POLLEN ANALYSIS OF PEAT UNDERLYING A TREELESS HEATH AREA IN THE FOREST - TUNDRA TRANSITION NEAR CHURCHILL, MANITOBA.

BY

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A Thesis

Submitted to the Faculty of Arts and Sciences

in Partial Fulfilment of the Requirements

for the Degree

Master of Arts

McMaster University

October, 1949

The author of this thesis holds the following degree:

Bachelor of Arts, Biology Option, 1946 (McMaster)

This thesis was done under the supervision of:

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Scope and contents of this thesis:

Peat from a treeless "barrens" of the forest-tundra transition has been studied by the method of pollen analysis. The frequencies of various fossil pollens at successively greater depths of the peat deposits have been determined and presented in pollen diagrams, whose use is discussed in the study of the characteristics, vegetational history and development of the terrain. Illustrated with photographs of the terrain and photomicrographs of microfossils.

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INTRODUCTION

The preservation in peat of identifiable pollen from various plants has been used by pollen analysts to indicate the vegetation growing in the locality when the peat was deposited. By studying successively older depths of the deposit, the past history of the vegetation may often be revealed and hence related climatic or physiographic changes in the region and their chronology.

Pollen analysis was undertaken of peat in the Churchill region as an aid to general knowledge of the peat and its relation to the northern terrain. This knowledge is especially important since approximately the northern two-thirds of Canada is covered not by soils, i.e. soils as derived in part from rock matrix, but by peat deposits (organic) of many sorts and complexities.

These complexities have long been recognized but not understood by specialists in various fields who have worked with the northern organic terrain as civilian and military engineers, foresters and scientists in general. Organizations which have supported the investigations of which this is a part are the National Research Council of Canada and the Defence Research Board.

It is possible there has been some misconception by those who have considered the environs of the town and military campsite at Churchill as typical of the region. The coastal strip of terrain at Churchill itself does not appear typical of the tundra nor of the one hundred and fifty miles of transitional forest to the south.

For significant terrain phenomena the assemblage of problems are better to be sought and studied to the south of what has frequently been regarded as the Churchill area. The first station selected to the south was a heath located in a typical "barrens", i.e. treeless area.

The scope of northern terrain or "Muskeg" research lies far beyond the aims of this thesis. At the station suggested, for instance, the complete investigation will involve such primary work as physiographic, ecological and other related studies which are involved in applied palaeobotany. The present investigation has to do almost entirely with interpretation from pollen analysis which has been suggested as fundamental to the many aspects of the work being investigated under Professor N. W. Radforth at McMaster University, and the Royal Botanical Gardens, Hamilton.

The scope of this thesis has been, first, to develop a method of analysis for the peat deposits selected, in order to facilitate characterization of the peat for various depths. This may be used in the comparison of organic deposits in that region. Also it is hoped that such an an analysis may throw light on the origin and development of this particular local class of treeless heath terrain. Finally, it is hoped that the analysis the writer is proposing will provide a basis for considering the physical qualities of the terrain itself, and suggest the possible reasons for variations noted in neighbouring tracts of ground.

The lack of any guide or basis for northern pollen studies in North America is shown by a review of the literature. In the subarctic, there has been only one study in Alaska, a small analysis in the Mackenzie district, a study in Greenland in connection with archaeological work, and an investigation on the Labrador Coast. In the arctic regions there have been none at all.

Pollen analysis itself is a young science. Erdtman, (1943) in his review of early literature notes that, although in 1885 the Swiss geologist, J. Fruh, observed numerous types of pollen preserved in peat, it was not until early in the present century that G. Lagerheim, a Swedish micro-palaeontologist, began to study fossil pollen quantitatively, and he has been termed by Erdtman "the father of modern pollen analysis". It was L. Von Post, however, who really developed fossil pollen study, whereby the vegetational history so revealed might be applied to historical climatology and geology. He also was the first to use pollen diagrams showing graphically the pollen frequencies at depths in a peat boring.

Pollen studies then went ahead rapidly in Europe. Northern Europe especially led the way and has remained the most important centre, where pollen studies have become numerous enough to be the basis for advanced work (Von Post, 1930).

In North America the first pollen analyses were those made in south-eastern Canada in 1926 by V. Auer (1930). Investigations began in the United States in 1927 (Fuller, 1927) and became frequent enough that several general papers have appeared covering pollen analytical problems in the United States. (Sears, 1935, 1938; Cain, 1939; Smith 1940).

In southern Canada, investigations following Auer have been made by Bowman (1931) in Quebec, by Wilson and Webster (1943) to the west of Lake Superior, and by Radforth (1945) in the Shipshaw area, Quebec. In western Canada, Erdtman (1931) made studies of peat bogs in central Alberta.

In the north, pollen analyses have been made of some Alaskan bogs by Bowman (1934) and of archaeological sites in Greenland by Iversen (1934). In Canada, peat from earth mounds in the Mackenzie district has also been studied by Iversen (Porsild, 1938). Extensive investigations have recently been made along the Labrador coast by Wenner (1947).

DESCRIPTION OF HEATH SITE

Location and Physiography

The site studied is located 33 miles south of Churchill on the Hudson Bay Railway. (See map, figure 1). The exact site of the sampling is two-tenths of a mile south of the railway section-point of Lamprey and 100 yards east of the railroad. The existence of Lamprey is indicated by a marker, "mile 477" on the railway, which is marked every mile from its starting-point at Le Pas, Manitoba, to its terminus at Churchill, mile 510.

Although the locality is Lat. 58° 17' N., (Long. 94° 9' W.), it is comparable in its tree-limit proximity, and in some aspects of its climate, to the Arctic coast at the Mackenzie River delta, and in northern Alaska which is inside the Arctic Circle.

Its physiographic region is that of the Hudson Bay Lowlands. This is the rather narrow belt of flat-lying Palaeozoic limestones covered with thick glacial till, which circles the lower portion of Hudson Bay within the Precambrian shield. The land is a very low, level plain, sloping gently into Hudson Bay. Thus, Lamprey, although the sea is 33 miles to the north and 40 miles to the east, is shown by the topographical maps to have an altitude of only 140 feet, a slope of five feet to the mile.

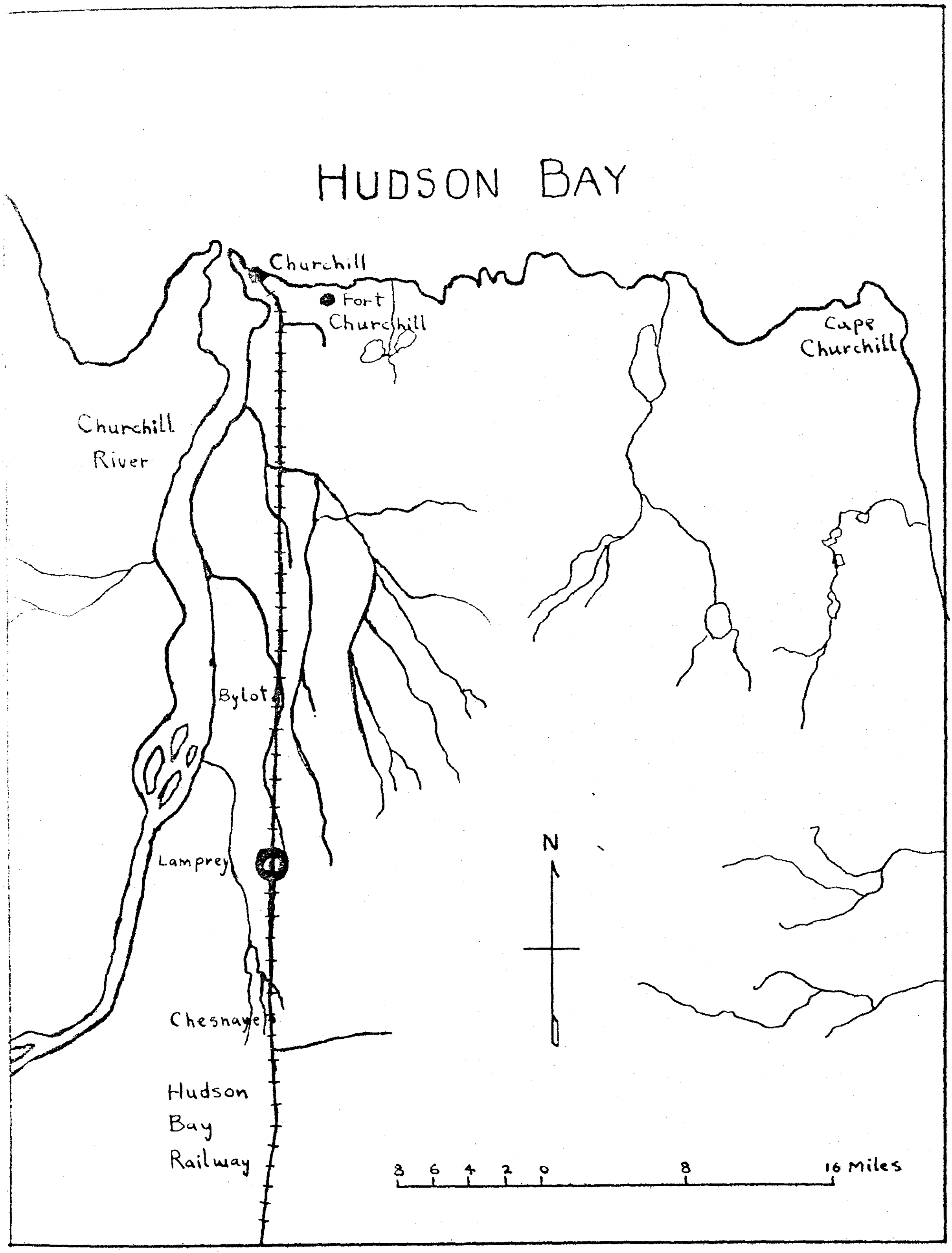

Figure 1. Map showing location (black circle) of heath studied, near Lamprey, Manitoba.

On the Lamprey barrens itself, the topography is so even that the horizon presents in all directions a perfectly straight line, only slightly broken by a few spruce patches (See Plate I). The level heath is only a foot or two higher than the water level of marshy ground and ponds. Two gravel ridges, only twenty to thirty feet high, between Lamprey and Churchill, present the only relief seen in a large area. These ridges were also the only places where there were visibl patches of mineral matter, although these were small. Otherwise, the entire country, including the shallow ponds, has a complete cover of organic deposits.

Johnston (1917) points out that since the glacial drift completely covers the flat bedrock of limestone (Upper Ordivician, at Lamprey) to a depth of probably one hundred feet, "the even surface is largely due to the deposition of a thick sheet of boulder clay, the somewhat irregular surface of which has been planed off by marine erosion and the depressions filled by deposition of marine sediments". At Lamprey, the sediments encountered were fine, light-coloured sands.

Marine shells and beaches occurring farther south down to the Nelson River indicate that the land was covered by sea after the Pleistocene glacial ice recession from the locality which had been depressed below sea-level by the glacier's weight. The action of the sea, in addition to making the level, reworked deposits mentioned above, is, at least in part, responsible for the mosaic of shallow depressions containing ponds and small lakes, which the writer estimates cover 30 per cent of the area at Lamprey.

An important feature of the terrain is the frost and its action. The heath peat, which is three to four feet in depth, is permanently frozen below the 14-18 inches which thaw out by the end of the summer. Although the ponds thaw out to a depth of at least four feet, the inhibitory effect can be seen on the drainage of the ponds if the surrounding heath is permanently frozen to a level higher than the watertable.

Another important feature of the terrain associated with frost action and presenting as many problems for related investigation, is the polygon formation of the surface of heath areas. These are trench-like depressions which traverse the heath and, in joining, cut off polygonal-shaped areas. Polygons in various forms are widespread in the arctic and in the subarctic region south of Churchill, although essentially absent in the vicinity of Churchill itself.

<u>Vegetation</u>

The effect presented by treeless northern country is shown by the established use of the term "barrens". This is in spite of the fact that the ground is not barren of vegetation, but, on the contrary, consists of a completely "closed" mat of vegetation.

The extent of the barrens south of Churchill may be seen when travelling southward on the Hudson Bay Railway from Churchill. After leaving the coastal five miles of partly barren country, one passes through fair-sized spruce forest, alternating with willow-birch scrub, until, twenty-five miles south of Churchill, the predominately barren country is entered, which extends south at least seventy miles. Since the barrens stretch forty miles east to the coast and at least thirty miles to the west, their area in this region alone, of the subartic, is a minimum of five-thousand square miles.

This region south of Churchill is classified by Halliday (1937) under the Northern Transition Section of the Boreal Forest. Hustich (1949) has pointed out that in Labrador, Halliday's Northern Transition should be divided into a Taiga and a more northerly Forest-Tundra section. Hustich says, "In the forest-tundra, the forest occurs only in patches and the whole area is dominated by barren ground with characteristic plant and animal life". Thus the Lamprey region would be termed "forest-tundra".

The nearest patch of forest to the Lamprey site is a spruce woods a mile-and-one-half to the north. This patch is approximately a mile wide, as is a similar patch seen seven miles south of Lamprey.

A single spruce, six feet high was growing on the site. This specimen was a black spruce (Picea mariana) while another, three-hundred feet away, was a white spruce (Picea glauca). The latter, although only six feet high, had at least sixty annual rings, of which the last twenty rings showed greater growth, perhaps due to the improved drainage when the railway was built.

The low, level habit of the vegetation, matching the topography can be seen in the photographs (Plate I). Shrubs of Betula glandulosum, and to a lesser degree, Salix spp. grow to a height of only one to three feet, and since they usually occur in the depressions, add little vertical variation to the terrain.

The heath mat is dense and level, although small tussocks of organic matter and clumps of Ledum palustre may give it a bumpy appearance. The mat itself is predominately reindeer lichen (Cladonia spp.), which appears to be succeeding its associates, members of the heath family - Vaccinium vitis-idaea, Empetrum nigrum, with occasionally Andromeda polifolia and Vaccinium oxycoccus. Also in the mat there occurred occasionally slight bits of sedge, while Rubus chamaemorus, the only forb seen in the mat, was particularly common at the site shown in Plate I, figure 2.

Depressed areas bordering ponds, as seen in Plate I, figure 1, showed a succession from open marsh of either or both of Eriophorum spp. or Carex spp., through a closed mat association of the same plants, in which dwarf birch then took hold. At the edge or in slight depressions of the mat, as in the trenches of polygons, Sphagnum spp. were growing, although dying and overgrown with lichen.

Certain features concerning the vegetation show relationships to accompanying physiography, which are being explored by other workers in related studies.

METHODS AND OBSERVATIONS

I Sampling

The usual methods of peat sampling were quite useless at this site. In spite of the ground thawing all summer, there were only fourteen inches of unfrozen material which could be drilled with the Davis peat borer, usually employed on peat deposits, and two other methods of sampling had to be used.

The first complete bore i.e. series of samples at successive depths from the surface to the bottom of the peat, was made by the following method, and will be referred to as Bore (A). The unfrozen peat was removed from an area six feet square, exposing the frozen peat surface, which was chopped to excavate a pit. Due to the peculiar and remarkably tough structure of the frozen peat, an axe was found to be more effective than a pick. From one side of the pit so formed, a series of samples, each five or six inches long and about two inches in diameter, were taken from the surface to the bottom of the pit. The outer surface of each channel sample was cut off in case there had been contamination from pollen in the air. Then the samples were placed quickly in covered sample-jars or honey-pails.

A second method of sampling was used to obtain Bore (B). The sharpened end of a heavy pipe of two-inch diameter was driven several inches into the frozen peat by numerous blows of a sledge-hammer; the pipe was then withdrawn, and the core pushed out. The pipe was replaced in the hole and the process repeated. This drill had been constructed by Mr. J. Croal, of Defence Research Board, for frozen soil studies.

Care was taken in replacing the drill in the hole to avoid knocking surface peat into the hole; but to be safe, a portion was cut off the top of each section. Partly due to a shortage of containers, the sections comprising the upper eighteen inches were separately wrapped in paper towelling, while the lower sections, which released considerable water on thawing, were peeled to fit into vials of three-quarter-inch diameter.

To preserve the peat against microbiological action, alcohol was added to bring the melt-water content of the containers to seventy per cent. Those samples in paper towelling were soaked in seventy per cent alcohol, and allowed to dry out completely. This latter method of wrapping and drying the peat was found most satisfactory, since the core kept its shape and structure, whereas the frozen peat put in containers melted and mixed.

The location of Bore (A) was on a small heath area having <u>Betula-Eriophorum</u> marsh within eight feet to the east and twelve feet to the west. Plate I, figure 1, shows the position of Bore (A) and the thirty feet of marsh to the east separating it from the large heath area on which Bore (B) was located.

II Description of Peat

The peat types encountered and their depths are shown in Table I. In Bore (A), the mineral substrate was not reached at the bottom at forty-two inches; but in Bore (B), fine, light-coloured sand was reached at forty-three inches.

More detailed observations of the peat layers were made on Bore (B) than on Bore (A). These revealed that the three groups of Sphagnum peat in Bore (A), alternating with black, decomposed peat, showed many small alternate layerings.

Comparisons of the descriptions indicated in the table reveal other structural variations in the peats. To account for these is not within the scope of this thesis. They are, however, significant and helpful in those investigations which parallel this one. Some of the variation assists in the explanation of statistical phenomena revealed in the pollen analyses as shown later.

The term, "undecomposed", has been frequently used in the table in connection with the term "Sphagnum peat". It should be noted that in most of this peat so little decomposition had occurred that complete plants of sphagnum could be picked out.

The wood indicated in the table consisted of several pieces, each of which was encased in one-quarter to one-half inch of pure ice. Small lenses of pure ice also occurred independently in the peat. The largest piece of wood measured three inches by one-half inch, and although quite soft, could be sectioned well enough to identify it as larch (Larix sp.).

Although studied only briefly in connection with this work, a few rough pH measurements were made of this peat. Fresh sphagnum peat near the surface was very acid, pH 3. Measurements made of similar peat, dried for some time, compared closely, thus making determinations appear possible after storage of peat. A thin layer of black, decomposed type of peat near the surface had a similar pH; but from the bottom of the peat deposit, black peat was only pH 6, while the sphagnum peat remained as acid as above.

TABLE I

Type of peat at depths of two borings

DEPTH INCHES	BORE (A) PEAT TYPE	DEPTH INCHES	BORE (B) PEAT TYPE
0-2	Black, decomposed	0-2	Dark brown, fibrous
2-10	Sphagnum (brown) undecomposed	2-15	Sphagnum, undecomposed
10-13	Black, fine, decomposed	14	(Frost surface)
13	(Frost surface)	15-16	Dark brown, fibrous, decomposed wood
13-22	Sphagnum, undecomp.	16-17	Sphagnum, undecomposed
22-25	Black, sl. decomp. Sedge leaves?	17-18	Black, fine, decomposed
26-29	Black, undecomposed Sedge? Wood	18-19	Sphagnum, undecomposed
29-32	Sphagnum, sl. decomp. and fibrous. Wood	19-20	Black, decomposed
32-34	Sphagnum, sl. decomp.	20-21	Sphagnum, undecomposed
34-42	Black, decomposed Sedge?	21-25	Black, fibrous, gritty
42	(Bottom still peat)	25-27	Sphagnum, sl. decomposed
		27-28	Black, gritty
		28-33	Sphagnum, sl. decomposed
		33-41	Black, fine, decomposed; Some ericaceous leaves
		41-43	Fine sand

III Analytical Techniques

The chief steps in the preparation of peat for pollen counts are:

(1) Deflocculation of peat.

(2) Concentration of pollen.

(3) Mounting the pollen.

(4) Counting and tabulating.

Deflocculation of the peat was by the alkali, potassium-hydroxide method. First, the sample for each depth (e.g. 0-6 or 6-11 inches) was thoroughly mixed. Approximately one cc. of the peat was boiled with fifteen cc. of ten per cent potassium hydroxide solution for twenty minutes.

The deflocculated peat was diluted with water and the pollen concentrated by centrifuging. The washing and centrifuging were then repeated.

A small amount of the pollen-bearing sediment was mounted in a media of three-quarter-strength corn syrup, without a cover glass. The surface of the mount was found to harden sufficiently within a few minutes to prevent any contamination from pollen settling from the air. As in all stages of the preparation, precautions were taken, such as continual covering of the material, to prevent contamination.

A cover glass was not used, as it has been observed that currents under the cover glass affected certain pollens but not others; thus altering their relative frequencies in the counts.

The corn-syrup medium used by Radforth (1945) was found to be simple and effective for temporary mounts. At any time, a drop of water applied to the surface softened the media sufficiently to allow manipulation of the grains to study identifying features. It was found, however, that the medium was not too reliable for permanent mounts, since some optical qualities are lost after a few months.

Pollen counts were made at a magnification of 150X, but all measurements and the examination of not-easily-identified grains was made at 430X. The slides were controlled by a mechanical stage. Counts were made of usually 200 microfossils, but as many as 400 were counted when one type was of high frequency and pollen were numerous.

Identification of the pollen types was made, using reference slides of modern pollen species - especially those of the present Churchill flora. Aid was also received from certain papers containing notes on identification and photomicrographs (Wilson and Webster, 1942) or drawings (Erdtman, 1943; Lewis and Cocke, 1929; Sears, 1930; Wilson, 1934; Wodehouse, 1935).

Photomicrographs were taken with a Leica camera and Ibso photomicrographic attachment, using Dupont Microcopy film and D11 developer. A Bausch and Lomb monocular microscope was used with a 43X, 0.65 N.A. achromatic objective, a 10X Leitz Periplan ocular, and a 1.25 N.A. Abbe condensor.

to that degree and where the genus is considered to be of particular paleoecological significance. Other pollen are tabulated as families or plant groups.

With Picea pollen, the species P. glauca (Plate II, figure 2) was found to be separable from the smaller P. mariana (Plate II, figure 1). Some grains of the former were at first considered to be the similar-sized Abies, as Wilson (1942) believes many workers have done. However, the hemispherical shape of the bladders, as seen in distal view, definitely distinguish P. glauca from the Abies, which shows spherical baldders. No fossil Abies pollen was observed. The grains of Pinus (Plate II, figure 3) were referable to P. banksiana, no larger grains of the more southerly P. resinosa being observed.

The pollen listed as Herbaceous was almost entirely Compositae and Rosaceae (Rubus chamaemorus was predominant for the group, and present only, in the two top depths of Bore (B)). Similarly, Plantago was the predominant herbaceous pollen in the base sample of Bore (A) and otherwise was present only slightly at the base of Bore (B).

An unidentified microfossil, termed grain "L" (Plate II, figure 16) was relatively common at thirty-two to thirty-six inches in Bore (A), and present only again in the surface sample of Bore (B).

TABLE II

Microfossil percentages of peat Bore (A)

POLLEN TYPE	DEPTH IN INCHES 40-42	36-40	32-36	26-32	22-26	17-22	11-17	6-11	0-6
Picea glauca	3	2	3.5	5	12	5	14	5	12
Picea mariana	5	10	2	4	6	3	17	19	18
Pinus	14	14	2.5	31	22	15	18	7	18
Betula	5	12	1.5	7	2	16	16	12	5
Alnus	1	1	1	-	-	4	4	1.5	1
Salix	-	-	.5	-	-	2	.5	2	3
Ericales	3	1	.5	-	-	-	3	1.5	-
Cyperacaae	33	54	3	40	46	34	24	22	25
Gramineae	5	2	1.5	3	4	5	1	7	4
Herbaceous	19	-	1	2	2	3	.5	-	-
Filicales	5	2	2	2	-	2	-	2	-
Lycopodium	-	-	.5	-	-	1	.5	-	-
Sphagnum	7	4	7.5	7	5	10	3	20	13
Stomata	2	-	-	4	3	2	1.5	-	-

TABLE III

Microfossil percentages of peat Bore (B)

	DEPTH IN INCHES								
POLLEN TYPE	40-43	36-40	32-36	26-32	22-26	17-22	11-17	6-11	0-6
Picea glauca	18	9	41	25	4	28	18	8	11
Picea mariana	16	50	8	9	2	15	12	14	28
Pinus	20	12	35	10	3	15	11	6	7
Betula	5	9	3.5	2.5	2.5	3	6	5	13
Alnus	-	-	-	4	1	-	-	6	5
Salix	4	-	-	2	-	-	-	-	3.5
Ericales	7	4	1.5	-	1	10	10	21	9
Cyperaceae	15	10	4	11	2.5	5	6	5	6
Gramineae	-	3	-	3.5	3	3	4.5	3	4.5
Herbaceous	8	-	-	-	1	8	6.5	14	5
Filicales	-	-	1	2	1	-	-	5	4
Sphagnum	7	3	5	32	82	13	24	13	6
Stomata	2	10	-	-	3	-	-	-	-

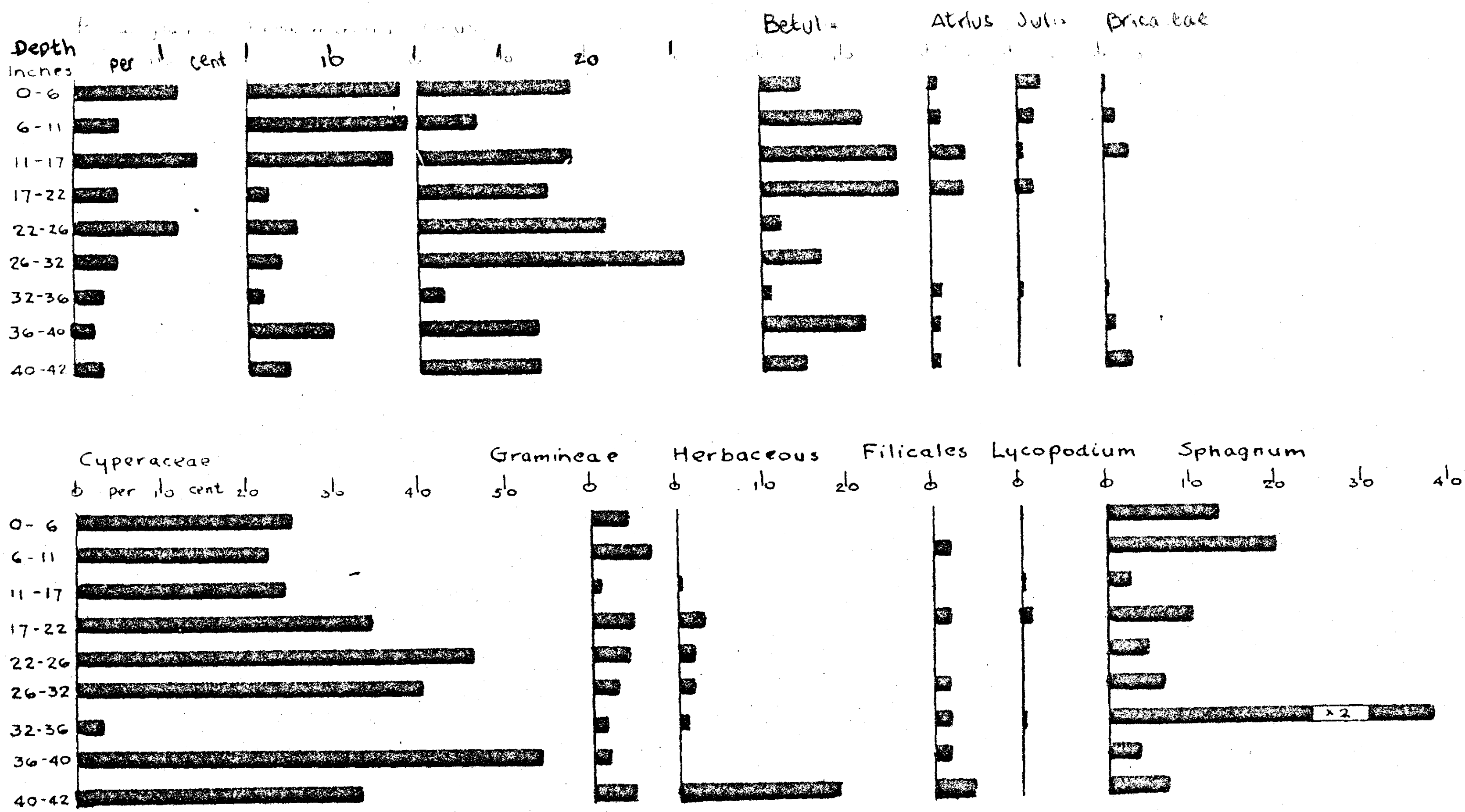

Figure 2.- Pollen percentages of peat bore (A)

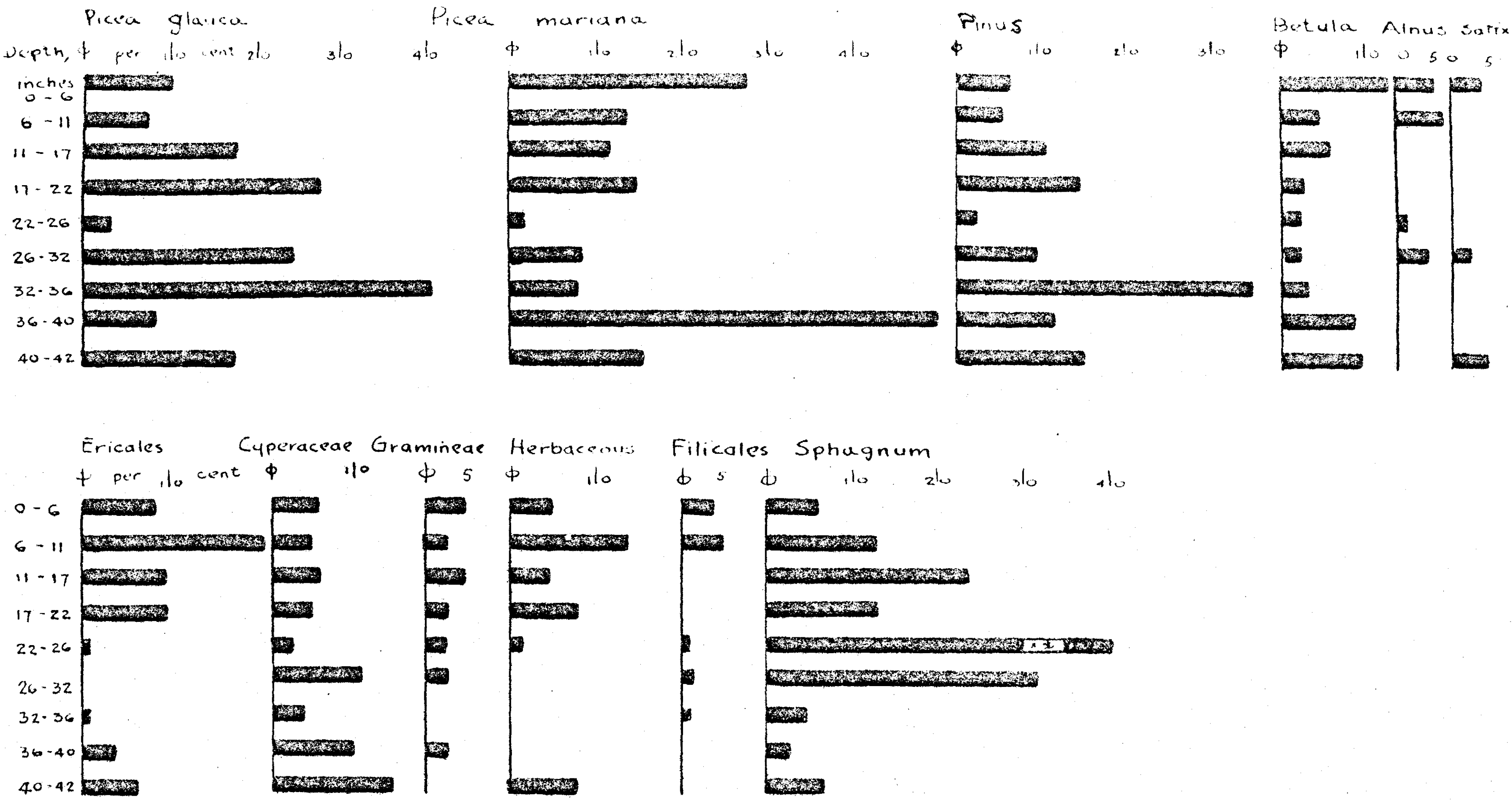

Figure 3.- Pollen Percentages of peat bore (B)

This sporadic appearance of Rubus, Plantago, and the grain "L", as well as the extremely high frequency of Sphagnum at one depth in each of Bore (A) and Bore (B), suggests the preservation in the peat of pollen in masses such as anthers. This is to be expected, perhaps, considering the very poor decomposition of the plant remains, especially sphagnum, as mentioned in the description of this peat.

DISCUSSION

In spite of the rather indefinite trends shown by some of the pollen diagrams, there are some features which are definite and others which are not so apparent.

Sphagnum in Bore (B) shows a definite maximum and a gradual decline. Pinus and Cyperaceae show gradual declines from the beginning of the deposit. Picea glauca shows a general maximum in the middle of the peat profile; while P. mariana, predominating earlier, reverts to a strong maximum in the upper layers of the peat. Revertence is also shown by Betula and Ericales, with Alnus and Salix showing that possibility. The Gramineae are stable, of low frequency and relatively unimportant, as are the Filicales. Herbaceous frequencies are substantial at the very bottom, but are contradictory in the upper halves of the two Bores.

The extent to which the pollen of the surface samples show discrepancies with the present vegetation on the barrens should be noticed. The conifers in both Bores represent just under 50 per cent of the total pollen, yet the nearest woods are 1½ miles away. The frequency of Pinus in Bore (A) is 18 per cent, although the nearest known pine stands are at least 175 miles distant. Alnus is present as five per cent, although the writer has never seen any in the Churchill region. It may, however, grow on the banks of near-by rivers, the closest of which is two miles.

The fossil pollen of plants may represent to a varying degree the importance of the plants in the vegetation at the time of the peat deposition.

Thus Pinus is often much over-represented, due to the prolific production and far-travelling ability of its pollen. Another reason for the non-representation of the surface samples is that they consist of the top six inches which includes underlying sphagnum peat. Since the cover today is lichen-ericaceous, the top sample includes the deposition of a previous and different vegetation and its pollen.

The indefinite trends and depth-to-depth fluctuations of some pollens such as Picea glauca and Sphagnum in Bore (A) may not necessarily reflect similar floral changes. They may be due to the preservation of pollen masses as mentioned previously, or due to the layers of different peat types having varying degrees of decomposition, which could alter the pollen preservation, as has been mentioned by Cain (1939). Wenner (1947) says of Labrador, "The fluctuations of the percentages, especially in short diagrams of the barren region are often difficult to interpret".

Differences may be seen between pollen frequencies for the two bores, such as the much higher frequencies of Cyperaceae in Bore (A). This is due to the peat at the site of Bore (A), which, being only eight feet from sedge [illegible], would receive more sedge pollen than Bore (B) which was at least fifty feet from a depression of sedge. Other differences between the Bores would be expected, since a certain peat facies in one Bore could be more compressed than in the second Bore, and an equivalent depth in each Bore would not contain the same peat strata. This difference in layers of the two Bores is seen in Table I.

These qualifying factors suggest that further borings should be analysed to study the relationships of local variations with vegetation on the one hand and peat stratification on the other. Until this is done, accurate conclusions cannot be drawn from the pollen diagrams regarding past vegetational history and its significance.

In sections of the United States, numerous analyses have been made by many workers, and study of their similarities and differences has established the significance of certain pollen types and their trends in pollen diagrams. From these, deductions have been made regarding past climatic and other phenomena, but with much resulting controversy.

Cain (1939) says, "As a matter of fact, until the relations between the modern distribution of trees and climate is better understood, interpretations of the past will be somewhat uncertain at the best. The evidence of pollen statistics should be bolstered by modern floristic geography and by stratigraphical, geological and archaeological facts wherever possible".

A few tentative suggestions regarding the past vegetation arise, however, from the observations on the peat and on the pollen diagrams. The peat, at least, suggests a non-sphagnum vegetation in the immediate vicinity at the beginning of the peat deposition. The presence of larch wood at a depth of 26-36 inches then indicates succession to at least some wooded cover.

Sphagnum then invaded the area and has been responsible for the majority of the peat deposition to date. The absence of trees from the region today confirms the extinction of forest by the acid sphagnum-bog conditions. The slight surface peat and the vegetation today, show that a recent change of conditions has allowed the replacement of sphagnum by lichen-ericaceous heath, and the immigration of the two small spruce mentioned in the description of vegetation. This sphagnum retrogression is similar to that recorded in Alberta "Muskegs" by Lewis and Dowding (1926), who present evidence for drier climate as the cause.

The fairly high percentages of pine pollen do not necessarily indicate that pine has grown at Lamprey in the past. Although today's probable pine limit is at least 175 miles either to the south or west of Lamprey (Halliday, 1937; Raup, 1936), pine pollen is common in surface samples even at Churchill to the north. Pinus, as mentioned, can be much over-represented by its abundant pollen even at long distances. Thus Erdtman (1931) says that bogs in Central Alberta showed a predominance of pine pollen, although pine was not growing near-by. If pine had grown near the Lamprey site, much higher percentages of pine pollen might have been expected. The diagrams suggest that the somewhat higher frequencies are only relative and are due to comparatively low depositions of spruce and other grains.

It is difficult to explain, however, the presence of pine macrofossils, the stomatal cells. In a similar case, Faegri (1945) suggested that they might have come from pine needles blown on the snow, but was surprised at their presence nine miles from the nearest pine forest. It is much more surprising at Lamprey to find them at least 175 miles from the present pine limit.

The pollen frequencies at the base of the deposit, suggest a herbaceous-ericaceous heath vegetation together with sedge, which throughout, probably dominated the wet habitats.

Shrub succession, or at least, rise, is indicated by a Hetula maximum.

The high frequencies next, in Bore (B) of first Picea mariana and then P. glauca, suggest the succession of spruce, while the unchanged frequencies in Bore (A) may indicate, together with the preserved larch wood, the dominance at Bore (A) of that tree. The advent of sphagnum is then indicated, especially in Bore (B), with extinction to some degree of the spruce suggested between the depths of 22-32 inches. The high frequency of Picea mariana then suggests the revival of the present-day spruce woods in their scattered patches.

High frequencies of the shrubs, Betula, Alnus and Salix occur in the top levels. The abundance of Ericales pollen, beginning as much as four depths from the top, point the way to the invasion of sphagnum by the heath group, culminating in the complete lichen-heath replacement of today.

SUMMARY

1. Peat from a treeless heath "barrens" of the forest-tundra transition, south of Churchill, Manitoba, has been studied pollen-analytically.

2. Two borings of the peat underlying areas of lichen-ericaceous heath, have been analysed to obtain the frequencies of certain pollen at nine successive depths, and the results presented diagrammatically.

3. The peat deposits were shown to be three-and-one-half feet deep, permanently frozen, except for the upper thirteen inches, and consisted largely of very undecomposed sphagnum peat, containing larch wood at a lower depth.

4. Apparent fluctuations and indefinite trends of certain pollens have been suggested as not representative of similar floristic action, but as due to local conditions, in particular, the peat.

5. Certain differences between the analyses of the two bores emphasize that numerous analyses and the study of related conditions must be made before reliable interpretation of past vegetation and conditions can be made.

The high frequency of Pinus, gradually declining, is not necessarily believed to represent the presence of pine in the immediate vicinity at any time, although the presence here of pine stomata at least 175 miles from the present pine limit is surprising.

For reasons presented, only a very tentative interpretation of the past history of the area can be proposed.

It is suggested that the past vegetational history followed this pattern: (sedge dominating the wet areas throughout) - herbaceous-ericaceous heath; birch shrub; spruce forest, probably black spruce followed by white spruce and larch; sphagnum, causing the extinction of the woods; revival of black spruce in the scattered patches of today, followed shortly by shrub immigration in other areas; rise of ericaceous plants in the sphagnum, ending in its extinction, and growth of the present lichen-ericaceous heath.

ACKNOWLEDGEMENTS

The writer wishes to express his deepest gratitude to Professor N. W. Radforth, for making possible this investigation, and for his kind advice and continued encouragement.

Grateful acknowledgement is made to the National Research Council of Canada and to the Defence Research Board for their interest in this work.

Sincere thanks are due to all who aided in securing the material, and to those who contributed suggestions and time during the investigation, as well as during the preparation of the thesis.

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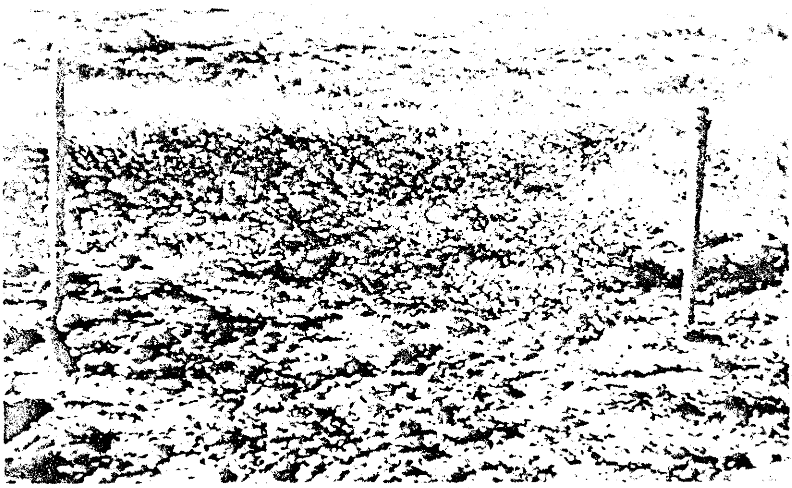
EXPLANATION OF PLATE I

The photographs show the terrain at the Lamprey heath, and the sites where the two peat profiles were sampled. Photographs were made on August 11, 1947, with a Leica camera, on 35 mm Kodachrome film from which black and white copies were made.

Figure 1 - Terrain at the Lamprey site - treeless heath interspersed with numerous small ponds and *Eriophorum-Carex* associations in wet areas. In the left foreground is the site where the pit was made, and in the centre of the heath beyond the sedge area the drill sample was made; looking east away from the railroad.

Figure 2 - The site of the drill sample looking north; Mr. E. Huff, Mr. J. Croal.

PLATE I



1

2

EXPLANATION OF PLATE II

The microfossil photographs are at an enlargement of 750X (Scale, 7.5μ to cm.). A Bausch & Lomb monocul microscope was used with a 43X, 0.65 N.A. achromatic object a 1.25 N.A. Abbe condenser, and a 10X Leitz Periplan ocular A Leica camera with a Leica Ibso photomicrographic attachme was used with Dupont Microcopy film and D11 developer.

Figure 1. - *Picea mariana*

Figure 2. - *Picea glauca*

Figure 3. - *Pinus banksiana*

Figures 4, 5, 6. *Betula sp.*

Figure 7. - *Alnus sp.*

Figure 8. - *Salix sp.*

Figure 9. - Ericales, probably *Empetrum nigrum*

Figures 10, 11.- Cyperaceae

Figures 12, 13.- *Lycopodium complanatum*

Figures 14, 15.- *Sphagnum sp.*

Figure 16. - Unidentified, Grain "L"

Figure 17. - Stomatal cell of *Pinus sp.*

PLATE II