTSHIP. By H. B. Hachey and N. O. Fothergill. Joint Committee on Oceanography, St. Andrews, N.B., 1953, 14 pp., map, graphs.

Current and wind observations taken at Sambro Lightship in late 1950 and early 1951 are used as the basis of this report on oceanographic conditions off the coast of Nova Scotia. With the aid of graphs it is shown that the direction and velocity of the surface current is influenced by the force and direction of the wind. At low wind velocities, however, the influence of semi-permanent currents is felt. Temperature adjustments in the water column at Sambro Lightship are shown to be the result of local winds and the prevailing atmospheric pressure distribution.

[V.W.S.]

MARSHLAND UTILIZATION IN NOVA SCOTIA AND NEW BRUNSWICK. By G. Haase and D. J. Packman. Canada, Dept. of Agriculture in cooperation with the Nova Scotia and New Brunswick Depts. of Agriculture, Ottawa, 1953, 56 pp., tables.

The purpose of this report is " . . . to describe the general features of agriculture in their relation to marshland use". This is achieved primarily by means of a large number of statistical tables that deal with the use of marsh and upland, livestock, investments, and farm practices. A short section of farm planning describes how various farm programs can be related to upland and marshland. The report concludes with an historical sketch that relates fluctuations in land reclamation, and prosperity and depression in agriculture, with historical events that affected the entire area, from 1605 onward.

[B.C.]

TIDAL CIRCULATION IN MIRAMICHI BAY. By N. O. Fothergill. Canada, Dept. of Mines and Tech. Surv., Surv. and Mapping Br., Ottawa, 1953, 18 pp., maps, graph.

Tidal current movements in Miramichi Bay, based on data obtained during the summer of 1952, are discussed in this report. Maps have been constructed to show the direction and velocity of the tidal current at maximum flood and maximum ebb. A net flow map is also included. This information is used in the report to show the influence of the water circulation upon such factors as shore and bottom erosion, deposition of transported material, and ice movement. The effect of the amelioration of climate upon the seasonal ice movement is discussed.

[V.W.S.]

NORTHERN QUEBEC, A NEW MINING AREA; A STUDY OF THE TERRITORY BETWEEN EASTMAIN RIVER AND UNGAVA BAY. By J. E. Gilbert. Quebec, Dept. of Mines, Geol. Surv. Br., Geol. Rept. 56, Quebec, 1953, 29 pp., illus., map, biblio.

Ce rapport géologique rassemble toutes les connaissances antérieurement acquises sur le Nouveau-Québec que l'auteur délimite ainsi: tous les bassins des rivières se déversant dans le détroit d'Hudson, la baie d'Ungava, la baie d'Hudson et la baie James au nord de la rivière Eastmain. La superficie étudiée est ainsi d'environ 330,000 milles carrés.

Après un bref aperçu historique et quelques considérations sur le caractère physique (relief et climat), biologique (végétation et faune) et humain de la contrée, il passe à la géologie descriptive puis à la géologie économique. Il termine par une courte bibliographie.

Cinquante-six remarquables photographies hors-texte, prises par différents auteurs, accompagnent le rapport, et une figure dans le texte indique l'emplacement des claims miniers, des permis de recherche minière et des soustractions au piquetage. Une carte fort utile, au 168,960^e, met à date les données sur la géologie du Nouveau-Québec.

[C.L.]

FARM OWNERSHIP IN QUEBEC. By A. Gosselin. Econ. Annalist, vol. XXIII, No. 1, 1953, pp. 11-14, tables.

Court article qui a rapport à la propriété agricole dans la province de Québec. On y analyse l'état de l'entreprise fermière en 1950, le changement survenu dans la superficie des fermes et leur valeur de 1900 à 1950. Ainsi, les en-têtes traitent des types d'entreprise, des étendues des fermes, de leur superficie labourée, de la valeur des fermes à l'acquisition et enfin de celle des biens immeubles.

[C.L.]

ST. LAWRENCE RIVER PILOT (CANADIAN EDITION). Canada, Dept. of Mines and Tech. Surv., Surv. and Mapping Br., Ottawa, 1953, 173 pp., map. Price $1.50.

This is the first Canadian edition of the St. Lawrence River Pilot, and covers the section of the river from Quebec Harbour to Kingston Harbour as well as the lower parts of Ottawa and Richelieu Rivers. A great variety of general information is included in the first section of the report. A partial list includes notes concerning charts, aids to navigation, and signal systems; canal navigation regulations; tidal information; weather and ice conditions. The main body of the booklet includes the information essential for safe navigation on the St. Lawrence River. Data are included on the depth of water in navigable channels, sailing directions for hazardous areas, and descriptions of navigation lights and buoys. Sailing directions are given for entering and leaving the harbours along the river. Wharf and harbour facilities are listed, and mention is made of the available marine services in the larger towns.

[V.W.S.]

BIG CREEK VALLEY CONSERVATION REPORT. Ontario Dept. of Planning and Development, Toronto, 1953, 84 pp., illus., tables, maps.

In the 7,500-acre area of Big Creek Valley, it is recommended that a forest be established that would be expanded through the years until the total area is reforested. With this in view, forestry is described from the time of settlement to present-day conditions. Forest conservation measures, in progress and required, are given in detail, bringing in demonstration woodlots, woodlot management, forest fire protection, forest insects, and diseases. The methods of acquiring land and the cost of land in the proposed Big Creek Forest are also discussed. Former conditions of wild life are outlined, giving the status of present species of mammals, birds, game, and fur of the area. The value and type of farm ponds and the role of the pond in the rural community are also considered.

[S.S.B.]

THE CLIMATE OF NORTHERN ONTARIO. By L. J. Chapman. Can. Jour. Agr. Sci., vol. 33(1), Jan.-Feb. 1953, pp. 41-73, maps, tables.

This paper presents an account of the climate of Ontario north of North Bay. It is a sequel to a similar paper on Southern Ontario that appeared in the same journal in 1938. In the warmest sections, the average spring temperatures reach 42°F. by about April 24, and in the Cochrane-Kapuskasing district by May 5, although the average date of the last killing frost is a month or more later. In the autumn, the frost-free period begins at North Bay, Sudbury, and Fort Frances by September 20, and farther north during the first week in September. The average precipitation is heavier in summer than in winter and serious deficiencies in soil moisture are not frequent. The present normals approximate to the climate of the future as there have only been small rises in average temperatures during the last century.

The author concludes by dividing the area into eight climatic regions, the characteristics of which he describes.

[N.L.N.]

PRESERVATION AND ENHANCEMENT OF NIAGARA FALLS. Report of the International Joint Commission, United States and Canada. Ottawa, 1953, 353 pp., illus., tables, map.

Recommendations concerning the nature and design of the remedial work necessary to enhance the beauty of Niagara Falls; the uses of the waters of Niagara River, the recommendations concerning the allocation of the task of construction of remedial works, and estimate of the cost of this project are outlined.

Several appendixes deal with flow and hydraulic conditions in Niagara River, and the results of various tests made with two models of the falls (including the cascades and adjacent regions).

[S.S.B.]

FACTS ABOUT DAUPHIN, NEEPAWA, PORTAGE LA PRAIRIE, SELKIRK, SWAN RIVER, VIRDEN. Manitoba Dept. of Industry and Commerce, Winnipeg, 1953, 32 pp., maps, illus.

These six booklets are part of a series designed to provide an inventory and analysis of physical and economic factors found in and around each of the incorporated centres of Manitoba.

Each settlement and its environs is described according to origin and background, natural resources, climate, transportation, communications, fuel, sites, power, water, population, markets, financial services, manufacturing and processing, municipal affairs, and social services.

[M.R.D.]

PRELIMINARY PLANNING STUDIES, CANORA, SASKATCHEWAN. Saskatchewan Dept. of Municipal Affairs, Regina, 1953.

A brief text describes the existing land use, utilities, business district, vacant land, and projected population growth of the town of Canora, Saskatchewan, with the purpose of informing the town's Community Planning Committee as to its planning needs. This is amplified by a chart of population growth and maps representing present land use, utilities, age of buildings, assessed values, and vacant land, and these constitute the main value of the work. Suggested procedure in community planning is added at the end of the report. The publication is not presented as a comprehensive planning report, but as an introduction to Canora's planning problem.

[L.P.]

SOME ASPECTS OF LAND CLASSIFICATION IN NORTHERN SASKATCHEWAN. By R. A. Stutt. Econ. Annalist, vol. XXIII, No. 3, June 1953, pp. 59-61.

An economic land classification for northern Saskatchewan is designed to provide a basis for sound land-use planning and to aid individuals and organizations in making a wise choice among many possible alternative uses for land. The classification encompasses not only the physical characteristics of the land resources but also the more dynamic factors found under existing and predictable economic, social, and technological conditions. The classification considers public interests, expressed in terms of resource conservation, and individual or group interests expressed in terms of securing the highest economic return on a sustained yield basis. A planned land policy, stemming from the economic land classification, will provide for a great variety of uses, including the wise exploitation of agricultural land and forests, the preservation of wild life, the conservation of mineral and water resources, the provision of recreational land, the development of transportation facilities, and urban growth.

[M.R.D.]

BACK TO THE LAND. By T. S. Rackham. Canada, Dept. of Agriculture in co-operation with the Alberta Dept. of Agriculture, Ottawa, 1953, 31 pp., map, tables, graphs; mimeo.

The Relief Settlement Plan, introduced in 1932, and continued until 1941, was a means by which Dominion, Provincial, and Municipal governments, contributing jointly, could assist families on relief to settle on farms.

Of the 1,092 settlers assisted, 38 per cent were successfully established on farms. About one-half of the remaining 62 per cent have become temporarily self supporting in other employment. This study reveals that the scheme did provide a means for rehabilitating a section of the unemployed and in other instances bridged the gap between unemployment and re-employment elsewhere.

[M.R.D.]

IRRIGATION FARMING IN SOUTHERN ALBERTA. By K. W. Hill and A. E. Palmer. Canada, Dept. of Agriculture, Pub. 883, Ottawa, 1953, 63 pp., map, tables, illus.

Since organized irrigation began in 1901, irrigation farming in this area of limited summer rainfall has succeeded in setting up a more and more stable agricultural economy.

This bulletin reviews in some detail such aspects of irrigation farming as drainage, methods of irrigation, crops grown under irrigation, crop rotation, the place of live stock on the irrigated farm, the use of commercial fertilizers, the control of soil drifting, weed control, and planning for permanence and balance in farm management.

The present irrigated acreage in southern Alberta is slightly more than 500,000 acres, and present plans call for the irrigation of 1,000,000 acres more.

Experience in over half a century of irrigation farming stresses the necessity for careful planning of crop practices, labour requirements, and fertility maintenance, in order to provide continuing stability and permanence.

[M.R.D.]

SOIL SURVEY OF THE HIGH PRAIRIE AND MCLENNAN SHEETS. By W. Odynsky, A. Wynnyk, and J. D. Newton. Canada, Dept. of Agriculture and the Univ. of Alberta, Rept. 17, Edmonton, 1952, maps, tables, illus.

This report is one of a series of reconnaissance soil survey publications covering agricultural areas of the Peace River district in Alberta.

A general description of the mapped area deals with topography, drainage, climate, vegetation, and other factors and the main section deals in full with the characteristics and agricultural adaptation of the various soil series shown on the soil map. The systems of soil classification and soil rating are carefully outlined in other sections, and are provided as aids for interpretation of the maps.

In addition to the soil map, on a scale 3 miles to 1 inch, there are three small-scale maps in black and white showing the distribution of tree cover, the distribution of cultivated, abandoned, and virgin land, and a soil rating map distinguishing the better from the poorer land.

[M.R.D.]

INCOME AND FARM PROGRESS ON WOODLAND AND PARKLAND SOILS IN NORTHERN ALBERTA. By H. L. Sharpe. Econ. Annalist, vol. XXIII, No. 4, August 1953, pp. 91-94, tables.

This article presents the findings of a farm business study, made in an area of comparatively recent settlement on parkland and woodland soils. The study area extends from High Prairie north to McLennan.

Following a description of the area, the farm business survey is presented under the following sections: size of farm; land utilization; live stock enterprises; farm receipts; farm capital; labour income; outside income; the normal situation; period of settlement; and gains in net worth.

Five tables set out pertinent statistics relating to farm businesses in the two soil groups.

[M.R.D.]

CATTLE PRODUCTION IN WESTERN SASKATCHEWAN AND EASTERN ALBERTA. By S. R. Burkell. Econ. Annalist, vol. XXIII, No. 3, June 1953, pp. 65-69, map, tables.

This article describes the results of a live stock production study covering ten census divisions in Saskatchewan and seven in Alberta. It is divided into four sections: development of the cattle industry; geographic distribution of the cattle population; place of cattle in farm organization; land use.

A map and four tables supplement the written material.

[M.R.D.]

CANADIAN WEST COAST EARTHQUAKES, 1951. Publications of the Dominion Observatory, Ottawa, vol. XVI, No. 3, 1951, 9 pp., tables, maps.

This report summarizes the findings of three west coast seismic stations—Victoria, Alberni, and Horseshoe Bay. The location of earthquakes recorded in the period from August to December 1951 is shown on a map as well as a more detailed breakdown of those experienced in the Nanaimo area. The significance of the location of the centres is discussed briefly.

[R.H.D.]

INDUSTRIES OF THE NORTHWEST TERRITORIES. Canada, Dept. of Resources and Development, Northern Admin. and Lands Br., Ottawa, 1953, 35 pp., map, illus. Price 15 cents.

TRANSPORTATION AND COMMUNICATIONS IN THE NORTHWEST TERRITORIES. Canada, Dept. of Resources and Development, Northern Admin. and Lands Br., Ottawa, 1953, 31 pp., map, illus. Price 15 cents.

These two pamphlets are part of a series of publications describing the Northwest Territories, the others being concerned with Administration, Flora, Fauna, Geology, and Natives. The first-named summarizes the natural resources on which the economy is based and provides an up-to-date account of the history and development of mining, fur production, fisheries, water power, agriculture, the reindeer industry, Eskimo handicrafts, and lumbering. The second pamphlet describes the advances made in transportation services and communications and includes a short description of each of the settlements and trading posts in the territories.

[J.K.F.]

PRELIMINARY SOIL SURVEY OF LANDS ADJACENT TO THE MACKENZIE HIGHWAY IN THE NORTHWEST TERRITORIES. By A. Leahey. Canada, Dept. of Agriculture, Exp. Farms Serv., Ottawa, 1953, 22 pp., map, tables.

The Mackenzie highway extends from Grimshaw, Alberta, to Hay River, N.W.T., a distance of 385 miles. The section north of the Alberta border, a stretch of 81 miles, was investigated in July 1952 for the purpose of "locating and describing the nature of potentially arable soils" along the highway. Dr. Leahey divides the report into two sections. Part I includes a general description of the area, a classification of the soils according to the types of land forms on which they are found, and a summary of agricultural possibilities. Part II includes descriptions of representative soil profiles, chemical analyses, soil temperatures, and an assessment of climatic factors.

The distribution of soil types is plotted on a preliminary blueprint map on a scale of 1 mile to 1 inch.

[J.K.F.]

ARCTIC BIBLIOGRAPHY. United States, Dept. of Defense, Washington, 1953, 4478 pp. (in 3 vols.). Price $12.75.

This outstanding work "aims to bring into a unified systematic record, publications resulting from the exploration and scientific investigation of northern regions hitherto little known or difficult of access and development by peoples native to the temperate zones".

The boundaries of the Arctic, for the purposes of this work, are admittedly arbitrary, and, as a result, include many areas that are, without doubt, subarctic. This is particularly true of Canada. Yet, despite this, several important items on Arctic Canada have been omitted. The project is, however, a continuing one, and it is anticipated that supplemental volumes will be published in the future which "will include not only the results of current investigations but older, even classic, literature not analysed in time for the present publication".

The first two volumes contain the entries themselves—over 20,000 of them—arranged alphabetically by the name of the author. Entries include the title of the publication, its publication details, and an annotation "descriptive of the publication's subject matter . . . mentioning the area, time and auspices or circumstances under which the exploration or investigation was made".

The third volume is a subject-geographic index to the bibliographic entries.

[N.L.N.]

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