

# General stratigraphic framework of the Quaternary in Eastern Canada

## Cadre stratigraphique général du Quaternaire de l'est du Canada

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### Article abstract

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# GENERAL STRATIGRAPHIC FRAMEWORK OF THE QUATERNARY IN EASTERN CANADA

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**ABSTRACT** In eastern Canada, interglacial and interstadial deposits have been reported from Nova Scotia and Québec, but in the other provinces only Wisconsinan deposits. In Nova Scotia, pollen from some organic deposits buried beneath one or more tills, indicates a warm, interglacial climate — presumably the Sangamon Interglacial Interval. Other buried organic deposits, in contrast, indicate a cool, boreal forest environment. As radiocarbon analyses have given 'greater than' dates the deposits are considered to be early Wisconsinan. The interval is tentatively correlated with the St. Pierre Interstadial of Québec. The only known mid-Wisconsinan deposit is at Salmon River on St. Mary's Bay, in southwestern Nova Scotia, where the marine shells have been dated at 38,600  $^{14}\text{C}$  years. Elsewhere in both coastal and interior Nova Scotia multiple till sections suggest a more or less continuous ice cover through-out the Wisconsinan. In central Nova Scotia, however, red tills have been considered late-Wisconsinan. In Québec, there is a very limited, but nevertheless important, record of the Sangamon Interglacial Interval. Compact clayey rhythmites in the Harricana River Basin, close to James Bay, appear to correlate with the lacustrine member of the Missinaibi Formation farther west in Ontario. In southern Québec, there is another indication of interglacial deposits for the oldest sediments exposed in the Sherbrooke region and in the Upper Chaudière River Valley beneath the lowest of three Wisconsinan tills. These deposits were weathered and cemented prior to deposition of the oldest till. As the gravels contain pebbles of Laurentian Shield gneiss there obviously was a pre-Sangamon glaciation. These two areas contain the most complete stratigraphic record of the Wisconsinan yet established in Québec.

**RÉSUMÉ** *Cadre stratigraphique général du Quaternaire de l'est du Canada.* Des dépôts interglaciaires et interstadias ont été décrits en Nouvelle-Écosse et au Québec. Dans les autres provinces, seuls les dépôts du Wisconsinien ont été identifiés. En Nouvelle-Écosse, du pollen trouvé dans des dépôts organiques enfouis indique un climat interglaciaire chaud, probablement sangamonien. D'autres sédiments organiques indiquent, au contraire, un milieu de forêt boréale. Les datations au  $^{14}\text{C}$  permettent uniquement d'attribuer un âge minimum aux dépôts; on peut dès lors considérer que ces derniers datent du début du Wisconsinien, et on peut les raccorder stratigraphiquement avec ceux de l'interstadial de Saint-Pierre (Québec). Le seul dépôt connu du milieu du Wisconsinien se trouve à Salmon River (baie de Sainte-Marie, SO de la Nouvelle-Écosse), où l'âge  $^{14}\text{C}$  obtenu sur des coquillages est de 38 600 années. Ailleurs, en Nouvelle-Écosse, des coupes suggèrent une couverture de glace plus ou moins continue pendant toute la durée du Wisconsinien. Au centre, toutefois, on considère que les tills rouges datent de la fin du Wisconsinien. Au Québec, il existe une vestige très limité mais néanmoins important de l'intervalle interglaciaire sangamonien. Des rythmites du bassin de l'Harricana, près de la baie de James, semblent se raccorder stratigraphiquement au membre lacustre de la formation de Missinaibi (Ontario). Au Québec méridional, on trouve d'autres vestiges interglaciaires. Dans la région de Sherbrooke et dans la vallée du cours supérieur de la Chaudière, on trouve d'anciens sédiments sous trois tills wisconsinien, et il y a eu, de toute évidence, une glaciation pré-sangamonienne. Ces deux régions contiennent les éléments stratigraphiques les plus complets jusqu'à maintenant sur les événements wisconsinien au Québec.

**РЕЗЮМЕ** ОБЩАЯ СТРАТИГРАФИЧЕСКАЯ СТРУКТУРА ЧЕТВЕРТИЧНОЙ СИСТЕМЫ ВОСТОЧНОЙ КАНАДЫ. В восточной Канаде, межледниковые и межстадиальные отложения были обнаружены в провинциях Новая Шотландия и Квебек, а в других провинциях только Висконсинские отложения. В Новой Шотландии, пыльца содержащаяся в органических отложениях скрытых под одним или несколькими слоями ледниковых глин (тиллерей) указывает на существовавший теплый, межледниковый климат. Видимо, это имело место во Sangamonского Межледникового Интервала. Другие же скрытые под поверхностью земли органические отложения, наоборот свидетельствуют о прохладной, бореальной лесной среде. Ввиду того, что радио-углеродные анализы дали больше, чем только датировку, эти отложения рассматриваются как ранневисконсинские. Поэтому, упомянутый Интервал может быть соотношен к Межстадиалом Св. Петра в Квебеке. Единственные известные средне-висконсинские отложения были обнаружены на реке Салмон вблизи бухты Св. Марии расположенной в юго-западной части Новой Шотландии. Найденные там морские раковины имеют возраст в 38 600 лет, как показала датировка произведенная с помощью углерода —  $^{14}\text{C}$ . В других местах, как на побережье, так и внутри провинции Новая Шотландия, изучение секций многочисленных тиллей, дает основания говорить о почти непрерывном ледяном покрове в течении всего Висконсинского периода. Однако, в центральной части Новой Шотландии, обнаруженные там красные тилли было принято считать как поздневисконсинские. В Квебеке же найдены очень немногие, но важные геологические следы Sangamonского Межледникового Интервала. Плотные глинистые ритмиты найденные в долине реки Харриканы, вблизи от бухты Джеймса, сходны с теми, которые были обнаружены стратиграфически далее на западе в районе формирования Миссинайби в провинции Онтарио. В южном Квебеке имеются также следы межледниковых отложений. Древнейшие осадки залегают в районе города Шербрука и в верхнем течении реки Шавер под самым нижним из трех Висконсинских тиллей, что служит доказательством существовавшего в этом районе до-Sangamonского оледенения. Эти два района содержат самые полные стратиграфические данные о Висконсинском периоде собранные в Квебеке до настоящего времени.

## INTRODUCTION

The diversity of information on the Quaternary stratigraphy of eastern Canada (Québec and eastward) necessitates a regional treatment. In the Atlantic Provinces, both interglacial and interstadial deposits are known from Cape Breton Island and mainland Nova Scotia, but neither have been recognized from Newfoundland, nor Prince Edward Island, and there is but one probable interstadial occurrence from New Brunswick. In Québec, organic deposits that predate the last glaciation have been reported from the Magdalen Islands, in Gulf of St. Lawrence, and from the Eastern Townships; also certain rhythmites that occur below the main Wisconsinan till south of James Bay carry detrital organic matter. Except for these occurrences the stratigraphy of eastern Canada pertains only to the last glaciation. This is not to say that the stratigraphy elsewhere is simple for, as is well known, late Wisconsinan stratigraphic sections involving glacial, glaciofluvial, glaciolacustrine, glaciomarine and postglacial deposits can be very complicated. Only a few of the latter will be dealt with — hopefully sufficient to denote the complexities that may be expected in some parts of eastern Canada. More attention is given here to the older record in that it serves to fill in the Quaternary stratigraphic column and to many of us it is of greater interest both stratigraphically and historically.

## NEWFOUNDLAND

Though I have no information on older organic-bearing deposits in Newfoundland the stratigraphic sections exposed around St. George's Bay on the south-west coast are of interest. There, following an initial retreat of the Newfoundland Ice Sheet and overlap of the sea onto the present coastal area about 13,700 years ago, there was a readvance of the ice around 13,000 to 12,700 years ago. The stratigraphy has been described recently by BROOKES (1969, 1974) and was first given publicity by MacCLINTOCK and TWENHOFEL (1940). The most interesting section perhaps is that at Robinsons Head where the younger marine sediments overlap kame gravels and lenses of sandy till which in turn overlie probable delta foreset beds that rest on the older, shell-bearing, marine silty clays and basal till.

The Island of Newfoundland is currently being studied in some detail by BROOKES and GRANT and we will no doubt soon be hearing of new sites where a more complete stratigraphic sequence is present. And I will hazard the opinion also that the fiords and highlands of the Labrador coast will probably also yield stratigraphic evidence of buried organic deposits and an involved Wisconsinan history, for they lie at the fringe of the Labrador sector of the Laurentide Ice Sheet. Evidence is growing that this ice mass was not as thick nor expansive as formerly believed.

## NOVA SCOTIA

In Nova Scotia, organic deposits buried beneath one or more tills or other materials are widespread (Fig. 1). Some of these provide evidence of a warm, interglacial environment and are tentatively referred to the Sangamon. Most buried organic deposits, however, though beyond the range of radiocarbon dating, indicate a cool climate and have tentatively been referred to the St. Pierre Interval or Interstade. They may, in part, represent very late Sangamon or earliest 'advance' Wisconsinan time in this maritime, fringe region. Lacking definitive data, at this time, the organic sediments (Table I) are here referred to the early Wisconsinan.

## CAPE BRETON

Judging by the palynological record, the most likely interglacial deposit on Cape Breton Island is known only from drill core samples from Leitches Creek near Sydney. Organic materials encountered beneath a till, at a depth of 18 to 21 m, yielded a boreal-forest pollen assemblage, similar to that at other sites on the island and all of which gave "greater than" radiocarbon ages; but the organics from a depth of 38.7 to 40.8 m in the borehole, and beneath a second till, were found to contain a pollen assemblage suggesting a somewhat warmer climate, perhaps the Sangamon. Significant amounts of pollen of blue beech, ironwood, basswood, maple and hazelnut (*Carpinus*, *Ostrea*-type, *Tilia*, *Acer* and *Corylus*) were identified by MOTT (GSC Palynol. Rept. 71-10).

A very interesting stratigraphic sequence is exposed in a 35 to 40 m seacliff in Bay St. Lawrence, Cape Breton. There an eastward-sloping marine platform, or bench, a few meters above sea level (GRANT, 1976b) is overlain by up to 6 m of dense bouldery till and some 10 m of well bedded silt, sand and gravel, with a 30 cm

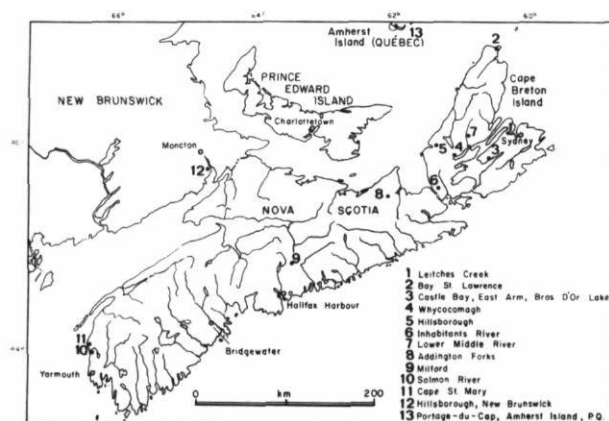


FIGURE 1. Location map with sites of old organic materials, Nova Scotia and environs.

Carte indiquant les sites de matériaux organiques anciens, Nouvelle-Écosse et provinces voisines.

QUATERNARY				Bay St. Lawrence	Leitches Creek	Bras d'Or Lake	River Inhabitants	Addington Forks	Milford Quarry	Salmon River	Cape St. Mary
PLEISTOCENE	HOLO-CENE	RECENT	WISCONSINAN							Marine S. & G.	Marine S.&G. (14,100±200)
			Early	Middle	Late	Gravelly sub-strat. till or colluvium	Red till(s)	Red till(s)	Red till(s)	Red clayey till(s)	Red clayey till
	Shell-bearing Si, S. & G.					(Middle River Mastodon 31,900±630)	(Esker & shells 32,100±900 till & shells > 34,000)		Sand & gravel	Marine S. with shells 38,600±1300	Iron-cemented gravel
	Si, S. & G. with detrital peat	Silty peat		Olive-brown till Si, S. & G. with peat & wood > 51,000	Si. & S. with peat & wood > 39,000		Red clay-silt till Grey-black till with wood Grey-black silt & wood	Red-brown foreign till with shells	Red-brown foreign till with shells > 38,000 Brown slate till		
	Stony till	Red till			(Bedrock)						
	SANGAMON	Raised intertidal platform	Silty peat Pebbles (Élev. 3m)	Oxid. gravel, /grey gravel or till (near sea level)		Sand peat & wood > 42,000	Organics (plants, bones shells) > 50,000	(presumed marine beds St. Mary's Bay)	Marine G. (Raised intertidal platform)		
	PRE-SANGAMON					Red, clayey till	Till(s) (Base of section near sea level)	Grey till (to sea level)	Cemented G. (Bridgewater?) (sea level)		

TABLE 1. Regional correlation table, Nova Scotia.

Corrélations régionales, Nouvelle-Écosse.

bed of detrital 'peat' in its lower part. Palynological study of the organic material indicates a cool, moist climate (MOTT and PREST, 1967). The organics have been dated at >38,300 years BP (GSC-283). The organics are overlain by up to 1 m silt, some 10 m of stratified silt, sand and gravel, and 3 to 4 m silt, sand and pebbles with sparse, thin-walled, marine gastropods and pelecypods. These have been reported by Clarke, National Museum, to be cold-water types. The marine shells have not been dated. At this time it need only be added that above the lenticular marine deposit there is some 9 to 18 m of gravelly colluvium (formerly thought to be substratified till) and then 1.5 to 6 m bouldery colluvium. The full sequence then is bouldery colluvium/substratified gravelly colluvium/marine sand and silt/stratified silt, sand and gravel/detrital peat/stratified gravelly sand and silt/till/bedrock.

Elsewhere on Cape Breton Island (East Arm of Bras d'Or Lake, Whycocomagh, Hillsborough, and Inhabitants River, as well as at Leitches Creek) one or more tills overlie organic beds that have given 'greater than' radiocarbon ages (GRANT, 1971, 1972; MOTT and

PREST, 1967). Palynological studies suggest that these all relate to an interstadial deposit which was tentatively correlated with the early Wisconsinan St. Pierre Interval as recognized in Québec. The stratigraphy, however, is different at each of these sites indicative of an involved depositional history, and of great erosional changes during and since that early interstadial interval. A further complication involving the history and stratigraphy of Cape Breton Island is that pertaining to a radiocarbon date on a *Mastodon* bone. The bone was uncovered (in 1834) during plowing of a field on the floodplain of Middle River near the hamlet of Lower Middle River. Through the courtesy of the Nova Scotia Museum, Grant submitted a sample for radiocarbon analysis and obtained dates of 31,900 ± 630 years BP (GSC-1220) and 31,800 ± 500 (GSC-1220-2). These dates suggest mid-Wisconsinan nonglacial conditions in this area (GRANT, 1975, p. 110). Such a concept is supported by a finite date of 32,100 ± 900 years BP (GSC-1048) on a small quantity of shells collected by GRANT from esker gravels in River Inhabitants valley, though shells from a till on Janvrin Island off Isle Madame, gave >34,000 years BP (GSC-1639); these dates are listed under River Inhabitants section for correlation purposes (Table 1).

## MAINLAND NOVA SCOTIA

On mainland Nova Scotia there is also stratigraphic and related evidence of 'old' glacial, interstadial and interglacial events. Probably the oldest Pleistocene deposit in the province is the heavily iron-cemented Bridgewater Conglomerate, which everywhere adheres tightly to the bedrock (PREST *et al.*, 1972). The massive part of this unit might be termed a 'tillite' for it is a rock-like glacial deposit containing some 'foreign' stones, and it has been seen to overlie a striated surface. It is exposed in many places along the central southeast shore and inland from this shore to elevations of 150 m, and also near the shore south of Yarmouth and probably at Cape St. Mary. Though commonly exposed at the surface, it has been observed beneath a till but its relationships with the more complex stratigraphic sections remains unknown.

At Addington Forks, near Antigonish, palynological studies of a buried organic deposit provided definitive evidence of a climate warmer than that of the present and hence an interglacial episode (MOTT and PREST, 1967). This deposit thus differs from all the Cape Breton occurrences except perhaps for the lower unit at Leitches Creek. At Addington Forks peat and wood occur within a 1 m thick sandy layer between two red clayey tills, the upper about 6 m thick. The wood was dated at >42,000 years BP (GSC-1598). Elsewhere in central interior Nova Scotia similar red tills separated by sand and gravel beds have both been regarded as late Wisconsinan in age. This indicates the care that must be exercised in assigning ages to stratigraphic units where definitive organic remains are lacking.

A more interesting stratigraphic section with interglacial affinities has been exposed in a gypsum Quarry near Milford (PREST *et al.*, 1972, p. 32-33). Here a red, clayey till rests on 2 or 3 m of buff, gravelly sand which in turn overlies a red clayey-silt till. Beneath the latter there is a black clayey-silt till, containing wood, and below this a black, stratified silty-clay with wood. Both these deposits fill depressions in the gypsum surface. Wood from the silty-clay was dated at >50,000 years BP (GSC-1642). The pollen spectra from the black silts suggest a climate similar to that near the southern extent of the boreal forest today. Perhaps this represents a cool part of the Sangamon because below all these sediments, in a deep sinkhole, a complex succession of varied sediments with an amazing fossil content was observed in 1953 by Take, then of the Nova Scotia Museum. He found beaver-sharpened sticks, beechnut, hickory nut, bayberry seed, white pine and hemlock cones, insects, molluscs, and frog and beaver bones. Certainly these deeply buried deposits relate to one or more interglacial intervals (Table I).

A unique stratigraphic assemblage, is exposed on the coast of St. Mary's Bay at Salmon River for here we

have had, until very recently, the only proven occurrence of mid-Wisconsinan deposits. The section has been described by GRANT (1976a), and NIELSEN (1974). The seacliff has a maximum height of about 12 m. At the base there is a grey, silt till overlain by a reddish brown-weathering till with plentiful shell-fragments. The shells were presumably derived from sediments in St. Mary's Bay that predated the ice advance responsible for the till. Resting on this reddish-brown till is 1 to 2 m of grey to yellow-brown, marine sand with molluscs. A large gastropod shell *Atractodon stonei* (now *Neptunea stonei*), at first regarded as a warm water interglacial form (CLARKE *et al.*, 1972), was dated at  $38,600 \pm 1300$  years BP (GSC-1440). It has been shown that this and other molluscs lived near the ice front though the water was surprisingly warm (NIELSEN, 1974). A Ur/Th date on another shell submitted by Grant gave an indicated age of about 44,000 years. Thus the Salmon River sand unit is now considered mid-Wisconsinan in age. The Salmon River beds are overlain by a pinkish-weathering, fossiliferous till and a more olive-grey nonfossiliferous till, followed by a bouldery, stony till that weathers a drab yellowish brown. The postglacial marine beds overlap both these upper units. Here, then, the stratigraphic section from the top down reveals late Wisconsinan marine beds/late-Wisconsinan local till/late Wisconsinan 'foreign' olive-grey and pinkish till with shells/mid-Wisconsinan beds with shells/early? Wisconsinan 'foreign' red-brown till with shells/older 'foreign' grey till. The varied fauna in the lower red till suggest non-glacial source beds, probably Sangamon, in St. Mary's Bay; GRANT (1975, p. 110) has suggested correlation with the St. Pierre Interval, but perhaps they are Sangamon in age (Table II).

Northward along the St. Mary's Bay shore there are numerous seacliff sections and it is common to find a reddish or pinkish-weathering shell-bearing till. As two such tills are known, however, and there are also both local and foreign-derived till, and the sections vary from place to place, the complete stratigraphic sequence remains in some doubt. For instance at Cape St. Mary (GRANT, 1975, p. 110) the section is basically marine sediments (dated  $14,100 \pm 200$  years, GSC-1259 at Gilberts Cove)/grey 'Scotian' till/gravel/red-brown shell-bearing till (>38 000, GSC-695)/brown slate till/cemented gravel (Bridgewater?). GRANT (1976a) has since recognized a raised intertidal platform or bench, mantled by gravels, which may relate to an interglacial interval.

Why such a complex stratigraphy in this part of Nova Scotia as compared to some other parts and to other provinces? Perhaps it is because of proximity to the ice margin and an always present re-entrant up Bay of Fundy. It is not due to the amount or degree of exploration for Grant has roamed widely over most of

Period & Epoch	Glacial & non-glacial subdivisions	Years B.P. (not to scale)	Matane—Cap Chat Region (mod. from Leblais & David, 1977)	Quebec City Region LaSalle (pers. comm. 1977)	Shawinigan—Trois-Rivières Region (Occhietti, 1976)	Grondines—Drummondville Region (after Gadd, 1971)	Sherbrooke Region (after McDonald & Shilts, 1971)	Montreal Island (Prest & Hode-Keyser, 1976)
QUATERNARY	HOLOCENE	Recent	Bog deposits	Bog and eolian deposits	Bog and eolian deposits.	Bog deposits. Eolian sand	Bog deposits Eolian sand River sediments	Pond and bog deposits Eolian sand
			Fluvial sediments	Fluvial and deltaic sediments	Fluvial and deltaic sediments.	High terrace sand: includes Trois-Rivières Delta. Champlain Sea sediments		Early St. Lawrence river & estuarine sediments
	PLEISTOCENE	9,500	Goldthwait Sea	Champlain Sea sediments	(St. Maurice Delta) Champlain Sea sediments	St. Narcisse deposits	Champlain Sea sediments	Champlain Sea sediments. (minor intercalated till).
		10,000	sediments	St. Nicolas deposits		St. Narcisse deposits.		
		12,500	Grand Volume Till			Glacial lake sediments	Glacial lake sediments	Glacial lake sediments
		13,800	Petite-Matane Till	Beaupré Till (Possibly two tills in the east)	Gentilly tills (minor intercalated sand & gravel).		Lennoxville Till	Fort Covington Till
		23,000	Langis Till			Gentilly Till	Glacial lake Gayhurst sediments	Middle-till complex (intercalated tills and stratified sediments).
			Glacial lake sediments				Chaudière Till	Malone Till
			Tamagodi Till	silt and clayey silt	Les Vieilles Forges sand L. Deschailions varved sediments	Glacial lake Deschailions varved sediments		
		60,000	Glacial lake sediments	sand and gravel with organic matter (St. Pierre or older)	St. Pierre sediments	St. Pierre sediments	Massawippi sediments	
		80,000		Lower till	Bécancour Till	Glacial lake sediments Bécancour Till Glacial lake sediments	Johnville Till	
	SANGAMON	125,000		Paleosol			Pre-Johnville sediments	

TABLE II. Late Quaternary regional correlation table, south-eastern Québec.

Corrélations régionales de la fin du Quaternaire, sud-est du Québec.

Nova Scotia. Also, parts of New Brunswick, all of Prince Edward Island, and many parts of Newfoundland have been studied in sufficient detail to discover similar complex sections if such were present. And one must wonder why no complex sections have been found near the ice sheet extremities in Newfoundland. Was the ice cover more continuous throughout the Wisconsinan in Newfoundland, Prince Edward Island, and New Brunswick? We obviously need more stratigraphic information but we must also give more attention to the matter of ice-margin positions pertinent to the stratigraphy, and maintain an open mind re the source and extent of the Wisconsinan ice cover.

### NEW BRUNSWICK

The sole, intriguing older deposit from New Brunswick is that of an occurrence of *Mastodon* remains uncovered from a sinkhole in gypsum some 24 km south of Moncton. Through the courtesy of the New Brunswick Museum, Grant obtained samples of both the bones and associated peat for radiocarbon dating. Though the bone was dated at  $13,600 \pm 200$  years (GSC-1222), the peat dated  $>43,000$  years BP (GSC-1680), hence 'old' buried organics are present in this area.

### QUÉBEC

#### THE MAGDALEN ISLANDS

This part of Québec is situated on the Magdalen Shallows (Shelf) in the southeastern part of Gulf of St. Lawrence, roughly 100 km west of Cape Breton and 100 km north of Prince Edward Island. The Magdalen Islands' remote location in the Gulf, to the south of Laurentian Channel, has had a profound bearing on their Pleistocene history and hence the stratigraphic record. The character of the deposits and their stratigraphy varies greatly from island to island, suggestive of the activity of ice lobes from two or more source areas and during two or more glacial stages; yet none of the islands bear evidence of having been scoured or overrun by an ice sheet (PREST, 1957; PREST *et al.*, 1976). Instead, though the southern major islands rise to elevations from 110 to 170 m, their upper parts are seemingly devoid of 'foreign' stones whereas below a maximum of about 48 m on Grindstone, 50 m on Alright and Amherst, and 90 m on Entry Island there are scattered foreign stones on the surface, in some gravelly deposits, and in a reddish-brown diamicton. If the islands were not scoured by glacier ice one might expect to find stratigraphic evidence to this effect. And indeed, the stratigraphy is unlike that of the adjacent

glaciated areas bordering the Gulf of St. Lawrence. The most intriguing section is exposed in a gravel pit at Portage-du-Cap on Amherst Island (Fig. 2). At one place where soft, red sandstone is exposed near the base of a borrow pit, at an elevation of about 14 m, it bears small round holes that were made by rockboring clams (probably *Zirfaea crispata*). Lying on this obviously unglaciated surface are several meters of gravel (elsewhere up to 12 m thick) with long foreset beds dipping generally northwestward. This appears to be a glacio-marine deltaic deposit. It contains some 15% foreign stones most of which are well rounded as are some of the local basaltic and sedimentary rocks. The rounded stones were probably derived from an older marine shoreline deposit. The rounded granitoid stones have deeply weathered rinds or are rotted throughout. Overlying the gravels, in one place only, is a lenticular deposit of sand, silt and peaty detritus exposed over a length of about 40 m and having a maximum thickness of 2 m. Study of diatoms from silty lenses in the thicker peat (30-35 cm), by Lichti-Federovich (PREST *et al.*, 1976) has revealed a marine littoral assemblage devoid of any freshwater forms. The diatoms, furthermore, together with the insect and macroplant assemblage, described by Matthews, and the palynological record, studied by Terasmae, clearly denote a climate warmer than the present (PREST *et al.*, 1976). This presumably relates to the Sangamon Interglacial Interval with sea level about 16.5-17 m higher than at present. Overlying the sand, silt and peaty beds, and throughout the rest of the pit area the gravels themselves, and elsewhere the bedrock, there is 2 to 3 m of a red sandy diamict, now referred to as the Demoiselle diamict. This is believed to be related to a Wisconsinan glaciation, probably as a drop-till from shelf ice or as a flow till from glacier ice that lay south of the Magdalen Islands. Perhaps, therefore, this borrow-pit exposure affords evidence of two interglacial and two glacial stages. The diamict over the pit area reaches a maximum elevation of 23 m, but in southwestern Amherst Island it occurs up to about 50 m.

Two of the northern islands (Wolf and Coffin) reveal quite a different but also complex stratigraphic record. Depressions or valleys in the red sandstone on Coffin Island are infilled with two discrete sand units and overlain by a very bouldery mantle that appears to be an ice-rafted accumulation. The age of the sand units is not known; the boulder mantle may be late Wisconsinan but could be older. On Wolf Island the basal sediment in one small valley (now a cove) is a highly cemented gravel that forms 'conglomerate' boulders on the modern beach. It is overlain by a very coarse bouldery deposit similar to the surface mantle on Wolf and Coffin Islands. Both boulder deposits contain a remarkably varied assemblage of foreign stones. Se-

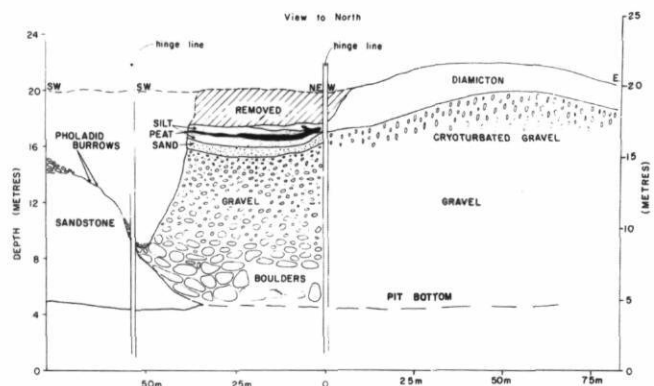


FIGURE 2. Buried organic site, Portage-du-Cap, Québec. Site de matériaux organiques enfouis, Portage-du-Cap, Québec.

parating the two boulder units on Wolf Island is 3 to 4 m of well bedded, red sand with scattered cobbles. This sand unit and the boulder layers may relate to a single glacial event but the lower gravel is clearly a marine shoreline deposit of greater antiquity. The older sand on Coffin Island clearly fills valleys in the bedrock and it underwent some erosion prior to deposition of the upper sand. The upper sand was deeply eroded prior to deposition of the bouldery deposit which is regarded as the product of ice-rafting at a time of higher sea level or perhaps during a glacial lake phase. This bouldery mantle may not correlate with the Demoiselle diamict and Demoiselle sand and gravel units, though both are tentatively regarded as late Wisconsinan in age.

There is also some stratigraphic as well as geomorphological evidence to suggest that the mantle of mostly stratified deposits surrounding the igneous rock core of the southern islands is in large part a relict of the Sangamon Interglacial Stage, masked by only a thin cover of late Wisconsinan Demoiselle deposits. Also a fossil sand dune on Grindstone Island may relate to this stage if, indeed, it is not older. This dune is partially lithified and overlapped by red Demoiselle diamict. Such relict forms may seem rather incongruous in eastern Canada where, for some decades, the region has been regarded as glaciated but they are indeed to be expected and should be looked for in unglaciated or in 'fringe' areas.

#### MAINLAND QUÉBEC

Turning now to mainland Québec, to my knowledge there is as yet no proven record of pre-middle-Wisconsinan deposits in Gaspesia, though perhaps some recent work has escaped my notice. The investigations of LEBUIS and DAVID (1977) in the Matane-Cap Chat region, of LASALLE (1976) in the Québec region, and of OCCHIETTI (1977) in the Trois-Rivières — Shawinigan

region, will add greatly to our knowledge of the stratigraphy of southeastern Québec. Farther west in the Chaudière — Trois-Rivières — Sherbrooke region we again have an intriguing and complex stratigraphic record. The work of GADD (1958, 1971) in the Grondines — Drummondville region provided the stratigraphic evidence that buried organic deposits there were probably early Wisconsinan in age; this has since resulted in general acceptance of the term St. Pierre Interstadial, as a part of our Wisconsinan terminology. Later work reported by McDONALD and SHILTS (1971) has expanded and elucidated a complex stratigraphy that spans the entire Wisconsinan and includes some older fluvial sediments containing Laurentian Shield rocks that afford evidence of an even older glaciation.

Two sections worthy of note at this time are the Aston Junction section of Gadd and the Sampson River section of Shilts. Near Aston Junction, an exposure on the Bécancour River, showed alluvial sand/Champlain Sea clay/Gentilly Till/some 18 m of St. Pierre sand and pebbly sand. The fluvial sands are much thicker here than at the famous peat sections farther north at St-Pierre-les-Becquets. At the Sampson River section there is Lennoxville Till at the top with Gayhurst Formation varves below and then the Chaudière Till overlying Massawippi floodplain silt, with channel-fillings of sand and gravel. Diapirs of varved sediments intrude the floodplain deposits (Shilts, pers. comm.). The varves are considered to relate to the retreat of Johnville ice. The Johnville Till is exposed farther upstream.

The stratigraphic sequence in the Matane — Cap Chat, Québec, Trois-Rivières, Sherbrooke, and Montréal areas, and a suggested correlation between them, is given in Table II. The stage names are from GADD (1971). The stratigraphic framework that has evolved from work in southeastern Québec is obviously comprehensive and rivals that of the perhaps better known southern Great Lakes region.

The James Bay region of northwestern Québec is another region where both early and pre-Wisconsinan deposits may be found. HARDY (1976) has described freshwater rhythmites from the Harricana River basin that very probably are correlative of the lacustrine member of the interglacial Missinaibi Formation. It is to be hoped that sections will yet be found comparable with those farther west in Ontario. I think it worthy of mention here that in Ontario the Missinaibi Formation also includes a forest peat and buried soil, and fluvial and marine beds; and beneath this formation three tills and two units of intertill sediments have been described (SKINNER, 1973). The James Bay region of Québec is also noteworthy in that the main Wisconsinan till is overlain over a vast area by varved clays that were deposited in glacial Lake Ojibway. The 'clays' are in turn overlain by the distinctive, clayey Cochrane till depo-

sited by the Hudson ice lobe (HARDY, 1976, 1977). The Cochrane till is overlain by a limited number of varves which are in turn overlain by sediments deposited in the Tyrrell Sea.

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