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TRIP C-4

# LATE-GLACIAL AND HOLOCENE GEOLOGY OF THE MIDDLE ST. JOHN RIVER VALLEY

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## Introduction

The middle St. John River valley lies between the towns of Grand Falls, New Brunswick and Frenchville, Maine (Figure 1). Throughout most of this field area the St. John River serves as the U.S.-Canadian international boundary. Complete topographic coverage of the area is included on three maps: the Canadian (1:50,000) Saint Andre and Edmundston quadrangles and the American (1:62,500) Stockholm quadrangle. The American (1:62,500) Van Buren, Grand Isle, and Frenchville quadrangles include portions of Maine also shown on the two Canadian maps. Most of our field work in this area was undertaken in 1977 and 1978, although this research is currently being extended into the upper St. John River valley.

The glacial history of northern Maine and New Brunswick greatly influenced late-glacial and Holocene events. Ongoing studies on both sides of the international border are putting together the Late Wisconsin glacial history of the region (Genes and Newman, Trip B-8; Gauthier, Trip B-9). The chronology determined by these studies undoubtedly will add to our understanding of postglacial events; however, in light of current knowledge we believe two galcial events, both recognized at least three decades ago, controlled drainage in the St. John watershed. The first event was the formation of an ice dam in the Edmundston area which created Lake Ennemond at altitudes of up to 680 ft in the western end of the field area (Kiewiet de Jonge, 1951). The second important glacial event was the construction of a large moraine across the valley at Grand Falls; after deglaciation, this moraine dammed Lake Madawaska, which extended throughout the middle St. John River valley at altitudes of up to 513 ft (Chalmers, 1886; Kiewiet de Jonge, 1951; Lee, 1963).

Lake Madawaska existed until about 10,000 B.P. when water level rapidly declined. The emergent lake bottom was covered first by extensive early Holocene swamps, and later by three different facies of early-to-middle Holocene alluvium. Two of these alluvial facies have been misinterpreted in other studies as either glaciolacustrine or glaciofluvial deposits even though identical sediments are accumulating in present-day St. John River environments. The St. John River has incised its bed in late Holocene time, leaving the old fluvial and lacustrine deposits exposed in terrace scarps.

## Acknowledgements

Robert Stuckenrath of the Smithsonian Institution provided 11 new radiocarbon dates and aided in the interpretation of these dates. A

Grant-in-Aid of Research from Sigma Xi, and Fellowships from the University of Maine at Orono supported field work. Keith A. Laskowski and Susan C. Kite provided able field assistance. This work benefited greatly from discussions with Andrew Genes, Glenn Prescott, George Denton, Barry Timson, Thomas Lowell, Bradford Hall, and Stephen Norton.

## Stratigraphy and Geomorphology

Ice-contact stratified drift is the lowest Quaternary strata exposed in the middle St. John River valley. This drift occurs in kames, kame terraces, and the moraine at Grand Falls. The stratified drift is composed of clasts ranging from fine silt to cobble-boulder gravel. Canadian Shield gneissic erratics are a minor constituent. Collapse features such as normal faults and steeply dipping beds are common. Flow till occurs at several localities. In most exposures, ice-contact stratified drift is capped by a layer of till; in one gravel pit the stratified drift underlying the till layer exhibits overturned glaciotectonic folding (Stop 10). The stratified drift presumedly accumulated during the next-to-last glaciation of the valley, the overlying till dates to the last glaciation. Several isolated ice-contact deposits in the field area are not capped by till and are probably younger than the till-mantled stratified deposits.

There are two distinctive tills which mantle the bedrock hills, kames, and kame terraces in the field area. A well-compacted grey (N4: wet color) diamicton is probably a lodgement (basal) till. This grey till is extremely poorly sorted; clasts are predominantly limestone and fine-grained detrital rocks with minor constituents of conglomerate, gneiss, and volcanic rocks. Up to 90 percent of cobble and boulder clasts are striated and there is a distinct orientation of elongate clasts. An oxidized greyish orange (10 YR 7/4) to yellowish brown (10 YR 5/2) till, less compact than the grey till, is widespread throughout the field area. This oxidized till was deposited as ablation or flow till. Again, gneissic erratics are minor constituents. Bedding is generally absent, but rare layers of sand or silt occur. The oxidized till has less distinctive fabric and fewer striated clasts than the well-compacted grey till. Despite distinct differences between the two tills, we do not believe there is sufficient evidence within the middle St. John River valley to assign these tills to different time periods or different ice masses. Both tills occupy the same stratigraphic position overlying the majority of ice-contact stratified drift in the field area; hence, we believe the tills represent different facies of the last glaciation. Older tills undoubtedly underlie the extensive ice-contact stratified drift, but we have not recognized outcrops of older till in this field area.

Two outwash deposits, composed of rounded cobbles and boulders with a sand-and-silt matrix, exist in the field area. A valley fill composed of up to 200 ft of rounded gravel lies at the eastern end of the field area. The head of this outwash train adjoins the Grand Falls moraine. South of Grand Falls, the outwash occurs in a steep-scarped terrace which is over 20 miles long. A second valley fill, 25 ft thick, is exposed in

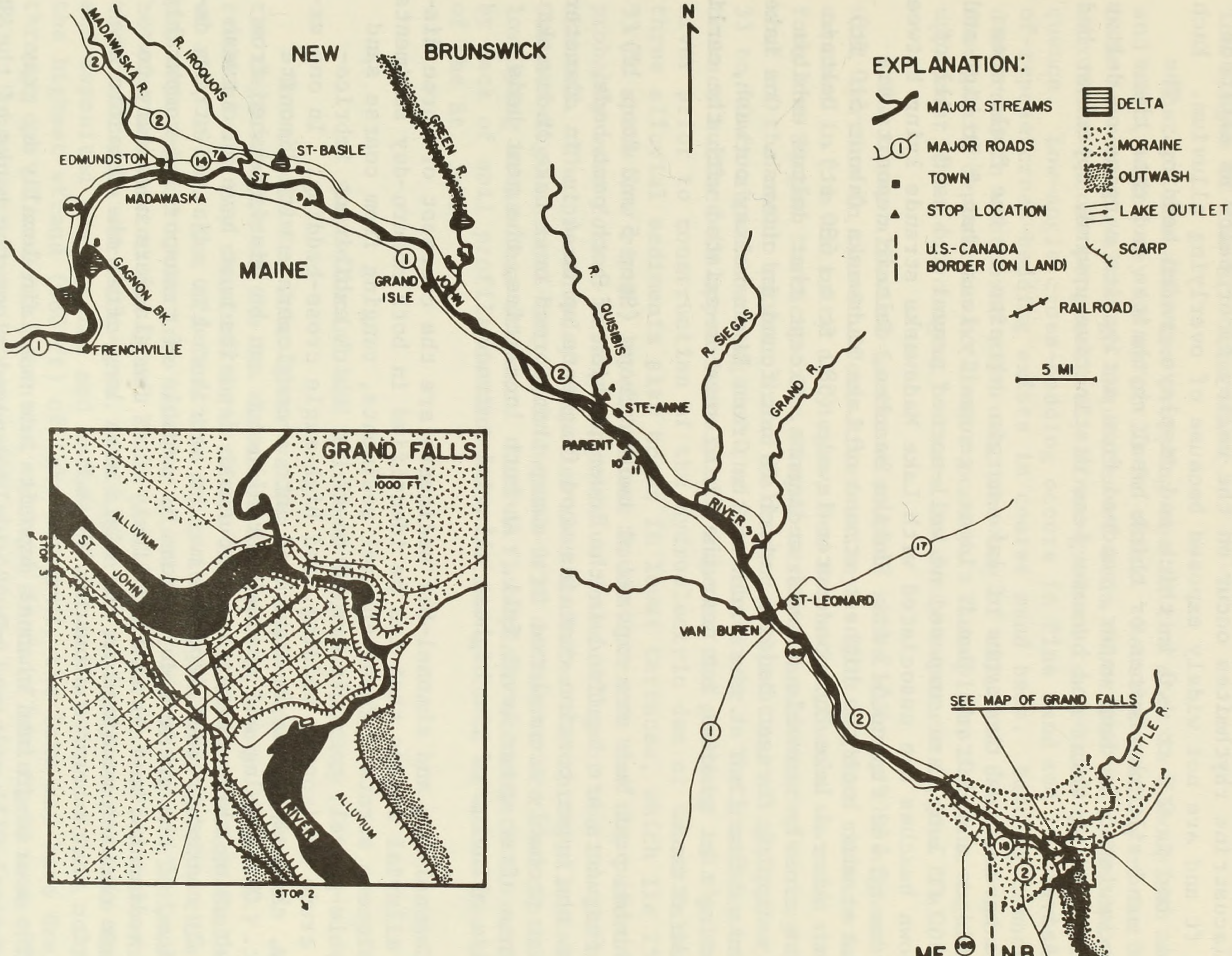


Figure 1. Middle St. John River valley. The St. John River is the international boundary throughout most of the field area.

terraces along the Green River valley. The outwash head is a small moraine north of the field area (Lee, 1955). Gneissic erratics occur at both localities.

Rhythmically bedded, grey (N5) silt and clay make up a large portion of the postglacial subsurface deposits in the field area. However these lacustrine rhythmites occur on the valley floor below an altitude of 505 ft and are not widely exposed because of overlying alluvium. Each rhythmic bed is 0.1 to 1.0 in thick and displays graded bedding. The lack of sand-silt rhythmites or thick basal rhythmites indicate these beds accumulated in deep water, removed from active ice margins or deltas. Rhythmic bedding thins and becomes less distinctive upward, uppermost beds are massive.

We have mapped two types of lake-margin deposits in the field area: beach ridges and deltas. Beach ridges, generally less than 5 ft high and up to 600 ft long, are composed of well-sorted gravel and sand. All of the known beaches are associated with Lake Madawaska strands lying between altitudes of 463 ft and 513 ft. Unlike beaches, deltaic deposits are associated with both the highest strand of Lake Madawaska (about 510 ft) and with several Lake Ennemond water levels (580 ft to 680 ft). Deltaic deposits closely resemble outwash sediments, except that deltas exhibit steeply dipping foreset bedding, which is not found in outwash. One Lake Madawaska delta lies at the mouth of the Green River valley outwash, suggesting that glacial ice near the field area co-existed with the earliest lake strand.

Buried peat beds are exposed at two outcrops (Stop 5 and Stop 11). Plant fragments are humified in the lower portion of both peat beds, whereas the upper portion contains wood fragments up to 4 in in diameter. The peat probably accumulated in a swamp that formed over Lake Madawaska sediments after water level fell. At both localities, the peat beds underlie alluvium of the highest alluvial terrace.

Channel-lag and channel-bar sediments are the coarsest of three distinct alluvial facies that can be identified in both modern-day sediments and Holocene strata. These channel sediments, ranging from coarse sand to cobble-gravel, commonly are 10 to 12 ft thick exhibiting imbrication, crude horizontal bedding, and high-angle cross-bedding. In one exposure, channel gravel is indurated into a conglomerate with limonite cement. Channel-lag and channel-bar alluvium can be distinguished from outwash using three criteria: 1) outwash deposits must have an outwash head; 2) coarse-grained deposits may be attributed to adjacent stream deposition, if the present day stream is capable of transporting comparably sized sediments; and 3) it is unlikely that the glaciers necessary to generate outwash remained in the field area long after the climatic amelioration that occurred about 10,000 B.P.

The coarse-grained channel deposits are overlain locally by grey (N5) channel-fill silt and clay, widely exposed along the banks of the St. John River and its tributaries. The fine-grained channel-fill lenses range from 3 to 15 ft in thickness and some exceed one-half mile in length. They commonly parallel the present-day stream course giving rise to outcrops that are thousands of feet long. Bedding appears massive, except in horizons rich in flat-lying plant fragments. Limonite mottling and amorphous blue masses of vivianite commonly surround plant fragments. We have collected numerous flattened leathery mollusk shells, which have been leached of calcite. Present-day channel-fill basins (such as the basin seen at Stop 9) are subaerially exposed only during low stages of the St. John River.

Most of the alluvium cropping out in the area is floodplain sand and silt, which may be up to 23 ft thick. Reverse grading of individual beds is common, although sequences of beds deposited in a floodplain environment become progressively finer-grained toward the top of the sequence. Low-angle cross-bedding occurs in fine sand and coarse silt; angle-of-repose cross-bedding exists in coarse sand beds. Bedding cannot be discerned in weathered silt near the top of alluvial terraces upon which floodplain deposition no longer occurs. Floodplain alluvium is the uppermost (hence, youngest) strata in every exposure in the field area.

The three alluvial facies discussed above make up the highest alluvial terrace in the St. John River valley. This highest terrace is best exposed in the vicinity of Siegas, New Brunswick; hence we call the landform the Siegas terrace. The Siegas terrace can be traced throughout most of the reach between Grand Falls and Edmundston, at altitudes of 33 to 40 ft above low stage of the St. John River. The gradient of the terrace surface is approximately the same as the gradient of the St. John River prior to construction of the hydroelectric dam at Grand Falls. All three alluvial sediments also occur in lower terraces, which lie 25 to 33 ft above low river level. These lower terraces are not paired and probably were formed during progressive downcutting of the St. John River channel. The present-day alluvium also includes the three alluvial facies. Channel-lag, channel-bar, and channel-fill sediments are restricted to low-lying areas near streams. Active floodplain accumulation, evidenced by lack of soil profile development, occurs up to 25 ft above low stage of the St. John.

## Late-Glacial and Holocene Geologic History

The middle St. John River valley was deglaciated in stages. After the deglaciation of the St. Lawrence lowlands at about 13,000 B.P., a residual ice cap remained in northern Maine and New Brunswick (LaSalle, et al., 1977). Cut off from ice domes in the Canadian Shield, this ice cap thinned and broke into smaller glaciers. One of these glaciers stood between Edmundston and Grand Falls while the western and eastern ends of the field area were ice-free. This glacier probably dammed Lake Ennemond and deposited the moraine and extensive outwash at Grand Falls. During the highest strand (680 ft) of Lake Ennemond, the lake may have drained through one of several potential outlets south of the field area (Figure 2A). Subsequent lower strands (660 to 580 ft) may record the opening of an outlet through the middle St. John River valley as the glacier wasted in place. It is possible that an arm of Lake Ennemond extended east of Edmundston as the glacier contracted After the glacier melted completely,

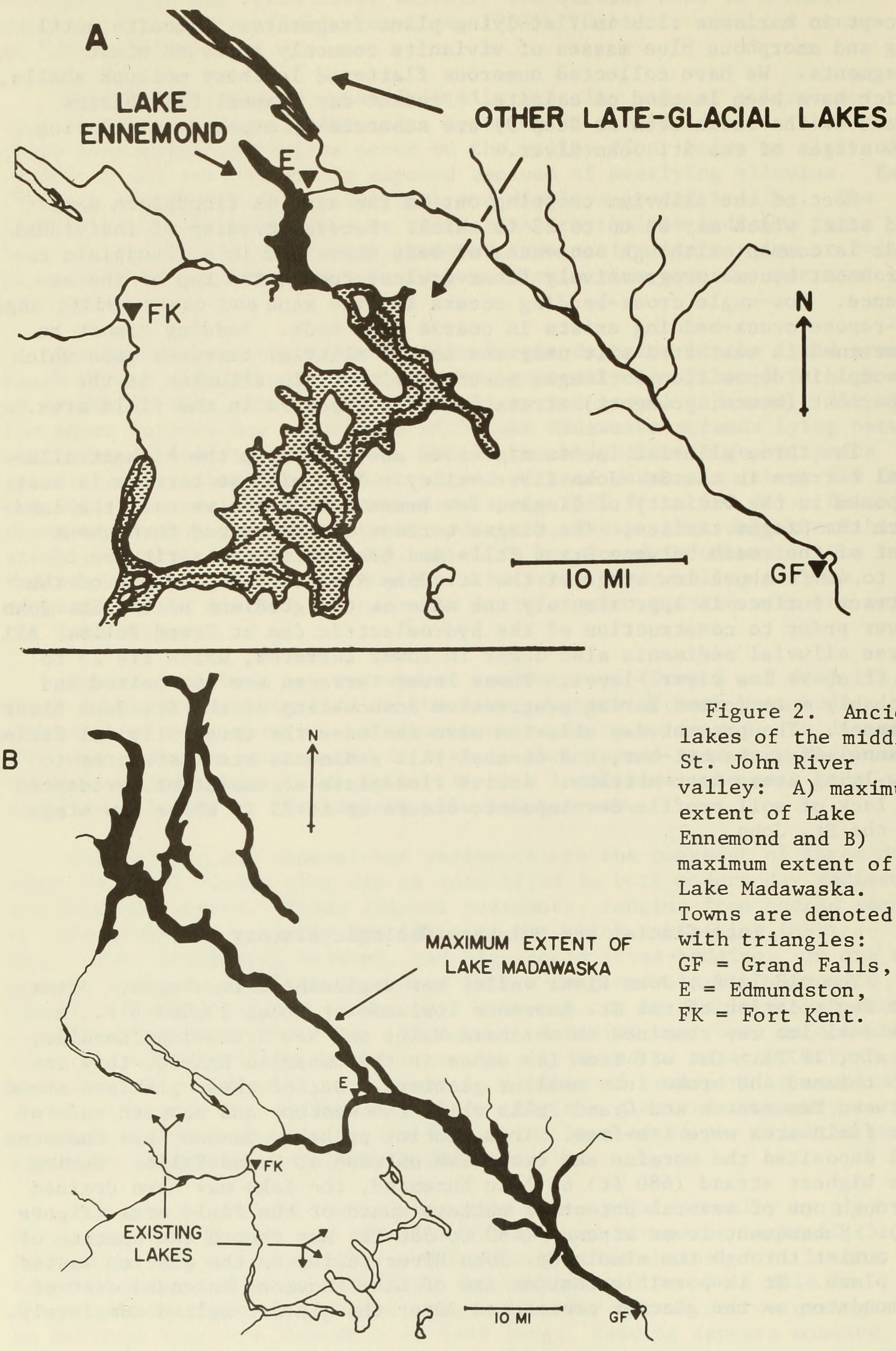


Figure 2. Ancient lakes of the middle St. John River valley: A) maximum extent of Lake Ennemond and B) maximum extent of Lake Madawaska. Towns are denoted with triangles: GF = Grand Falls, E = Edmundston, FK = Fort Kent.

the only obstruction of drainage in the valley was the Grand Falls moraine and associated outwash, the drift which dammed Lake Madawaska (Figure 2B). In its early history the lake apparently drained through two outlet channels at Grand Falls. One outlet paralleled the present-day course of the St. John, whereas the other outlet was about one-half mile south of the Grand Falls gorge (Figure 1).

The date of deglaciation and onset of lacustrine sedimentation can be inferred from an exposure on Green River (Stop 5); here, an estimated 1200 rhythmites underlie the base of a peat bed which has yielded 5 credable radiocarbon dates of about 10,000 B.P., with an average of 9979 ± 108 B.P. If the rhythmites are assumed to be varves, and if we assume there is no hiatus in the stratigraphic sequence, then the oldest lake sediments accumulated at about 11,200 B.P. Deglaciation probably occurred immediately before deposition of the lake sediments. The highest recognized strand deposits in the vicinity of the Green River exposure occur at elevations of about 510 ft; the altitude of these strands suggests that the 11,200 B.P.-aged lake sediments accumulated in Lake Madawaska.

Beaches below the highest strand record water levels during the regression of Lake Madawaska (Figure 3). The only well-exposed beach in the field area (Stop 10) overlies a shallow-water silt deposited while other beaches formed at higher altitudes. As the water level fell, the emergent lake bottom was covered by swamps. The 10,000 B.P.-aged peat bed at the Green River exposure (altitude: 474 ft) formed after Lake Madawaska dropped about 36 ft below its highest nearby strand. This 36 ft regression occurred in about 1200 years, indicating an average water level drop of 3 ft/100 years. A 9,900 B.P.-aged peat bed near Parent, Maine (altitude: 446 ft; Stop 11) suggests that the lake level fell 28 ft within the century after 10,000 B.P. Indeed, the radiometric control over the Parent and Green River exposures does not preclude the possibility that the 28 ft drop in lake level occurred catastrophically. Our field data suggest the decline after 10,000 B.P. was so rapid that no mappable beach deposits formed below the 10,000 B.P. strand. The southern outlet to Lake Madawaska was probably abandoned during the rapid drop in lake level. Organic-rich channel-fill sediments taken from the abandoned outlet yielded a rabiocarbon date of 9830 ± 160 B.P. (GSC-56).

We have considered a number of possible causes for the rapid demise of Lake Madawaska. Three of the more probable causes include isostatic uplift in the upper St. John watershed, failure of a drift dam or ice dam, and changes in the hydrology of the watershed induced by climatic amelioration. Research in the upper St. John valley hints that other extinct lakes in the watershed had similar histories to Lake Madawaska.

Wood incorporated into channel gravel indicates that a river flowed over the emerged lake bottom by 9820 ± 130 B.P. (GSC-18), or possibly somewhat later if the wood was reworked prior to deposition. Lake Madawaska ceased to exist before this event, although small discontinuous lakes may have persisted for a short time in lower areas of the valley. The early Holocene St. John River deposited gravel at altitudes as low

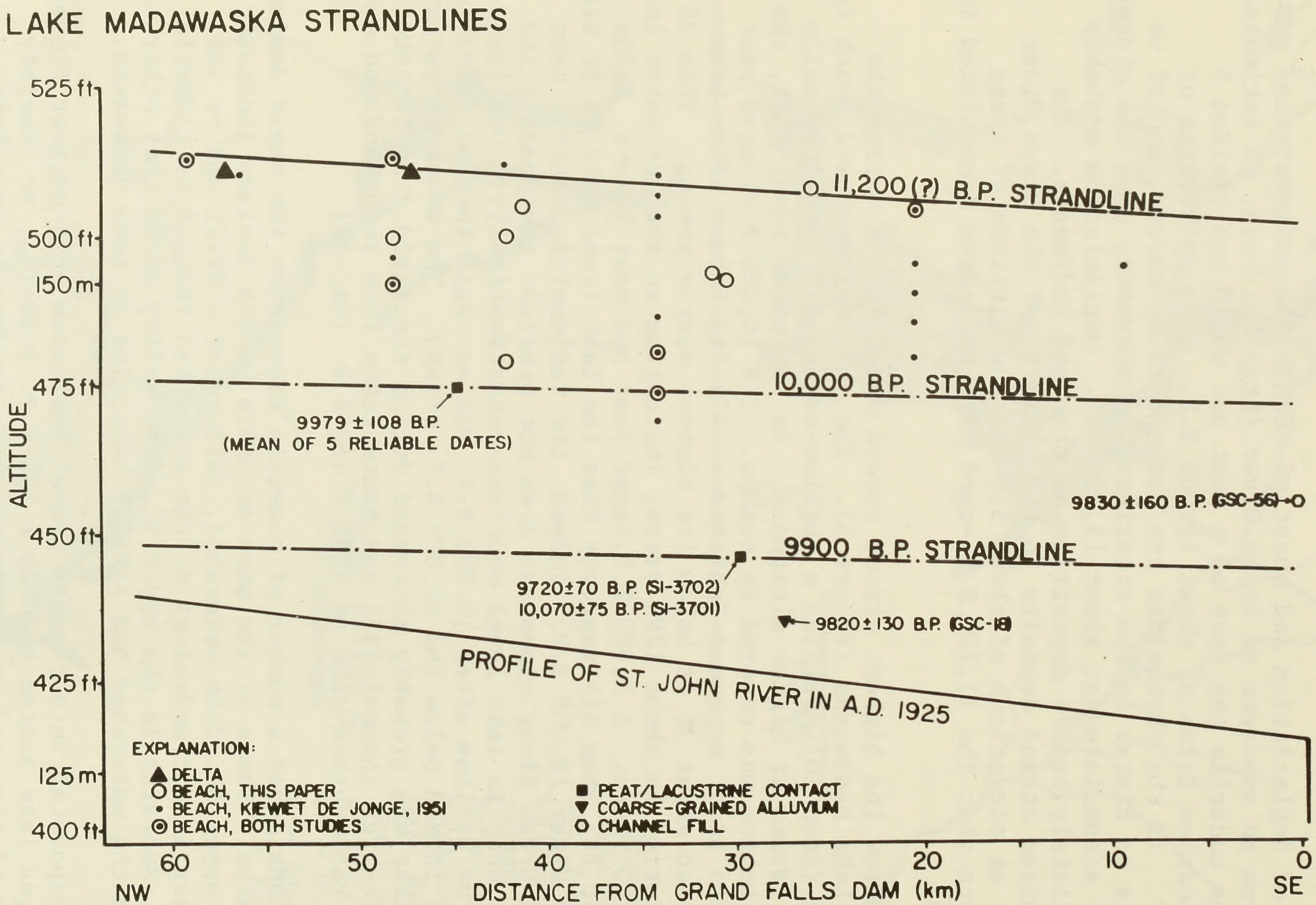


Figure 3. Lake Madawaska strandlines. The 10,000 B.P. and 9900 B.P. strandlines are inferred from age of peat/lacustrine contacts; tilt of both strandlines is based on arbitrary assumption that isostatic warping was one-half of the warping in the 11,200 (?) B.P. strandline.

as 427 ft. The newly formed reach of the river had an extremely low gradient over the former lake bottom. Immediately after the draining of the lake the St. John River and its tributaries began an aggradational episode, which was widespread by 8200 B.P. (Figure 4). Aggradation continued until after 4250 ± 50 B.P. (SI-3703). By the end of the aggradational episode a broad floodplain existed with a surface that sloped from 480 ft near Grand Isle to 458 ft near Grand Falls. Small, coarse-grained alluvial fans, a few feet above the floodplain surface, formed near the mouths of many tributaries.

Downcutting of the St. John River began once the river attained a graded profile. The floodplain and alluvial fans were incised to form the Siegas terrace. Lower terrace-like surfaces fall into two age groups. Weathered surfaces lying 5 to 15 ft below the Siegas terrace are alluvial terraces abandoned during the late Holocene. Unweathered surfaces 10 to 30 ft below the Siegas terrace are part of the present-day floodplain.

## Geoarcheology

We did not find any artifacts in our field work, but the stratigraphy of the middle St. John River valley suggests potential for significant archeological sites. Lake Madawaska persisted long after the arrival of man in Maine and the Maritimes, as evidenced by the Paleo-Indian site at Debert, Nova Scotia, which is dated 10,589 ± 47 B.P. (Stuckenrath, oral communication, 1979). Some of the Lake Madawaska beaches apparently are contemporaneous with the Debert site, and significant Paleo-Indian sites may be located on, or just above, these relict lake shores. The alluvial stratigraphy of the Siegas terrace spans most of the period between 10,000 B.P. and 5000 B.P., during which time there is little known about man in Maine and the Maritimes. The Siegas terrace probably contains sites that could fill this void in the archeological record. Sites of this age within the Siegas terrace may have a well-developed stratigraphy in which each artifact assemblage is temporally separated from other assemblages. Late Holocene artifacts probably occur in surface sites on the Siegas terrace, surface and buried sites on younger alluvial terraces, and buried sites on the present-day floodplain.

## References

Chalmers, R. C., 1886, Preliminary report on the surface geology of New Brunswick: Geology and Natural History Survey of Canada Annual Report 1885, part GG, 58 p.

Kiewiet de Jonge, E. J. C., 1951, Glacial water levels in the St. John River valley (Ph.D. dissertation): Worcester, Mass., Clark University, 116 p.

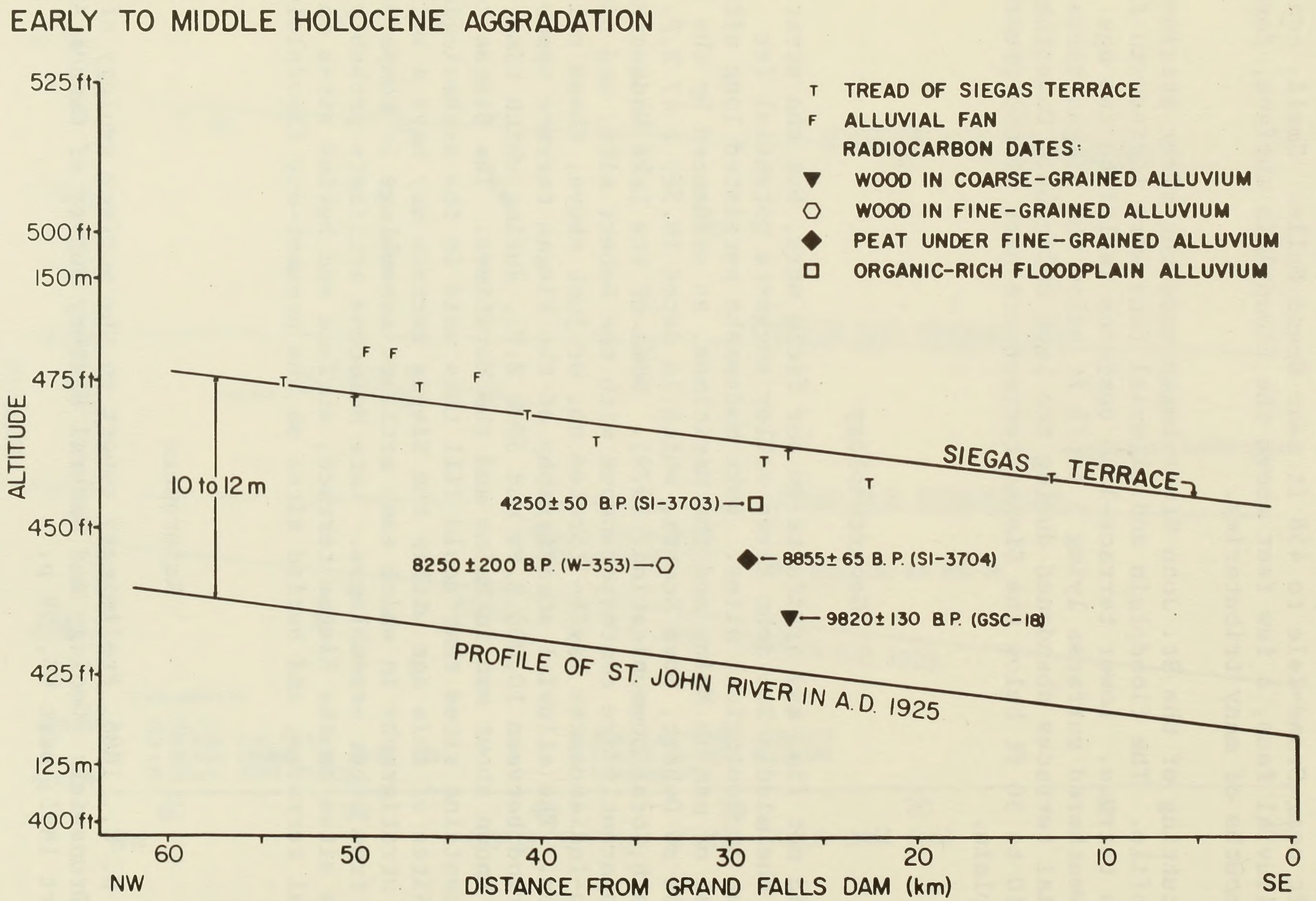


Figure 4. Early to Middle Holocene aggradation. Three other dates were obtained from the organic-rich floodplain alluvium: 5795 ± 70 B.P. (SI-3901), 6160 ± 85 B.P. (SI-3900), and 8770 ± 100 B.P. (SI-3901A).

LaSalle, P., Martineau, G., and Chauvin, L., 1977, Morphology, stratigraphy, and deglaciation in Beauce-Notre-Dame Mountains-Laurentide Park area: Ministère des Richesses Naturelles (Quebec), DPV-516, 74 p.

Lee, H. A., 1955, Surficial geology of Edmundston, Madawaska and Temiscouata Counties, New Brunswick and Quebec: Geological Survey of Canada Paper 55-15, 14 p.

_____1963, Field trip guide for the Friends of the Pleistocene 26th annual reunion, Rivière-du-Loup, May 25-26: Quebec, 29 p.

## Itinerary

Mileage

0.0 Assemble at entrance to Centennial (Municipal) Park, Grand Falls, New Brunswick, Saint-Andre 1:50,000 quadrangle. Starting time 8:30 A.M. Eastern (9:30 A.M. Atlantic). Walk west 300 yd to bridge over St. John River.

0.0 Stop 1. Walk to center of bridge, facing waterfall.

Grand Falls at the confluence of St. John and Little Rivers. The St. John drops over 120 ft within one mile of the hydroelectric dam; most of the drop occurs at this waterfall. The view is most spectacular during April or May, when spring meltwater increases discharge to as much as 1.65 million U.S. gallons per second. Carefully walk to the other side of the bridge to view gorge. The erosive power of the river during peak discharge is evidenced by the large potholes and the treeless zone that extends far up the sides of the gorge. Before 10,000 B.P., the path of the gorge was the northernmost of two Lake Madawaska outlets. The southern outlet, 900 yd from this bridge, was underlain by over 200 ft of drift in the Grand Falls moraine (Figure 1). The drift-floored southern outlet was abandoned about 10,000 B.P. The northern outlet probably was drift floored at 10,000 B.P., also; if it had been bedrock floored, the St. John River would have become entrenched in the more easily eroded southern outlet. Hence, the deep gorge beneath the bridge was apparently carved after 10,000 B.P. because of superposition of Lake Madawaska's northern outlet.

Return to assembly point, proceed in vehicles northwest on Victoria St.

0.2 Turn left on Broadway.

0.6 Turn left on Condon St. The railroad tracks visible south of the intersection overlie the abandoned southern outlet of Lake Madawaska.

0.8 Cross railroad tracks.

0.95 Turn left on River Road at 3-pronged intersection; cross railroad tracks again.

2.35 Turn right at entrance to large gravel pit.

2.35 Stop 2. Park well out of truck traffic.

Grand Falls outwash. This coarse gravel was deposited by meltwater from the glacier that built the Grand Falls moraine. Cobble and boulder lithologies include Canadian Shield gneisses which originated west of the St. Lawrence, it is possible that these erratics were not transported across the St. Lawrence by the Grand Falls glacier but were reworked from older drift. Large trough cross-bedding was exposed in the southern face of the pit in 1977 and 1978. A veneer of sand and silt caps the coarse gravel. These finer sediments probably mark a reduction in meltwater after the glacier retreated from Grand Falls.

Return to vehicles, turn left on River Road.

3.75 Turn right on Condon St., immediately after crossing railroad tracks.

5.2 Turn left onto Route 2 (Trans-Canada Highway) west.

9.4 Bridge over Canadian Pacific Railroad tracks; note the view to southwest across St. John River. Landforms include modern-day floodplain, the Siegas alluvial terrace (site of several farms and paved road) and a till-mantled bedrock ridge. These landforms are shown on both Saint-Andre 1:50,000 and Van Buren 1:62,500 quadrangles.

11.6 Note the well-developed segment of the Siegas terrace on this side of the St. John River.

16.5 Intersection of Route 2 and Route 17, continue west on Route 2.

18.4 Cross Grande Rivière (Grand River).

18.5 Stop 3. Park in front of gate on left side of road. Follow trail to river bank 300 yd south of gate.

Three alluvial facies of a late Holocene terrace. At least 6.0 ft of gravel crop out at the base of this exposure. The gravel unit displays sedimentary structures (crude bedding and imbrication) and grain-size distribution similar to present-day channel-lag and channel-bar deposits; the gravel in the exposure probably accumulated in a channel facies. 4.6 ft of massive silt and clay overlie the gravel. Sedimentary characteristics include abundant carbonized plant fragments concentrated near bottom of unit and limonite mottling. The depositional environment was probably similar to the modern-day channel-fill facies.

The channel-fill clay and silt are covered by 3.6 ft of sand and silt which were deposited in the floodplain facies.

Return to cars. Proceed west on Route 2.

21.0 Cross Rivière Siegas (Siegas River).

21.2 Note the unpaved road to left which leads to the abandoned site of Siegas Station. The Siegas terrace, the highest alluvial terrace in the field area, is best developed in this vicinity. An excellent exposure of the three alluvial facies of the Siegas terrace occurs on the Canadian bank of the St. John River, 400 yd southwest of Siegas Station. This exposure can be seen from Stop 11 and from U.S. Route 1 in Maine. The deposits are similar to those exposed at Stop 4. We will not have time to visit this exposure; continue west on Route 2.

24.7 Enter Edmundston 1:50,000 quadrangle in the town of Ste-Anne-de-Madawaska.

25.2 Stop 4. Turn right at last intersection before bridge over Rivière Quisibis (Quisibis River). Follow right turn with a quick left. Park car on dead end road paralleling Route 2. Walk across bridge and proceed to exposure on bank of Rivière Quisibis 125 yd southwest of bridge.

Alluvial facies of the late to middle Holocene Siegas terrace. Again channel gravel, channel-fill silt and clay, and floodplain sand and silt are exposed. The contact between the channel-fill and floodplain facies is marked by alternating beds of sand and fine silt. An organic-rich zone at the base of the channel-fill alluvium yielded wood dated 8250 $\pm$ 200 B.P. (W-353, Lee, 1955). During low-water levels, silts, possibly deposited in Lake Madawaska, are exposed below the channel-gravel unit. Another exposure of the same units occurs on the bank of the St. John River 400 yd southeast of this locality.

Return to vehicles, continue west on Route 2.

25.3 Cross Rivière Quisibis.

31.0 Cross Green River (Rivière Verte).

31.2 Turn right on gravel road located a few yards east of exit to town of Rivière Verte (Green River Station). Continue northeast between brick house and campsites; proceed as far as road conditions permit.

32.0 Stop 5. Park before reaching shallow gravel pits; walk to first gravel pit.

Holocene point-bar and floodplain deposits. This operation is extracting gravel that is nearly identical to point-bar sediments accreting along Green River (Stop 6). Much of the gravel appears to be derived from an outwash plain and a delta (altitude: approx. 510-515 ft) formed at the mouth of the outwash plain north of this locality.

Walk southeast under power line. Cross Green River in vicinity of mid-channel bar. (During high water, fording the stream can be avoided by approaching this outcrop from the east along the power line right of way. However, this eastern approach requires a one-half mile foot traverse through poorly-drained terrain.)

Green River exposure (Figure 5). This is the best exposure of Lake Madawaska sediments in the middle St. John River valley. The compact grey diamicton at the bottom of the exposure displays a distinct orientation of elongate clasts: long axes trend N 60° W. Canadian Shield gneisses are a minor constituent of this diamicton which is probably a basal till. The compact grey till is overlain by a highly deformed unit that includes gravel, sand, silt, and clay. Portions of this unit contain rhythmic beds indicating glaciolacustrine deposition. Glaciolacustrine deposition of the deformed unit is also supported by the fact that this unit underlies a thick sequence of rhythmically-bedded clays and silts which were deposited in Lake Madawaska. There are approximately 1200 rhythmic beds in this exposure. The upper one-half foot of lake sediments does not display rhythmic bedding, possibly because they were deposited in shallow water. Assuming the rhythmic beds are varves (i.e. deposited annually) Lake Madawaska sedimentation lasted for about 1200 years at this locality. The oldest beds of this lacustrine unit are probably the same age as the highest lacustrine beaches and deltas in this vicinity (altitude: approx. 510 ft). The base of the peat overlying the lake sediments has yielded five credable $^{14}C$ dates with a mean age of 9979 ± 108 B.P. and a median age of 10,090 ± 130 B.P. If there was no hiatus between lacustrine and peat deposition the oldest lake sediments date to about 11,200 B.P. Hence, this locality was probably deglaciated shortly before 11,200 B.P. The top of the peat bed dates to 9285 ± 70 B.P. (SI-3706); after this date the peat was buried under the fining upward alluvial sequence exposed at the top of the outcrop.

Return to vehicles, turn around and drive <u>toward</u> Route 2.

32.7 <u>Stop 6</u>. Park in front of campsites, <u>before</u> reaching Route 2. Walk 250 yards southeast to west bank of Green River.

Present-day point-bar and floodplain deposits. The west bank of Green River consists of a point bar. Note the coarse grain size and clast imbrication. Total thickness of the gravel, including gravel below river level, is about 20 ft.

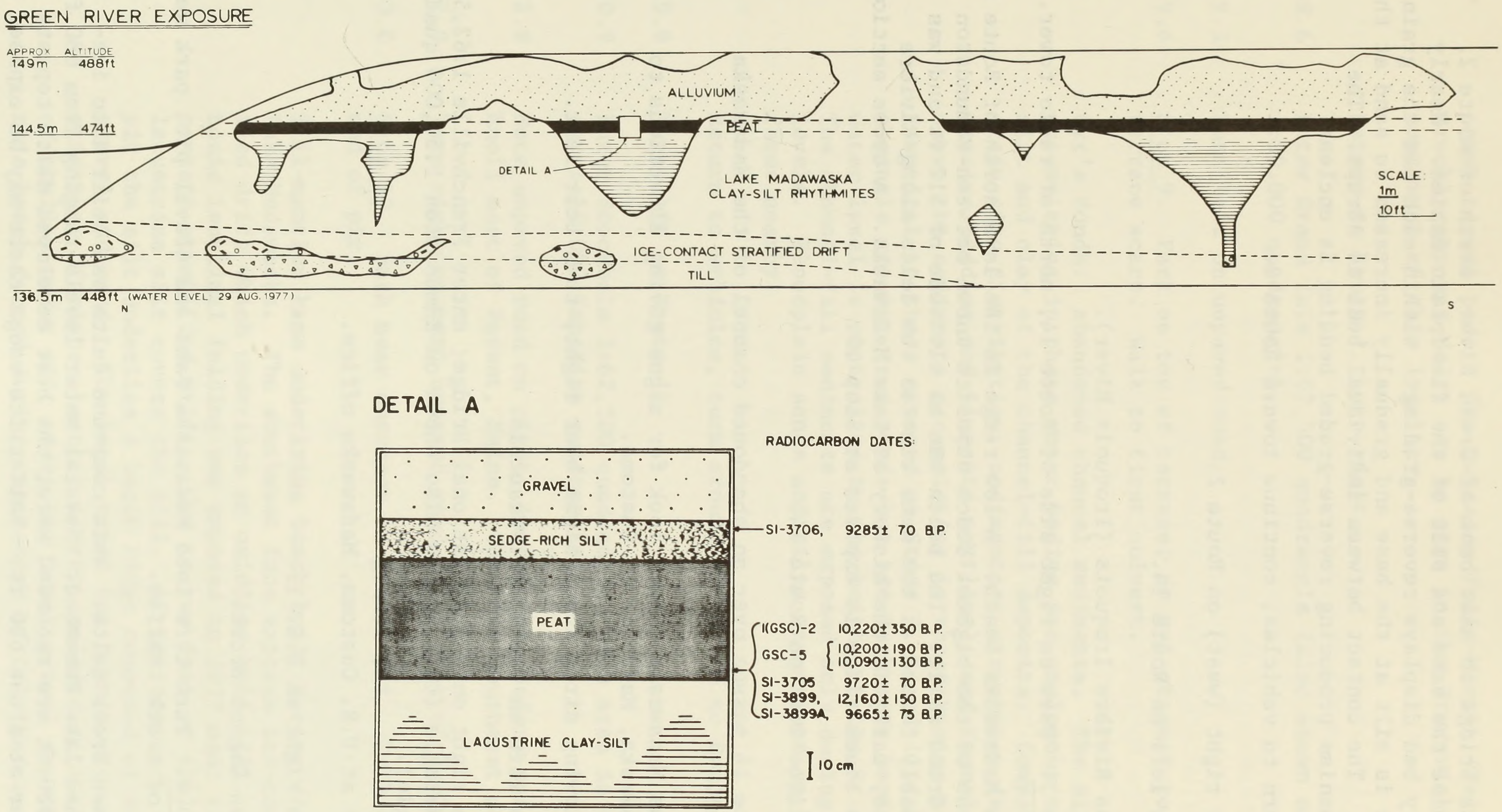


Figure 5. Stop 5: Green River exposure. Five of six radiocarbon dates obtained from samples taken at the bottom of the peat bed cluster around 10,000 B.P. The sample that yielded the anomalous date of 12,160 $\pm$ 150 B.P. (SI-3899) probably included reworked organic material derived from older deposits.

Cross bridge to east bank of Green River, north of Route 2. Examine the sand and silt of the floodplain facies. Nearly every bed displays reverse-grading: within each bed the grain size is silt at the base and gradually increases to sand at the top. The contact between individual beds is abrupt. The mechanism producing reverse-graded bedding is unclear.

Return to vehicles, continue toward Route 2.

32.8 Turn right (west) on Route 2.

37.5 Turn left on Route 14.

41.0 Cross Rivière Iroquois (Iroquois River).

41.5 Stop 7. Park on right side of Route 14, north of radio tower.

Lake Madawaska beach. A low ridge in the lawn north of Route 2 is one of the highest beach deposits known between Edmundston and Grand Falls. The beach has an altitude of 512 ft and was probably formed at the same time as the delta along Rivière Verte, early in the history of Lake Madawaska. A cross section of a beach ridge is exposed at Stop 10.

Continue west on Route 14.

42.6 Route 14 passes over an abandoned channel of the Madawaska River.

43.3 Cross Madawaska River; look for signs giving directions to Madawaska, Maine or to Customs.

43.5 Following directional signs bear right, then bear left.

43.6 Turn left on Rue de St. Francois.

43.7 Turn right onto International Bridge; enter Frenchville 1:62,500 quadrangle (this leg is also shown on Edmundston 1:50,000 quadrangle).

44.0 Stop at U.S. Customs, Madawaska office.

44.1 Turn right on U.S. 1.

48.3 Cross Gagnon Brook.

48.6 Stop 8. Turn left into Madawaska Sand and Gravel pit, park well out of truck traffic.

Gagnon Brook delta. This compound delta was built into ice-dammed Lake Ennemond. Several water levels ranging from 680 ft to 580 ft are recorded here, the best developed delta topsets occur at about 620 ft. Relict ice-wedge casts may be exposed in these topset beds. The Ruisseau Felix-Martin (Felix Martin Brook) compound delta can be seen in New Brunswick, one mile southwest of this locality.

Return to Route 1, turn right.

58.6 Enter Grand Isle 1:62,500 quadrangle (also shown on Edmundston 1:50,000 quadrangle).

59.3 Turn left on unpaved road.

59.6 Stop 9. Park on top of terrace; do not attempt to drive down terrace scarp. Walk to first culvert.

Cyr's Ponds: abandoned channel sediments. The silt and clay accumulating in these water bodies are analogous to the massive silt and clay of the channel-fill deposits. Comparison of grain-size distribution, sedimentary structures (especially massive bedding and limonite mottling), and faunal assemblage shows the sediments accumulating in these basins are nearly identical to those exposed at Stops 3, 4 and 11. The abandoned channels are not true ponds but are backwater basins in which water level is controlled by the height of the St. John River. The channel-fill sediments are exposed only during low water levels. Floodplain sands and silts accumulate on higher surfaces nearby.

Return to vehicles, turn around and drive to Route 1.

59.9 Turn left on Route 1.

70.9 Enter Stockholm 1:62,500 quadrangle (this area is not shown on any 1:50,000 Canadian quadrangle).

72.8 Note unpaved road on right, immediately before passing over knoll east of Parent, Maine. Continue southeast on Route 1.

72.9 Turn right on next unpaved road, just east of knoll crest.

73.0 Stop 10. Park near entrance to gravel pit. Walk to southwest end of pit.

Till-mantled kame underlying beach built during regression of Lake Madawaska. The southwest face exposes ice-contact stratified drift which underlies an oxidized buff till. Glaciotectonic isoclinal folding was exposed in 1977 near top of ice-contact stratified drift. One to two feet of shallow water lacustrine silt covers the till. At the southern corner of the pit the silt underlies a beach ridge composed of subrounded gravel and sand. The beach crest has been stripped away. The existance of higher beaches nearby, coupled with the presence of shallow-water silt under the beach gravel demonstrate that this beach formed during regression of Lake Madawaska.

Return to Route 1.

73.1 Turn right on Route 1.

73.8 Stop 11. Park on right side of road across from white transformer. Walk 100 yd northeast to St. John River bank.

Parent exposure (Figure 6). At least 700 rhythmic beds of Lake Madawaska silt and clay are exposed near river level; the basal contact of this lacustrine unit is not exposed. Radiocarbon dates obtained from samples taken along contact between lacustrine sediments and overlying peat bed indicate that the level of Lake Madawaska dropped below this elevation (446 ft) about 9900 B.P. Peat deposition ended about 8855 ± 65 B.P. (SI-3704). The massive grey silt and clay overlying the peat bed is similar to sediments previously identified as channel-fill deposits. However, these massive sediments are not underlain by channel gravels. These sediments probably accumulated in a flood basin that formed when the St. John River began building levees during the early Holocene aggradation. The uppermost horizons in the exposure are floodplain deposits. The youngest radiocarbon date obtained from organic lenses in the floodplain sediments is 4250 ± 50 B.P. (SI-3703). Floodplain deposition on the upper surface of the Siegas terrace ended after this date.

Return to vehicles. End of field trip. Those returning to Presque Isle should continue southeast on Route 1, taking care not to miss the right turn in Van Buren.

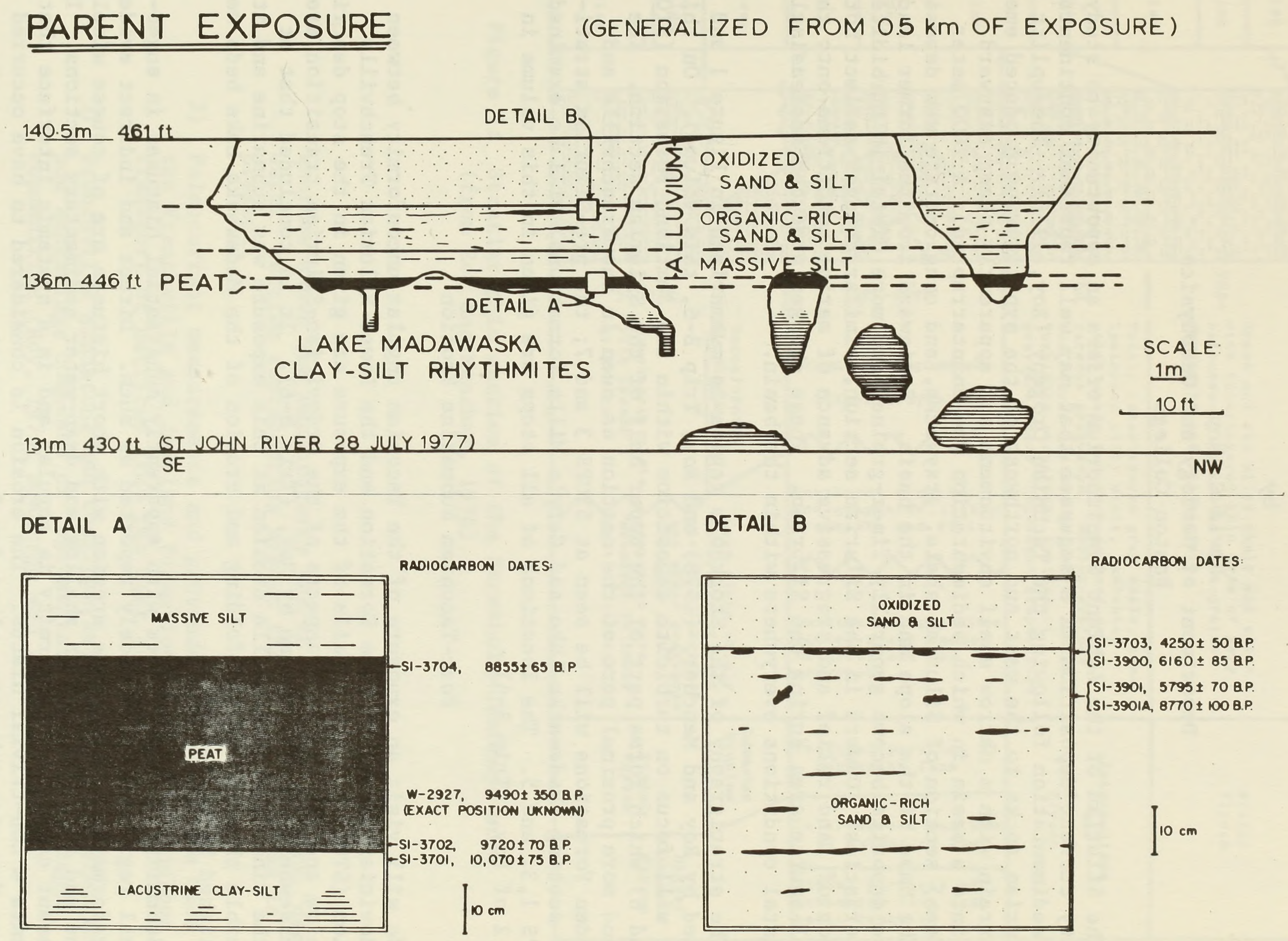


Figure 6. Stop 11: Parent Exposure.