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J. Terasmae

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OF CANADA

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Part I—A Palynological Study of Post-Glacial Deposits in the St. Lawrence Lowlands 21 L, 31 H I

Part II—A Palynological Study of Pleistocene Interglacial Beds at Toronto, Ontario 30 M

By

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DEPARTMENT OF
MINES AND TECHNICAL SURVEYS
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PREFACE

In this Bulletin the author presents the results of two further studies in Pleistocene stratigraphy, based on the examination of spores and pollen grains. The clarification of stratigraphic problems that have not yielded to classical methods once more demonstrates the value of this new tool.

J. M. HARRISON,
Director, Geological Survey of Canada

OTTAWA, March 4, 1959

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A PALYNOLOGICAL STUDY OF POST-GLACIAL DEPOSITS IN THE ST. LAWRENCE LOWLANDS

Abstract

After the retreat of the ice, lacustrine conditions prevailed over the part of the St. Lawrence Lowlands between Montreal and Quebec City. This was followed by the marine inundation known as the Champlain Sea.

Over much of the area occupied by the Champlain Sea, bogs were subsequently developed and a study of the pollen content of those bogs has led to the recognition of six pollen zones. The oldest of these started to form some 9,000 years ago when the sea stood at about the position of the present 250-foot contour, 200 feet or so below its maximum.

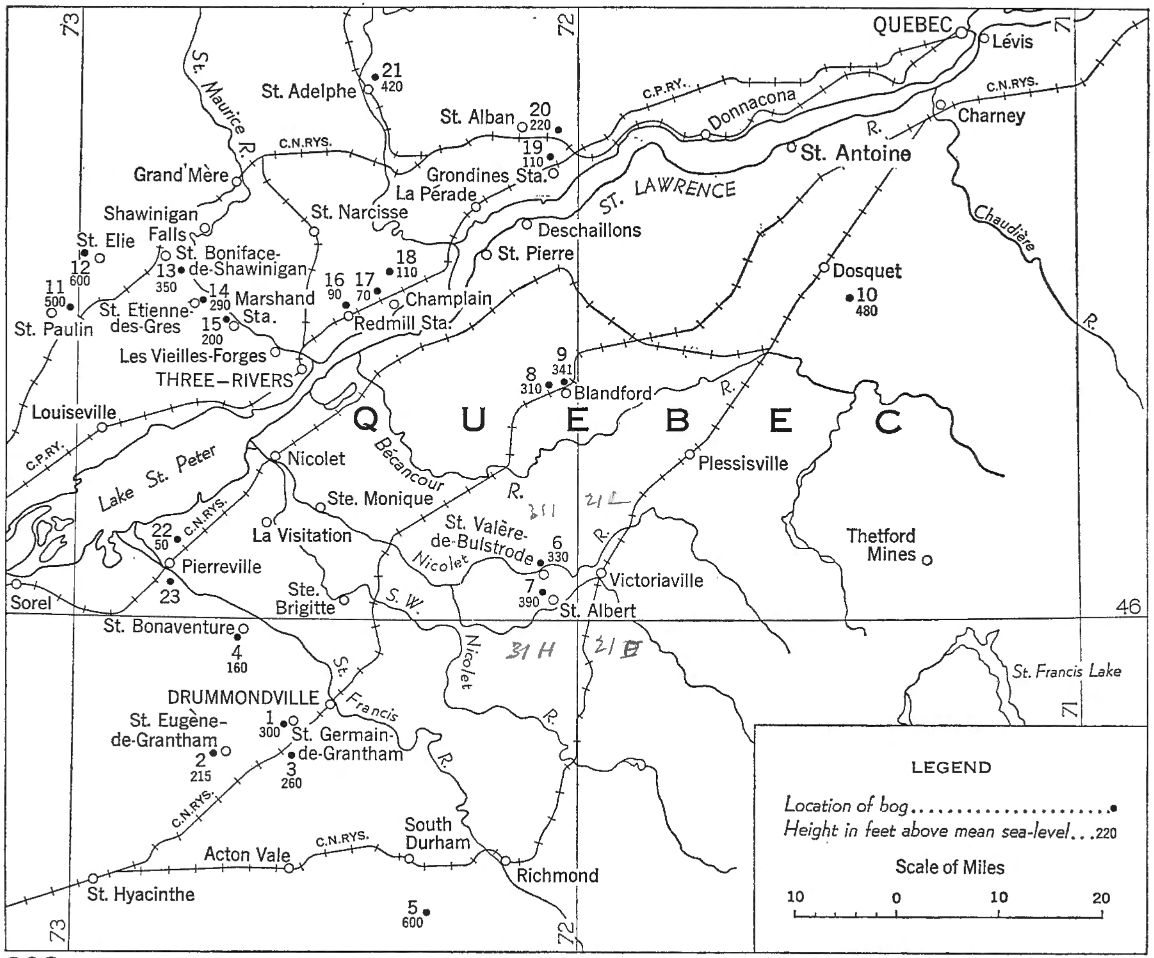
Although marine fossils are largely absent in deposits below this level, the pollen content of the bogs shows that they started to form in an orderly sequence from higher to lower levels. Thus, by means of palynological studies terraces on either side of the river may be correlated.

Résumé

Après le recul des glaciers, un régime lacustre régna dans la région des basses terres du Saint-Laurent entre Montréal et Québec. Puis survint la transgression marine qui produisit la mer Champlain.

Sur une grande partie du bassin de cette mer, il se forma ensuite des marais. Une étude du pollen recueilli dans ces marais a fait connaître l'existence de six zones de pollen, dont la plus ancienne commença de se constituer il y a quelque 9,000 ans; le niveau de la mer Champlain était alors inférieur d'environ 200 pieds à son niveau maximum et à peu près à la hauteur de l'actuelle courbe de niveau de 250 pieds.

Bien que les dépôts situés au-dessous de ce niveau ne contiennent presque aucun fossile d'origine marine, le pollen des marais révèle que ces dépôts se mirent à se former dans un ordre régulier, en descendant de hauts niveaux à des niveaux plus bas. C'est ainsi que la micropaléobotanique permet de mettre en corrélation les terrasses situées sur les deux rives du Saint-Laurent.



G.S.C.

LIST OF BOGS

1. St. Germain
2. St. Eugène
3. Birch Bog
4. St. Bonaventure
5. Wilson Pond
6. St. Valère
7. St. Albert
8. Blandford
9. Louise Lake
10. Dosquet
11. St. Paulin
12. Patterson Lake
13. St. Boniface
14. St. Etienne
15. Marchand
16. Red Mill
17. Sherwin - Williams muck pit
18. Champlain
19. Grondines
20. St. Alban
21. St. Adelphe
22. Pierreville
23. Rivière aux Vaches

Figure 1. *Index map of St. Lawrence Lowlands region showing location and elevation of non-glacial deposits.*

INTRODUCTION

Field work for this palynological study was done during the summers of 1953-55 and 1957 in the central part of the St. Lawrence Lowlands (*see* Figure 1). Notes on the geological background have been provided by N. R. Gadd and P. F. Karrow, who mapped the Pleistocene deposits in the areas concerned.

Earlier palynological studies in Quebec were made by V. Auer (1930)[1], E. J. Potzger (1953), Potzger and Courtemanche (1956) and H. Ignatius (1956). These studies were, however, essentially botanical in scope and no close correlation with the present concept of the Pleistocene stratigraphy in the St. Lawrence Lowlands was attempted. In the present study an effort is made to establish a chronological sequence for the post-glacial events in the St. Lawrence Lowlands by means of pollen analysis.

ICE RETREAT AND THE POST-GLACIAL DEPOSITS

The following summary is based on N. R. Gadd's studies.

Retreat of the Wisconsin ice-sheet from the St. Lawrence Lowlands was first followed, at least locally, by lacustrine conditions. Further ice retreat, however, opened the eastern part of the present St. Lawrence River valley and the Lowlands were inundated by marine waters, the Champlain Sea. At least once, the ice readvanced into the Champlain Sea from the north and glacio-marine conditions resulted. The highest known shorelines of the Champlain Sea were not recorded in the area, probably because ice formed the shore at that time. Later, many shorelines were formed by the receding Champlain Sea and still later by a part brackish and part fresh body of water. The estuarine conditions were followed by the cutting of terraces and the redeposition of sand and clay by the present St. Lawrence River.

The post-glacial deposits in the St. Lawrence Lowlands include, in the main: pre-Champlain Sea silts and sands, silty clay and sand of the Champlain Sea, reworked marine deposits, river sand, aeolian sand, and organic deposits.

DESCRIPTION OF BOGS

A total of twenty-three sites (*see* Figure 1) were sampled for pollen analysis. Samples were collected from lacustrine deposits, peat, and the underlying inorganic deposits. Pollen diagrams have been prepared for fourteen of these sites.

Palynological terms (pollen diagram, pollen zone, etc.) have been defined and explained by Faegri and Iversen (1950), Terasmae (1958), and also in this bulletin.

[1] Dates in parentheses are those of references cited at the end of Part I of this report.

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St. Germain bog (31 H/15, E½[1], Upton map-area; elevation *ca.* 300 feet; Figure 2). This bog is 0.6 mile west of St. Germain-de-Grantham village and south of the highway. The boring was made in the open area near the northern margin of the bog. This bog has developed in a depression on the crest of the Drummondville moraine. Till, overlain by fossiliferous, marine sand is exposed in drainage ditches cutting the margin of the bog.

Pollen analysis indicates that the earliest pollen-bearing sediments were deposited in pollen zone VI.

St. Eugene bog (31 H/15, E½, Upton map-area; elevation *ca.* 215 feet; Figure 3). This bog is 1.5 miles southwest of St. Eugène-de-Grantham village and can be seen on aerial photograph A 12811-30 (National Air-Photo Library). The bog has developed in a shallow embayment on the northern flank of the Drummondville moraine and the organic deposit is underlain by clay and sand, presumably marine. The boring was made near the central and higher part of the bog.

Pollen analysis indicates that the earliest pollen-bearing sediments were deposited in pollen zone IV.

Birch bog (31 H/15, E½, Upton map-area; elevation *ca.* 260 feet; Figure 4). This bog, named by the writer, is 3.5 miles south of the St. Germain-de-Grantham village and is visible on aerial photograph A 12811-38. The bog has developed in a shallow depression on the southern flank of the Drummondville moraine. The organic deposit is underlain by marine clay and sand. The boring was made in the open area near the centre of the bog.

Pollen analysis indicates that the earliest pollen-bearing sediments were probably deposited in pollen zone VI.

St. Bonaventure bog (31 H/15, E½, Upton map-area; elevation *ca.* 165 feet; Figure 5). This bog is 1.5 miles southwest of St. Bonaventure village and is visible on aerial photograph A 12809-136. The bog has developed in a shallow depression on the marine clay plain north of the Drummondville moraine. Marine silty clay underlies the organic deposits. The upper part of the medium to poorly decomposed *Sphagnum*-peat is used commercially. The boring was made across the road and south of the peat factory. This bog is known also as the Yamaska bog (Girard, 1947).

Pollen analysis shows that the earliest pollen-bearing sediments were deposited in pollen zone IV.

Wilson Pond bog (31 H/9, Richmond map-area; elevation *ca.* 600 feet). This bog is 4.5 miles south-southeast of South Durham village. It developed in a depression in the bedrock. This depression is partly filled with glacial deposits and a part of the original lake remains as a pond. The organic deposit is underlain

[1] Number of National Topographic Series, map published by Surveys and Mapping Branch of the Department of Mines and Technical Surveys.

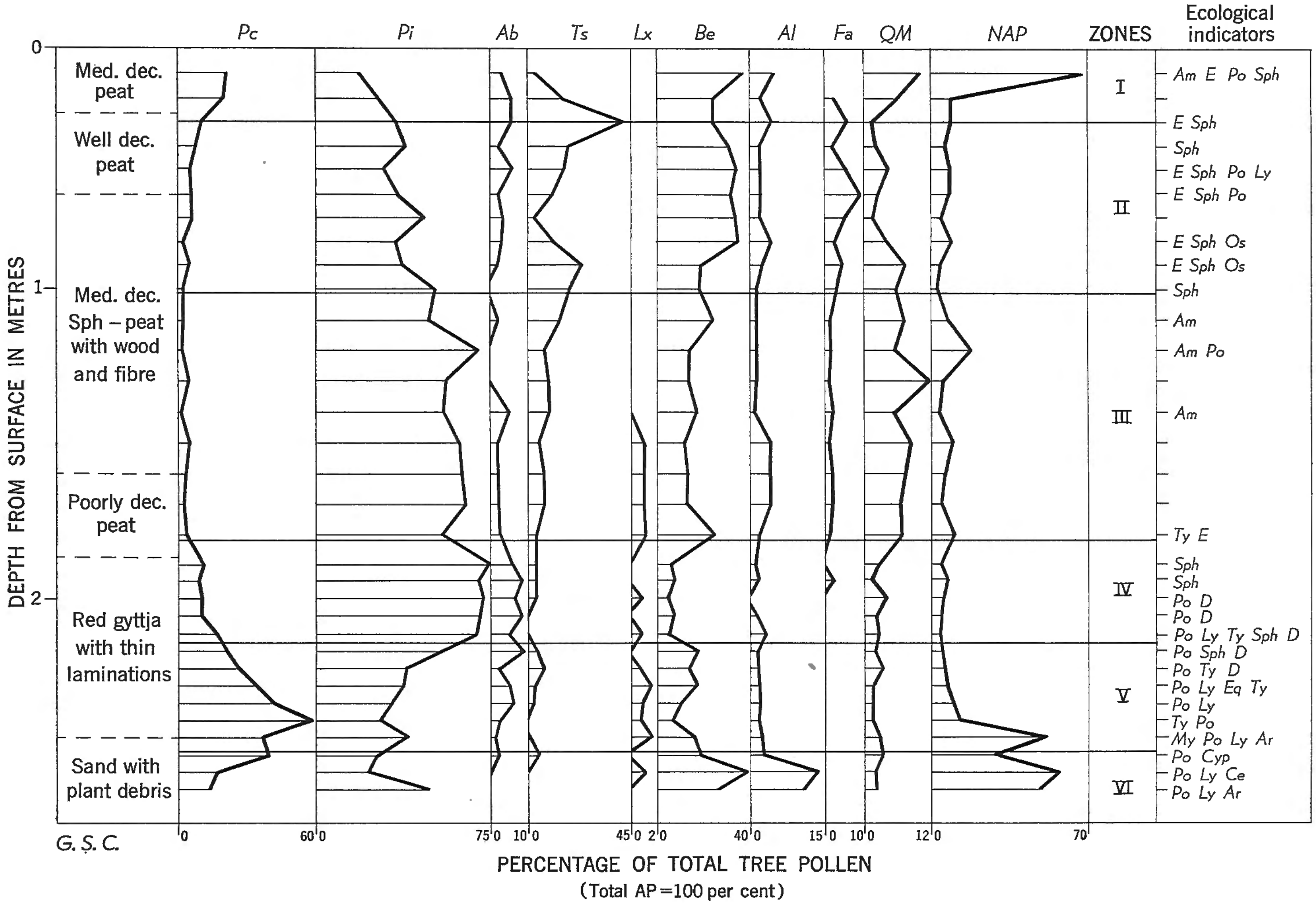

Figure 2. *St. Germain bog.*

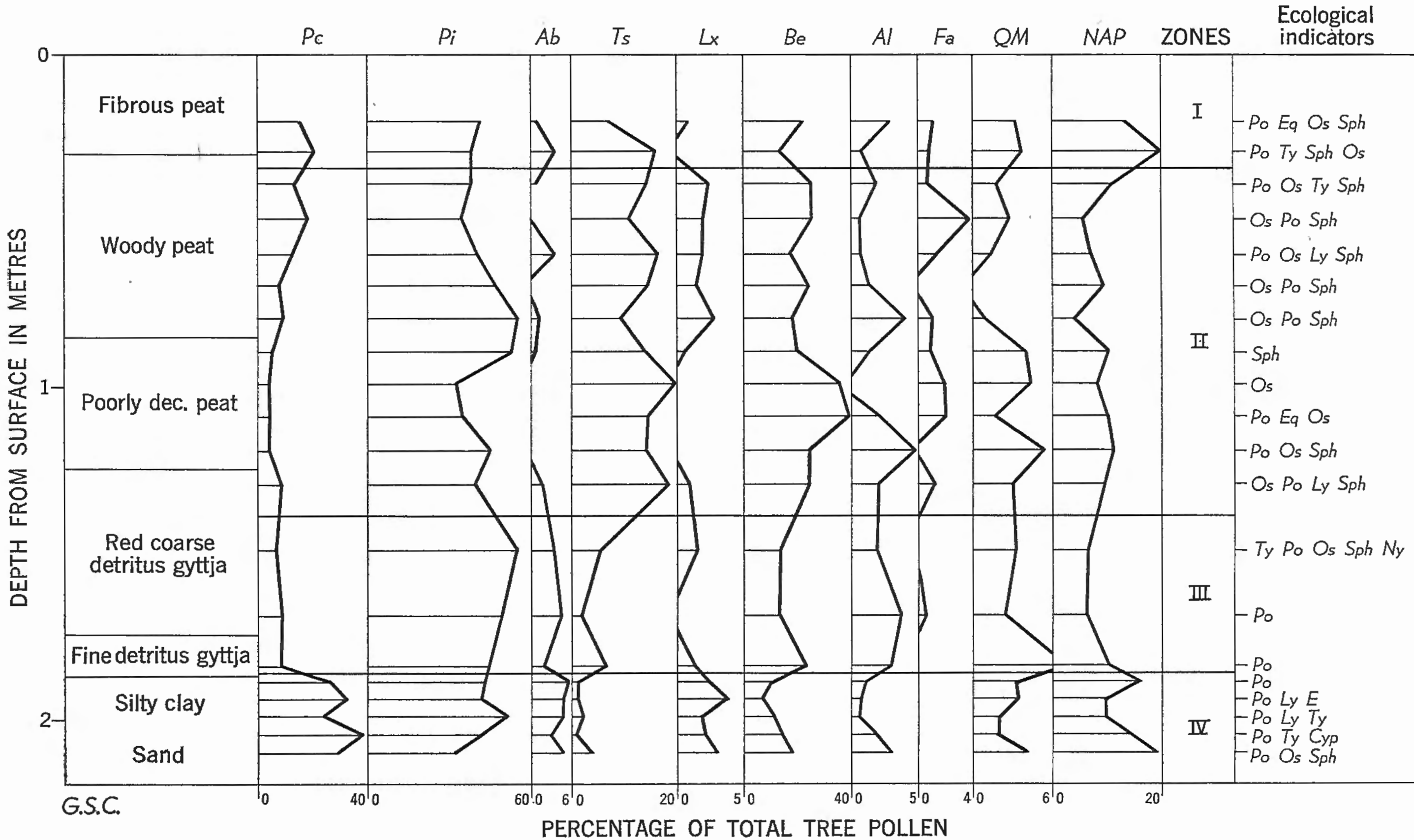

Figure 3. *St. Eugene bog.*

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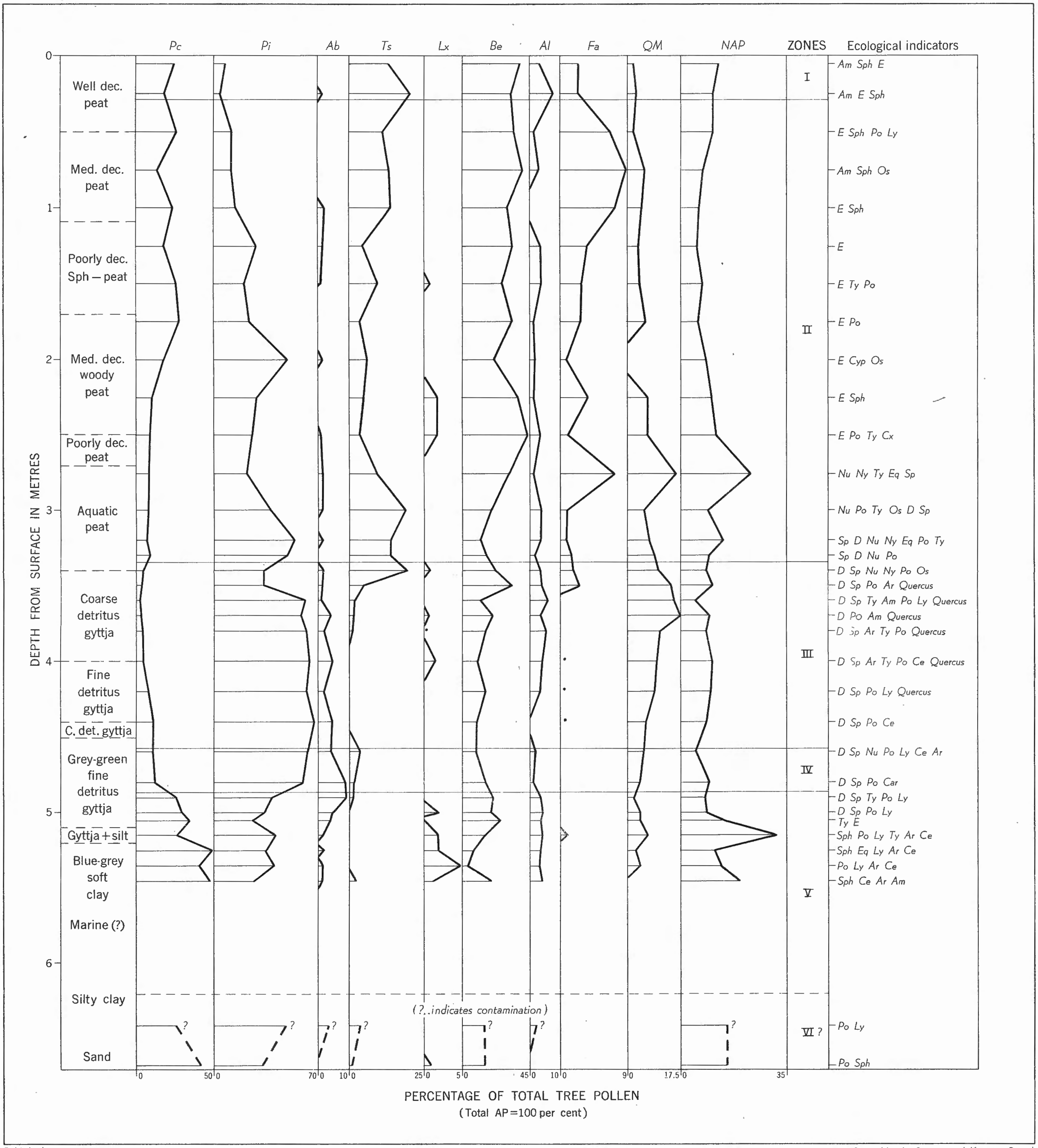

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Figure 4. Pollen diagram of Birch Bog, Quebec

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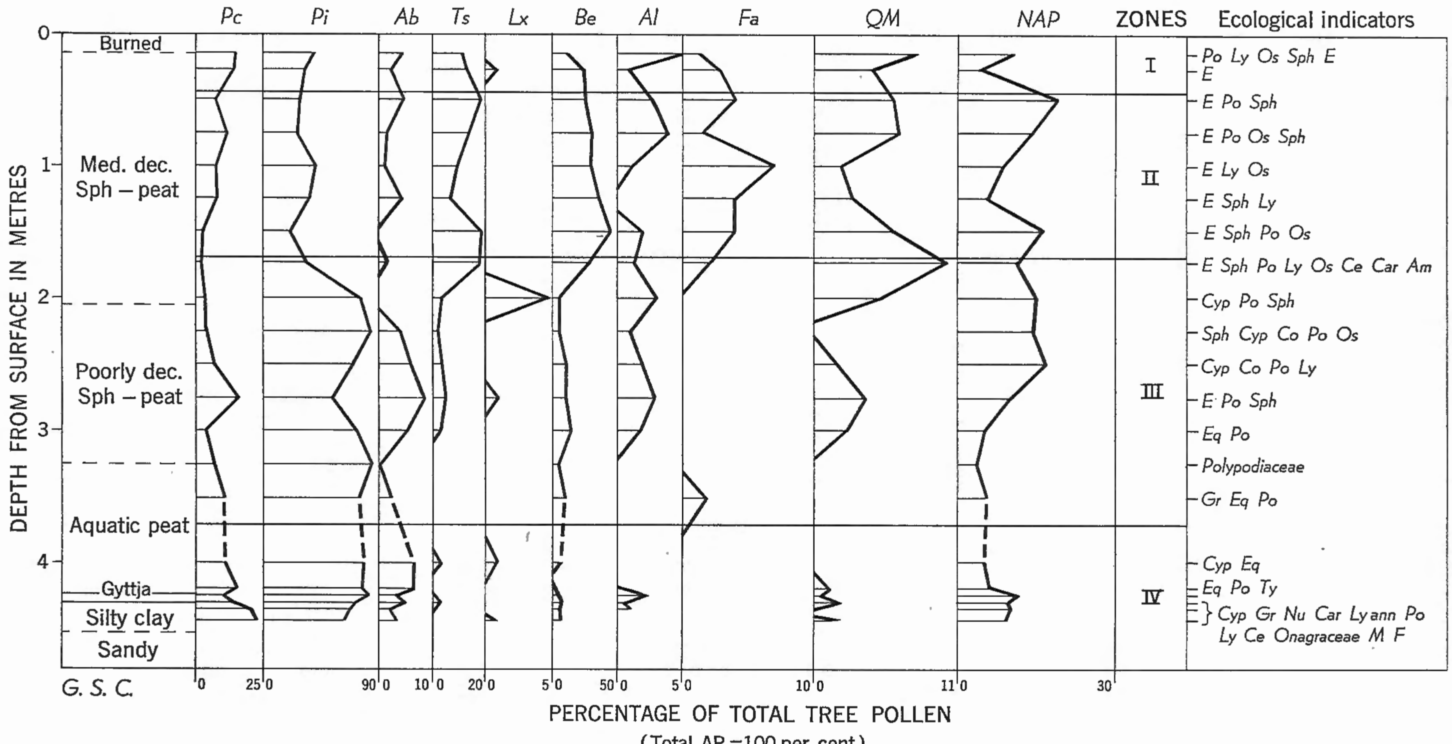

Figure 5. *St. Bonaventure bog.*

by stratified silty clay and sand changing gradually downwards into sandier material with angular pebbles. The boring was made about 650 feet southwest of the pond.

Pollen analysis shows that the earliest pollen-bearing sediments (silty clay with some sand and angular pebbles of black limestone) were deposited in pollen zone V, but the geological evidence seems to indicate a possible greater age. Further palynological study is desirable.

St. Valere bog (31 I/1, Aston map-area; elevation *ca.* 325 feet). This bog is about 0.7 mile north of the St. Valère-de-Bulstrode village. It has developed in a shallow depression and the organic deposit is underlain by sand. No clay was encountered by boring. It is probable that the depression is in a modified outwash deposit south of the Drummondville moraine. A strong beach was developed at about the position of the present 400-foot elevation on the slope of a bedrock outcrop about 2.5 miles south of the bog. The boring was made a quarter mile west of the main road and on the south side of the side road.

Pollen analysis indicates that the earliest pollen-bearing sediments were deposited in pollen zone V and possibly at the end of zone VI.

St. Albert bog (31 I/1, Aston map-area; elevation *ca.* 390 feet; aerial photograph A 13027-140). This bog is 1.5 miles north-northeast of St. Albert village in a shallow depression enclosed and underlain by sand. Fossiliferous, marine sand is exposed in the river bank at St. Albert village. The boring was made about 100 feet west of the jog in the road across the bog.

Pollen analysis indicates that the earliest pollen-bearing sediment (sand) was deposited in the end of pollen zone VI and early in zone V.

Blandford bog (31 I/8, Becancour map-area; elevation *ca.* 310 feet). This bog is 3.25 miles northwest of Blandford, in the southeast corner of the map-area. It is in a shallow depression on the top of the Drummondville moraine, northwest of the fairly extensive dune area. The boring was made in the open part of the bog east of the road.

Pollen analysis indicates deposition of the earliest pollen-bearing sediments early in zone V.

Louise Lake bog (31 I/8, Becancour map-area; elevation *ca.* 341 feet; aerial photograph A 13026-181). This bog is about 2.7 miles north-northeast of Blandford in a depression among high dunes on the crest of the Drummondville moraine. The boring was made a short distance to the southwest of the residual pond.

Pollen analysis indicates deposition of the earliest pollen-bearing sediments late in zone V.

Dosquet bog (21 L/6, St. Sylvestre map-area; elevation *ca.* 480 feet; Figure 6). The bog is about 4.5 miles southeast of Dosquet village. It has developed in a shallow depression on a sand plain between the Drummondville moraine to

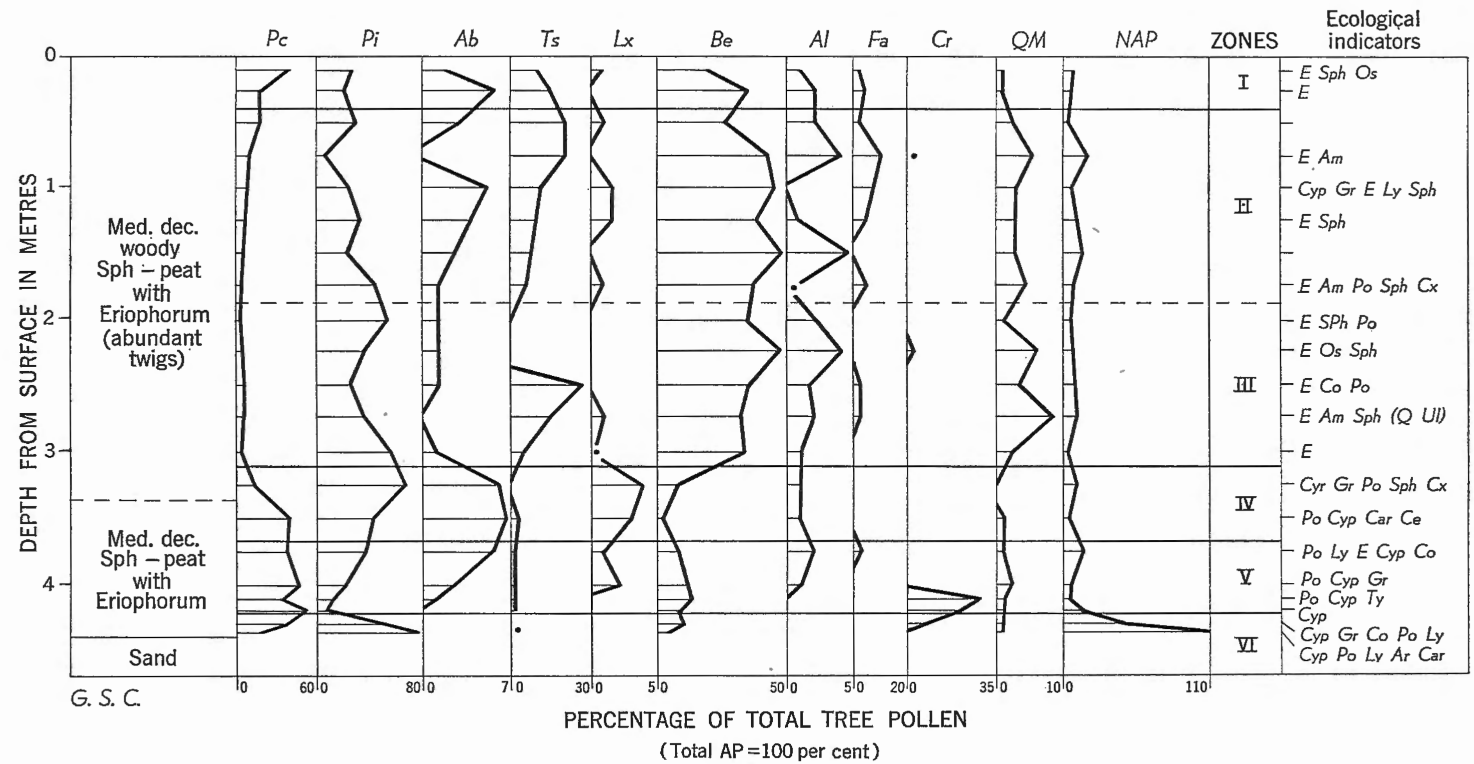

Figure 6. **Dosquet bog.**

the north and a bedrock highland to the south. The peat is underlain by sand. The boring was made in the open area, about 100 yards southwest of main road through the bog.

Pollen analysis shows that the earliest pollen-bearing sediments were deposited during pollen zone VI.

St. Paulin bog (31 I/7, Three Rivers map-area; elevation *ca.* 500 feet; Figure 7). This bog is 1.5 miles east of St. Paulin (St. Gabriel map-area; 31 I/6, E½) near the northwest corner of the Three Rivers map-area. The bog has developed on a silt and sand plain and is surrounded by dunes. Peat is underlain by sand. The boring was made south of the residual pond.

Pollen analysis indicates that the earliest pollen-bearing sediment (sand) was deposited during pollen zone IV.

Patterson Lake bog (31 I/7, Three Rivers map-area; elevation *ca.* 600 feet; Figure 8). This bog is 1¼ miles northwest of St. Elie village and east of Lake Patterson in the northwest corner of the map-area. The depression is surrounded by bedrock outcrops and the organic material is underlain by clay and silty clay (10 feet of clay was penetrated by boring but the sediment was too soft to sample).

Pollen analysis shows that the earliest pollen-bearing sediment (clay) was deposited in pollen zone VI.

The vertical distribution of fern spores in this bog seems to warrant further study. Spores of *Osmunda* are confined to zones I and II and Polypodiaceae reach a maximum in zone III (*see* Figure 8).

St. Boniface bog (31 I/7, Three Rivers map-area; elevation *ca.* 350 feet; Figure 9). This bog has developed in a shallow channel on a sand plain (delta), about 1.5 miles southeast of St. Boniface-de-Shawinigan village. The peat is underlain by sand. The boring was made west of the highway, in the open part of the bog.

The earliest pollen-bearing sediment (sand) was deposited in pollen zone V.

St. Etienne bog (31 I/7, Three Rivers map-area; elevation *ca.* 290 feet; Figure 10). This bog is about a half mile south-southeast of St. Étienne-des-Grès village, in an abandoned channel across a sand plain along the St. Maurice River. The boring was made near the middle of the bog and west of the highway.

Accumulation of pollen-bearing sediment (sand) started early in pollen zone IV.

Marchand bog (31 I/7, Three Rivers map-area; elevation *ca.* 200 feet; Figure 11). This bog is about a half mile southwest of Marchand Station and has developed in an abandoned channel in the sand plain along St. Maurice River. The boring was made west of the side road where some of the peat has been excavated. The peat is underlain by sand.

Accumulation of pollen-bearing sediment (sand) started in pollen zone III.

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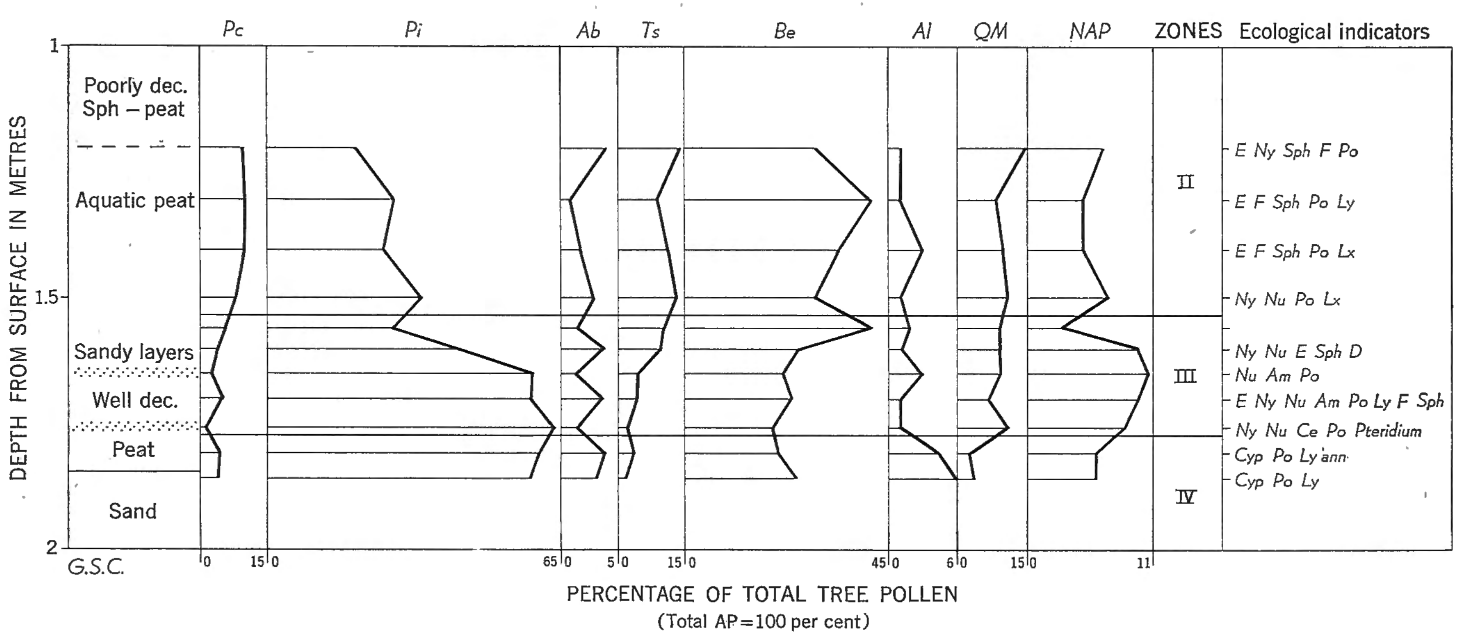

Figure 7. *St. Paulin bog.*

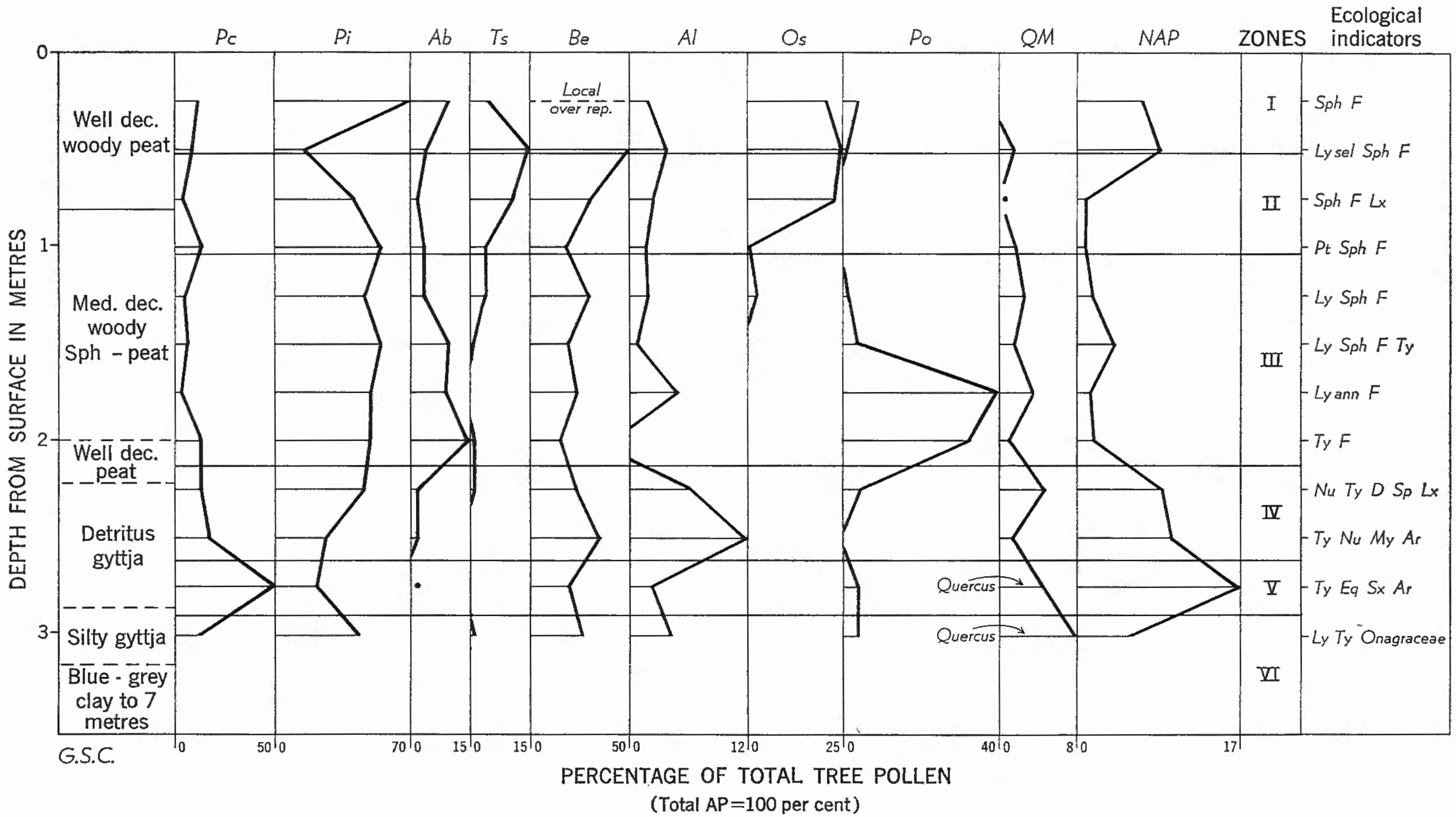

Figure 8. *Patterson Lake bog.*

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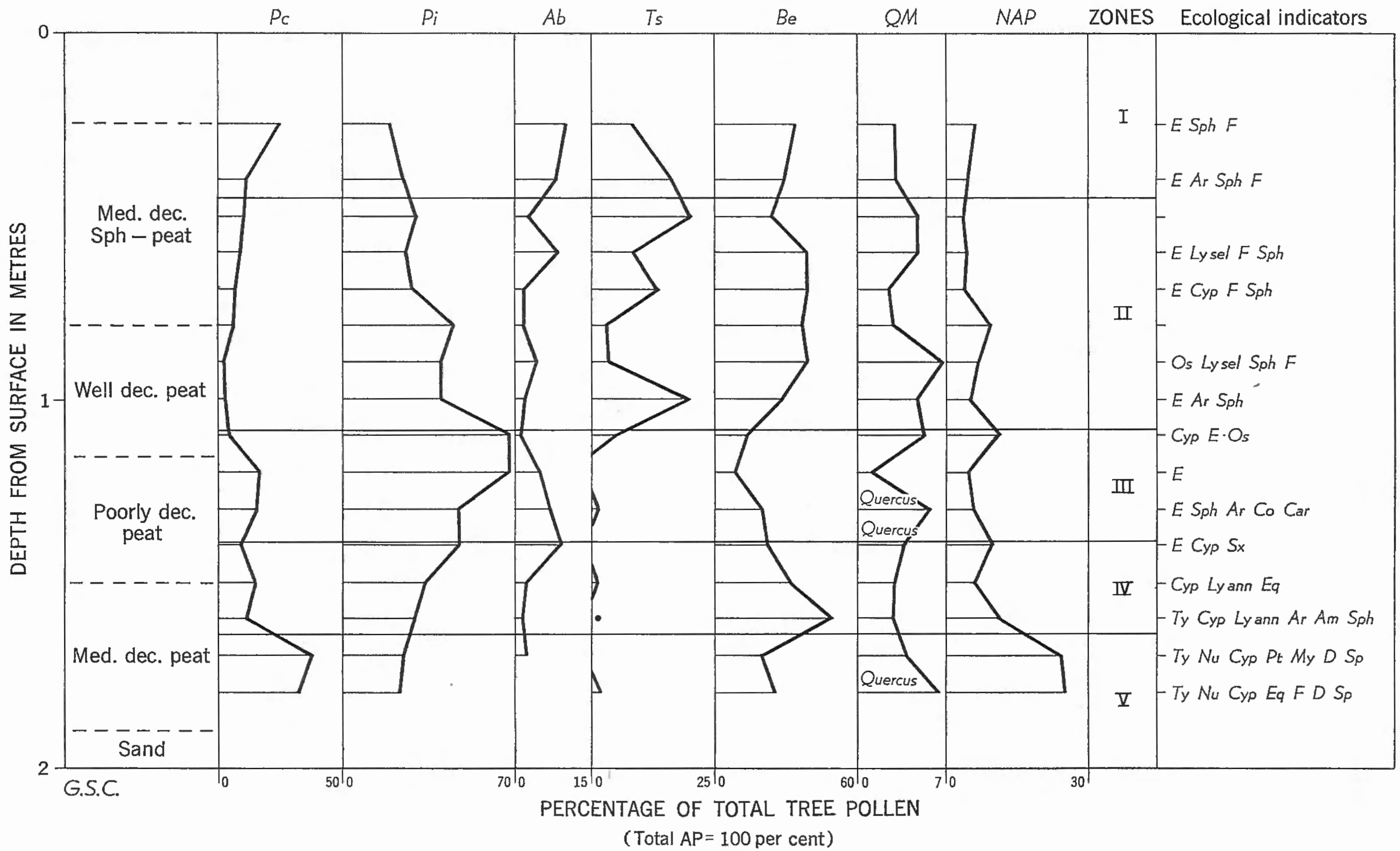

Figure 9. St. Boniface bog.

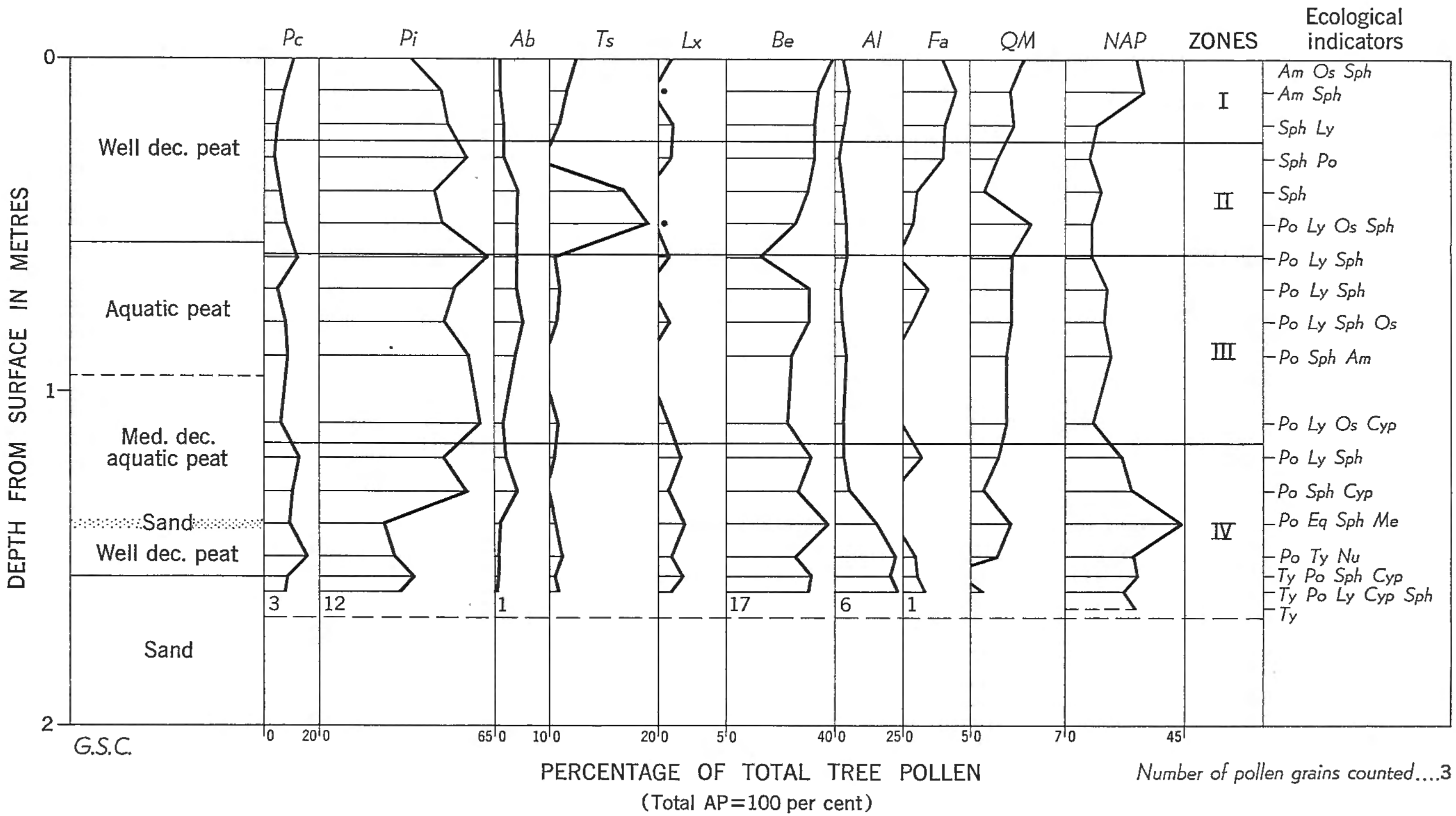

Figure 10. *St. Etienne bog.*

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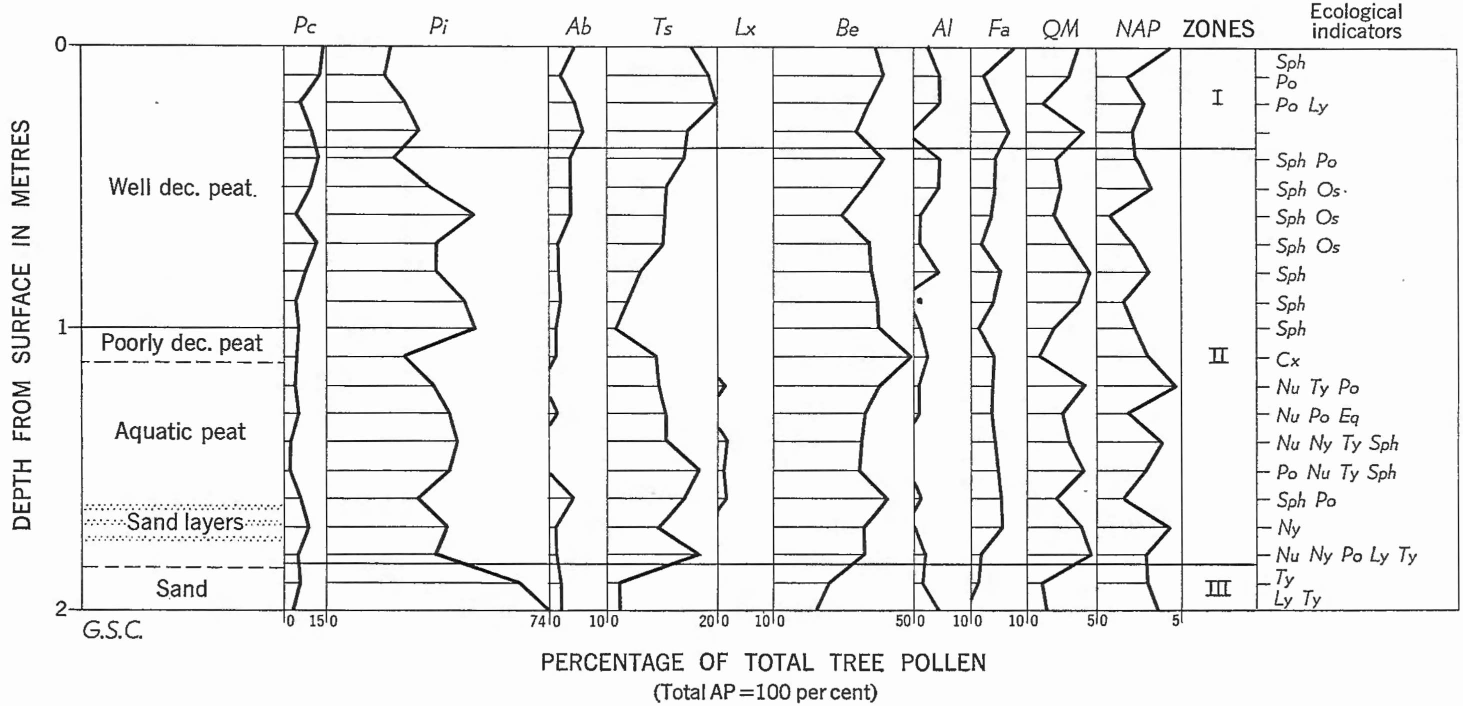

Figure 11. *Marchand bog.*

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Figure 12. Pollen diagram of Grondines Bog, Quebec

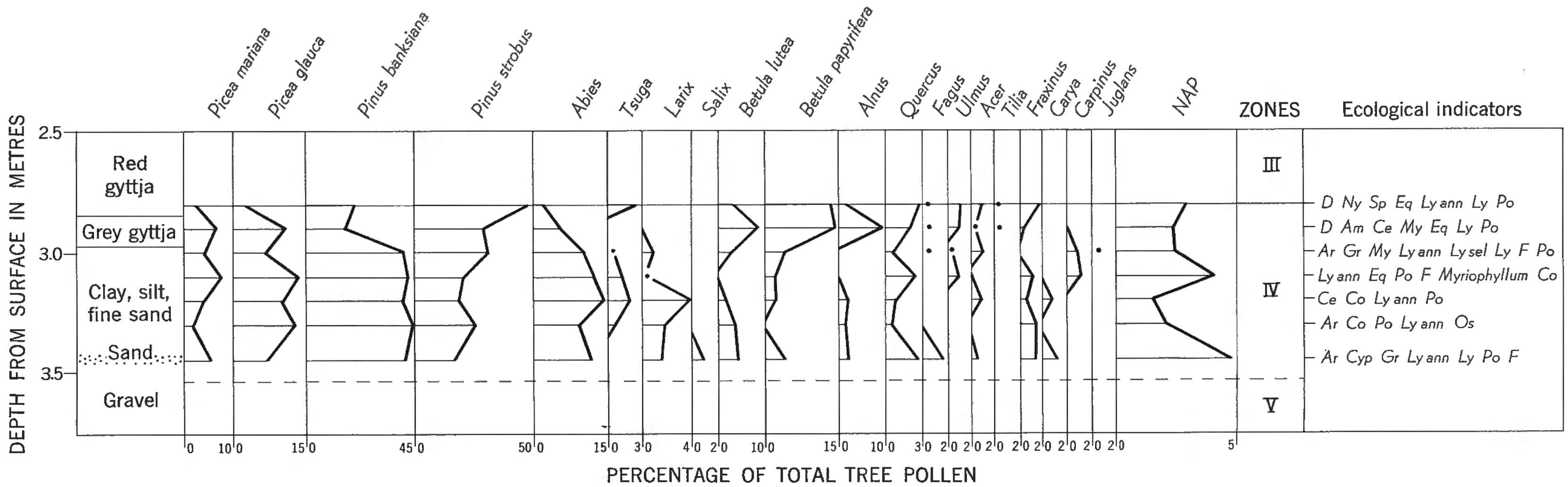


Figure 13. Pollen diagram of St. Alban Bog, Quebec

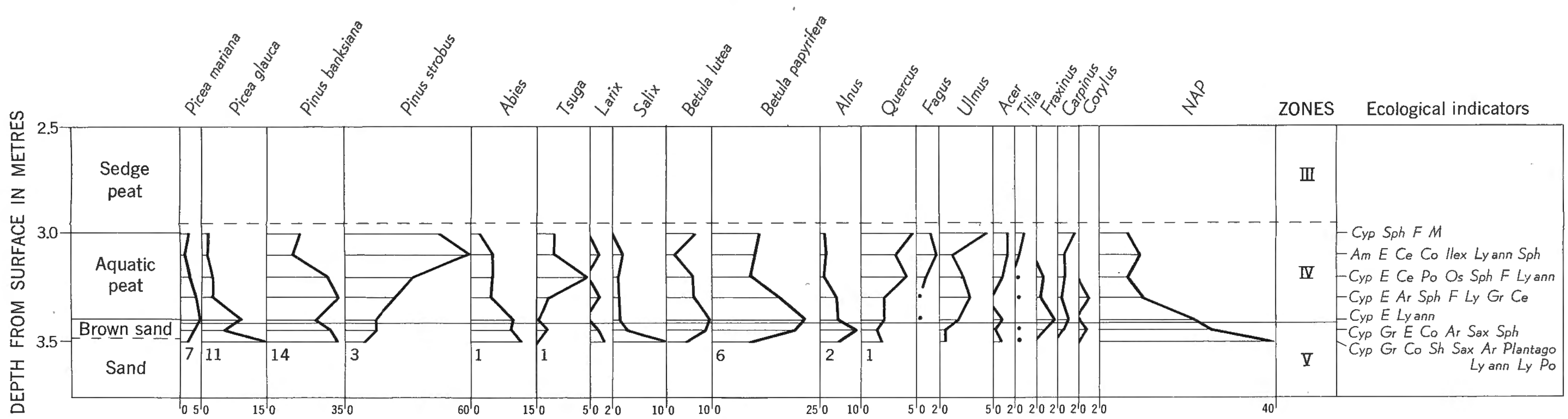
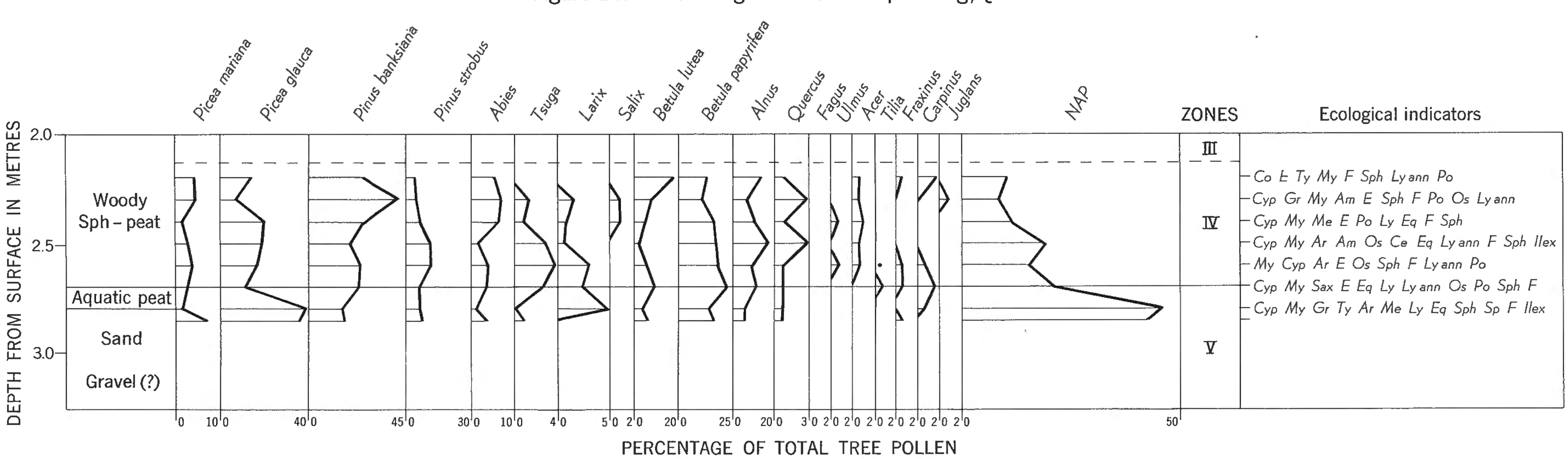


Figure 14. Pollen diagram of St. Adelphe Bog, Quebec



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Red Mill peat deposit (31 I/8, Becancour map-area; elevation *ca.* 90 feet). This peat deposit, partly buried under dune sand is exposed along the drainage ditch 100 to 200 yards north of Red Mill Station. The bog was formed on an ancient St. Lawrence River terrace, cut into marine clay, and later partly buried by sand blown from the scarp.

The buried peat was exposed by digging and pollen analysis shows that the peat was formed in the early part of pollen zone III.

Sherwin-Williams muck pit (31 I/8, Becancour map-area; elevation *ca.* 70 feet). This bog is about 2¾ miles west-northwest of Champlain village and has developed in an ancient channel of St. Lawrence River.

The peat is excavated commercially in order to recover the contained iron oxide for paint manufacture. The iron oxide is concentrated in the peat from iron-rich ground water that seeps through it.

Pollen analysis shows that the peat started to form early in zone III.

Champlain bog (31 I/8, Becancour map-area; elevation *ca.* 100 feet). This bog is about 3 miles northwest of Champlain village, in an old river channel. Samples were collected from an exposure in a drainage ditch along the west side of the road. The peat is underlain by sand.

Pollen analysis indicates that deposition of the earliest pollen-bearing sediments started early in zone III or late in zone IV.

Grondines bog (31 I/9, Grondines map-area; elevation *ca.* 110 feet; Figure 12). This bog is about a half mile northeast of Grondines Station in an old river channel and is shown on aerial photograph A 14601-65. The boring was made east of the road in a recently burned part of the bog. The organic deposit is underlain by stratified clay, silt, and sand, and the boring stopped in gravel.

The earliest pollen-bearing sediment (sand) was deposited early in pollen zone IV.

St. Alban bog (31 I/9, Grondines map-area; elevation *ca.* 220 feet; Figure 13). This bog has developed in a lagoonal depression (Karrow, 1957) behind a sandbar, 1.3 miles southeast of the St. Alban village. Dunes are common south and east of the bog which can be seen on aerial photograph A 14592-95. The boring was made near the centre of the open part of the bog.

Accumulation of the pollen-bearing sediment (sand) started in pollen zone V.

St. Adelphe bog (31 I/9, Grondines map-area; elevation *ca.* 420 feet; Figure 14). This bog has developed in an old river channel, about a mile northeast of St. Adelphe village. The boring was made about 100 feet north of the junction where the highway turns to the northeast.

Accumulation of the pollen-bearing sediment (sand) started in pollen zone V.

Pierreville section (31 I/2, W½, Yamaska map-area; elevation *ca.* 50 feet; Figure 15). This section is about 1.6 miles north-northeast of Pierreville where

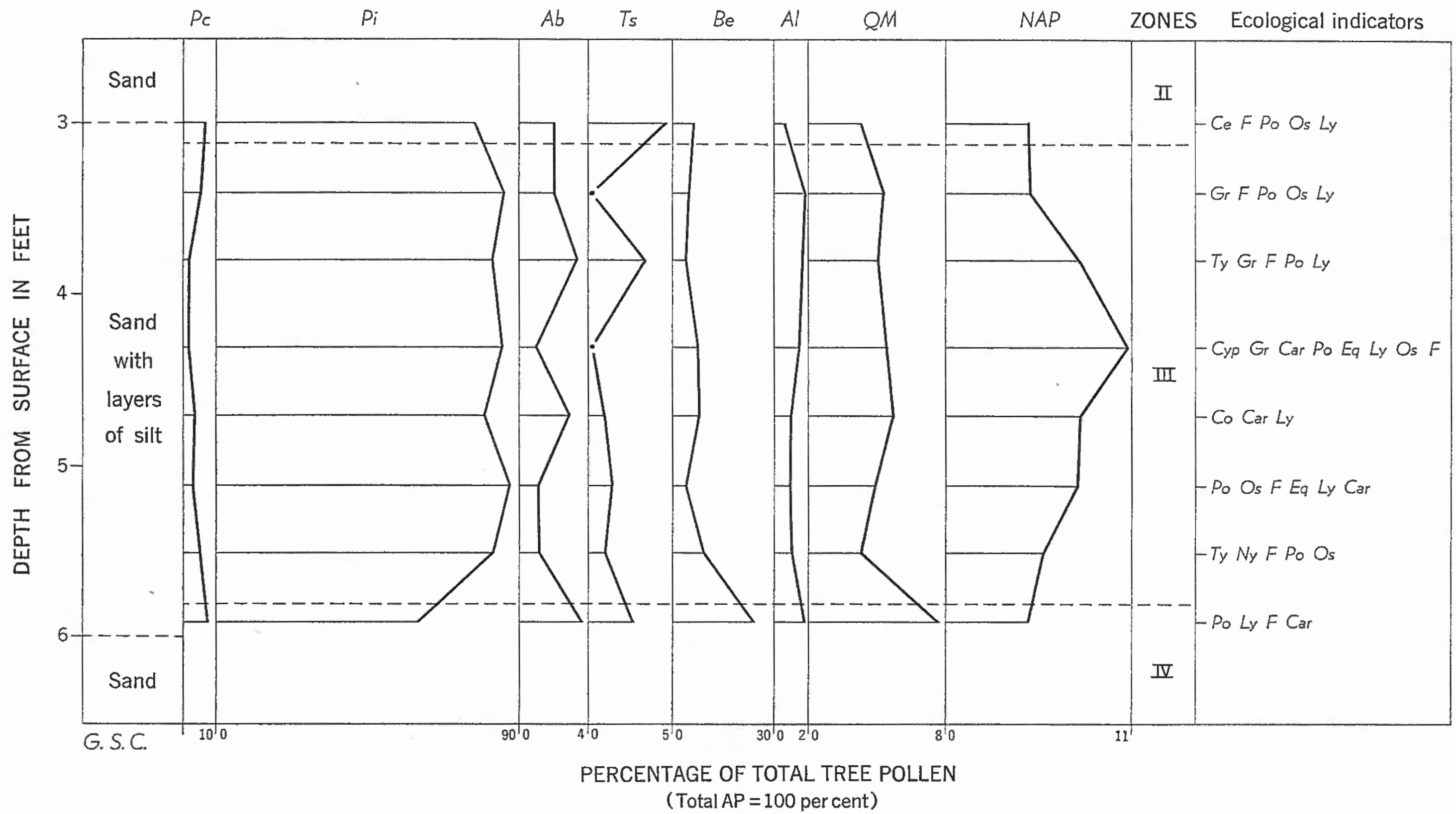

Figure 15. *Pierreville section.*

a sideroad cuts the river scarp. Horizontal layers of silt and fine sand, in coarse sand are exposed in the road-cut. The silt contains plant detritus and samples were collected for pollen analysis from these layers. The silt and sand are presumably alluvial deposits of an earlier stage of the present St. Lawrence River.

Pollen analysis shows that these deposits started to accumulate late in pollen zone IV or early in zone III.

PROCEDURE

The field sampling technique and laboratory treatment of samples have already been outlined by the writer (Terasmae, 1955 and 1958). Due to the primarily geological aim of this study, only parts (usually the earliest deposited parts) of some of the available sedimentary sequences were analysed for pollen. This procedure has proved sufficient for correlation and determination of the relative age of the partial sequences where they could be correlated with the standard pollen diagram for the region (Terasmae, 1958). For the same reason, only the necessary detail is shown in the pollen diagrams because of the need to cover a large area in a short space of time.

No radiocarbon analyses were made although many Hiller peat-borer samples were collected, as the writer believes that the sampling process may result in the contamination of one horizon by another (*see also* Hafsten, 1956, p. 31). To test this, comparative radiocarbon datings should be made of Hiller peat-borer samples and samples from nearby actual exposures of the same layers.

On the other hand it should, perhaps, be mentioned that recent studies have shown that rather extreme contamination is necessary to change significantly the radiocarbon dates for relatively recent deposits.[1]

THE REGIONAL POLLEN DIAGRAM AND THE POLLEN ZONES

After preliminary examination of the pollen diagrams from the bogs described above, the St. Germain bog was selected to provide the representative standard diagram for this part of the St. Lawrence Lowlands.

It is customary to divide a pollen diagram into zones (pollen zones) based on regionally recognizable changes in the pollen curves, caused by changes of climate and vegetation.

A zonation of the pollen diagrams for northern Quebec has been proposed by Ignatius (1956), but is not readily applicable to the present study. Another scheme for areas north of the St. Lawrence Lowlands has been proposed by Potzger (1953) and by Potzger and Courtemanche (1956). These authors

[1] After completion of this report a radiocarbon date was obtained for the basal organic deposits of the St. Germain bog, which indicates an age of 9,550±600 years (L 441-C) and 9,430±250 years (L 441-C; treated fraction of the sample).

recognize five pollen zones for post-glacial time in Quebec labelled Q-I to Q-V, Q-I being the oldest. The zones, as applied to the St. Lawrence Lowlands, have been defined and limited as follows (Potzger, 1953).

Q-I *Initial warm period.* Pine high, spruce-fir low, low hemlock peak, rising paper birch, low oak.

Q-II *Colder, moist.* Spruce-fir higher, small decrease in pine, small increase in paper birch, increase in oak and other broadleaved genera.

Q-III *Maximum warmth, dry (post-glacial thermal maximum).* Pine peak, decline of paper birch and hemlock, spruce-fir very low, increase in oak.

Q-IV *Warm, moist.* Hemlock, pine, beech, and other broadleaved genera, rising spruce-fir.

Q-V *Colder and moist.* Increase of spruce-fir, paper birch, broadleaved genera and yellow birch, appearance of chestnut, decline of pine and hemlock.

Potzger's zones can be applied to the present study, but, for the St. Lawrence Lowlands, the writer has found it necessary to subdivide the Q-III zone. He, furthermore, prefers to start numbering from the present and work 'down' the section, rather than number from the bottom up. This provides a fixed beginning point and allows for addition of zones, as older beds are recognized, without having to renumber the entire sequence. This system of numbering would prevent a recurrence of the difficulties encountered in northeastern United States where the gradual unfolding of the information resulted in the development of a complex system of zones (*see* Deevey and Flint, 1957).

On the basis of the standard pollen diagram for the region (that for the St. Germain bog), the pollen zones as shown in Table I are proposed. Table I also shows the probable correlation with pollen zones for northeastern United States and Quebec north of the St. Lawrence Lowlands.

For correlation and dating the problem of the time equivalence of pollen zones from different regions is important. The terms post-glacial and late-glacial are closely associated with ice movements and hence do not denote the same time in different regions. As shown in Table I, late-glacial deposits of Connecticut are older than those of Maine, although the younger zones are equivalent in time. Caution is therefore necessary in applying the radiocarbon dates of pollen zones in one region to pollen zones in another region. Studies made in Sweden by Lundqvist (1957 a, b) show, however, that at least the more recent pollen zones are equivalent in time over wide areas.

Time equivalence of zones III and IV of the St. Lawrence Lowlands with zone C1 of Maine seems satisfactory to the writer, as an approximate age of 9,500 years for the bottom of zone VI in the St. Lawrence Lowlands seems probable. This estimate is based on the application of radiocarbon chronology established for pollen zones in Connecticut (Barendsen, Deevey, Gralenski, 1957) by correlating the pollen diagrams of the two areas.

Table I

Pollen zones for the St. Lawrence Lowlands and their probable correlation with other zones proposed for eastern North America.

NORTHEASTERN UNITED STATES (Deevey and Flint; 1957) YEARS B.P.	ZONES				QUEBEC (Potzger and Courtemanche 1953, 1956)	ST. LAWRENCE LOWLANDS (This report)	
	C III		POST-GLACIAL	SUB-ATLANTIC Oak - chestnut	Q-V Colder, moist	POST-GLACIAL	I *Decline of hemlock, pine; Increase of spruce and Quercetum mixtum (QM)*
2,000	C II	HYPSITHERMAL	POST-GLACIAL	SUB-BOREAL Oak - hickory	Q-IV Warm, moist	POST-GLACIAL	II *High beech, hemlock Decline of pine, QM Slight increase of spruce, fir, birch*
4,000 – 6,000	C I	HYPSITHERMAL	POST-GLACIAL	ATLANTIC Oak - hemlock	Q-III Warm, dry	POST-GLACIAL	III *Low spruce, fir, hemlock, beech; High white pine, QM*
8,000						POST-GLACIAL	IV *High jack-pine, fir; low birch, QM; decline of spruce*
	B	HYPSITHERMAL	POST-GLACIAL	BOREAL Pine	Q-II Colder	LATE-GLACIAL	V *Spruce maximum, low pine decline of NAP*
10,000					Q-I	LATE-GLACIAL	VI *Low spruce; high pine, birch, alder, NAP*
12,000	A L IN MAINE	LATE-GLACIAL MAINE		PRE-BOREAL Spruce, fir, pine, oak		LATE-GLACIAL	CHAMPLAIN SEA; ST. NARCISSE RE-ADVANCE
							LACUSTRINE EPISODE
	T III	LATE-GLACIAL MAINE		YOUNGER HERB ZONE Park-tundra		MAIN WISCONSIN GLACIATION	
14,000	T II	LATE-GLACIAL CONNECTICUT		PRE-DURHAM SPRUCE Spruce, pine, birch		MAIN WISCONSIN GLACIATION	
	T I	LATE-GLACIAL CONNECTICUT		OLDER HERB ZONE Tundra		MAIN WISCONSIN GLACIATION	

G.S.C.

THE CHAMPLAIN SEA

The marine inundation of the St. Lawrence Lowlands, the Champlain Sea episode, has been the subject of many papers. For the historical background the reader is referred to the studies of Gadd (1955) and Karrow (1957).

The present investigation, based on geological observations and the study of pollen diagrams, indicates that the level of the Champlain Sea had receded to the position of the present 250-foot elevation, when, about 9,000 years ago, the crest of the Drummondville moraine emerged. Whether or not this datum can be considered to mark the end of the Champlain Sea episode is perhaps questionable, because marine conditions may have prevailed for some time after that event. However, it is noteworthy that marine fossils are present in surface deposits between the 250- and the 450-foot elevations whereas below 250 feet the surface deposits (generally sand) are mostly non-fossiliferous.

Palynological studies of stratified silt and sand beneath the marine sediments in the Riviere aux Vaches section, exposed in the west bank of the St. Francis River 3 miles southeast of Pierreville (Table II), may shed light on the beginning of the Champlain Sea episode. In this exposure grey till (Gadd, 1955) is overlain by 2 to 3 feet of sand and stratified silt. This silt and sand is interpreted as evidence for a lacustrine episode (Table I) following deposition of the grey (upper) till, because no marine fossils could be found in this sediment even by a microscopic examination. This sand and silt grades upwards into marine sediments. Pollen assemblages from the stratified silt and sand are illustrated in Table II.

Table II

Pollen Assemblages from Riviere aux Vaches Section

Lithology	Percentages of pollen based on the total count of arboreal pollen							Ecological indicators
	Pc	Pi	Be	Al	Ab	QM	NAP	
Marine sediments								
Stratified lacustrine silt and sand	53	27	12	5	—	4	6	Po Co
	58	24	9	5	1	3	5	Ly Po Os Sph
	45	27	13	12	1	2	9	Ly Po Sph Cyp Co Ce
	55	19	18	4	3	1	12	Po Sph E Co
Till (sandy, calcareous, grey)								

Similar pollen and spore assemblages were found from deposits in the same stratigraphic position exposed in the banks of Southwest Nicolet River south of La Visitation (Figure 1).

The writer hesitates to suggest a definite age for these pre-Champlain Sea sediments before more studies have been made, but a sub-arctic climate may be inferred.

There is good agreement between the results of the present palynological investigation of the St. Lawrence Lowlands, and those made on the highlands to the north of it by Potzger (1953), Potzger and Courtemanche (1956), and Ignatius (1956). The studies north of the Lowlands indicate that the ice had retreated north of the Mont Tremblant Park (about 70 miles north of Montreal) prior to the post-glacial thermal maximum (the Hypsithermal interval according to Deevey and Flint, 1957), and that central Labrador was deglaciated during that warm post-glacial episode.

As the St. Narcisse readvance occurred before the Champlain Sea had receded below the position of the present 250-foot elevation, an event tentatively dated at about 9,500 years ago, a minimum age of this order is indicated for that readvance.

The palynological study also indicates that the recession of the Champlain Sea from its postulated maximum level was rapid; pollen diagrams from sites near the crest of the Drummondville moraine, which emerged at or near the close of the Champlain Sea episode, and from sites near the maximum level of the Champlain Sea both show pollen zone VI at the base.

CHRONOLOGY OF POST-CHAMPLAIN SEA EVENTS AND DIFFERENTIAL UPLIFT

After the sea-level had receded below the position of the present 250-foot elevation in the Drummondville area the further gradual recession is indicated by numerous scarps and terraces. The pollen diagrams from bogs developed on these terraces reveal that the bottom sediments become progressively younger the lower the terraces are. The bottom sediments from bogs at about the 50-foot elevation near Pierreville were formed early in zone III. These bogs and the corresponding terrace are believed to be 6,500 years old. It appears that rapid down-cutting of the St. Lawrence River took place during the time of pollen zone IV. No pollen diagrams have been worked out for bogs on the lowermost 25-foot terrace.

A comparative analysis of pollen diagrams from the Lowlands, both north and south of St. Lawrence River, shows that the 'oldest' bogs, all within the limits of the Champlain Sea inundation on both sides of the river, extend back to zone VI. It is probable that all these bogs (*see* Figures 2, 3 and 4 near Drummondville; and Figures 8 and 14 at Lake Patterson and St. Adelphe, north of the river) started to develop at about the same time. The bogs north of the

St. Lawrence River, however, are at present about 200 feet higher than the bogs near Drummondville. It is suggested that this is due to differential uplift during post-Champlain Sea time. The distance between these bogs in north-south direction is about 70 miles. A differential uplift of 3 or 4 feet per mile is necessary to account for this difference in elevation.

Many of the ancient river channels cut into the complex delta formation along the St. Maurice River are partly filled with peat deposits. A palynological study of the earliest formed pollen-bearing sediments in these channels also shows that channels at lower elevations are successively younger. Pollen diagrams from the oldest channels studied show that the channels were abandoned during pollen zone V, about 8,500 years ago. The St. Boniface bog (Figure 9) formed in a channel at about 350-foot elevation. Another channel (the Marchand bog, Figure 11) at about 200-foot elevation seems to have been abandoned during pollen zone III, about 6,000 years ago. This date seems, however, to be too late, probably because rapid accumulation of windblown sand may have prevented the preservation of the pollen for some time after the channel was abandoned. Detailed palynological studies on bogs developed on the terraces along the St. Lawrence would enable the correlation of terraces on either side of the river, and over great lateral distances.

The present palynological study has also shown that in some instances (for example the St. Paulin bog, Figure 7) a significant hiatus may be present between the time a depression is isolated and pollen-bearing sediment starts to accumulate. This seems to be particularly true for depressions in bedrock or enclosed by sand deposits.

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PART II

A PALYNOLOGICAL STUDY OF THE PLEISTOCENE INTERGLACIAL BEDS AT TORONTO, ONTARIO

Abstract

Interglacial sands, silts, and clays are exposed in the Don Valley brickyard and the Scarborough Bluffs along the shore of Lake Ontario at Toronto. The basal beds consist of York till separated by a time interval from the overlying non-glacial beds. These are subdivided into the Don beds at the base and the Scarborough beds above, which are separated from each other by a hiatus and possibly a short glacial episode. The glacial beds above this are subdivided into the Sunnybrook till, the Danforth beds, and the Thorncliffe beds, in ascending order.

Palynological and palæontological studies show that Don beds were laid down when the annual mean temperature was warmer by some 5°F than now, and the Scarborough beds when it was some 10° colder.

The Don beds were certainly deposited during an interglacial period, possibly to be correlated with the Sangamon. The Scarborough beds are tentatively assigned to the St. Pierre interval and may have formed during a substage in the onset of the Wisconsin stage proper.

Résumé

Des sables, des vases et des argiles interglaciaires affleurent dans la briqueterie de la vallée Don et les falaises de Scarborough, le long de la rive du lac Ontario, à Toronto. Les lits de base se composent de till York séparé par un intervalle chronologique des lits surjacents, d'origine non glaciaire. Ces derniers se subdivisent en lits Don à la base et lits Scarborough au haut, séparés les uns des autres par une lacune stratigraphique et peut-être aussi par un court intervalle glaciaire. Puis se superposent des couches d'origines glaciaire, qui sont, de bas en haut, le till Sunnybrook, les couches Danforth et les couches Thorncliffe.

Il ressort d'étude paléomicrobotaniques et paléontologiques que la mise en place des lits Don et des lits Scarborough s'est produite à des époques où la température moyenne annuelle était plus élevée de 5°F qu'à l'heure actuelle dans le premier cas, et plus basse de 10°F dans le second.

Il est certain que les lits Don se sont formés au cours d'une période interglaciaire, à rattacher peut-être à l'intervalle Sangamon. On fait remonter, jusqu'à plus ample informé, les lits Scarborough à l'intervalle Saint-Pierre. Il se peut que leur formation date d'un sous-âge des premiers temps de l'âge Wisconsin proprement dit.

INTRODUCTION

The Toronto interglacial beds are best exposed in sections at the Don Valley brickyard and at the Scarborough Bluffs along the shore of Lake Ontario. They have been known to students of Pleistocene geology for almost a century, and their chronology and stratigraphic position in the Pleistocene column has been the subject of many studies.

A comprehensive investigation of the problem was made by A. P. Coleman who reported on the results in several publications over a period of 50 years (*see especially* Coleman, 1933 and 1941). In connection with the Toronto Rapid Transit Subway construction another study was made of these interglacial beds by A. K. Watt (1953, 1957). The lithology of the Toronto interglacial beds was the subject for a M.Sc. thesis by A. B. Gray (1949), and further lithological studies, especially of the till-sheets, were made by Dreimanis (1955, 1958).

Assemblages of plant and animal fossils in the interglacial deposits were studied by Coleman (1933), and were used by him to interpret the climate and chronology. A palynological and lithological study of the interglacial beds was recently part of the subject for a Ph.D. thesis by the writer (1955).

The study of macrofossils, lithology, and stratigraphy failed to establish a definite chronological position for the interglacial beds (Baker, 1920; Flint, 1947) and it is hoped that the study of microfossils will shed new light on the problem. This study is in part a continuation of the writer's earlier studies.

LITHOLOGY OF THE PLEISTOCENE DEPOSITS AT TORONTO

Don Valley Brickyard

Although detailed descriptions of the lithology and sequence of the Pleistocene deposits of the Don Valley brickyard (*see* Plate I) have been given by Coleman (1933), Gray (1949), and Terasmae (1955), additional description appears warranted because of the importance of the deposits. Especially is this so because some of the beds pinch out and a buried erosional valley occurs in the section. Furthermore, quarry operations continued to remove the beds. The present account of the brickyard deposits combines observations made during the last 5 years.

The bedrock in the Don Valley brickyard is Ordovician shale, belonging to the Dundas formation. The first record of Pleistocene glaciation is that of glacial striae. The writer observed these on only one occasion when glacial till was being stripped from the shale to permit further quarrying, and they were soon obliterated by the heavy truck traffic. The striae indicated that ice flowed from the Lake Ontario basin.

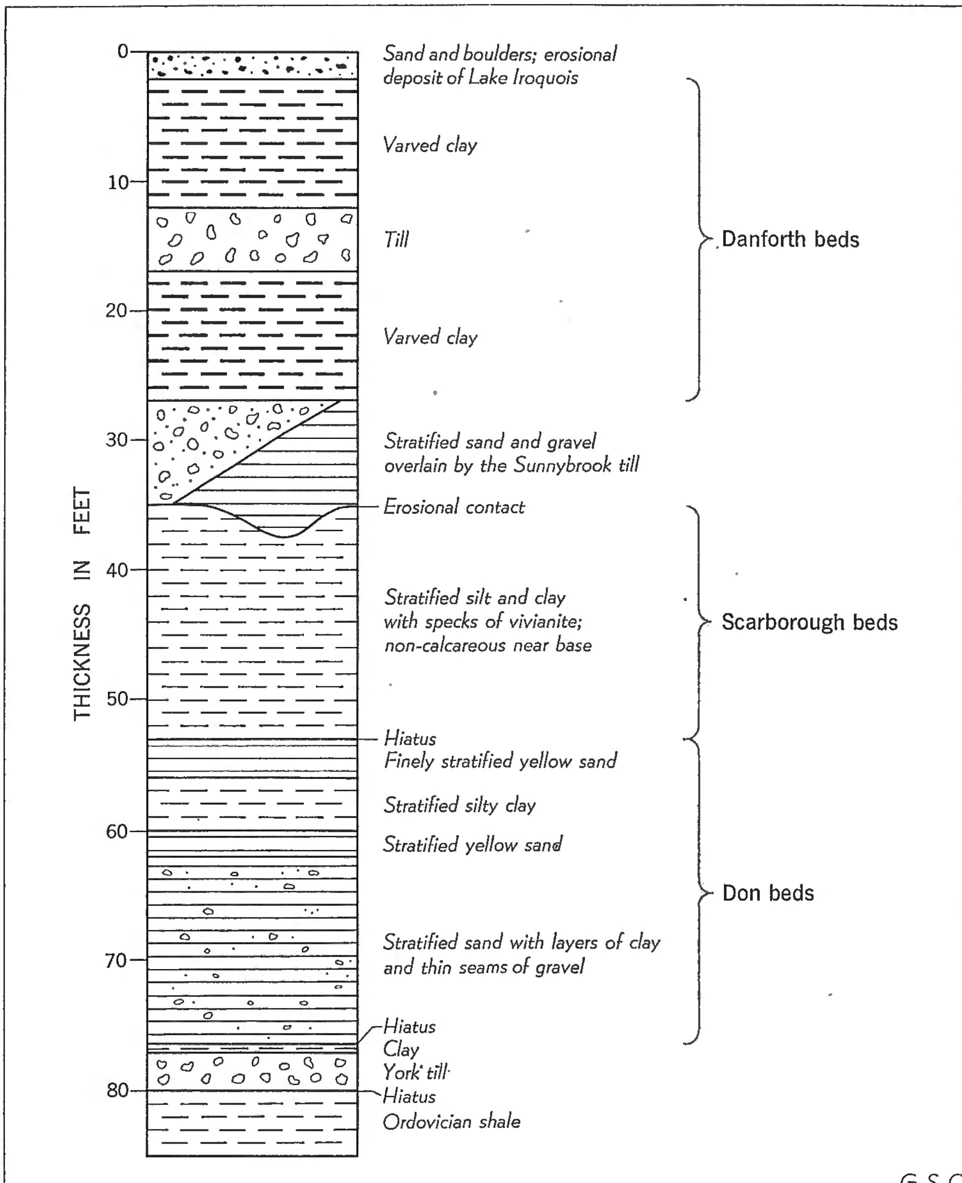

Figure 16. ***Sequence of Pleistocene deposits in the Don Valley brickyard.***

The Ordovician shale is overlain by till, a foot to 4 feet thick. This till-sheet is here named the York till to distinguish it from other till-sheets in the region (*see* Figure 16). The upper surface of this till is uneven and no weathering has been observed. Immediately overlying the York till is a layer of clay generally a few inches thick. Microfossils from this clay suggest deposition during a warm, interglacial climate. A significant hiatus is therefore present between the York till and the sequence of deposits that follow, and the surface of the till has been eroded.

The York till is overlain by the interglacial Don beds, which have a maximum thickness of 25 feet. The Don beds consist of stratified sand, interbedded with layers of clay and silt and lenses of gravel (Plate III A). None of the lithologic members is continuous horizontally across the exposure (Gray, 1949). Microfossils are most abundant in the clay and silt layers, whereas pelecypods and gastropods are mostly concentrated in the sand and fine sand. Fossil wood (Plate III B) has been found chiefly in a sequence of stratified sand and laminated silt about 10 feet above the top of the York till. Coleman (1933) reported abundant fossil leaves from this part of the Don beds, and seams of plant detritus (Plate IV A) have been observed by the writer. The alternating beds of stratified sand and silt near the top of the sequence have been oxidized to a yellow colour. The topmost rust-brown sand bed is partly cemented. All members of the Don beds are more or less calcareous.

The Don beds are separated from the overlying Scarborough beds by a layer of hard, compact sand. This sand is non-calcareous and contains pebbles and occasional cobbles. It is probable that a considerable hiatus is present between the Don and the Scarborough beds.

The Scarborough beds consist of stratified silt and clay with a total observed thickness in the brickyard section of about 20 feet. The base is non-calcareous and contains specks of blue vivianite.

The Scarborough beds were eroded by proglacial streams that carved valleys of appreciable size. These were later partly filled with sand, gravel, boulders, and slabs of the laminated Scarborough silt (Plate IV B). In the Don Valley brickyard the valley filling carries a limited freshwater molluscan fauna whereas the adjacent Scarborough beds are non-fossiliferous.

The contact between the Scarborough beds (Plate IV B valley fill unit) and the overlying glacial deposits is also an erosional contact. The glacial deposits comprise a complex of interfingering till-sheets and varved clays with gradational contacts. Antevs (1928) counted about 1,500 varves in this complex.

The surface of the till-varved clay complex, in the brickyard section, is a terrace of Lake Iroquois and lying on it is a thin mantle of sand and boulders. Farther up the Don Valley the till-varved clay complex is overlain by sand and yet another till (Coleman, 1933), the Thorncliffe beds and the Leaside till, respectively (Figure 17).

Scarborough Bluffs

The most complete section through the Pleistocene deposits at the Scarborough Bluffs is exposed in the almost vertical sides of Seminary gully (*see* Plate II) and along the lake shore east and west of this gully, that is, about 1,000 feet east of the end of Undercliffe Drive on the property of St. Augustine Seminary.

Coleman (1933) reported that the Don beds were encountered a few feet below lake level by digging a test-hole at the foot of the bluffs at Scarborough. In 1956 the writer made ten test borings with a hand auger, east and west of Seminary gully. One boring about 50 yards west of the gully, at the foot of the bluffs, penetrated 12.5 feet of Scarborough beds. These consist of stratified silt and clay. The bottom 2 feet were found to be non-calcareous and the silt contains specks of blue vivianite. Beneath the silt is a layer of hard sand, similar to that at the base of the Scarborough beds in the Don Valley brickyard exposure. This was penetrated with difficulty but once through it the auger dropped suddenly about 2 feet. This drop occurred in loose sand, saturated with water under pressure. A rush of water and gas escaped up the bore-hole when the auger was withdrawn. The gas was ignited and a small explosion and fire ensued which exhausted the gas supply in a few seconds (*see also* Coleman, 1933, p. 54).

Correlation between the basal 15 feet of the Scarborough beds in the Don Valley brickyard section and those penetrated at the foot of the Scarborough Bluffs is indicated by their lithological similarity. The palynological evidence for this correlation is discussed later in this report. It also seems reasonable to assume that the sand, encountered below the base of the Scarborough beds, corresponds to the top of the Don beds of the Don Valley brickyard section.

The section above lake level in Seminary gully, herein termed the Seminary section, (*see* Figure 17) begins with about 100 feet of silty clay, silt, and sand. The sand occurs as partings in well-stratified silt beds (Plate VI B), and mostly carries plant detritus. Finely disseminated plant detritus, pollen, and spores are also present in beds of massive silt and fine sand (Plate VI A). The origin of these massive beds is not known but they are not unlike the loess deposits near Bloomington, Indiana (Thornbury and Wayne, 1957).

Overlying the 100-foot silty clay and silt member is about 40 feet of stratified sand (the sand-member). In the basal few feet of this sand are isolated seams of sand charged with plant detritus, which also occurs in coarse, crossbedded sand near the top of the sand member of the Scarborough beds (*see* Plate V B). These two members comprise the Scarborough beds.

An erosional unconformity separates the Scarborough beds from the overlying Sunnybrook till (Plate V A). This till is continuous over the length of Seminary gully and varies in thickness from 10 to 20 feet. It is a dense, light grey, calcareous silt till with few pebbles. Above this till are the Danforth beds, made up of some 50 feet of interfingering layers of till and sand with minor silt and silty clay.

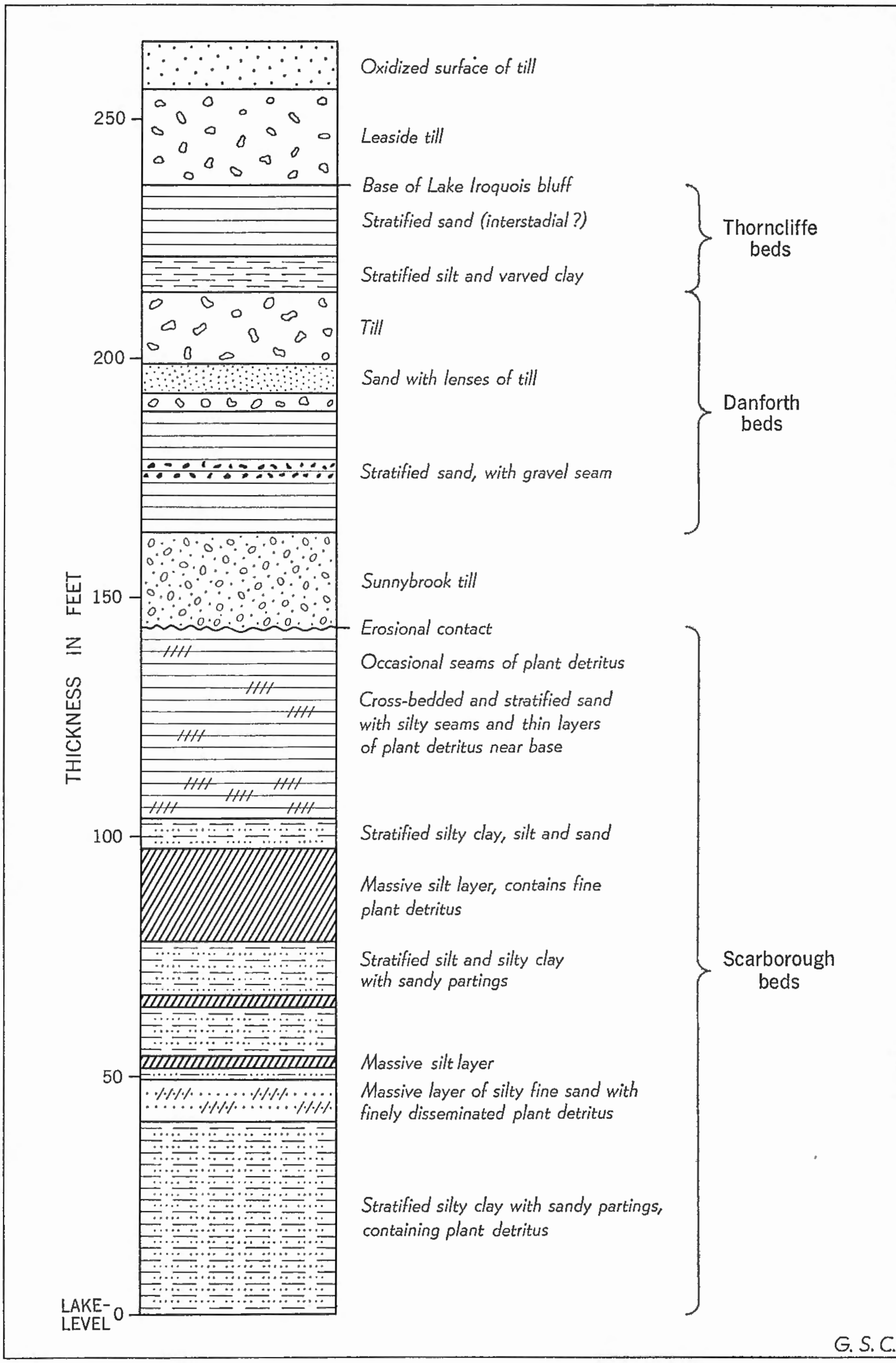

Figure 17. **Sequence of Pleistocene deposits in the Seminary section.**

Above these beds in turn are the Thorncliffe beds. These are about 20 feet thick and consist of a basal part of silt and varved clay, and an upper sandy part. Watt (1953) suggested that these sands may be interstadial.

Resting on the Thorncliffe beds is the Leaside till. This is about 30 feet thick and is oxidized to a depth of 10 feet. Erosion of the waves of glacial Lake Iroquois removed much of this till from the underlying Thorncliffe beds back from the present shore of Lake Ontario. They thus form a marked bluff with its base in the uppermost part of the Thorncliffe sand beds (Plate II B).

Another good section of the Sunnybrook till and the Danforth beds occurs at the south end of Scarbora Crescent, about 0.4 mile west of the Seminary gully. This section is herein termed the Dutch Church section (*see* Figure 18). The Sunnybrook till forms vertical cliffs that rise about 65 feet above the lake shore. The till is overlain by 80 to 85 feet of stratified silty clay and varved clay which is being eroded along the lake front and in adjoining gullies. Like the till, it maintains very steep to vertical slopes. In places differential erosion produces

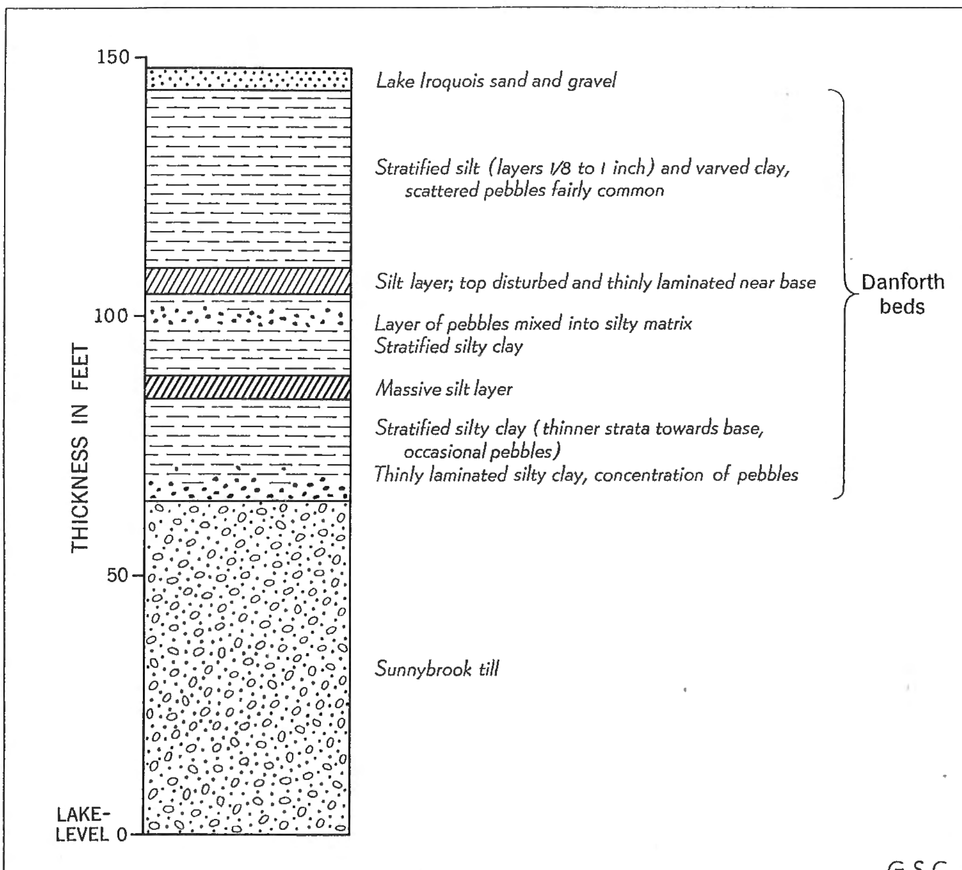

Figure 18. ***Sequence of Pleistocene deposits in the Dutch Church section.***

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sharp spires, and the remarkable assemblage of spires in this vicinity led to this phenomenon being known locally as 'the Dutch Church' (Coleman, 1933).

In 1958 a buried soil profile was discovered by A. Dreimanis of the University of Western Ontario, in exposures between the Seminary and the Dutch Church sections. The section was examined by the writer. The soil profile has developed on the Lake Iroquois terrace, and is buried under 2 to 4 feet of calcareous sand; depth of leaching is about 8 inches. Its chronological position has not been determined.

THE TORONTO FORMATION AND AN INTERPRETATION OF ITS LITHOLOGY

The interglacial beds at Toronto were named the Toronto formation by Coleman (1933). According to him the Toronto formation consists of two probably conformable members, the Don beds and the Scarborough beds. This terminology has been followed to date.

Coleman (1933) appreciated (on basis of fossils) the climatic differences that prevailed during the deposition of the Don and the Scarborough beds, but he felt that a continuous section was nevertheless present. The changes in deposition he concluded were being brought about by advancing ice that caused higher lake levels and a colder climate immediately before the area was completely overridden.

Gray's study (1949), however, suggests that there was a hiatus between the Don and Scarborough beds, and the presence of a probable till, now disintegrated, is proposed. Further observations made by the writer in the field and in the laboratory have yielded sufficient evidence to suggest that there is a significant break between the Don and the Scarborough beds, and that a glacial episode probably took place.

On the basis of present evidence the writer suggests that the Pleistocene deposits at Toronto be submitted as shown on Table III.

The sequence of events as interpreted from the lithology and the organic record of the Pleistocene deposits at Toronto has been outlined by Coleman (1933), Gray (1949) and Watt (1953). As the interpretation of the same lithological sequence by the writer differs somewhat, a brief discussion of the lithology seems pertinent.

The lithology of the Don beds indicates that they were deposited in a shallow lake, whose level was probably 60 feet higher than that of present Lake Ontario (Coleman, 1933). The stratified deposits were laid down by a river entering the former lake from the north and the position of the river channel must have shifted from time to time to account for the rapid changes in the sequence of sediment (Plate III A). The uppermost part of the Don beds consists of stratified sand, and this is interpreted as evidence for a further shallowing of the lake. This lowering of the lake level was accompanied by a cooling of the climate, as

Table III

Table of Pleistocene Formations

Era	Period or epoch	Formation		Lithology	Correlation
CENOZOIC	PLEISTOCENE	Leaside till		Sandy, till, pebbles of local bedrock abundant	Wisconsin glacial stage
		Thorncliffe beds		Stratified sand and varved clay	
		Danforth beds		Lenticular till beds stratified sand, silt and varved clay	
		Sunnybrook till		Silt till, few pebbles	
		Unconformity			
		Scarborough beds	Upper	Stratified sand (fossiliferous)	St. Pierre interstadial(?)
			Lower	Stratified silty clay (fossiliferous)	
		Unconformity (glacial episode?)			
		Don beds		Stratified sand, clay, gravel (fossiliferous))	Sangamon interglacial
		Unconformity			
		York till		Pebbly, clay till	Illinoian (?)
Unconformity					
Palæo-zoic	Upper Ordovi-cian	Dundas formation		Interbedded shale and limestone (fossiliferous)	

indicated by the palynological evidence (*see* Figure 19). The lowering of the lake level cannot be explained by upwarp of the land because at the end of a long interglacial interval the rebound of land should have ceased. More probably, the writer suggests, it was caused by an approaching glacial episode which resulted in somewhat lower sea-level and a renewed down-cutting by rivers. The marked cooling of the climate, resulting in a decrease in evaporation and a correspondingly higher run-off, caused conditions favourable for leaching. The non-calcareous, leached sand, separating the Don beds from the Scarborough beds, marks this episode of low lake level and increased leaching. This is supported by Gray's statement (1949) that much time elapsed between the Don beds and the Scarborough beds, "... because of the extreme effects of weathering".

The writer tentatively correlates this episode of increased leaching with an advance substage of the approaching Wisconsin glaciation (Terasmae, 1957), although the ice may not have reached the Toronto area.

After the deposition of the leached sand beneath the Scarborough beds an episode of high lake level is indicated by the lower Scarborough stratified silty clay (*see* Figure 17 and Table III). Both palynological and palæobotanical evidence indicate boreal to sub-arctic climatic conditions at that time, and a coniferous forest grew in the Toronto area. It has been suggested by Coleman (1933), Gray (1949), and Watt (1953) that the high lake level was caused by advancing ice blocking the outlet. If the drainage from the former stage of Lake Ontario followed the present one, through the St. Lawrence Valley, the blocking of this outlet by ice should have occurred at the northeastern end of the St. Lawrence Lowlands.

Retreat of ice once more allowed the drainage from Lake Ontario basin to flow through the St. Lawrence Valley and the lake level dropped, as indicated by the upper Scarborough stratified sand. It is tentatively suggested by the writer that the St. Pierre interval is a correlative of this episode.

The down-cutting that followed lowered the lake level still farther and eventually valleys were cut through the Scarborough beds; occasionally even through the Don beds. The advance of the main Wisconsin ice overrode the St. Pierre beds in the St. Lawrence Lowlands and the Scarborough beds at Toronto depositing the Sunnybrook till.

The Danforth beds, the Thorncliffe beds, and the Leaside till were deposited during the retreat of the Wisconsin ice.

PALYNOLOGICAL STUDY OF THE INTERGLACIAL BEDS

The results of the palynological study have been compiled into two pollen diagrams (*see* Figures 19 and 20), one for the Don Valley brickyard section and the other for the Seminary section of the Scarborough Bluffs.

All deposits sampled were predominantly inorganic and the chemical treatment of samples involved five principal steps.

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Figure 19. Pollen diagram of Don Valley Brickyard section Toronto, Ontario

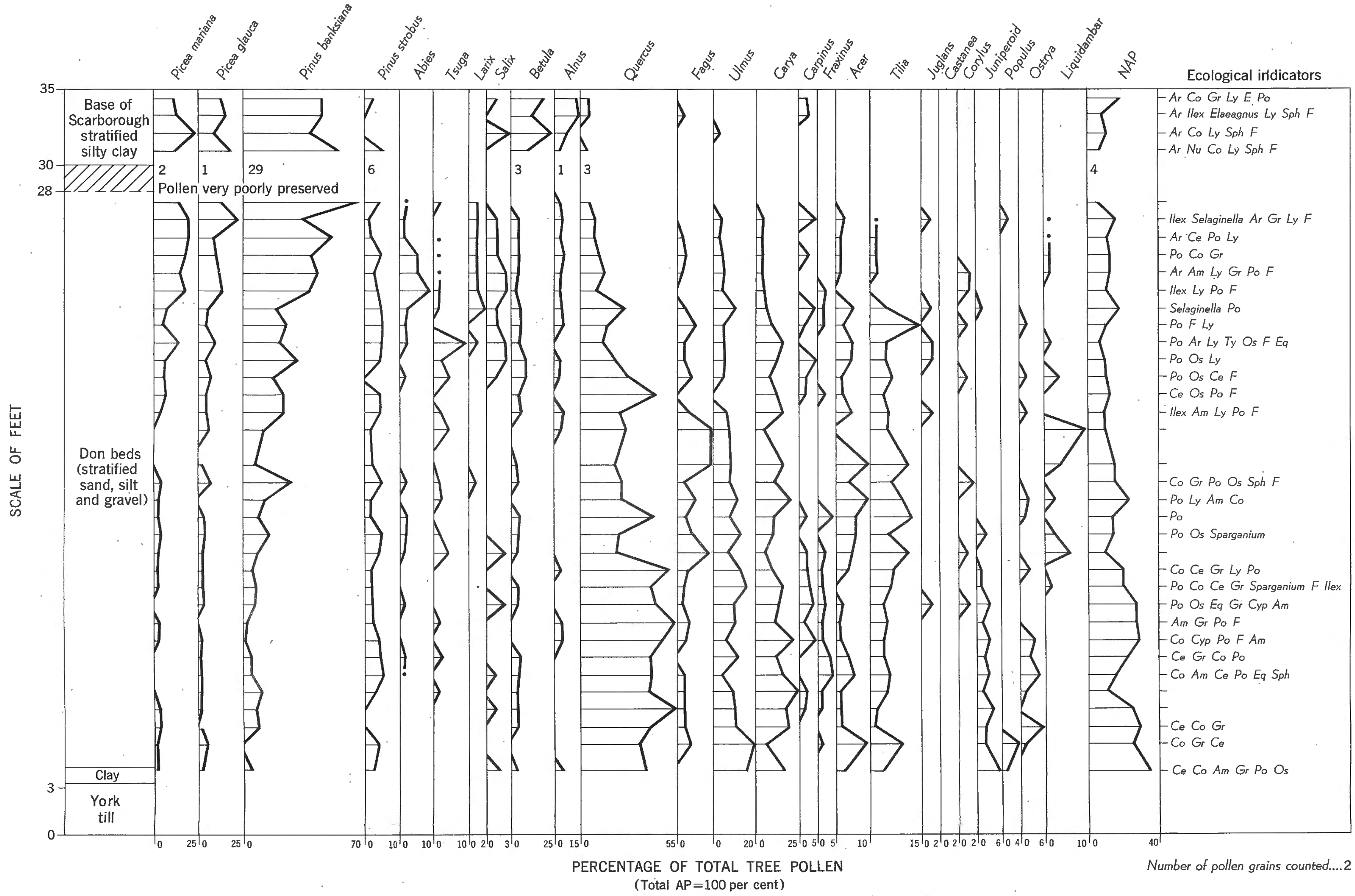
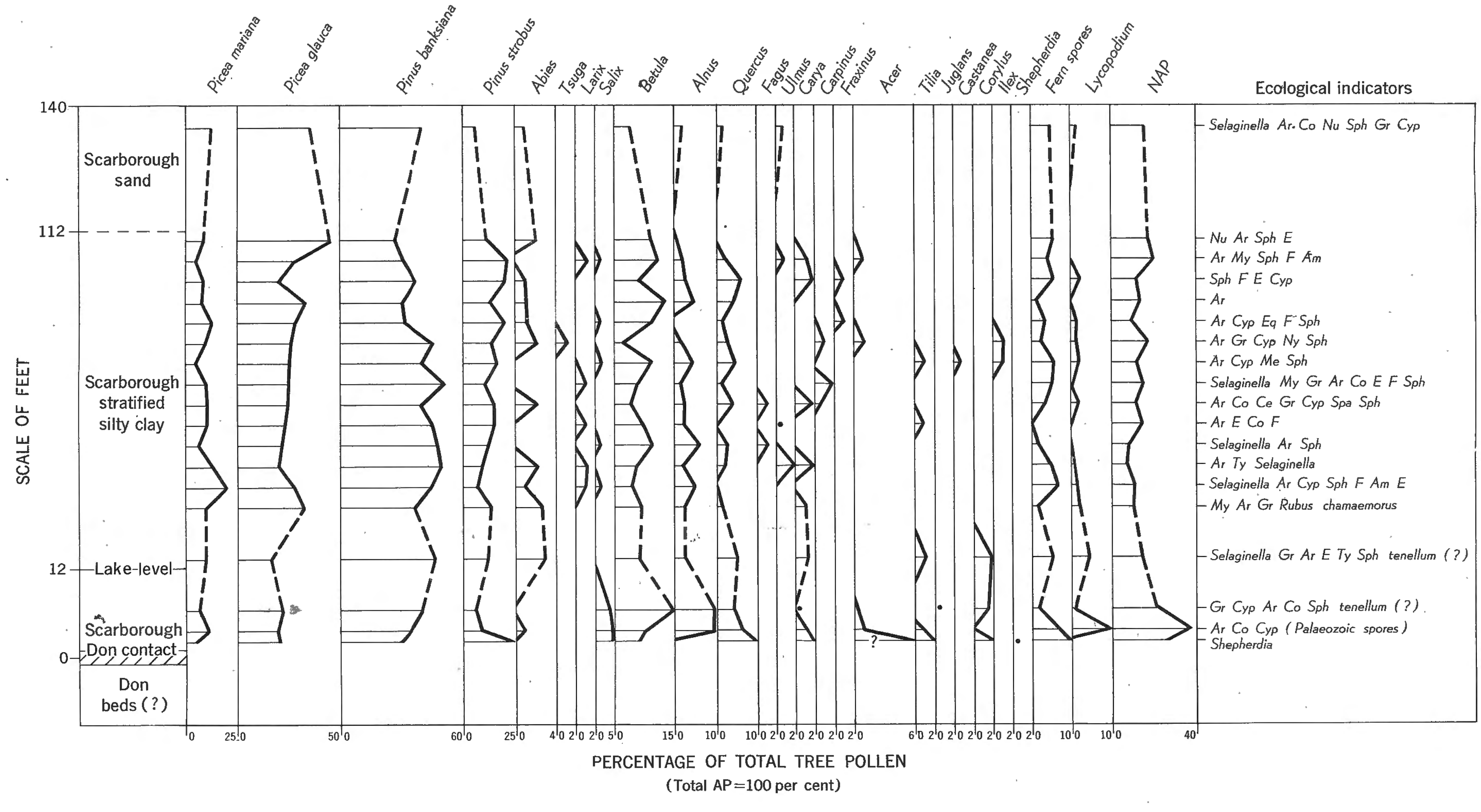


Figure 20. Pollen diagram of the Seminary section, Scarborough Bluffs, Toronto, Ontario



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1. Mechanical or chemical disaggregation.
2. Removal of the coarse fraction by decantation.
3. Removal of carbonates by hydrochloric acid.
4. Removal of silica by hydrofluoric acid.
5. Concentration of pollen and spores by the acetolysis method.

The problem of secondary pollen and spores has been considered but, as the pollen diagrams show an orderly sequence of changes in the vegetation, the amount and influence of the secondary pollen upon the primary pollen assemblages seems in most cases to be of little importance.

Samples of only the fine-grained layers (clay, silt, and fine sand) were collected for pollen analysis. Coarse sand and gravel were also sampled but proved deficient in pollen.

Diatoms have been studied in several samples from the Don beds by the writer and one representative assemblage will be described in this report.

The Don Beds

As shown in Figure 19, the pollen sequence in the Don Valley brickyard section begins with assemblages indicative of temperate climatic conditions. The forest was composed of oak (*Quercus*), elm (*Ulmus*), hickory (*Carya*), basswood (*Tilia*), maple (*Acer*), and an unimportant component of spruce (*Picea*), and pine (*Pinus*). Birch (*Betula*), alder (*Alnus*), willow (*Salix*), poplar (*Populus*), cedar (*Thuja*), and juniper (*Juniperus*) were present. The late-glacial and boreal episodes of the preceding glacial (Illinoian) stage and the beginning of the Sangamon interglacial stage are entirely missing, indicating a hiatus between the York till and the basal clay of the Don beds.

Judging by what is known of the development and succession of the post-glacial forests, it is probable that the record of at least 5,000 years is missing at the base of the Don beds. The hiatus, however, may be much longer as the deciduous forest indicated by the pollen assemblages from the base of the Don beds is closely similar to the present one in southern Ontario, and forest of this type may have existed at the Don Valley site for an appreciable part of the inter-glacial episode without being preserved, because of unsuitable conditions.

The pollen assemblages from the lower part of the Don beds reveal the presence of a hardwood forest indicative of a warm, interglacial climate. The presence of *Liquidambar* pollen, which is not found today in the Toronto region, is of particular interest.

The pollen assemblages from the top part of the Don beds show a definite change to a boreal climate, as indicated by a decline in hardwoods and a marked increase in coniferous tree species. The change is such as to quite surely indicate a change from an interglacial to a glacial environment.

To gain a better picture of the ecological-climatological conditions that existed during the interglacial interval, the microfossil record should be complemented with that of the macrofossils. Coleman (1933) studied both the plant and animal remains found in the Don beds. He presented a comprehensive list of Pelecypoda and Gastropoda (Coleman, 1933, p. 12) but because of the uncertain ecological implications and doubt as to the range of the species listed, this information need not be considered further here. Much more valuable information is to be gleaned from the list of plants identified by D. P. Penhallow (Coleman, 1933).

	Common name
Acer saccharum	Sugar, hard, or rock maple
A. saccharinum	Silver or white maple
A. spicatum	Mountain maple
A. pleistocenicum #	
A. torontoniensis #	
Asimina triloba	Pawpaw
Carya ovata	Shell-bark or shag-bark hickory
Chamaecyparis thyoides *	Southern white cedar
Clethra alnifolia	White alder
Fraxinus quadrangulata *	Blue ash
F. nigra	Black ash
F. americana	White ash
Gleditsia donensis #	Honey locust
Juniperus virginiana	Red cedar
Maclura pomifera *	Osage orange
Ostrya virginiana	Hop hornbeam
Pinus strobus	White pine
Platanus occidentalis	Sycamore
Populus balsamifera	Balsam poplar
P. grandidentata	Large-toothed aspen
Prunus sp.	Cherry or plum
Quercus stellata *	Post oak, iron oak
Q. alba	White oak
Q. rubra	Red oak
Q. velutina	Black oak
Q. macrocarpa	Bur oak
Q. muhlenbergii *	Chestnut oak
Robinia pseudacacia *	Black locust
Salix sp.	Willow
Ulmus sp.	Elm
Taxus canadensis	Yew
Thuja occidentalis	Eastern white cedar
Cyperaceae	
Eriocaulon sp.	

	Common name
Festuca ovina	
Hippuris vulgaris	
Vaccinium uliginosum	
Chara sp.	
Drepanocladus capillifolius	
Hypnum sp.	

The above list was revised by A. Hollick and J. R. White and Hollick supplied the following additional species (Coleman, 1933).

Acer carolinianum (?) Walt.	Maple
Alnus serrulata Willd.	Common alder
Castanea sp.	Chestnut
Ilex sp.	Holly
Tilia sp.	Basswood
Vitis sp.	Grape

Trees marked with * do not now range as far north as Toronto. Trees marked with # were considered extinct by Coleman (1933, p. 10), but the fossil leaves of the 'extinct' maples were later re-examined by R. W. Brown (1942) and identified as the leaves of *Platanus*.

Seeds of *Naias* sp., *Scirpus* sp., and *Sicyos angulatus* were identified by W. L. McAtee (Coleman, 1933).

Coleman (1933, p. 11) reported the following animal fossils from the Don beds.

Arctomis monax	groundhog
2 species of deer	(antlers)
Bison	
Bear	(grizzly ?)
Castoroides ohioensis	giant beaver

Pollen has been found of most species listed by Coleman and, in addition, the writer has identified the following plants by their pollen and spores.

Abies sp.	Fir
Betula sp.	Birch
Carpinus sp.	Blue beech
Corylus sp.	Hazel
Fagus sp.	Beech
Juglans sp.	Walnut
Larix sp.	Tamarack
Liquidambar sp.	Sweet gum
Picea glauca	White spruce
P. mariana	Black spruce

	Common name
Tsuga canadensis	Eastern hemlock
Ambrosia sp.	Ragweed
Artemisia spp.	Wormwood
Caryophyllaceae	
Chenopodiaceae	
Compositae	(several species)
Potamogeton sp.	Pondweed
Rumex sp.	Dock or sorrel
Sparganium sp.	Bur-reed
Typha latifolia	Common cat-tail
Sphagnum spores	
Adianthum sp.	Maiden-hair fern
Botrychium sp.	Grape-fern
Osmunda sp.	Flowering fern
Polypodiaceae	
Equisetum sp.	Horsetail
Lycopodium	Club-moss (2 species)
Selaginella sp.	Spikemoss
Fungus spores, reproductive structures and hypheae	

A study of diatoms by the writer revealed the following assemblage representative for the middle part of the Don beds.

Campylodiscus hibernicus Ehrenb.
Cocconeis disculus (Scum.) Cleve
C. placentula Ehrenb.
Cymbella spp.
Diploneis elliptica (Kütz.) Cleve
Epithemia hyndmanni W. Smith
E. Muelleri Fricke
E. turgida (Ehrenb.) Kütz. Cleve
Fragilaria lapponica Grun.
Gyrosigma attenuatum (Kütz.) Cleve
Melosira granulata (Ehrenb.) Ralfs.
Navicula scutelloides W. Smith
Opepora Martyi Heribaud
Pinnularia spp.
Stephanodiscus astraea (Ehrenb.) Grun.
S. astraea var. *minutulus* (Kütz.) Grun.
Surirella cf. *ovata* Kütz.
Synedra capitata (Kütz.) Cleve
Tabellaria fenestrata (Lyngb.) Kütz.
T. flocculosa (Roth.) Kütz.
Sponge spicules

Such an assemblage, judging by the ecological work of Boyer (1927) and Hohn (1951), indicates a variety of habitats (streams, springs, small and large rivers, ponds, lakes, cedar swamps, and bogs). It seems probable that most of these habitats were present during the deposition of the Don beds. All the species listed have been found by Hohn living south of and in Lake Ontario at present.

An ecological-climatological interpretation of all evidence supplied by the fossils from the Don beds suggests that the annual mean temperature at the time of their deposition reached a maximum probably 5°F warmer than the present.

The Scarborough Beds

The palynological investigations of the Scarborough beds carried out by the writer indicate a boreal climate during the greater part of the non-glacial interval, but with a probable sub-arctic climate at the beginning and end of the interval. The forest was composed of coniferous species with but few hardwoods.

The following plants from the Scarborough beds were reported by Coleman (1933, p. 20).

Alnus sp.	*Scirpus fluviatilis*
Carex aquatilis	*Potamogeton* sp.
C. utriculata	*Chenopodium* sp.
Picea sp.	*Brasenia purpurea*
Salix sp.	*Prunus* sp.
Equisetum	*Polygonum* sp.
Vaccinium oxycoccus	*Ceratophyllum demersum*
V. uliginosum	

An early study of the Scarborough beds by G. J. Hinde (1878) yielded the following fossils (Coleman, 1933, p. 16): diatoms, mosses, spores, seeds, pieces of wood, and remains of beetles. Scudder (Coleman, 1933, pp. 20-21) identified seventy-two species of fossil beetles from the Scarborough beds. According to Coleman (1933, p. 23) seventy species of the beetles have become extinct. The writer believes that a re-examination of the evidence presented, and indeed a further study of the beetles from the Scarborough beds, should be made in the light of present information on this order of insects.

The writer's palynological investigations (*see* Figure 20) indicate that the following plants were growing in the Toronto area when the Scarborough beds were being deposited.

Abies sp.	*Larix* sp.
Acer spp.	*Picea glauca*
Betula sp.	*P. mariana*
Castanea sp.	*Pinus banksiana*
Carpinus sp.	*P. strobus*
Carya sp.	*Quercus* sp.

Corylus sp.
Fagus sp.
Fraxinus sp.
Ilex sp.
Shepherdia sp.
Tilia sp.
Tsuga canadensis
Ulmus sp.

Ambrosia sp.
Artemisia sp.
Caryophyllaceae
Chenopodiaceae
Ericaceae
Gramineae
Menyanthes sp.
Myrica sp.
Myriophyllum sp.
Nuphar sp.
Nymphaea sp.
Rubus chamaemorus
Sparganium sp.
Typha latifolia

Polypodiaceae
Osmunda sp.

Sphagnum spores

Lycopodium annotinum
Lycopodium sp.
Selaginella sp.
Fungus spores

The plants listed above were identified by their pollen and spores. The study of the microfossils clearly indicates that the Scarborough beds were deposited during cool climatic conditions with an annual mean temperature about 10°F lower than the present. The palynological work suggests a correlation between the Scarborough beds in the Toronto area and the St. Pierre non-glacial sequence in the Three Rivers region of the St. Lawrence Lowlands. It is especially interesting in this regard to note that hemlock (*Tsuga canadensis*) was practically absent from the forests in both places.

If pollen diagrams from the Don Valley section and the Scarborough Bluffs are compared, the palynological evidence supports the correlation of the basal Scarborough beds in the Don Valley brickyard exposure with those below lake level at the Scarborough Bluffs. Thus it seems certain that Don beds were encountered by boring at the Scarborough Bluffs, after penetrating the cemented, leached sand beneath the Scarborough beds.

CHRONOLOGICAL POSITION OF THE INTERGLACIAL BEDS AT TORONTO

A combined study of the stratigraphy, lithology, and fossils of the Pleistocene deposits at Toronto suggests that both the Scarborough and the Don beds were formed before the classic Wisconsin.

The Don beds were definitely deposited during an interglacial interval. The beds preserved in the Don Valley brickyard section represent only a part of this interval and during that episode the temperature reached a maximum at least 5°F warmer than the present mean annual temperature for the Toronto area.

The Scarborough beds were deposited under climatic conditions cooler than the present and the annual mean temperature may have been about 10°F lower. A probable correlation with the St. Pierre interval is indicated. The writer suggested (Terasmae, 1957) that the St. Pierre interval represents a non-glacial episode separated from the main (classic) Wisconsin glacial stage by an advance substage. If this is so, the Don beds can be correlated with the recognized Sangamon interglacial age. If, however, interglacial rank is given to the St. Pierre interval a major revision of the present Pleistocene chronology would be necessary, and that is beyond the scope of this paper.

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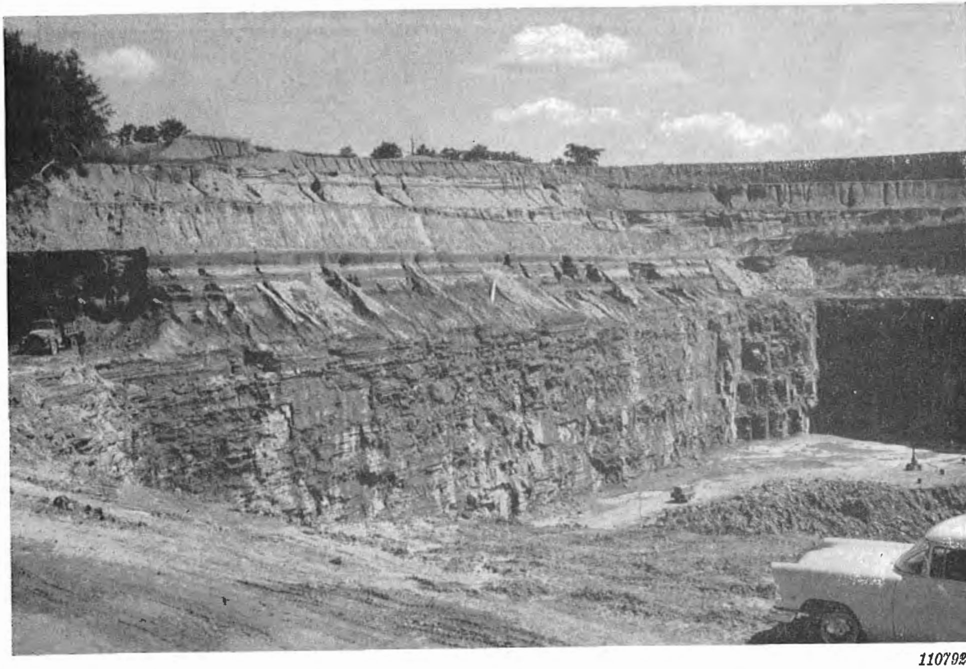
APPENDIX

List of abbreviations

AP	**Arboreal pollen**
Ab	*Abies* (fir)
Al	*Alnus* (alder)
Ac	*Acer* (maple)
Be	*Betula* (birch)
Ca	*Carya* (hickory)
Cp	*Carpinus* (blue beech)
Cr	*Corylus* (hazel)
Cs	*Castanea* (chesnut)
Fa	*Fagus* (beech)
Fx	*Fraxinus* (ash)
Ju	*Juglans* (butternut)
Jp	*Juniperus* (juniper)
Li	*Liquidambar* (sweet gum)
Lx	*Larix* (tamarack)
Or	*Ostrya* (ironwood)
Pc	*Picea* (spruce)
Pi	*Pinus* (pine)
Ps	*Populus* (poplar, aspen)
Q	*Quercus* (oak)
QM	Quercetum mixtum (includes temperate deciduous trees)
Sx	*Salix* (willow)
Ti	*Tilia* (basswood)
Ts	*Tsuga* (hemlock)
Ul	*Ulmus* (elm)
NAP	**Non-arboreal pollen**
Am	*Ambrosia* type
Ar	*Artemisia* type
Car	Caryophyllaceae
Ce	Chenopoliaceae
Co	Compositae
Ct	*Comptonia*
Cx	*Carex*
Cyp	Cyperaceae (sedges)
E	Ericaceae
El	*Elaeagnus* (silverberry)
Gr	Gramineae (grasses)
Ix	*Ilex* (holly)
Me	*Menyanthes*
Mm	*Myriophyllum*
My	*Myrica*
Ne	*Nemopanthus*
Nu	*Nuphar*
Ny	*Nymphaea*
Sax	*Saxifraga* type
Sh	*Shepherdia* (soapberry)
Spa	*Sparganium*
Ty	*Typha*
Um	Umbelliferae
Spores	
Eq	*Equisetum*
F	Fungus
M	Moss
Ly	*Lycopodium*
Ly ann	*Lycopodium annotinum*
Ly sel	*Lycopodium selago*
Os	*Osmunda*
Po	Polypodiaceae
Pt	*Pteridium*
Sel	*Selaginella*
Sph	*Sphagnum*
Miscellaneous	
D	Diatoms
P	Means that a pollen or spore type is present in the sample but not encountered in the pollen count. (● = P in certain pollen diagrams)
Sp	Sponge spicules



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A. *General view of the Don Valley brickyard exposure, looking north across quarry. Valley fill in Scarborough beds shown at upper right.*

Plate I

B. *Don Valley brickyard exposure. Sequence of varved clay overlain conformably by glacial till. Rod marked in decimetres.*

110792B

110792C

A. *General view of the Seminary section at Scarborough Bluffs looking north.*

Plate II

B. *Lake Iroquois scarp, looking east across Seminary gully.*

110792D

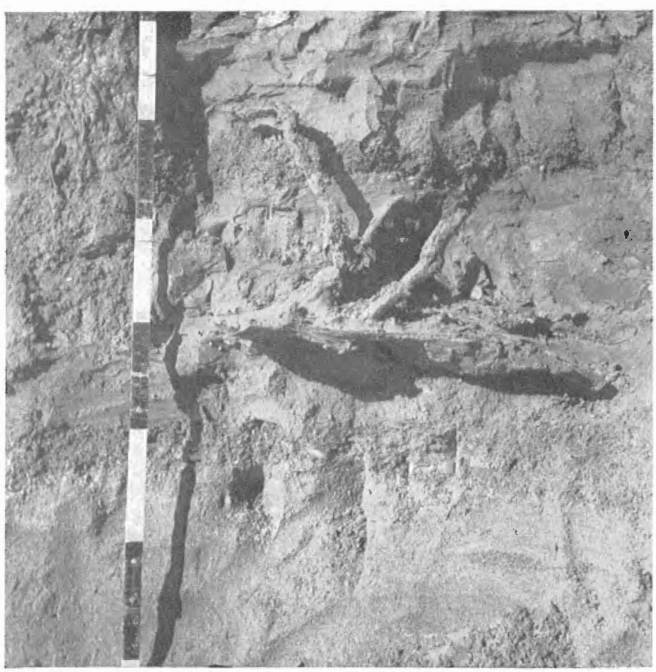
Plate III

A. *Exposure in lower part of Don beds in Don Valley brickyard section. Scale in decimetres.*

110792E

Plate III

B. *Fossil wood in situ in the middle part of Don beds, Don Valley brickyard section.*



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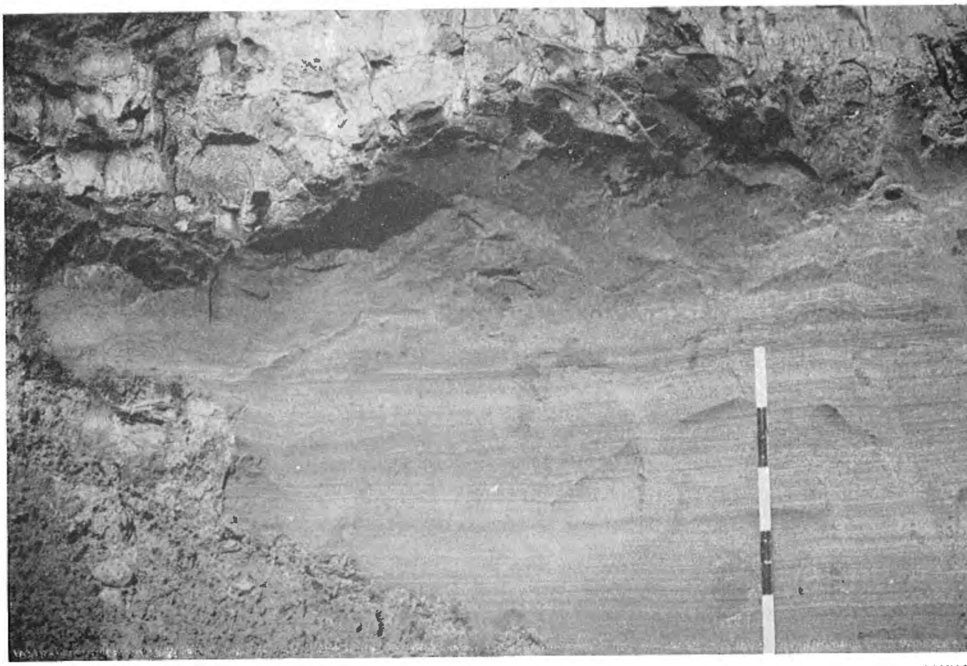
110792G

A. *Seam of plant detritus (thickness ca. 1½ inches) from middle part of Don beds, Don Valley brickyard section.*

Plate IV

B. *Detail of valley fill in top part of Scarborough beds, Don Valley brickyard section. A slab of stratified silty clay is shown in the valley fill (upper right-hand corner). Scale in decimetres.*

110792H



110792J

A. *Seminary section at Scarborough Bluffs. Contact between Scarborough beds and overlying Sunnybrook till. Scale in decimetres.*

Plate V

B. *Seminary section. Plant detritus in crossbedded sand near top of Scarborough beds.*

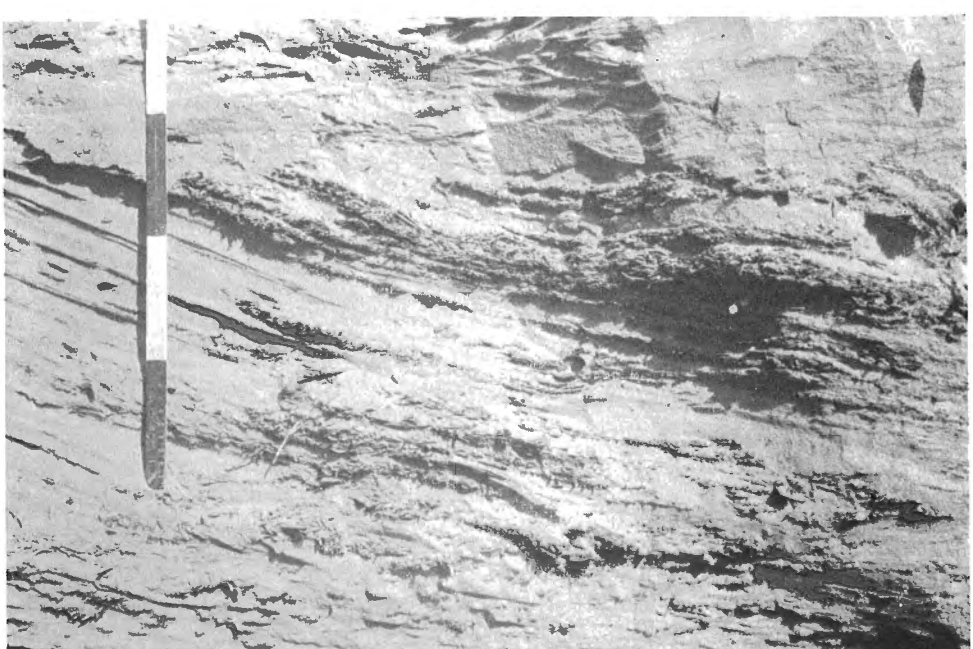


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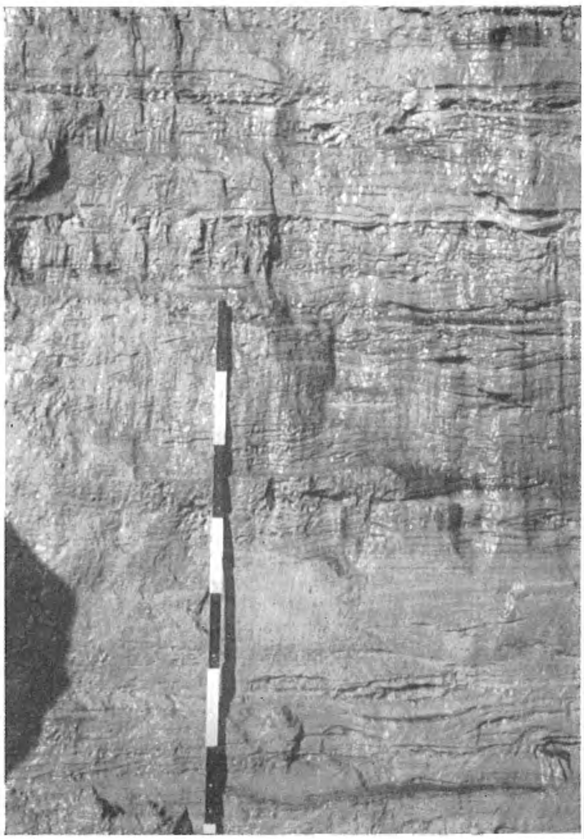
Plate VI

A. Seminary section at Scarborough Bluffs.
A bed of massive silty fine sand (loess?) in the lower part of the Scarborough stratified silty clay.
Scale in decimetres.

Plate VI

B. Seminary section.
Detail of the lower member of Scarborough beds (stratified silty clay with sandy partings containing fine plant detritus).



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