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THE SANGAMONIAN POINTE-FORTUNE SITE, ONTARIO-QUÉBEC BORDER*

Thane W. ANDERSON, John V. MATTHEWS, Jr., Robert J. MOTT and S. Henry RICHARD**, Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8.

ABSTRACT Inter-till sediments (Units 2, 3, 4) in a sand pit located 115 km east of Ottawa, Ontario, contain a predominance of deciduous tree pollen including oak, elm, beech and hickory (*Quercus, Ulmus, Fagus,* and *Carya*) and minor amounts of basswood, ash and sweetgum (*Tilia, Fraxinus* and *Liquidambar*). Unit 4 also contains macrofossils of several plant taxa which presently do not grow much north of the site. The fossils portray an interglacial environment (the Sangamonian) with conditions as warm as or warmer than the present in the area. By contrast, overlying Unit 4a reveals a dominance of boreal indicators such as pollen of spruce, pine, willow and alder (*Picea, Pinus, Salix* and *Alnus*) and the beetles, *Bembidion transparens, Eucnecosum,* and *Olophrum boreale*. Unit 4a fossils indicate a climate that was colder than at present but no colder than the climate of central Québec — suggesting a correlation with the waning phase of the warm interval, or alternatively, with the St. Pierre Interstade of the St. Lawrence Lowlands. Thus the lower till is interpreted as Illinoian in age; the upper till may be Middle to Late Wisconsinan or Early to Late Wisconsinan.

RÉSUMÉ *Le site sangamonien de Pointe-Fortune, à la frontière du Québec et de l'Ontario.* Les sédiments contenus entre deux couches de till (unités n^{os} 2, 3 et 4), situés dans une sablière, à 115 km à l'est d'Ottawa, en Ontario, renferment surtout des grains de pollen de feuillus, dont le chêne, l'orme, le hêtre et le caryer (*Quercus, Ulmus, Fagus* et *Carya*) et des quantités moins importantes de pollen de tilleul, de frêne et de liquidambar (*Tilia, Fraxinus* et *Liquidambar*). L'unité n°4 renferme aussi des macrofossiles de divers taxons de végétaux qui ne croissent plus beaucoup au nord de la région. Les fossiles reflètent un milieu interglaciaire (le Sangamonien) où le climat était au moins aussi chaud que maintenant. Au contraire, l'unité n° 4a, susjacente, renferme surtout des indicateurs de milieu boréal comme les pollens d'épinette, de pin, de saule et d'aulne (*Picea, Pinus, Salix* et *Alnus*) et les coléoptères *Bembidion transparens, Eucnecosum* et *Olophrum boreale*. Les fossiles de l'unité n° 4a témoignent d'un climat plus froid que celui d'aujourd'hui, mais pas plus froid que celui du centre du Québec, laissant ainsi entrevoir une corrélation avec la fin de l'intervalle chaud, ou alors avec l'Interstade de Saint-Pierre des basses terres du Saint-Laurent. Ainsi, le till inférieur remonterait à l'Illinoien; le till supérieur pourrait dater du Wisconsinien moyen à supérieur ou du Wisconsinien inférieur à supérieur.

ZUSAMMENFASSUNG *Der sangamonische Fundplatz von Pointe-Fortune an der Grenze zwischen Ontario und Québec.* Zwischen-Till-Sedimente (Einheiten 2, 3, 4) in einer Sandgrube 1,5 km östlich von Ottawa, Ontario, enthalten vor allem Pollen von Laubbäumen, darunter Eiche, Ulme, Buche und Hickory (*Quercus, Ulmus, Fagus* und *Carya*) und geringere Mengen von Pollen von Linde, Esche und Liquidambar (*Tilia, Fraxinus* und *Liquidambar*). Die Einheit 4 enthält auch Makrofossile von verschiedenen Pflanzen-Taxa, welche gegenwärtig nicht mehr viel nördlich des Platzes wachsen. Die Fossile geben ein Bild einer interglazialen Umwelt (das Sangamonium), die so warm wie oder wärmer als die gegenwärtige in dem Gebiet war. Im Gegensatz dazu enthält die darüberliegende Einheit 4 überwiegend Indikatoren nördlichen Milieus, wie Pollen von Rottanne, Kiefer, Weide und Erle (*Picea, Pinus, Salix* und *Alnus*) und die Käfer *Bembidon transparens, Eucnecosum* und *Olophrum boreale*. Fossile der Einheit 4a weisen auf ein Klima, das kälter als gegenwärtig war, aber nicht kälter als das Klima des Zentrums von Québec, was auf eine Korrelation mit der ausgehenden Phase des warmen Intervalls oder aber mit dem St. Pierre Interstadium des Tieflands des St. Lawrence schliessen lässt. So wird das Alter des unteren Tills auf das Illinoium datiert; das obere Till könnte mittleres bis spätes Wisconsinium oder frühes bis spätes Wisconsinium sein.

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** Deceased in 1987

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INTRODUCTION

A sand pit located about 115 km east of Ottawa, Ontario has become a significant site in deciphering the Quaternary history of the Ottawa Valley. The sand pit, owned and operated by M. Réjean Bélanger, is located on the Ontario-Québec border 2.2 km south of the community of Pointe-Fortune, Québec (site 1, Fig. 1); it is thus referred to here as the Pointe-Fortune site.

Exposed sediments at the site were initially interpreted by Gwyn and Thibault (1975) as till overlying crossbedded glacio-fluvial sand. Prichonnet (1977) proposed a fluvial origin for the sub-till sands. Richard (1978) related the sand to subaqueous outwash deposited in the Champlain Sea. Gadd *et al.* (1981) discussed the sediments observed in an excavation in the floor of the pit and described preliminary fossil identification carried out on a grab sample from these sediments. They argued against the glacio-fluvial and glacial marine origins for both the exposed and buried deposits. Based on a wood date of > 42,000 years BP from the sub-floor, organic-rich sands and that the overlying till is probably equivalent to the Gentilly Till of the St. Lawrence Lowland, they suggested a probable correlation of the organic-rich sands with the St. Pierre Sediments of the St. Lawrence Lowland. Veillette and Nixon (1984) dealt in more detail with the overall stratigraphy including both the exposed and buried sediments. They developed a stratigraphic framework (units 1 to 6) for the site based on exploratory drilling of the sub-floor deposits, shallow seismic surveying between the drill sites, and back-hoe trenching.

Anderson *et al.* (1987) summarized the results of pollen and plant macrofossil analyses undertaken on an organic clay interval within the exposed sand unit and concluded that the fossil evidence supported the Gadd *et al.* (1981) assignment of the sand and organic unit to the St. Pierre Interval which has been renamed Les Becquets Interstade (Lamothe, 1989). Since that study, new evidence has come to light which offers an alternative explanation for the sand unit (Anderson *et al.*, 1988). This new evidence is primarily based on pollen studies of the organic-bearing sand and silt and interbedded clay which extends to about 8 m below the pit floor.

In this paper we examine plant and insect fossils extracted from both the exposed and buried sediments in the sand pit (units 3 and 4 of Veillette and Nixon, 1984) and infer the paleoenvironmental and paleoclimatic conditions existing at the time of deposition. Based on these findings, we show the stratigraphic position of these sediments in the Quaternary sequence of events for the central St. Lawrence Lowlands.

REGIONAL PHYSIOGRAPHY, CLIMATE AND VEGETATION

PHYSIOGRAPHY

The sand pit is situated along the south shore of the Ottawa River within the St. Lawrence Lowlands physiographic region of Bostock (1970). This region stands in sharp contrast with the highlands to the north, west and south. Surface elevations of the St. Lawrence Lowlands reach a maximum of about 150 m and relief is less than 30 m. Locally, lowland elevations range from about 61 m to about 92 m with the exception of Montagne de Rigaud which reaches over 150 m (Fig. 1).

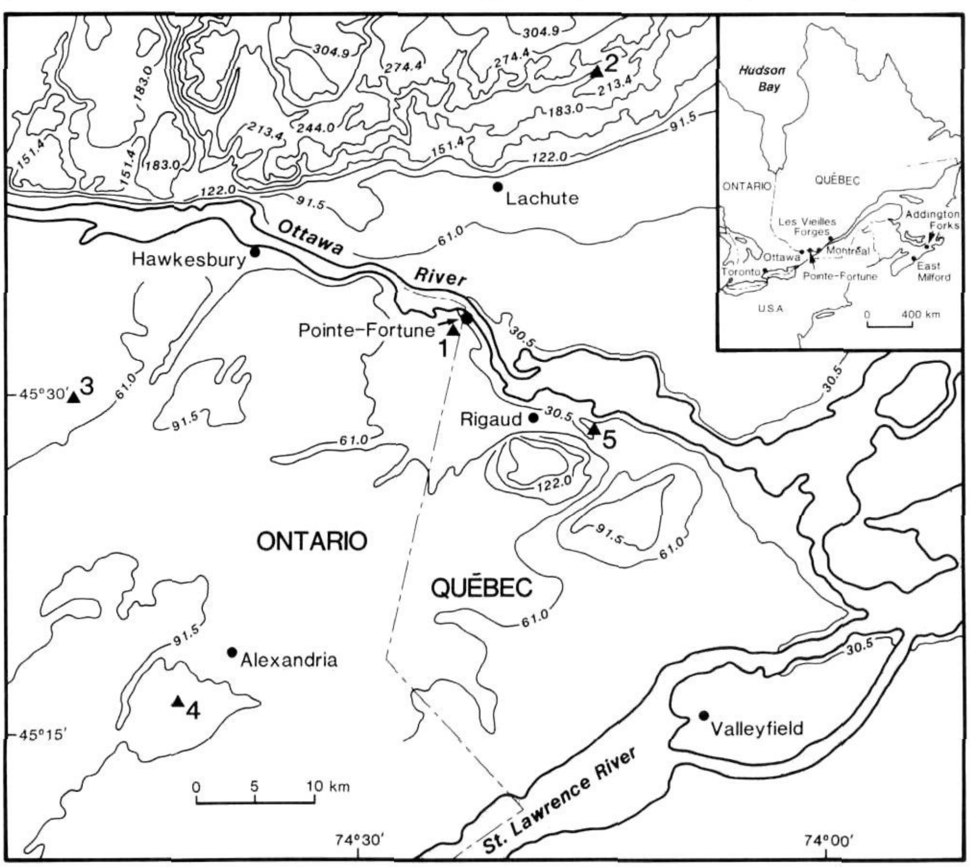


FIGURE 1. Location map. Site 1 is the Bélanger sand pit (Pointe-Fortune site). Sites 2, 3, 4 and 5 are lakes and bogs that were analyzed for the settlement and pre-settlement pollen record. Topographic contours are in metres asl converted from 100 foot elevations asl. Inset map shows locations of other sites discussed in the text.

Localisation des sites: 1) sablière Bélanger (site de Pointe-Fortune); 2, 3, 4 et 5) lacs et tourbières qui ont servi à l'établissement de la palynologie avant et après la colonisation. Les courbes de niveau ont été converties en mètres. Le carton donne la localisation d'autres sites mentionnés dans le texte.

The Quaternary deposits and features of the Ottawa Valley are described in Gadd (1986a,b; 1987, 1988) and Richard (1974, 1975). Fulton and Richard (1987), Anderson (1988) and Rodrigues (1988) discuss the chronology of Late Quaternary events for the western Champlain Sea basin based on ^{14}C dates on marine shells and pollen stratigraphy, respectively.

The surficial features are generally believed to have been deposited by the Wisconsin Glaciation and the disintegration of Late Wisconsinan ice. The Champlain Sea inundated the Ottawa-St. Lawrence Lowlands between about 11.5 ka and 10 ka (Anderson, 1988; Rodrigues, 1988). Thus many of the deposits and features in the vicinity of the site relate to the Champlain Sea episode and post-Champlain Sea events associated with the evolution of the Ottawa Valley.

CLIMATE

The area falls within the cool temperate ecoclimatic province as defined by the Canada Committee on Ecological Land Classification (1989). The summers are warm and the winters are cold. Mean July temperatures average about 20°C whereas mean annual temperatures average about 5°C (Wilson, 1971). Mean annual precipitation, which is generally lower in winter than in summer, amounts to about 914 mm. The length of the growing season is about 190 days.

VEGETATION

The regional forest of the eastern Ottawa River Valley falls within the Great Lakes-St. Lawrence Forest Region of Rowe (1977). It is a transitional forest between the Boreal Forest to the north and the Deciduous Forest to the south. Sugar maple (*Acer saccharum*), beech (*Fagus grandifolia*), yellow birch (*Betula lutea*), red maple (*Acer rubrum*) and eastern hemlock (*Tsuga canadensis*) along with white and red pine (*Pinus strobus* and *P. resinosa*) characterize the highland areas to the north, west and south. Also common at higher altitudes are varying amounts of white spruce (*Picea glauca*), balsam fir (*Abies balsamea*), trembling aspen (*Populus tremuloides*) and white birch (*Betula papyrifera*). The forest of the lowlands consists mainly of sugar maple and beech, as well as red maple, yellow birch, basswood (*Tilia americana*), white ash (*Fraxinus americana*), largetooth aspen (*Populus grandidenta*) and red and bur oak (*Quercus rubra* and *Q. macrocarpa*). Local occurrences in the lowlands include white oak (*Quercus alba*), red ash (*Fraxinus pennsylvanica*), grey birch (*Betula populifolia*), rock elm (*Ulmus thomasii*), blue-beech (*Carpinus caroliniana*) and bitternut hickory (*Carya cordiformis*). Black spruce (*Picea mariana*), black ash (*Fraxinus nigra*), white elm (*Ulmus americana*) and eastern white cedar (*Thuja occidentalis*) dominate hardwood and mixed-wood swamps and bogs, whereas butternut (*Juglans cinerea*), eastern cottonwood (*Populus deltoides*), silver maple (*Acer saccharinum*) and slippery elm (*Ulmus rubra*) occur sporadically along river valleys.

The pre-settlement forest history of the region is inferred from fossil pollen stratigraphy at William Lake, Québec, northeast of the site, at nearby Alfred bog to the east, at a small pond near Loch Garry southwest of the site, and at a bog site near Rigaud, Québec (site numbers 2, 3, 4 and 5 respectively in Figs. 1 and 2). Figure 2 shows the trends of the dominant pollen taxa in the uppermost sediments. The pollen diagrams are divided into two pollen assemblage zones. Zone 1, the pre-settlement zone, is consistently dominated by relatively high percentages of *Betula* and *Tsuga* at all four sites although the latter decreases slightly upward at sites 2, 3 and 4. *Pinus* and the hardwoods, notably *Fagus, Ulmus, Quercus* and *Fraxinus* are also prominent taxa, whereas *Picea* is variable and *Abies* is negligible. Pollen of *Carya, Tilia, Juglans* and *Celtis* are rare.

Hemlock was abundant in the inferred pre-settlement upland forest dominated mainly by sugar maple (Richard, 1976, 1977). Spruce, pine (mainly white pine) and the northern hardwoods, beech, oak, elm, maple and ash were widely distributed. Hickory, basswood, walnut and hackberry (the most southerly hardwoods) occurred as minor constituents. The higher percentages of white pine, birch and beech pollen at site 2 indicate that these trees were more prevalent in the highlands north of the site than in the lowlands. Oak, elm, hickory, walnut and basswood, on the other hand, were more common in the lowlands.

Zone 2, the settlement zone, is characterized by sharp increases in pollen of the Compositae (mainly *Ambrosia*), Gramineae and at sites 2 and 4, *Rumex, Tsuga, Fagus* and *Ulmus* decline substantially from the high values in zone 1, especially at sites 2, 3, and 4, whereas *Alnus* increases towards the surface at sites 2, 4, and 5. The increase in pollen of weeds and grasses in zone 2 denote forest clearance and the onset of agriculture associated with European settlement of the area in the early 1800's. Increase of *Alnus* in this zone possibly relates to drainage changes brought about by forest clearing and land disturbance.

LOCAL GEOLOGICAL SETTING AND STRATIGRAPHY

The surficial materials of the local area were mapped by Richard between 1977 and 1981; the 1:100,000 scale map of the Lachute-Arundel area represents a culmination of this detailed study (Richard, 1984). The sand pit is situated within a till plain that is characterized by generally low relief. The top of the till plain at the site is at 51 m elevation. The pit is cut into the south flank of an abandoned early Ottawa River channel. The sediment sequence constitutes part of a fluvial terrace feature.

The stratigraphic framework for the sand pit (Fig. 3) is based on numerous observations of the exposed sediments by the authors (mainly S. H. Richard) and from sub-surface drilling as discussed in Veillette and Nixon (1984). A lower till (Unit 1) was encountered by Veillette and Nixon at 6 to 8 m below the pit floor. This is a silty, sandy till, and because of its stratigraphic position and significant content of Shield erratics, it is correlated with the Bécancour Till of the central St. Lawrence Lowlands (Veillette and Nixon, 1984). This till is overlain in places by a 1 m thick sand-clay unit (Unit 2) believed to contain organic-rich bands (Veillette and Nixon, 1984). This sand-clay unit and lower till, in turn, are overlain by about 2-4 m of massive clay (Unit 3) which grades upward into 6-8 m of mainly stratified fine sand and silt (Unit 4) containing disseminated organics and occasional lenses of massive clay. Veillette and

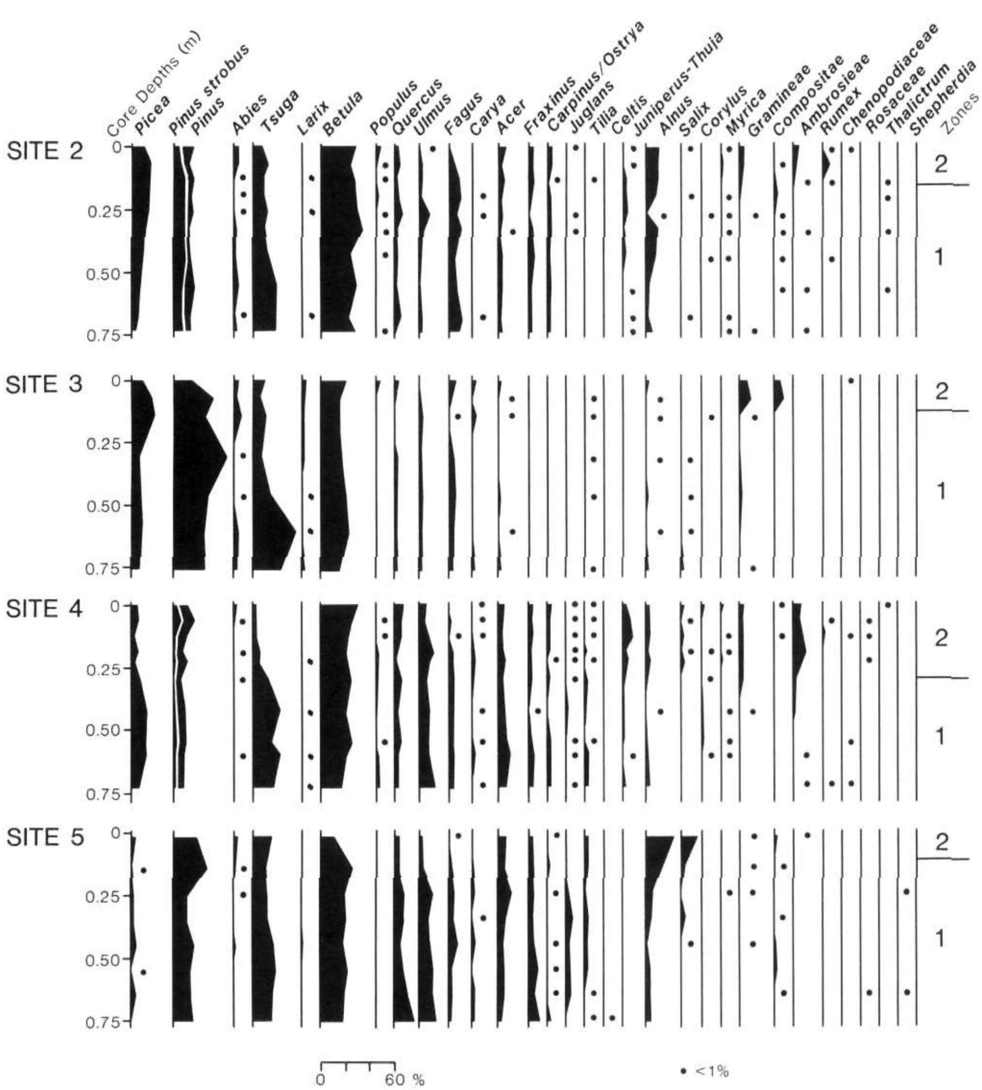


FIGURE 2. Settlement and presettlement pollen stratigraphy at four sites in the vicinity of the Pointe-Fortune site showing only tree, shrub and upland herb pollen taxa.

Stratigraphie pollinique avant et après la colonisation de quatre sites situés dans les environs du site du Pointe-Fortune qui ne révèle que le pollen des taxons d'arbres d'arbustes et d'herbes.

Nixon (1984) noted that organic-rich bands occur within this unit at depths of about 2 and 3 m below the pit floor (Fig. 4).

Unit 4 extends above the pit floor and is exposed in the west wall of the pit (Fig. 5). Stratification is particularly distinct within the lower 2 m of the exposure (Fig. 6) where the sediments are medium to highly oxidized. However, pockets of less oxidized or unoxidized grey sand or sandy clay occur just below reddish crusty layers within this unit. The sediments are olive grey (5Y 4/2) towards the top of the unit. The overlying organic-rich sediments (Unit 4a) consist of a wedge of compressed, wood-bearing organic silt (Fig. 6) which thickens northward into dark grey (5Y 4/1) highly distorted silt with organic seams (Fig. 7). The contact between units 4 and 4a is conformable. However, units 4 and 4a are unconformably overlain by up to 8.5 m of unfossiliferous, cross-bedded sands (Unit 5) (Figs. 3 and 5). The entire sequence is capped by up to 4 m of stony, sandy till (Unit 6). The contact with the upper till unit is generally abrupt, but there are places where it becomes gradational (D. R. Sharpe, pers. comm.). This till is the Fort Covington Till according to Gwyn and Thibault (1975) and is probably related to the Trois-Rivières Stade (Occhietti, 1982). Veillette and Nixon (1984) correlated it with the Gentilly Till of the St. Lawrence Lowlands (Gadd, 1971). Parts of the upper till and of units 4a and 5 are missing underneath the north-facing slope which represents the scour surface of a former river terrace.

We propose here that the stratigraphic units as defined in Veillette and Nixon (1984) and discussed above be formally named as follows: Unit 1 (Rigaud Till), Units 2, 3, 4 and 4a (Pointe-Fortune Sediments), Unit 5 (Carillon Sands) and Unit 6 (Border Till).

FIELD AND LABORATORY METHODS

The sand pit was actively excavated in 1981 so the authors visited it at that time to examine new exposures and to collect samples from the west wall of the pit. Monolith samples were obtained from across the organic-rich silts at the top of the Pointe-Fortune Sediments for pollen analysis (Fig. 6). Bulk samples were also collected from these silts for radiocarbon dating and for study of fossil insects and plant macro remains. The site was photographed and a composite stratigraphic sequence was established.

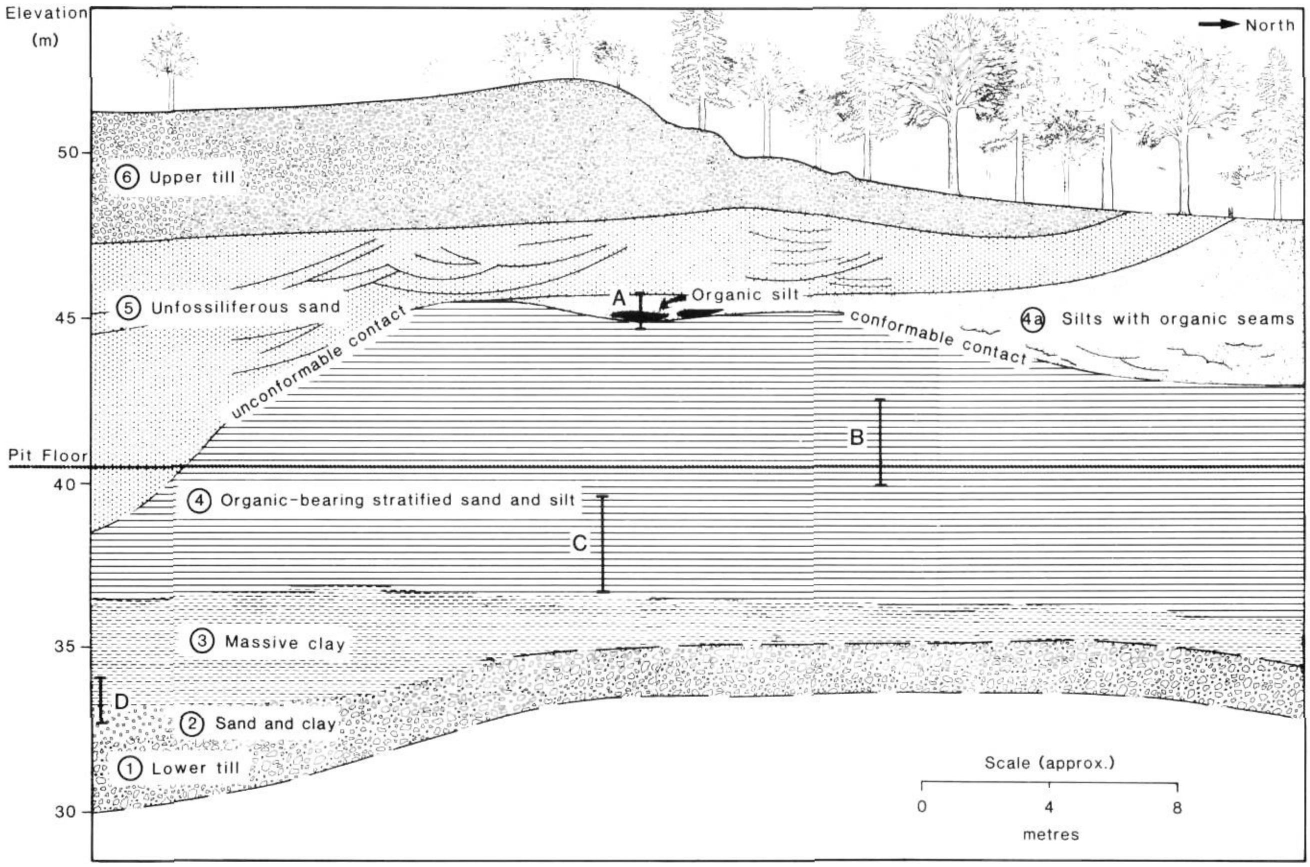


FIGURE 3. Composite sketch of the stratigraphy along the exposed west wall of the sand pit and below the pit floor. The sub-surface stratigraphy and sediment units (except Unit 4a) are from Veillette and Nixon (1984). Letters A, B, C and D denote the sediment intervals analyzed for pollen.

Shéma de la stratigraphie le long de la paroi ouest de la sablière et sous la surface. La stratigraphie sous la surface du sol et les unités sédimentaires (sauf l'unité n^o 4a) sont de Veillette et Nixon (1984). Les lettres A, B, C et D donnent l'intervalle de sédiments analysés pour l'établissement de la palynologie.

FIGURE 4. View of sub-surface stratigraphy in a back-hoe trench showing a horizontally bedded, organic-rich layer in Unit 4 (photograph from Veillette and Nixon, 1984).

Aperçu de la stratigraphie sous la surface dans une tranchée qui montre une couche de l'unité n^o 4 à lits horizontaux riches en matière organique (photographie de Veillette et Nixon, 1984).

Sediment was also received from several levels in two boreholes (cores 1 and 5 in Veillette and Nixon, 1984) below the pit floor and from a 2.5 m trench in the floor of the pit. Even though quantities were small, these samples proved to be significant for pollen and macrofossil studies and radiocarbon dating of the Pointe-Fortune Sediments.

The site was revisited early in 1989 to sample, for additional pollen studies, the pockets of less oxidized or unoxidized sand just below the reddish crusty layers in the Pointe-Fortune Sediments exposed above the pit floor. These samples provided the basis for the intervening pollen record between the buried sediments and the exposed organic-rich silts.

Laboratory procedures to extract fossil pollen and spores involved acid digestion with HF and HCl followed by acetolysis and mounting in silicone oil for microscopic study. Sand and silt were removed by decantation prior to the acid treatments.

Continuous slices, 2.5 cm in width and about 10 cm in diameter, were removed from the monoliths obtained across the organic-rich beds. The material was sieved with the 100 mesh/inch (149 mm) screens and the concentrated organic fractions were picked under a dissecting microscope for plant macrofossils and any insect fossil fragments that might be identified. The fossil remains were stored in a glycerin-alcohol mixture.

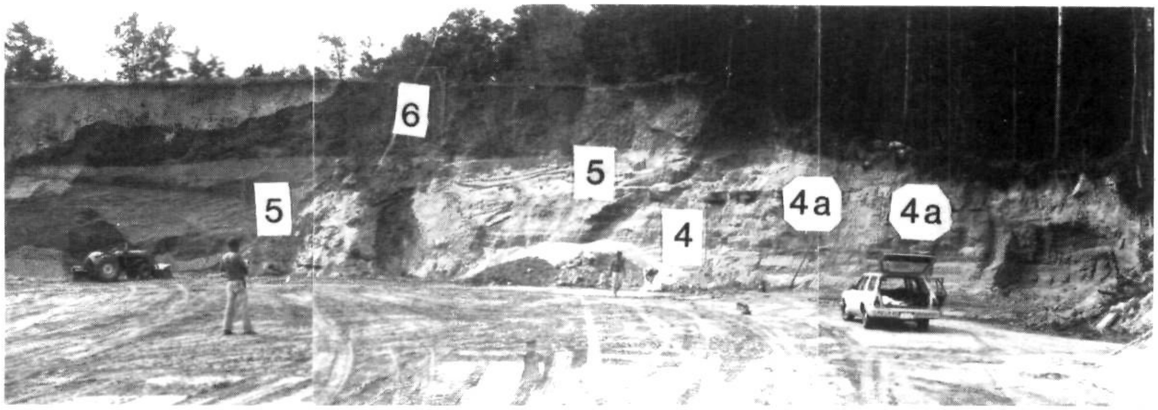


FIGURE 5. Composite view (1981) of the exposed sediments along the west wall of pit. Numbers represent sediment units. North is to the right.

Montage photographique (1981) des sédiments de la paroi ouest de la sablière. Les numéros identifient les unités sédimentaires. Le nord est à droite.

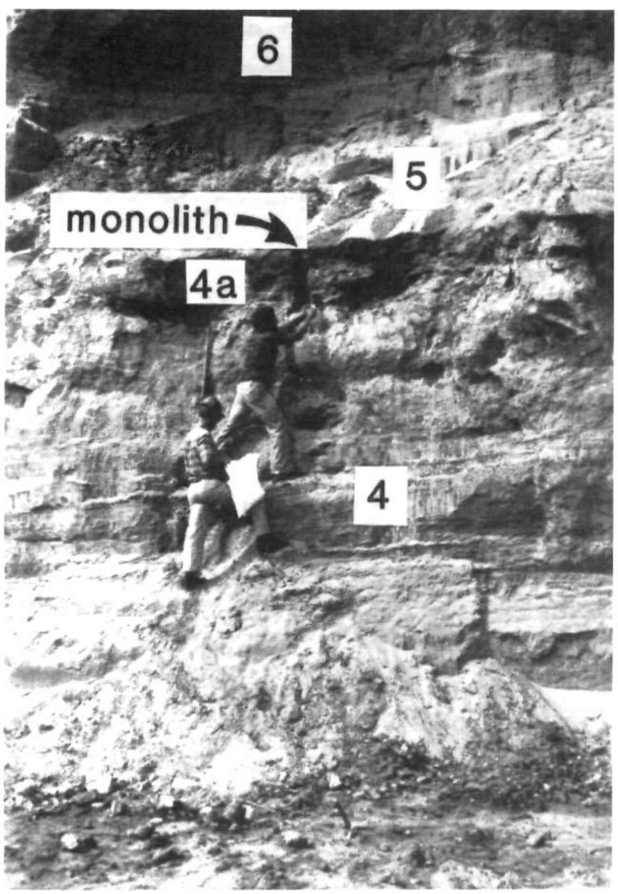


FIGURE 6. Close-up view of wedge of wood-bearing organic silt (Unit 4a) and adjacent units along the west wall of pit (interval A in Fig. 3). Photograph taken in 1981. North is to the right.

Gros plan du coin de silt organique renfermant du bois (unité n° 4a) et des unités adjacentes le long de la paroi ouest de la sablière (intervalle A de la fig. 3). Photographie prise en 1981. Le nord est à droite.

Bulk samples were separately boiled in water containing a strong disaggregating solution to extract fossil insects and plant macrofossils. Approximately 13 litres of the organic-rich silt were processed in this manner; the result after sieving with 10 and 80 mesh/inch (100 and 180 μm) sieves was 1.5 l of organics and undisaggregated lumps of clay. Some of this fraction was examined for plant macrofossils and insects without further processing, but because of its large volume, much of the sample was processed in kerosene to concentrate the insect fossils. The picked insect and plant fossils were either mounted on slides or stored in alcohol.

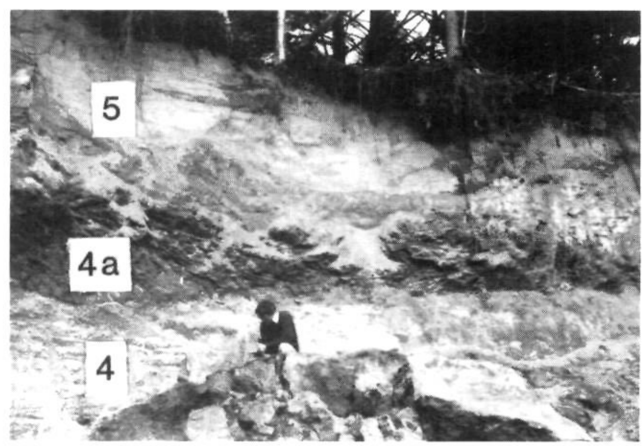


FIGURE 7. Photograph of thick organic silt bed (Unit 4a) to right of that shown in Figure 6. Photograph also shows the underlying stratified sand and silty sand (Unit 4) and the overlying cross-bedded sands (Unit 5). Photograph taken in 1982.

Photographie (1982) d'un lit de silt organique (unité n°4a) situé à droite de la photographie précédente (fig. 6). La photo montre également les lits de sable et de sable silteux sous-jacents (unité n° 4) et les sables à stratification entrecroisée sus-jacents (unité n° 5).

FOSSIL OCCURRENCES

POLLEN

The pollen stratigraphy of the Pointe-Fortune Sediments consists of three pollen assemblage zones (Fig. 8). The lowermost zone, zone 1, is characterized by up to 40% maximum of *Quercus* and *Pinus*, moderate amounts (about 10-15%) of *Betula, Ulmus, Fagus*, and *Carya* and minor values (less than 5%) of *Picea, Abies, Acer, Fraxinus* and *Tilia*. Gramineae and Cyperaceae are the dominant non-arboreal pollen attaining maximum percentages of about 10 to 20%.

Zone 2 straddles the sediments above and below the pit floor. It is dominated by higher percentages of *Picea* (up to 20% maximum), *Abies* and *Alnus* (5-10%), and reductions in the percentages of *Quercus, Ulmus, Fagus* and *Carya* from the previous zone. Of significance in zone 2 are the occurrences of *Liquidambar* (sweetgum) pollen (less than 5%) at 40 to 43 m elevation. *Alnus* and spores of the Lycopodiaceae and *Dryopteris* type increase markedly upward in the zone. Gramineae reaches peak percentages of 20 to 30% maximum.

Pollen spectra near the top of the Pointe-Fortune Sediments comprise zone 3 which is subdivided into subzones 3a and 3b. Subzone 3a is dominated by peaks in *Alnus* (about 35% maximum) and *Myrica* (20% maximum) and moderate amounts of *Pinus*. Pollen of *Betula* and the hardwoods is insignificant with *Quercus* reaching only about 5% maximum and other hardwoods no more than 1%, down substantially from zone 2. *Picea* changes little from the previous zone. Pollen of aquatic plants

FIGURE 8. Pollen diagram showing dominant fossil pollen and spores at the Pointe-Fortune site. The pollen sum consists of total tree, shrub and herb pollen excluding Cyperaceae, aquatic plants and spores. Numbers 1 to 5 are the stratigraphic units and A, B, C and D denote the sediment intervals analyzed for pollen (see also Fig. 3).

Diagramme pollinique montrant le pollen et les spores fossiles dominants du site de Pointe-Fortune. La somme pollinique comprend le total des grains de pollen des arbres, des arbustes et des herbes et exclut ceux des Cypéracées, des plantes aquatiques et des spores. Les numéros identifient les unités statigraphiques et les lettres (A, B, C et D) donnent les intervalles de sédiments analysés pour l'établissement de la palynologie (voir aussi la fig. 3).

is represented by 5% or less of Cyperaceae, *Typha*, *Sparganium* and up to 40% *Dryopteris* type spores.

Marked changes in some pollen profiles take place across the subzone 3a/3b boundary. *Picea* increases abruptly and characterizes subzone 3b at about 35% maximum. *Pinus* and *Salix* increase upward to about 40% and 10% maxima, respectively, whereas *Alnus* and *Myrica* decrease proportionately to less than 10% at the top of the zone. Cyperaceae shows the greatest change amongst the aquatics, reaching over 20% maximum up more than 15% from the previous subzone.

INSECT AND PLANT MACROFOSSILS

Table I shows a listing of the insect and plant macrofossils extracted from the more organic-rich intervals within the Pointe-Fortune Sediments. Numbers and diversity of insect fossils are lower in Unit 4 than in Unit 4a but this may be attributed to the smaller quantity of material examined from Unit 4. Plant macrofossils, on the other hand, are more diverse in Unit 4 than in Unit 4a.

Only about six different taxa of insects were identified in Unit 4, and none of these are diagnostic for paleoenvironmental reconstruction. On the other hand, Unit 4a contains about 25 taxa, three of which are climatically diagnostic, *i. e. Bembidion transparens, Olophrum boreale* and *Eucnecosum*; fossil remains of two of these species are illustrated in Figure 9.

Up to about 40 taxa of plant macrofossils were extracted from Units 4 and 4a. Fossils of the aquatic and marsh plants, *Carex* (more than two species), *Eleocharis* (at least one species of the *E. palustris/uniglumis* type), *Juncus, Potamogeton* (three species), *Scirpus, Najas* (two species), *Potentilla* (at least one species — *P. palustris*), *Sagittaria, Sparganium, Nuphar*, and *Menyanthes trifoliata* dominate. Seeds within the Cyperaceae (Carex) and Rosaceae (*Potentilla palustris* and *Potentilla* sp.) are much more prevalent in Unit 4a than in Unit 4, but again this may be due to the greater availability of Unit 4a material. Figure 10 shows that these seeds are concentrated in the middle of Unit 4a. They give way upward in the unit to a peak in numbers of bud bracts identified as being similar to the bracts of *Salix* (G. Argus, pers. commun. 1988). Numbers of bud bracts decrease abruptly towards the top of the unit. Two species of moss plants, *Drepanocladus exannulatus* and *Calliergon stramineum*, were extracted and identified from this unit (L. Ovenden, Peat Report LO 3, 1987) and poorly preserved conifer needles occur near the base and top of the unit (Fig. 10). Five taxa of seeds (*Najas gracillima, Diervilla Lonicera* and species within the genera *Hypericum, Verbena* and *Sambucus*) from Unit 4 are diagnostic as paleoclimatic indicators. Fossil seeds of three plants are illustrated (Fig. 11).

PALEOENVIRONMENTAL INTERPRETATION

POINTE-FORTUNE SEDIMENTS (UNITS 2, 3, 4)

Macrofossils and pollen are of sufficient quantity and quality in units 2, 3 and 4 to reconstruct the paleoenvironmental conditions existing at time of deposition of the Pointe-Fortune Sediments. The organic-bearing sediments in the back-hoe trench and from the drill core are allochthonous in that they represent the coexistence of several communities adjacent to a

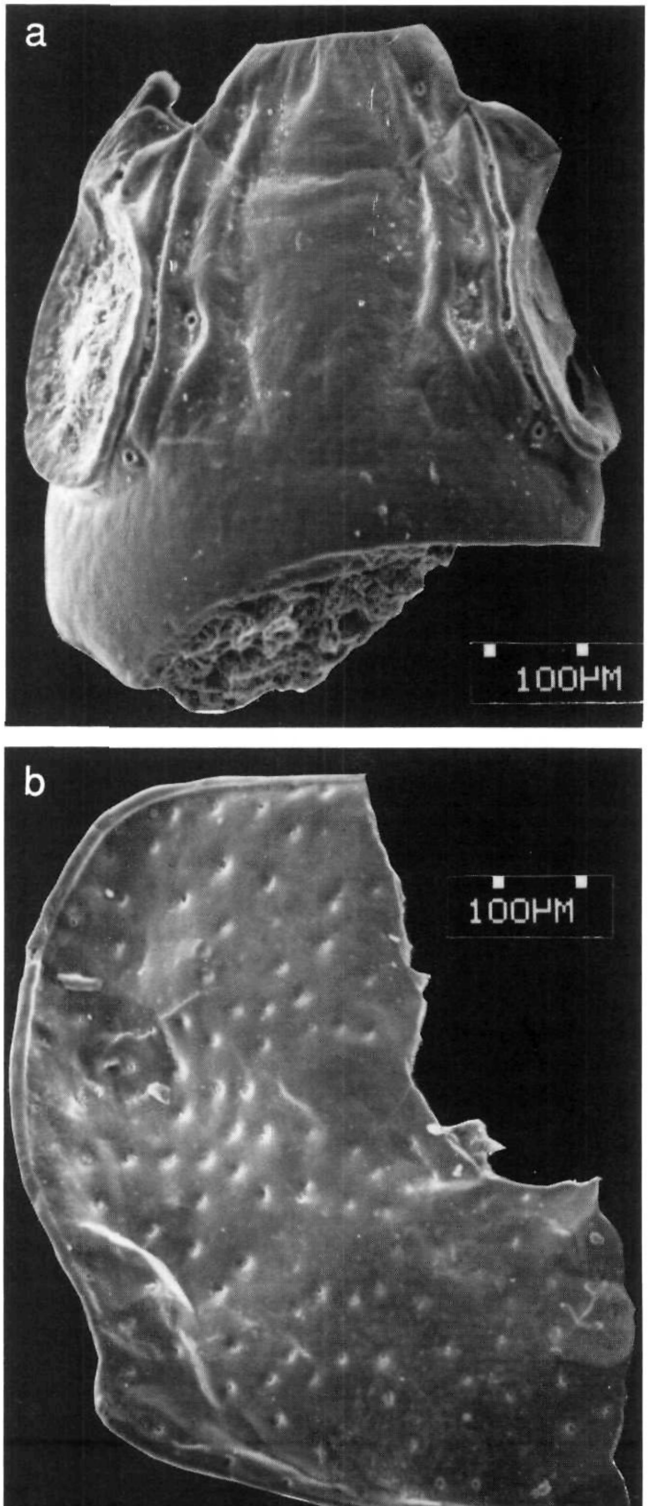


FIGURE 9. Scanning electron micrographs of fossil remains of (a) *Bembidion transparens* (Gebl.) (tête) and (b) *Olophrum boreale* (Payk.) (left half of pronotum) extracted from Unit 4a. Scale bar = 100 μ.

Micrographies par balayage électronique des restes de fossile de (a) Bembidion transparens *(Gebl.) (tête) et (b)* Olophrum boreale *(Payk.) (moitié gauche du pronotum) recueillis dans l'unité n° 4a (échelle = 100 μ).*

TABLE I

Insect and other arthropod remains and plant macrofossils from Units 4 and 4a at the Bélanger sand pit (Pointe-Fortune site)

	Unit 4	Unit 4a
INSECTS AND OTHER ARTHROPODS		
Coleoptera		
Carabidae		
Patrobus sp.		+hd,el
Trechus apicalis Motsch.		+hd,pr,el
Bembidion transparens Gebl.		+hd,pr,el
Bembidion concretum Csy.		+pr,el
Bembidion fortestriatum Motsch.		+pr,el
Bembidion wingatei Bland		+el
Tachys angulatus Csy.		+el
Dyschirius sp.	+el	
Pterostichus sp.	+pr	
Agonum melanarium grp.		+pr
Dytiscidae		
Genus?		+pr,el,ff
Gyrinidae		
Gyrinus sp.		+el,ff
Hydraenidae		
Ochthebius sp.		+el
Hydrophilidae		
Cercyon sp.	+el	
Staphylinidae		
Pycnoglypta sp.		+pr
Eucnecosum sp.		+pr
Olophrum boreale (Payk.)		+pr
Olophrum consimile Gyll.		?pr
Acidota sp.		+pr
Stenus sp.		++pr,hd,el
Lathrobium sp.		+el
Tachinus sp.		?el
Gymnusa sp.		+pr,el
Pselaphidae		
Genus?	+el	
Scarabaeidae		
Genus?		+lg
Helodidae		
Cyphon sp.		+el
Chrysomelidae		
Donacia sp.		+hd,ff
Curculionidae		
Genus?		+hd
Rhynchaenus sp.		+el
Trichoptera	?lv,md	
Arachnida		
Acari		
Oribatei		
Genus?	+	+
PLANTS		
Bryophyta		
Drepanocladus exannulatus (B. S. G.) Warnst.		++ff
Calliergon stramineum (Brid.) Kindb.		rff
Pinaceae		
Thuja sp.	+lf	
cf. *Picea* sp.	+nd	r
Salicaceae		
cf. *Salix* sp.		++bd
Sparganiaceae		
Sparganium sp.	+	
Najadaceae		
Potamogeton cf. *P. diversifolius* Raf.	+	
Potamogeton Spirillus Tuckerm.	+	
Potamogeton cf. *P. obtusifolius* Mert. & Koch	+	
Najas flexilis (Willd.) Rostk. & Schmidt	+	
Najas gracillima (A. Br.) Magnus	+	
Hippuridaceae		
Hippuris vulgaris L.		+
Alismaceae		
Sagittaria sp.	+	
Cyperaceae		
Carex crinita Lam.	+	
Carex lupulina Muhl.	+	
Carex sp.		++
Eleocharis palustris/uniglumis type		++
Eleocharis sp.	+	+
Scirpus sp.	+	
Juncaceae		
Juncus sp.		+
Betulaceae		
Betula cf. *B. populifolia* Marsh.	++bd;sd	
Alnus sp.	+bd;sd	
Myricaceae		
Myrica Gale L.	+	
Polygonaceae		
Polygonum or *Rumex* sp.	+	
Nymphaeaceae		
cf. *Nuphar* sp.	+	
Saxifragaceae		
Saxifraga cf. *S. Aizoon* Jacq.	+	
Rosaceae		
Rubus sp.	+	
Physocarpus sp.	+	
Potentilla palustris (L.) Scop.		++
Potentilla sp.		++
Fragaria virginiana Duch.		+
Violaceae		
cf. *Viola* sp.		+
Hypericaceae		
Hypericum sp.	+	
Primulaceae		
cf. *Androsace* sp.	+	
Gentianaceae		
Menyanthes trifoliata L.	+	
Verbenaceae		
Verbena cf. *V. hasta* L.	+	
Labiatae		
Lycopus americanus Muhl.	+	
Caprifoliaceae		
Sambucus sp.	+	
Diervilla Lonicera Mill.	+	
Compositae		
Several types undiff.	+	

Plant and insect fossils are explained by symbols abbreviated below. Absence of symbols for plants indicates the fossils are seeds (achenes, fruits or nutlets). Abbreviations: ++ = taxon abundant; + = taxon present; r = taxon rare; Genus? = genus unknown; cf. *Salix* = identification of genus uncertain due to poor fossil preservation; *Betula* cf. *B. populifolia* = identification of genus certain but species uncertain due to poor fossil preservation; Compositae undiff = one or more types are present; sd = seed(s); nd = needle(s); lf = leaf or leaf fragment(s); bd = bud(s), bud scale(s), or bud bract(s); pl,ff = plant fragment(s); el = elytron(a); hd = head(s); pr = pronotum(a); lg = leg; lv,md = larval mandible(s).

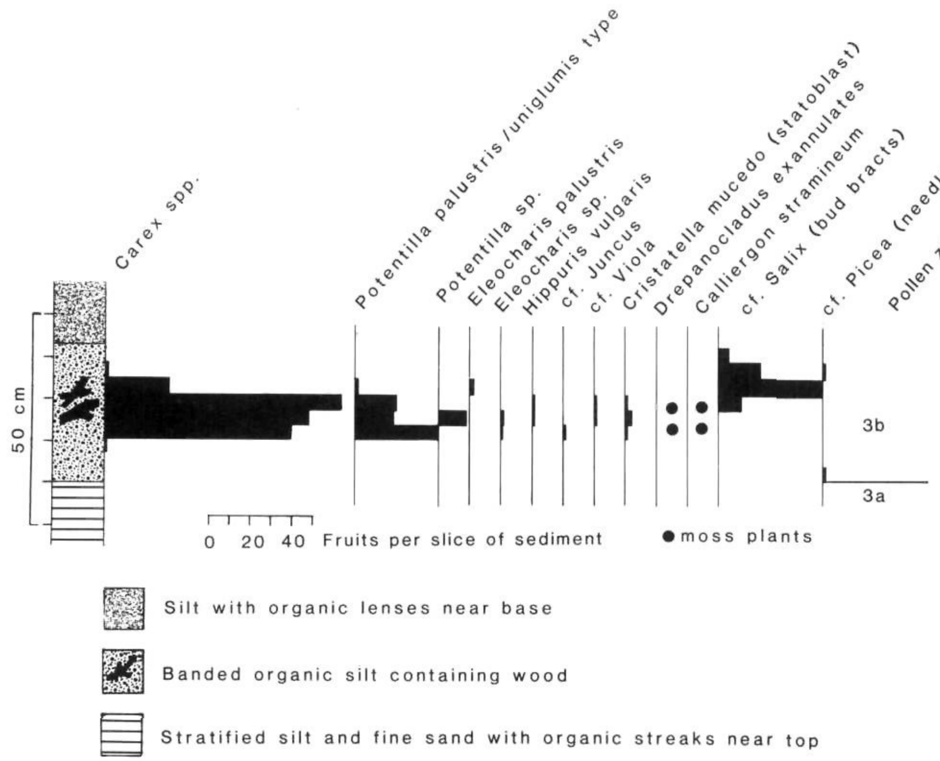


FIGURE 10. Plant macrofossil diagram showing relative numbers of fossils in contiguous sediment slices from Unit 4a monolith.

Diagramme de végétaux macrofossiles montrant le nombre relatif de fossiles dans des tranches de sédiments successives de l'unité monolithique n° 4a.

former flood plain and thus the fossil assemblages can be expected to be diverse. Fossil insects are rare compared to plant remains and preservation of both is poor.

Plant macrofossil occurrences of submersed rooted plants within the Sparganiaceae, Alismataceae and Nymphaceae and presence of ostracode shells (Veillette and Nixon, 1984) indicate that lacustrine habitats having abundant pond weeds formed part of a floodplain environment during deposition of the buried sediments. Taxa within the Cyperaceae, *i. e. Carex crinita, C. lupulina, Eleocharis* and *Scirpus* presumably formed part of an aquatic vegetation zone in the shallower waters and along the margins of pools.

Though pine was present initially (judged from the high percentages of *Pinus* pollen at the base of zone 1), the relatively high representation of pollen of *Quercus, Ulmus, Carya* and *Fagus* and low percentages of *Picea* and *Abies* in pollen assemblage zone 1 indicate a deciduous forest occupied the area. This forest became less deciduous-like and more boreal in character in pollen assemblages zone 2 as shown by significant increases in *Picea, Abies* and *Alnus*, minor occurrences of *Tsuga* and upward decreases in the deciduous hardwoods notably *Ulmus, Fagus* and *Carya*. The high *Quercus* and presence of *Liquidambar* (sweetgum) pollen represent a significant contribution from the Deciduous Forest. This forest was probably at about the same distance beyond the site as the present-day Deciduous Forest on account of the similarity of the major pollen profiles and those of the late Holocene or pre-settlement zone in Figure 2. The presence of *Liquidambar* pollen suggests that the "paleo-deciduous forest" was closer in composition to the modern southern hardwood forest of southeastern United States than to the deciduous forest of southern Canada. Isopoll maps for the southeastern United States show that within the range of *Liquidambar* (Fowells 1965), *Quercus* and *Pinus* are the dominant pollen taxa of the modern pollen assemblages (Delcourt and Delcourt, 1985).

Figure 12 shows the modern distribution limits of some key plant macrofossils extracted from the upper part of Unit 4. It is interesting to note that the Pointe-Fortune site lies about 700 km south of the present-day northernmost limit of *Hypericum* spp., *Diervilla Lonicera* and *Sambucus*. The present-day northern limits of *Verbena, Carex lupulina* and *Najas gracillima* and southern limit of *Saxifraga Aizoon* are just north (within 150 km) of the site. At time of deposition, the Pointe-Fortune site probably lay well within the distributional limits of the corresponding plants.

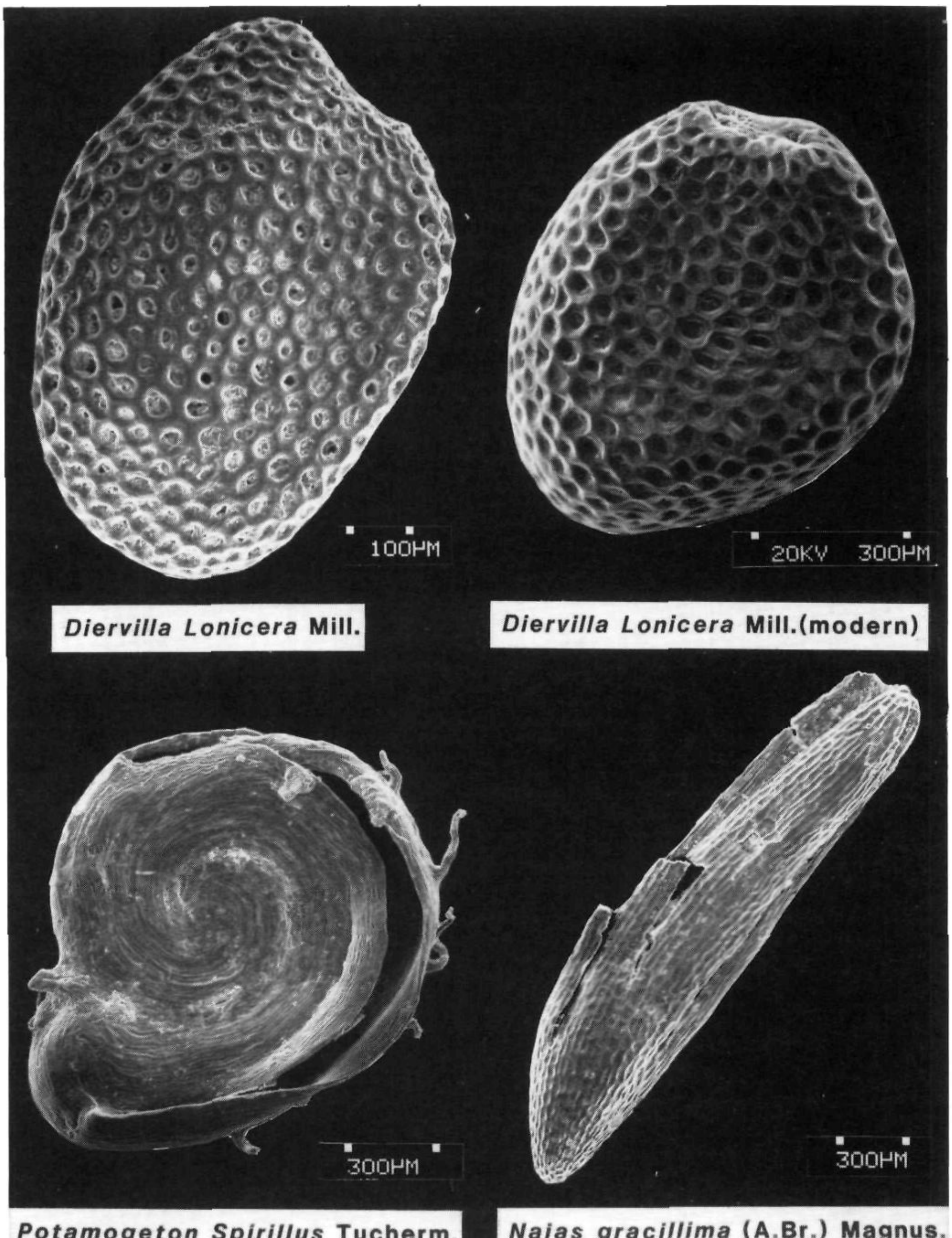
The plant macrofossil occurrences indicate climatic conditions in the area at the time were at least similar, and probably substantially warmer, than the present climate of the area. This is also borne out by the changes in pollen stratigraphy. Compared with the late Holocene (pre-*Ambrosia*) pollen records from lakes and bogs in the vicinity of the site (Fig. 2), the zone 1 and 2 pollen assemblages have a distinctly more deciduous character. Thus an interglacial environment (most likely the Sangamonian), which was probably warmer than present, is implied during the interval represented by pollen assemblage zones 1 and 2 though gradual deteriorating conditions are evident in pollen zone 2.

POINTE-FORTUNE SEDIMENTS (UNIT 4A)

Fossil insects are more numerous and the assemblage is more diverse in Unit 4a than in Unit 4. Plant macrofossils on the other hand are less diverse. Some insect and plant macrofossil taxa not present in the underlying units are especially abundant in Unit 4a, *i. e.* remains of the beetle, *Stenus* and

FIGURE 11. Scanning electron micrographs of three fossil seeds extracted from an organic-rich layer in Unit 4. Also shown is a modern seed of *Diervilla Lonicera* (Mill.) for comparison with the fossil.

Micrographies par balayage électronique de trois graines fossiles extraites d'une couche riche en matière organique de l'unité n° 4. Pour fins de comparaison, on montre une graine moderne de Diervilla Lonicera *(Mill.).*



fruits identified as *Eleocharis palustris/uniglumis* type, *Potentilla palustris, Potentilla* sp. and *Carex* spp.

The depositional environment of Unit 4a sediments resembled a small pond but this pond was probably shallower and more eutrophic than earlier judging by the organic nature of the sediments, by presence of fruits of emergent aquatics such as *Hippuris vulgaris, Eleocharis palustris/uniglumis* type, *Carex, Juncus,* and *Sparganium* and by absence of pollen and plant macrofossils within the Najadaceae. High percentages of Cyperaceae, Gramineae and *Typha/Sparganium* pollen, seeds of *Potentilla palustris* and moss fragments of *Drepanocladus exannulatus* and *Calliergon stramineum* indicate sedges, bullrushes, grasses, cinquefoil and aquatic mosses may have occupied the shallower parts of the pond. Pollen occurrences of *Alnus, Myrica, Salix, Shepherdia canadensis* and macrofossils (including wood and bud bracts) of *Salix* in zone 3 suggest that these and other shrubs formed part of the terrestrial vegetation bordering the pond. Most of the insect taxa listed in Table I are to be expected near the *Carex*-dominated margins of such a small pond. The absence of bark beetles and only single occurrences of conifer needles in the plant macrofossil assemblage (Table I) may mean that the pond was located in a relatively open site, probably a poorly drained region of the stable part of a floodplain.

The successive maxima of *Alnus, Picea* and *Pinus*, minor occurrences of *Abies* and *Salix* and lack of significant amounts of deciduous hardwood pollen in subzone 3a and 3b indicate that the regional forest was distinctly boreal-like. Other supporting evidence is the occurrence of a single flattened piece of wood (ident. as conifer wood, R. J. Mott, GSC Wood

Identification Report No. 82-21) that was extracted from a lens of organic silt and poorly preserved needles identifiable only as coniferous.

The fossil insect remains contrast with the plant macrofossils in providing more insight into regional climate prevailing during deposition of Unit 4a. Figure 13 shows that the site is south of the northern limits of many of the specifically identified carabid beetles. Some of the species are predominantly boreal in distribution (*e. g.* the ground beetle *Bembidion transparens*) and as well, the rove beetles *Eucnecosum* and *Olophrum boreale* are rare today in southern Québec; most of the localities in southern Québec and the adjacent United States are montane or boreal enclaves. The insect data appear to portray climatic conditions slightly colder than at present and, in combination with increasing alder, spruce, pine and willow suggest a boreal forest not unlike that of the present-day Boreal Forest region of north-central Québec and northern Ontario. Thus deteriorating conditions representing either a downturn from a warm interval or a separate cool interval are implied.

DISCUSSION

The deciduous hardwood pollen assemblages of zones 1 and 2 and presence of diagnostic pollen of *Liquidambar* and seeds of plants that presently occur south of, or not much north of, the Pointe-Fortune site provide unequivocal evidence for a warmer-than-present climate, *i. e.* an interglaciation, substage 5e in the marine oxygen isotope record (CLIMAP Project Members, 1984). The increased frequencies of *Picea, Abies,* and *Alnus* and decrease of *Quercus* and other hardwoods in zone 2 and successive maxima of *Alnus, Myrica, Picea, Pinus,* and *Salix* in zone 3 make it tempting to relate these changes to a colder phase of the interglaciation. The subzone 3a/3b boundary occurs at the contact between Units 4 and 4a and because this contact is conformable, it is unlikely that there is a major chronological break between the two units and therefore between subzones 3a and 3b. Pollen subzone 3b thus denotes either a later, colder part of the same warm interval (late substage 5e) or a separate interval (substages 5c or 5a).

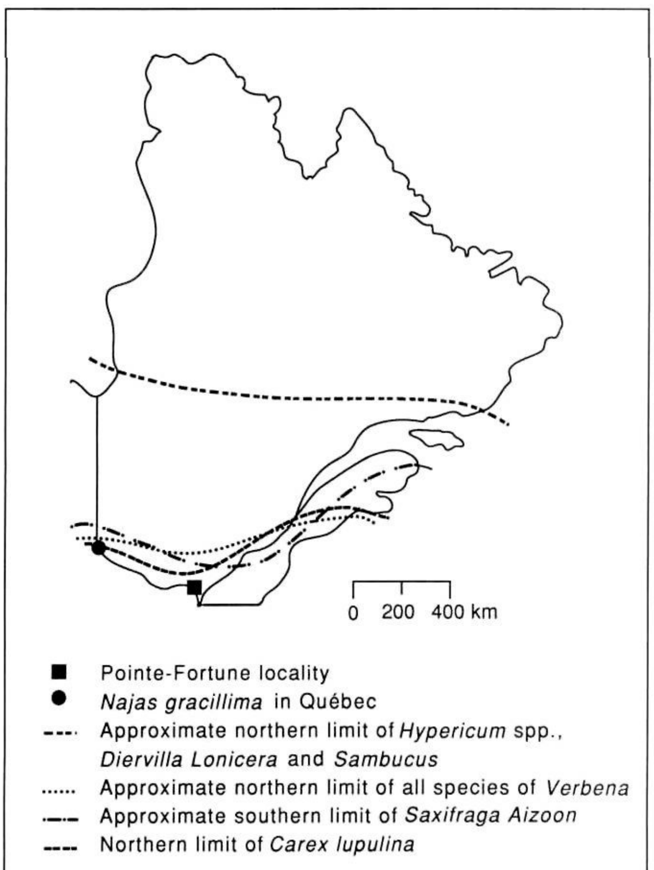


FIGURE 12. Modern distribution limits (in Québec) of some key plants represented by macrofossils extracted from an organic-rich layer in Unit 4. The distributional information is from Haynes (1979) and Rousseau (1974).

Limites de répartition modernes au Québec de quelques végétaux clés représentés par des macrofossiles recueillis dans une couche riche en matière organique de l'unité n° 4. Les données sur la répartition sont de Haynes (1979) et de Rousseau (1974).

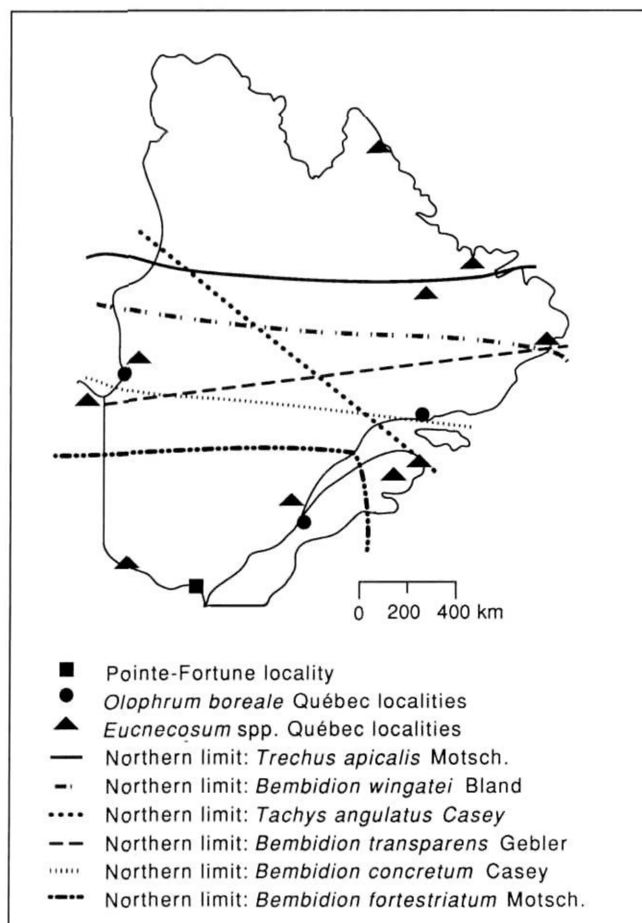


FIGURE 13. Modern distribution limits (in Québec) of some diagnostic insects represented by macrofossils extracted from Unit 4a. The distributional information is from Larochelle (1975) and Campbell (1983, 1984).

Limites de répartition modernes au Québec de quelques insectes indicateurs représentés par des macrofossiles recueillis dans l'unité n° 4a. Les renseignements sur la répartition sont de Larochelle (1975) et de Campbell (1983, 1984).

The pollen stratigraphy of the basal part of the Pointe-Fortune Sediments (zones 1 and 2) is comparable to the abbreviated pollen diagram from the well-known Don Valley Brickyard Section, Toronto, Ontario shown in Figure 14A. There too, pollen of deciduous hardwoods such as *Quercus, Carya, Fagus, Acer, Ulmus, Tilia* and *Liquidambar* dominate pollen zone 1 (basal part of section) giving way towards the top of the Don Beds to significantly higher, in some cases, maximum percentages of *Picea, Pinus* and *Abies* (pollen zone 2); hardwoods decrease appreciably across the zone 1/2 boundary. Terasmae (1960) interpreted this part of the record as signifying a warm climate followed by a cooling trend higher in the sequence. He suggested that during deposition of the lower (Don) beds the climate was 2°C warmer than present and assigned these beds to the Sangamonian interglacial interval. He correlated high percentages of *Picea, Pinus, Salix, Betula* and *Alnus* at the base of the overlying (Scarborough) beds (top of zone 2) to the St. Pierre interstadial interval and inferred a climate change to 4°C cooler than present at time of deposition. Yet the similarity between pollen spectra of the Scarborough Beds and the upper part of the Pointe-Fortune Sediments (subzones 3a and 3b) is striking, suggesting the Scarborough Beds, likewise, may represent a later phase of the Sangamonian.

Other correlative pollen records occur in the St. Lawrence Lowlands and Maritime Provinces. Pointe-Fortune subzones 3a and 3b exhibit the same characteristics as those of the peat-bearing, St. Pierre Sediments of the St. Lawrence Lowlands as analyzed by Terasmae (1958) and Clet and Occhietti (1988). For example, in Les Vieilles Forges section (Fig. 14C), the major pollen taxa consist of *Picea* (average of about 40%), *Pinus* (about 33%), *Abies* (about 3%), *Betula* (about 7%), *Alnus* (up to 80% maximum) and less than 2% deciduous hardwood pollen. Terasmae interpreted the pollen stratigraphy as depicting a climate colder than present in the area and named the event the St. Pierre Interstade.

An abbreviated pollen diagram from East Milford, Nova Scotia (Fig. 14D) shows a basal assemblage (zone 1) dominated by *Fagus, Betula* and *Tilia* along with smaller amounts of *Quercus*, and *Acer*. Complementing the pollen occurrences are macrofossil remains of *Fagus, Betula* and *Acer* at one or more levels in Zones 1, 2 and 3. Other taxa represented by macrofossils are *Sambucus* cf. *canadensis* (elder), *Claytonia* cf. *caroliniana* (spring-beauty) and *Laportea canadensis* (wood-nettle) (Mott *et al.*, 1982). Pollen of the hardwoods decline upwards in the diagram and are replaced by successive maxima in *Betula* (zone 2), *Abies* (zone 3) and *Alnus* and *Picea* (zone 4). The dominance of hardwoods at the base of the diagram is correlated with altithermal conditions early in the interglacial interval; the change to a conifer-dominated assemblage towards the top of the diagram is correlated with gradual deteriorating conditions late in the interval (Mott, 1989).

Also in Nova Scotia, the basal zones 1, 2 and 3 of the Addington Forks diagram (Fig. 14E) are characterized by high percentages of *Quercus* and *Carya* and smaller quantities of *Pinus* and other hardwoods which include *Ulmus, Fagus* and *Tilia*. The upper zones 4 and 5 are marked by successive maxima in *Picea, Abies* and *Alnus*. Mott and Grant (1985) interpreted the pollen evidence to signify an interglacial mixed hardwood forest being replaced by a coniferous forest under deteriorating climatic conditions (cooler temperatures and possibly greater rainfall).

The common pollen component in all the sites, with the exception of Les Vieilles Forges section, is an initial record which translates into a climate that was at least as warm as the present. This is succeeded by a pollen spectra and an inferred climatic signal that was substantially colder than the present. The colder-than-present spectra (Pointe-Fortune zone 3, Don Valley Brickyard section zone 2, East Milford Quarry section zone 4 and Addington Forks section zones 4 and 5) are not too unlike the Les Vieilles Forges pollen sequence suggesting that these, as well as other equivalent non-glacial records in the St. Lawrence Lowlands (Terasmae, 1958; Clet, 1987; Clet and Occhietti, 1988) might possibly represent the waning phase of the interglacial interval. Alternatively, these spectra could be representative of the St. Pierre Interstade as is already suggested for the Les Vieilles Forges section (Terasmae, 1958). As yet, no warm-type fossil assemblages equivalent to Pointe-Fortune assemblage zones 1 and 2 have been discovered in the St. Lawrence Lowlands.

Assigning the Pointe-Fortune Sediments to the Sangamon Interglaciation makes the lower till Illinoian in age and the upper till Wisconsinan in age. On the basis of this discovery (Anderson *et al.*, 1988), Lamothe (1989) now considers the lowermost till (Bécancour Till?) that underlies much of his study area to be pre-Sangamonian or Illinoian in age. This is succeeded by rhythmites and then sand (Lotbinière Sand) which he maintains represents a non-glacial event. Fossil insects (J. V. Matthews, Jr., GSC Fossil Arthropod Report 86-19) from the upper part of this sand unit show an assemblage that differs slightly from typical St. Pierre Sediments but the pollen assemblages (R. J. Mott, GSC Palynological Reports 87-16, 87-17 and 87-18) are not too unlike St. Pierre. Since both insect and pollen evidence suggest a climate that was colder than at present in the area, the Lotbinière Sand probably correlates best with the latter part of the Sangamonian (late substage 5e).

Table II is a correlation chart of Late Quaternary units showing the stratigraphic sequences at the Pointe-Fortune sand pit and for the St. Lawrence Lowlands (Lamothe, 1989) and a revised sequence of events for the Ottawa-St. Lawrence Lowlands. The revised changes from previous correlation charts (Gadd, 1971, 1976; LaSalle, 1984) are based mainly on the sediment and fossil records as defined here for the Pointe-Fortune site. New additions are the recognition of the Illinoian (Rigaud Till) and Sangamonian (Pointe-Fortune Sediments) chronostratigraphic units, stages 6 and 5, respectively, in the marine oxygen isotope stratigraphy.

The Pointe-Fortune Sediments and pollen assemblage zones 1 and 2 correspond to the earliest and warmest part of the Sangamonian (Substage 5e) of which there is no equivalent in the St. Lawrence Lowlands. The upper part of these sediments (Unit 4a) and corresponding pollen subzone 3b as well as comparable pollen assemblages from the Lotbinière Sand of the St. Lawrence Lowlands possibly equate with a colder part of the interglacial interval, *i. e.* late substage 5e, 5c or 5a. Furthermore, the similarity between Pointe-Fortune assem-

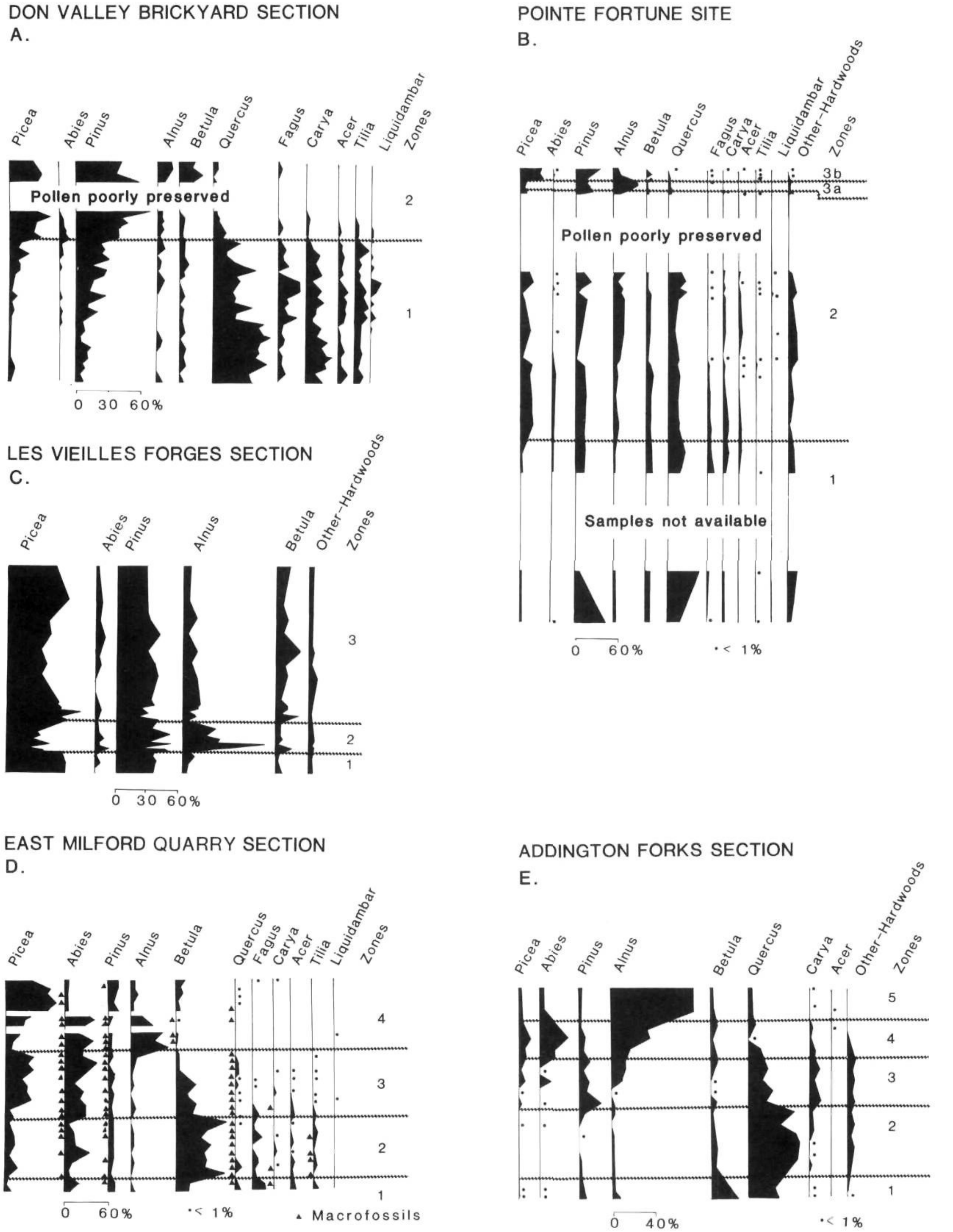


FIGURE 14. Abbreviated pollen diagrams of the Pointe-Fortune site and of correlative sites from eastern Canada. A) Don Valley Brickyard section, (modified and rezoned from Terasmae, 1960). B) Pointe-Fortune site (this study). C) Les Vieilles Forges section (modified and rezoned from Terasmae, 1958). D) East Milford Quarry section (modified from Mott *et al.*, 1982). E) Addington Forks section (modified from Mott and Grant, 1985).

Diagrammes polliniques sommaires du site de Pointe-Fortune et de sites corrélatifs de l'est du Canada. A) Coupe de la Don Valley Brickyard (modifiée et rezonée à partir de Terasmae, 1960) B) Site de Pointe-Fortune (présente étude). C) Coupe des Vieilles-Forges (modifiée et rezonée à partir de Terasmae, 1958). D) Coupe d'East Milford Quarry (modifiée à partir de Mott et al., *1982) E) Coupe d'Addington Forks (modifiée à partir de Mott et Grant, 1985).*

TABLE II

Correlation chart, central St. Lawrence Lowlands

	TIME	POINTE-FORTUNE SITE (THIS STUDY)	ST. LAWRENCE LOWLANDS (LAMOTHE, 1989)	OTTAWA-ST.LAWRENCE LOWLANDS (PROPOSED REVISION)	MARINE ISOTOPE STAGES (CLIMAP PROJECT MEMBERS, 1984)
			CHAMPLAIN SEA SEDIMENTS	CHAMPLAIN SEA SEDIMENTS	1
12ka	LATE WISCONSINAN	BORDER TILL CARILLON SANDS	GENTILLY TILL GRAY VARVES	GENTILLY TILL	2
25ka	MIDDLE WISCONSINAN	↓ (?)	ST.PIERRE SEDIMENTS	↓ (?)	3
65ka	EARLY WISCONSINAN		LÉVRARD TILL DESCHAILLONS VARVES CAP LÉVRARD VARVES		4
75ka	SANGAMONIAN		LOTBINIÈRE SAND	ST. PIERRE SEDIMENTS	5a
				LÉVRARD TILL (?)	5b
				LOTBINIÈRE SAND	5c
				LÉVRARD TILL (?)	5d
		POINTE-FORTUNE SEDIMENTS		POINTE-FORTUNE SEDIMENTS	5e
128ka	ILLINOIAN	RIGAUD TILL	RHYTHMITES BÉCANCOUR TILL	BÉCANCOUR TILL	6

blage zone 3 and that of the St. Pierre Sediments suggests that the latter, too, may correspond to either late substage 5e, 5c or 5a. The finite date of 74 700 +2700 -2000 BP (QL-198; Stuiver *et al.*, 1978) on wood from the St. Pierre Sediments indicates that they must be at least as old as Substage 5a. Pre-St. Pierre glacial sediments comprising the Deschaillons Varves (locally referred as Cap Lévrard varves) and Lévrard Till may therefore relate to the colder isotopic substage 5b and/or 5d rather than to Stage 4 as suggested by Lamothe (1989). These glacial sediments might possibly represent a local readvance of ice into the St. Lawrence Lowlands as equivalent sediments do not occur at Pointe-Fortune.

The Pointe-Fortune cross-bedded sands (Unit 5) and upper till (Unit 6), herein called Carillon Sands and Border Till, respectively, and equivalent Gentilly Till and associated varves of the St. Lawrence Lowlands may be Early, Middle and Late or Middle and Late Wisconsinan in age (Fulton, 1984; Occhietti, 1982) and thus correspond to isotope stages 4 to 2 inclusive (Table II). This could mean that the entire Ottawa-St. Lawrence lowland region might have been completely ice covered from Early to Late Wisconsinan time which would contrast with an ice-free Middle Wisconsinan period in southern Ontario and the Great Lakes (Karrow, 1984).

Other sites in southern Québec have yielded plant macrofossils and insects which appear to be of interglacial and interstadial age (Matthews, 1987). Work underway by A. Telka and Matthews shows some of the same "warm" plant fossils occur at the Rivière des Plantes section in the Chaudière River valley (Shilts and Smith, 1987; Matthews, 1987) as in the lower part of the Pointe-Fortune Sediments. The Missinaibi Beds in the James Bay Lowlands also contain plants and insects indicative of warmer-than-present conditions (Lichti-Federovich, 1974; Matthews, 1987). Thus in the near future we may have a better basis for comparison of the Pointe-Fortune macroremains with those from other interglacial sites in Québec.

SUMMARY AND CONCLUSIONS

1) Basal clay and overlying stratified sand and silt (units 2, 3 and 4) at the Pointe-Fortune site are collectively named the Pointe-Fortune Sediments. These sediments are characterized by deciduous hardwood pollen of *Quercus, Fagus, Acer, Carya, Ulmus, Tilia,* and *Liquidambar; Picea* increases appreciably within Unit 4. Climatic conditions at onset of deposition are interpreted to have been as warm or warmer than at present in the area but deteriorating conditions are evident upwards in the sequence.

2) Organic-rich silts (Unit 4a) comprise the upper part of the Pointe-Fortune Sediments. Coniferous tree and shrub pollen including *Picea, Pinus, Abies, Alnus* and *Salix*, which dom-

inate these silts, imply climatic conditions were colder than at present in the area at time of deposition.

3) Though present in small quantities, plant macrofossils and fossil insect remains support the paleoenvironmental interpretations deduced from the pollen record. The site lies close to the present-day northern limits of some key plants found as fossils in the Pointe-Fortune Sediments but well south of the present-day northernmost distribution of some of the fossil carabid beetles.

4) The Pointe-Fortune Sediments and corresponding pollen assemblage zones 1 and 2 are equated with the warmest part of the Sangamonian Stage (early in oxygen isotope Substage 5e), thus making the underlying till (herein named Rigaud Till) Illinoian in age and correlative with oxygen isotope Stage 6.

5) The upper part of the Pointe-Fortune Sediments and corresponding pollen subzone 3b most likely represent a colder phase of the Sangamonian Stage (late in oxygen isotope Substage 5e). On the other hand, subzone 3a and 3b pollen assemblages show a likeness with those typical of St. Pierre Sediments in the St. Lawrence Lowlands (Les Becquets Interstade).

6) The cross-bedded sands (Unit 5) and upper till (Unit 6) which we named, respectively, Carillon Sands and Border Till, could be Early, Middle or Late Wisconsinan in age or represent continuous glaciation back to Early Wisconsinan time.

7) The Pointe-Fortune site thus provides the only evidence to date for warm interglacial conditions in the St. Lawrence Lowlands and in the entire region between the Great Lakes and Nova Scotia.

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