Géographie physique et Quaternaire

The Sangamonian Pointe-Fortune Site, Ontario-Québec Border

Thane W. Anderson, John V. Matthews, Jr., Robert J. Mott et S. Henry Richard

Résumé de l’article

Les sédiments contenus entre deux couches de till (unités nos 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 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 boréal. 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.

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


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 not colder than the climate of central Quebec — 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 nos 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 pois­lons 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'Illinoïen; 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 Ottawas, 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 Makrofossilien von verschiedenen Pflanzen­Taxa, 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 gegenwärtig im Gebiet war. Im Gegensatz dazu enthält die darüberliegende Einheit 4 überwiegend Indikatoren nördlicher Milieus, wie Pollen von Rottanne, Kiefer, Weide und Erle (Picea, Pinus, Salix und Alnus) und die Käfer Bembidion 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 Interstadum des Tieflands des St. Lawrence schliessen lässt. So wird das Alter des unteren Tills auf das Illinoïum datiert; das obere Till könnte mittleres bis spätes Wisconsinium oder frühes bis spätes Wisconsinium sein.

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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 inter-val 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).

radiocarbon 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 ecoregion 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), large tooth aspen (Populus grandidentata) 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 thomasi), 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 sily, sandy till, and because of its stratigraphic position and significant content of Shield erratics, it is correlated with the Becancour 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
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.

Figure 4. View of sub-surface stratigraphy in a backhoe trench showing a horizontally bedded, organic-rich layer in Unit 4 (photograph from Veillette and 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.

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.

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.

Géographie physique et Quaternaire. 44(3), 1990

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 Carra 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

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**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).
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 gracililima, 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 μm.

Microographies 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 μm).
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<thead>
<tr>
<th>INSECTS AND OTHER ARTHROPODS</th>
<th>Unit 4</th>
<th>Unit 4a</th>
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<td>Coleoptera</td>
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<td>Carabidae</td>
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<td>Bembidion concretum Csy.</td>
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<td>Bembidion wingatei Bland</td>
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<td>Bembidion transparens Gebl.</td>
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<td>Scarabaeidae</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acrotylus sp.</td>
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</tr>
<tr>
<td>Staphylinidae</td>
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<td></td>
</tr>
<tr>
<td>Olophrum boréale (Payk.)</td>
<td>+el</td>
<td></td>
</tr>
<tr>
<td>Olophrum consimile GyII.</td>
<td>+el</td>
<td></td>
</tr>
<tr>
<td>Acidota sp.</td>
<td>+el</td>
<td></td>
</tr>
<tr>
<td>Chrysomelidae</td>
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</tr>
<tr>
<td>Donacia sp.</td>
<td>+el</td>
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</tr>
<tr>
<td>Curculionidae</td>
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</tr>
<tr>
<td>Rhynchaenus sp.</td>
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</tr>
<tr>
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<tr>
<td>?lv,md</td>
<td>+</td>
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</tr>
<tr>
<td>Arachnida</td>
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<td></td>
</tr>
<tr>
<td>Acari</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Genus?</td>
<td>+</td>
<td>+</td>
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</tr>
<tr>
<td>Bryophyta</td>
<td>+ +</td>
<td></td>
</tr>
<tr>
<td>Drepanocladus exannulatus (B. S. G.) Warnst.</td>
<td>+ff</td>
<td></td>
</tr>
<tr>
<td>Callicarpa drummondii (Brid.) Kinds.</td>
<td>rff</td>
<td></td>
</tr>
<tr>
<td>Pinaceae</td>
<td></td>
<td></td>
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<tr>
<td>Thuya sp.</td>
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<td></td>
</tr>
<tr>
<td>cf. Picea sp.</td>
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<tr>
<td>Salicaceae</td>
<td></td>
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</tr>
<tr>
<td>cf. Salix sp.</td>
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<tr>
<td>Sparganaceae</td>
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<tr>
<td>Sparganium sp.</td>
<td>+</td>
<td></td>
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<tr>
<td>Najadaeceae</td>
<td></td>
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<tr>
<td>Potamogeton cf. P. diversifolius Rat.</td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>

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); ld = leaf (or leaf fragment(s); bl = bud(s), bud scale(s), or bud bract(s); pl,ff = plant fragment(s); el = elytron(a); hd = head(s); pr = pronotum(a); Ig = leg; Iv.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. lupilina, 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 southeastern hardwood forest of 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 lupilina 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
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, bulrushes, 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 Eucnecosomum 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).
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, Betulia and Tilia along with smaller amounts of Quercus, and Acer. Complementing the pollen occurrences are macrofossil remains of Fagus. Betulia 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 Caraya 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 hard-wood 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 it 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 cooler 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-
TABLE II
Correlation chart, central St. Lawrence Lowlands

<table>
<thead>
<tr>
<th>TIME</th>
<th>POINTE-FORTUNE SITE (THIS STUDY)</th>
<th>ST. LAWRENCE LOWLANDS (LAMOTHE, 1989)</th>
<th>OTTAWA-ST. LAWRENCE LOWLANDS (PROPOSED REVISION)</th>
<th>MARINE ISOTOPE STAGES (CLIMAP PROJECT MEMBERS, 1984)</th>
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<tr>
<td>12ka</td>
<td>LATE WISCONSINAN</td>
<td>BORDER TILL</td>
<td>GENTILLY TILL</td>
<td>CHAMPLAIN SEA SEDIMENTS</td>
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<td></td>
<td></td>
<td>CARILLON SANDS</td>
<td>GENTILLY TILL</td>
<td>CHAMPLAIN SEA SEDIMENTS</td>
</tr>
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<td>25ka</td>
<td>MIDDLE WISCONSINAN</td>
<td>ST PIERRE SEDIMENTS</td>
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</tr>
<tr>
<td>65ka</td>
<td>EARLY WISCONSINAN</td>
<td>LÉVRARD TILL (?</td>
<td>DESCHAILLONS VARVES</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CAP LÉVRARD VARVES</td>
<td></td>
</tr>
<tr>
<td>75ka</td>
<td>SANGAMONIAN</td>
<td>LOTBINIÈRE SAND</td>
<td>ST. PIERRE SEDIMENTS</td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>LÉVRARD TILL (?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>LOTBINIÈRE SAND</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>LÉVRARD TILL (?)</td>
<td></td>
</tr>
<tr>
<td>128ka</td>
<td>ILLINOIAN</td>
<td>RIGAUD TILL</td>
<td>RHYTHMITES BÉCANCOUR TILL</td>
<td>BÉCANCOUR TILL</td>
</tr>
</tbody>
</table>

Blige zone 3 and that of the St. Pierre Sediiments suggests that the latter, too, may correspond to either late substages 5c or 5a. The finite date of 74 700 ± 2700 -2000 BP (QL-198; Stuiver et al., 1978) on wood from the St. Pierre Sediiments 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 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 Sediiments. 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*, *Atrhus* 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.

ACKNOWLEDGMENTS

Prior to his untimely death in 1987, S. H. (Henry) Richard had studied in detail the stratigraphic and geomorphic relationships of the Bélanger sand pit. He led numerous field excursions to the site; Anderson, Matthews and Mott are fortunate to have been on one or more of these trips. We are deeply grateful to Henry for getting us initially involved with paleoenvironmental studies of the exposed sediments. He was able to recognize quite early that this was a potentially significant site in the Late Quaternary sequence of events of the Ottawa-St. Lawrence Lowlands. Additional fossil studies of the buried sediments after his death proved him correct.

We thank G. Argus, National Museum of Natural Sciences, for kindly identifying the fossil willow bud bracts, L. Ovenden (Postdoctoral visitor, Geological Survey of Canada) for identifying the fossil bryophytes, D. Walker, (GSC) for SEM analyses, H. Jetté (GSC) for assistance with pollen processing and counting and D. Sharpe (GSC) for helpful discussions on interpretations of sediment history. J. Veillette and M. Nixon (GSC) provided key core samples from the buried sediments upon which the interglacial status was inferred for these sediments. We thank S. Occhietti, P. J. H. Richard, and J. Veillette for providing helpful comments on the manuscript.

REFERENCES


THE SANGAMONIAN POINTE-FORTUNE SITE


