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GEOLOGICAL SURVEY OF CANADA RADIOCARBON DATES XXIV

W. BLAKE, Jr.

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The present date list, GSC XXIV, is the thirteenth to be published directly in the Geological Survey's Paper series. Lists prior to GSC XII were published first in the journal **Radiocarbon** and were reprinted as GSC Papers. The lists through 1967 (GSC VI) were given new pagination, whereas lists VII to XI (1968 to 1971) were reprinted with the same pagination.

GEOLOGICAL SURVEY OF CANADA RADIOCARBON DATES XXIV

Abstract

This list presents 139 radiocarbon age determinations made by the Radiocarbon Dating Laboratory. They are on 128 geological samples from various areas as follows: Labrador Shelf (1); Nova Scotia (25); New Brunswick (11); Quebec (3); Ontario (3); Manitoba (3); Saskatchewan (3); Alberta (10); British Columbia (20); Yukon Territory (25); Northwest Territories, mainland (2); Northwest Territories, Arctic Archipelago (31); Alaska (1). Tables 1 and 2 summarize details of background and standard for the 2 L and 5 L counters during the period from November 2, 1983 to October 8, 1984; Table 3 gives the number of counts used to determine the average background and standard counting rates; and Table 4 lists the number of different background and standard gas preparations used for counting.

Résumé

Ce rapport présente les résultats de 139 datations effectuées sur 128 échantillons géologiques par le Laboratoire de datation au radiocarbone. Ces échantillons proviennent des régions suivantes: plateau continental du Labrador (1); Nouvelle-Ecosse (25); Nouveau-Brunswick (9); Québec (3); Ontario (3); Manitoba (3); Saskatchewan (3); Alberta (10); Colombie-Britannique (20); Yukon (25); Territoires du Nord-Ouest, continent (2); Territoires du Nord-Ouest, archipel Arctique (31). Tableaux 1 et 2 résument les valeurs de mouvement propre et de l'étalonnage des compteurs 2 L et 5 L, pour la période allant du 2 novembre 1983 au 8 octobre 1984; le tableau 3 donne le nombre de coups utilisés pour déterminer la moyenne des taux d'impulsions du mouvement propre et de l'étalonnage; et, le tableau 4 présente le nombre de préparations de gaz pour le mouvement propre et pour l'étalonnage utilisées pour le comptage.

INTRODUCTION[1]

During the period November 1983 to October 1984, both the 2 L counter (Dyck and Fyles, 1962) and the 5 L counter (Dyck et al., 1965) were operated for the entire 12 months. The 2 L counter was operated at 2 atmospheres (atm) throughout the year. The 5 L counter was operated at 1 atmosphere except for the latter part of June, all of July, and most of August 1984, when it was operated at 4 atmospheres.

The average background and oxalic acid standard counting rates which were used for age calculations are shown in Tables 1 and 2, respectively. On a monthly basis, the counting rates were within statistical limits. Table 3 lists the number of one-day counts used to determine the average background and oxalic acid standard counting rates for the period noted above, and Table 4 gives the number of different background and (oxalic acid) standard-gas preparations used.

Sample gas preparation and purification were carried out as described in Lowdon et al. (1977). Carbon dioxide gas proportional counting techniques have been discussed by Dyck (1967). For a recent review of laboratory operations the reader is referred to Lowdon (in press).

Age calculations were done on a CDC Cyber 70 Series/Model 74 computer. Calculations are based on a ^{14}C half-life of 5568 ± 30 years and 0.95 of the activity of the NBS oxalic acid standard. Ages are quoted in radiocarbon years before 'present' (BP), where 'present' is taken to be 1950. The error assigned to each age has been calculated using only the counting errors of sample, background, and standard, and the error in the half-life of ^{14}C (Lowdon and Blake, 1973). Finite dates are based on the 2σ criterion (95.5% probability) and 'infinite' dates on the 4σ criterion (99.9% probability).

If $^{13}C/^{12}C$ ratios were available, a correction for isotopic fractionation was applied to the sample date, and the $\delta^{13}C$ value reported. The "normal" values used for correction relative to the PDB standard are $\delta^{13}C = -25.0‰$

Table 1. Monthly average count for background during the period November 2, 1983 to October 8, 1984

Month	2 L Counter (2 atm) cpm*	5 L Counter (1 atm) cpm*
November 1983	1.164 ± 0.018	2.258 ± 0.039
December	1.162 ± 0.037	2.290 ± 0.045
January 1984	1.160 ± 0.035	2.265 ± 0.031
February	1.153 ± 0.023	2.330 ± 0.025
March	1.143 ± 0.018	2.244 ± 0.036
April	1.144 ± 0.018	2.269 ± 0.036
May	1.143 ± 0.023	2.311 ± 0.041
June	1.165 ± 0.035	2.283 ± 0.044
July	1.181 ± 0.034	2.820 ± 0.028**
August	1.109 ± 0.018	
September	1.123 ± 0.017	2.254 ± 0.024
October	1.121 ± 0.024	2.199 ± 0.025

* cpm = counts per minute
** counted at 4 atmospheres

Table 2. Monthly average count (N_o)* for oxalic acid standard during the period November 2, 1983 to October 8, 1984

Month	2 L Counter (2 atm) cpm	5 L Counter (1 atm) cpm
November 1983	17.919 ± 0.092	27.720 ± 0.120
December	18.047 ± 0.100	27.862 ± 0.124
January 1984	17.885 ± 0.100	27.980 ± 0.122
February	17.958 ± 0.098	27.850 ± 0.123
March	18.066 ± 0.066	27.871 ± 0.143
April	18.065 ± 0.097	27.682 ± 0.124
May	18.122 ± 0.187	27.783 ± 0.125
June	17.923 ± 0.135	27.781 ± 0.127
July	18.015 ± 0.101	103.789 ± 0.239**
August	18.052 ± 0.101	
September	18.353 ± 0.097	27.828 ± 0.162
October	18.114 ± 0.127	27.906 ± 0.120

* N_o = 0.95 of the net counting rate of the NBS oxalic acid standard
** counted at 4 atmospheres

[1] Data for the tables in the introduction were compiled by R.N. McNeely, Laboratory Supervisor since November 1981. The introduction itself follows the style developed by J.A. Lowdon. The date list has been compiled by W. Blake, Jr. from descriptions of the samples and interpretations of age determinations provided by the collectors and submitters.

Table 3. Number of one-day counts used to determine average counting rates for background and oxalic acid standard during the report period

Month	Background 2 L	Background 5 L	Standard 2 L	Standard 5 L
November 1983	4	4	3	3
December	4	4	3	3
January 1984	4	4	3	3
February	4	4	3	3
March	4	4	3	3
April	4	4	3	3
May	4	4	3	3
June	4	4	3	3
July	4	9*	2	6*
August	4		3	
September	5	6	3	3
October	4	4	3	3

*high pressure (4 atm) July-August

Table 4. Number of monthly background and standard gas preparations used during the report period

Month	Background 2 L	Background 5 L	Standard 2 L	Standard 5 L
November 1983	3	4	1	2
December	2	3	2	2
January 1984	3	2	2	2
February	2	2	2	2
March	3	3	2	2
April	2	2	2	2
May	3	2	2	2
June	3	3	1	2
July	3	3*	1	1*
August	3		1	
September	3	3	2	2
October	3	3	2	2

*high pressure (4 atm) July-August

for wood, terrestrial organic materials, and bones (terrestrial and marine), and 0.0‰ for marine shells. All $^{13}C/^{12}C$ determinations were made on aliquots of the sample gas used for age determinations. Since 1975 all $^{13}C/^{12}C$ ratios have been determined under contract by Professor P. Fritz and R.J. Drimmie of the Department of Earth Sciences, University of Waterloo, Waterloo, Ontario, or by Waterloo Isotope Analysts, Inc., Kitchener, Ontario (R.J. Drimmie, chief analyst) using the same equipment as at the University of Waterloo.

Acknowledgments

Appreciation is expressed to I.M. Robertson (1964 to present), S.M. Chartrand (1969 to 1976), J.E. Tremblay (1976 to 1980), and A.M. Telka (since 1980) for the preparation, purification, and counting of samples in the laboratory. Supervision of laboratory operations has been as follows: W. Dyck (1960 to 1965), J.A. Lowdon (1965 to 1981), and R.N. McNeely (1981 to present).

Identification of materials used for dating or associated with the material being dated has been carried out by the following specialists, to whom I extend my sincere thanks: R.J. Mott and L.D. Farley-Gill (wood); R.J. Mott, J.V. Matthews, Jr., S. Lichti-Federovich, C.E. Schweger and T. Habgood, both at the University of Alberta, Edmonton, and J. Terasmae, Brock University, St. Catharines (pollen); J.V. Matthews, Jr. (plant macrofossils and fossil arthropods) and D.J. Larson, Memorial University of Newfoundland (fossil arthropods); M. Kuc, formerly GSC, and J.A.P. Janssens, formerly University of Alberta, Edmonton, now University of Minnesota, Minneapolis (mosses); A.H. Clarke, Jr. and M.F.I. Smith, both formerly National Museum of Natural Sciences, Ottawa, F.J.E. Wagner, formerly Atlantic Geoscience Centre, Dartmouth, C.G. Rodrigues, University of Windsor, Windsor, and I. Lubinsky, University of Manitoba, Winnipeg (molluscs); S. Lichti-Federovich (diatoms); and C.R. Harington, National Museum of Natural Sciences, Ottawa, C.A. Repenning, U.S. Geological Survey, Menlo Park, California, F.C. Whitmore, Smithsonian Institution, Washington, D.C., and C.S. Churcher, Royal Ontario Museum, Toronto (vertebrates).

G. Mizerovsky, formerly GSC, carried out a number of elevation measurements on a sterotope plotting instrument. A.C. Roberts, Mineralogy Section, made the X-ray diffraction determinations on shell samples. R.J. Richardson, J.A. Snider, L. Barton, and J.E. Dale assisted in the processing and examination of samples prior to their submission to the laboratory. K.E. Rolko helped with the compilation of this report.

GEOLOGICAL SAMPLES

Eastern Canada

Labrador Shelf

GSC-3605. Northwest Saglek Bank — modern
$\delta^{13}C = -0.3‰$

Marine pelecypod shells (sample Hu-82-054-001D; 8.1 g; **Macoma calcarea**; identified by F.J.E. Wagner) from the top of a moraine on the northwest Saglek Bank, inner Labrador Shelf (59°45.1'N, 63°02.4'W), in a water depth of 141 m. Collected October 1982 by H. Josenhans.[1]

Comment (H. Josenhans): The moraine from which the sample was recovered consists of the uppermost till in the area (as identified by high resolution Huntec DTS profiles). The sample appears to represent only the reworked surface veneer or modern material worked into the subsurface by iceberg grounding. Recent observations have shown that the upper 1 to 5 m are frequently reworked in this area and that dating shells within this "iceberg turbate" (as defined by Vorren et al., 1983) is probably of little value. The data nevertheless support the interpretation of a high rate of surface reworking.

Comment (W. Blake, Jr.): The sample submitted to the laboratory consisted of six intact pairs of **Macoma calcarea**. All had the ligament and at least part of the periostracum still intact, and one pair was still joined. The shells exhibited no pitting or encrustations, and good internal lustre characterized all valves. The largest measured 3.2 x 2.3 cm; the smallest, 2.2 x 1.5 cm. In general these valves seemed a little thicker than those normally encountered in the High Arctic. Other species present were: **Clinocardium ciliatum, Balanus balanus, Nucula proxima,** and **Turbenilla interrupta** (all identified by F.J.E. Wagner). Because of the small sample size, pretreatment with HCl was omitted. Sample was mixed with dead gas for counting. Date is based on one 1-day count in the 2 L counter.

[1] All persons referred to as collectors or submitters of samples are with the Geological Survey of Canada unless otherwise specified.

Nova Scotia

GSC-2678. Leitches Creek >52 000

Highly compressed peat (sample LC-1 (New Jersey Zinc Co.) or PL-67-20; 102.4 g) in a drill core from beneath approximately 20 m of surface till, and overlying a till which in turn buries a peat bed, from a 60 m mineral-exploration borehole to bedrock, 1.2 km north of Leitches Creek village on the east side of the road to Georges River, Sydney area, Cape Breton Island, Nova Scotia (46°09.20'N, 60°22.87'W). Collected 1967 by E.A. Goranson, then with New Jersey Zinc Exploration Company; submitted by R.J. Mott via V.K. Prest (then GSC).

Comment (D.R. Grant): This drill core is the only direct evidence of two separate intertill organic intervals in the Quaternary sequence of the Atlantic Provinces (analytical work based on a new core taken in 1982 is still in progress). The upper bed indicates boreal forest conditions ('Early Wisconsin interstadial') like that at Bay St. Lawrence and River Inhabitants (cf. GSC-3636, 44 200 ± 820 BP; GSC-1406-2, >49 000 BP; both in this list), whereas the lower organic bed contains significant deciduous pollen and thus indicates a slightly warmer climate (unpublished GSC Palynological Report No. 71-10 by R.J. Mott). Although the till between the organic beds has not been studied and has no obvious correlatives in the region, except perhaps the Miller Creek till (Stea, 1982), this and other cool-climate beds have been hitherto labelled "interstadial" and assumed to be Wisconsinan. Grant and King (1984) instead tentatively assigned both beds to cool and warm phases within the last interglacial stage and correlate them with stages 5a and 5e, respectively. Date is based on one 5-day count in the 5 L counter at 4 atmospheres.

GSC-3636. Bay St. Lawrence 44 200 ± 820

Wood (sample MS-82-22; 45.0 g; from a woody organic bed resting on littoral gravel and overlain by subsorted gravelly colluvium, at an elevation of 9 to 11 m and exposed in a coastal cliff on Cabot Strait, 1.9 km east of the harbour entrance to the village of Bay St. Lawrence, northern Cape Breton Island, Nova Scotia (47°00.75'N, 60°26.83'W). Collected 1982 by R.J. Mott.

Comment (D.R. Grant): The purpose of the long count at high pressure was to obtain a greater finite age or to extend minimum age (cf. GSC-283, >38 300; GSC V, 1966, p. 100), as justification for dating by enrichment method in order to test Wisconsinan age as Mott and Prest (1967) implied. The site has unusual stratigraphy and occupies a crucial position in relation to inferred glacial limits in this area of highlands and submarine troughs. Contrary to Newman (1971) there is no till in the section, but Guilbault (1982) suggested ice marginal dumping to account for a higher lens of silt with reworked deepwater deposits. The peat succeeds a high sea level phase assigned to the Sangamonian (Grant, 1981) and is overlain by a thick periglacial sequence. On geomorphic grounds the site lies beyond the limit of Late Wisconsinan ice (Grant, 1977). Against this may be judged the date which, if finite as stated, could give a first reliable indication of Middle Wisconsinan ice-free conditions in the area (cf. GSC-1220-2, 31 300 ± 500 BP; GSC-1408, 32 100 ± 900 BP; both in this list; and GSC-2469, 37 200 ± 1310 BP; GSC XXIII, 1983, p. 9); if minimal, as is normally suspected of dates in this range, then a late interglacial/early glacial age (stage 5a) is more likely (D.R. Grant, Surficial geology and Quaternary history of Cape Breton Island, Nova Scotia; unpublished manuscript). A complete tundra/boreal forest/tundra cycle is recorded (de Vernal, 1983; de Vernal et al., 1983). The age of the peat bed remains ambiguous, and deglacial isochrones for Laurentian Channel hinge on this site.

Comment (W. Blake, Jr.): The sample submitted was 16 cm long, 3.5 cm in diameter. The original weight (wet) was 275.2 g; after trimming away the outside wood the weight was reduced to 214.5 g, and upon oven drying the weight decreased to 78.8 g. Date is based on one 3-day count plus two 1-day counts in the 5 L counter at 4 atmospheres.

Dingwall Series

Wood in organic silt or gyttja at elevation approximately 3 m, overlying till and gypsum and buried by tills, gravels, and younger organic beds; exposed as a sinkhole(?) filling, truncated by coastal cliffs, 0.2 km south of the entrance to the harbour at Dingwall on Aspy Bay (Cabot Strait), northern Cape Breton Island, Nova Scotia (46°54.05'N, 60°27.02'W). Collected 1981 by R.J. Mott, V.K. Prest, and D.R. Grant.

GSC-3381. Dingwall A 32 700 ± 560
$\delta^{13}C = -25.4‰$

Wood (sample MS-81-5W; 12.5 g; **Picea** sp.; unpublished GSC Wood Identification Report No. 81-8 by R.J. Mott) from the lower organic bed.

GSC-3417. Dingwall B >39 000

Wood (sample MS-81-5W(B); 12.6 g; **Picea** or **Larix**; unpublished GSC Wood Identification Report No. 82-43 by R.J. Mott) from the basal part of the same lower organic bed from which GSC-3381 was collected.

GSC-3541. Dingwall C >39 000

Wood (sample MS-81-5G(A); 11.7 g; **Picea** sp.; unpublished GSC Wood Identification Report No. 82-44 by R.J. Mott) as a reworked clast in granite-cobble gravel overlying the lower woody peat bed referred to above.

GSC-3541-2. Dingwall D >48 000

Wood (sample MS-81-5G(A); 42.6 g) – a new preparation from the remainder of the sample used for GSC-3541.

Comment (D.R. Grant): Though the stratigraphic sequence at Dingwall was first described by Newman (1971, p. 40), the organic bed was discovered by R.B. Taylor in 1981. Analysis of his samples prior to dating (unpublished GSC Wood Identification Report No. 81-6 by R.J. Mott; unpublished GSC Palynological Report No. 81-1 by R.J. Mott) showed more spruce than in typical postglacial sequences, and greatest similarity with other buried organic beds, particularly the upper part of Milford Interglacial Bed (cf. Mott et al., 1982). Therefore the original finite date GSC-3381, which gave a Middle Wisconsinan age, was questioned and was subsequently attributed to an anomalous background at time of counting; this hypothesis was confirmed by GSC-3417. Two further dates, GSC-3541 and -3541-2, on wood reworked into the overlying gravel, confirm the supposition that the bed is pre-Middle Wisconsinan and probably last interglacial, as pollen data suggest. In this respect its relation to the enclosing tills is crucial, more so because the timing of glaciation is virtually unknown in this area supposedly outside the limit of Late Wisconsinan ice (Grant, 1977). Moreover, deposition on a karstic terrain makes the stratigraphic context ambiguous. However, regardless of distortion by differential collapse, superposition shows that peat formation followed deposition of a brown sandy till; the peat was buried by a well rounded clean gravel, texturally similar to interglacial emerged littoral gravel nearby, but which also could be (glacio)fluvial. The gravel is buried by the regional reddish silty surface till of northern provenance, which is here surmounted by a local thin sandy

till or colluvial derivative. The organic bed thus predates the main glaciation of the area, as represented by the red till, which is tentatively correlated with northern tills of supposed Early Wisconsinan age (D.R. Grant, Surficial geology and Quaternary history of Cape Breton Island, Nova Scotia; unpublished manuscript). The colluvial(?) mantle, like that at Bay St. Lawrence (GSC-3636, 44 200 ± 820 BP; this list), might therefore represent a lengthy postglacial interval.

Comment (W. Blake, Jr.): GSC-3381 is based on two 3-day counts in the 5 L counter; GSC-3417 is based on one 4-day count in the 5 L counter; GSC-3541 is based on one five day count in the 5 L counter; and GSC-3541-2 is based on one 3-day count plus one 4-day count in the 5 L counter at 4 atmospheres.

Castle Bay Series

Organic mud and wood exposed in a shore cliff on East Bay of Bras D'Or Lake, 1 km east of the village of Castle Bay, Cape Breton Island, Nova Scotia (45°55.22'N, 60°38.75'W). Collected 1971 by D.R. Grant.

GSC-1577. Castle Bay A >42 000

Organic mud (sample GS/T71-20; 350 g; typical lake bottom sediment according to unpublished GSC Bryological Report No. 136 by M. Kuc) at an elevation of 5 m a.s.l., overlying beach(?) gravel and overlain by a complex of delta sand foresets, gravel, massive silts, and tills.

GSC-1619. Castle Bay B >52 000

Wood fragment (sample GS/71-71; 34 g dry; **Picea** or **Larix**; unpublished GSC Wood Identification Report No. 71-62 by R.J. Mott) enclosed in a 1 to 2 m-thick bed of till-like diamicton overlying the delta foresets described above.

Comment (D.R. Grant): The sequence originally described (Grant, 1972) has been correlated with others along the East Bay shore. The basal gravel is assigned to a higher sea level (stage 5e); the organics have varying climatic affiliations (here fairly cool), assigned to different parts of last interglacial (D.R. Grant, Surficial geology and Quaternary history of Cape Breton Island, Nova Scotia; unpublished manuscript). The overlying delta is judged to be ice-marginal in glacial Lake Cameron (Grant and King, 1984). The wood clast occurs in the part of the sequence deposited subaquatically; the date was intended to provide an age for the lacustrine interval in case the enclosing bed was not glacial as suspected. Both organic beds, whatever their precise local origin, predate the till sequence and the main glacial advance over the area.

Comment (W. Blake, Jr.): GSC-1577 is based on one 3-day count in the 5 L counter. For GSC-1619 a preliminary count (one 1-day count in the 5 L counter) gave >40 000 BP; the main determination is based on one 3-day count plus one 1-day count in the 5 L counter at 4 atmospheres.

GSC-1220-2. Middle River 31 300 ± 500
$\delta^{13}C = -19.8‰$

Bone (sample 68/GS-51); property of the Nova Scotia Museum, Halifax; 258.5 g; femur of elephant **Mastodon (=Mammut) americanum**, identified by C.S. Churcher, Royal Ontario Museum, Toronto) turned up by plow on the farm of Alexander MacRae on the modern floodplain of Middle River, near the settlement of Lower Middle River, Cape Breton Island, Nova Scotia (46°8.1'N, 60°55.2'W). Collected, according to Dawson (1868, p. 84 and plate) and Piers (1915), in 1834; the location was cited as 1.5 miles south-southeast of Middle River bridge, and finder was presumably A. MacRae. The femur was ultimately acquired by the present Nova Scotia Museum. Submitted by D.R. Grant. Two determinations were made:

GSC-1220.	850 g of crushed bone given 'standard' treatment with 3 N HCl and overnight leach with 0.1 N NaOH. 30.5 g of organic material burned. Date is based on one 3-day count in the 5 L counter.	32 000 ± 630 $\delta^{13}C = -18.7‰$
GSC-1220-2.	258.5 g of crushed bone mixed with H_2O and acetic acid; acid added until reaction ceased. The 45 g of organic material obtained in this way was burned. Date is based on one 3-day count in the 5 L counter.	31 300 ± 500 $\delta^{13}C = -19.8‰$

Comment (D.R. Grant): The specimen is one of several fossils of Quaternary age solicited from Maritimes museums for purpose of chronostratigraphic development. The age and sedimentary context suggest that the fossil has been reworked by fluvial action, and perhaps also by glaciers, from a pre-existing deposit, probably within a few kilometres of the site judging by the lack of wear. No systematic search has yet been made for exposures of the host sediments. The site is believed to lie beyond the limit of Late Wisconsinan glaciers (Grant, 1977). If the agreement in ages between organic fraction obtained by two preparation methods means little or no contamination, the date can be considered finite as determined. Unless the bone was transported into Cape Breton by glacier, an ice-free interval during Middle Wisconsinan time is indicated (cf. GSC-1408, -1440, -3206 and -3381, all in this list; cf. also GSC-2469, GSC XXIII, 1983, p. 9). Whether there was subsequent glacial cover is not yet resolved on stratigraphic grounds (D.R. Grant, Surficial geology and Quaternary history of Cape Breton Island, Nova Scotia; unpublished manuscript).

The bone has a darkened ferruginous stain and pore spaces have calcite fillings, suggesting lengthy burial below water table. Cemented organic detritus (dung?) adhering to bone cavities was analyzed for pollen; this material contained "a rather large hardwood component compared to the modern boreal forest" (J. Terasmae, Brock University, St. Catharines, personal communication, 1970). Hence it is possible that the bone dates from an earlier, more temperate nonglacial period (an interglacial stage) and the age is therefore minimal.

GSC-1639. Janvrin Island >34 000

Fragments of marine shells (sample GS/70-262; 27 g; **Mercenaria mercenaria**; identified by A.H. Clarke, Jr., then National Museum of Natural Sciences, Ottawa) in red clay till at an elevation of 1 to 3 m, exposed in a coastal cliff cut in a drumlin forming a peninsula of Janvrin Island, south Cape Breton Island, Nova Scotia (45°31.3'N, 61°06.7'W). Collected 1970 by D.R. Grant.

Comment (D.R. Grant): Shells, usually rare and widely scattered in tills of this area (Grant, 1971), were fairly abundant at this site. Associated molluscs include **Crassostrea virginica** and **Mya arenaria** (identified by A.H. Clarke, Jr.) and **Balanus** sp. (identified by W. Blake, Jr.). Fossils thus represent an open sea with temperatures comparable to the present prior to the first major

glacial advance. May date either from Middle Wisconsinan if the age is just slightly beyond the date given (cf. GSC-1220-2, 31 300 ± 500 BP; GSC-1408, 32 100 ± 900 BP, this list) or more probably from the last interglacial stage (D.R. Grant, Surficial geology and Quaternary history of Cape Breton Island, Nova Scotia; unpublished manuscript).

Comment (W. Blake, Jr.): The shell fragments were up to 10 mm in thickness. Date is based on one 3-day count in the 2 L counter.

GSC-3206. Big Brook 36 200 ± 1280

Organic silt (sample 80-GS-79; 869 g) deposited in a small solution cavity (lapiés) in gypsum, overlain by two tills and two other organic layers, and exposed in the working quarry of the Georgia-Pacific Gypsum Corp., near the hamlet of Big Brook, southwestern Cape Breton Island, Nova Scotia (45°48.4'N, 61°12.9'W), at an elevation of approximately 30 m. Collected 1980 by D.R. Grant.

Comment (D.R. Grant): Given that the sediment underlies a weathered zone beneath a till sheet attributed to regional glaciation, this date has more stratigraphic significance than a nonfinite age on a piece of wood included as an erratic in the overlying till (GSC-3289, >49 000; GSC XXII, 1982, p. 4; note, same elevation, not 150 m as given). While there is no **a priori** reason to reject the finite Middle Wisconsinan age as given (cf. GSC-1220-2, 31 300 ± 500 BP; GSC-1408, 32 100 ± 900 BP, both in this list; and GSC-2469, 37 200 ± 1310 BP, GSC XXIII, 1983, p. 9), the date was expected to be much older in view of the temperate character of the vegetal remains (unpublished GSC Palynological Report No. 80-12 by R.J. Mott) and the stratigraphic position of the organic silt below what is presently regarded as an Early Wisconsinan till, which is generally underlain by Sangamonian or older beds (Grant and King, 1984). A date on the organics between the red till and the underlying weathered zone will help resolve the problem.

Comment (W. Blake, Jr.): On air drying the sample decreased in weight from 1000 to 869 g. NaOH leach was omitted from sample pretreatment. The sample had an extremely low organic content, as the 659.08 g burned produced only 24.0 cm of CO_2. Date is based on one 3-day count in the 2 L counter.

GSC-1408. Grantville 32 100 ± 900

Fragments of marine shells (sample GS/70-103; 17.5 g; judged by D.R. Grant to be **Mercenaria mercenaria** on the basis of similarity to GSC-1639, >34 000 BP; this list) picked from a thin fossiliferous horizon in gravel of an esker exposed in a borrow pit on the west side of the highway, 0.8 km southeast of the village of Grantville, Richmond County, Cape Breton Island, Nova Scotia (45°38.50'N, 61°14.20'W), at an elevation of approximately 10 m. Collected 1970 by D.R. Grant.

Comment (D.R. Grant): The shells evidently were winnowed by glaciofluvial recycling of the surrounding tills which also contain scattered fragments of fossils including foraminifera (cf. GSC-1406-2, >49 000, and -1639, given above; both in this list; Grant, 1971). Taken at face value, the date indicates that the source area for the tills, the Scotian Shelf, was ice free in Middle Wisconsinan time in order for temperate marine conditions to prevail. However this conflicts with King's (1980) belief that a land-based ice sheet extended onto the shelf at this time. Alternatively the date could be minimal, and since the shells suggest water temperatures comparable to the present (cf. Wagner, 1977), an interglacial age would be equally plausible. Hence, the evidence for a mid-Wisconsinan ice-free interval remains equivocal. Sample was mixed with dead gas for counting. Date is based on one 5-day count in the 2 L counter.

GSC-1406-2. River Inhabitants >49 000

Wood (sample 70-GS-202; **Picea** sp.; unpublished, GSC Wood Identification Report No. 71-13 by R.J. Mott) occurring as detritus of large branches and roots in peat layers intercalated with pebbly rubble buried by fluvial gravel and two tills (one shelly); this horizon is exposed in a cutbank through a buried valley along the east side of Northwest Arm Brook, a tributary of River Inhabitants, 6.4 km north-northeast of Port Hawkesbury, Cape Breton Island, Nova Scotia (45°40.47'N, 61°19.58'W), at an elevation of approximately 53 m. Collected 1970 by D.R. Grant. Two determinations were made:

GSC-1406.	40 g of wet wood (10 g of dry wood burned). Standard treatment with NaOH, HCl, and distilled water rinses. Date is based on one 4-day count in the 2 L counter.	>39 000
GSC-1406-2.	40.0 g of dry wood, treated as above. Date is based on one 3-day count and one 1-day count in the 5 L counter at 4 atmospheres.	>49 000

Comment (D.R. Grant): The site was first reported by Dawson (1868) and interpreted as "tender coal" by Fletcher (1881, p. 114) but, because the location was given as Black Brook – a name no longer used – the occurrence became effectively lost until 'rediscovered' in the course of surficial mapping (Grant, 1971). Though work continues on this deposit, as with others of similar stratigraphic context, preliminary findings can be given. On palynological grounds (unpublished GSC Palynological Report No. 71-8 by R.J. Mott) a boreal subarctic or open woodland tundra characterized by abundant **Sphagnum**, sparse **Pinus** and **Betula**, and increasing **Picea** from bottom to top was inferred. The climate changed from cold and moist, to cold and dry, to warmer and wetter. Mott (1971) tentatively correlated the deposit with other cool-climate ("interstadial-type") buried organic beds in Cape Breton, previously described (Mott and Prest, 1967). On stratigraphic grounds the bed predated the first (Early?) Wisconsinan till and has been assigned to the later, cooler part of the last interglacial stage (Grant and King, 1984).

GSC-3317. Mabou >53 000

Wood (sample 81-GS-46; 49.1 g; **Abies balsamea**; unpublished GSC Wood Identification Report No. 85-10 by R.J. Mott) from a peat bed exposed in a roadcut (and later exposed in a trench in an adjacent gravel pit by R.J. Mott) through outwash and possibly till on the bank of Northeast Mabou River, 2.1 km northwest of Mabou, western Cape Breton Island, Nova Scotia (46°05.17'N, 61°24.52'W). Collected 1981 by D.R. Grant.

Comment (D.R. Grant): The organic bed was dated to provide a maximum age for red clay till which appears to underlie it at a nearby locality. From stratigraphic relations elsewhere, the organics could be Middle Wisconsinan. The prime reason for dating the sample, however, was to provide a minimum age for the overlying outwash gravel which, except for the problematic superficial muddy layer (till?) on top, is a marginal feature of the last glacier to retreat inland. On geomorphic grounds that glacier is pre-Late Wisconsinan (Grant, 1977); the date, though nonfinite,

supports that hypothesis. However, silt over the organic layer has a well developed Podzol B-zone which suggests a lengthy temperate weathering; hence the deposit may be as old as last interglacial. Paleoecological studies continue. Compare GSC-3320, also >53 000 BP, this list.

Comment (W. Blake, Jr.): The wet wood was oven dried in two batches: 104.0 g decreased to 38.5 g; 27.6 g decreased to 9.9 g. Date is based on one 5-day count in the 5 L counter at 4 atmospheres.

GSC-3320. Green Point >53 000

Wood (sample 81-GS-51; 48.3 g; **Juniperus** sp.; unpublished GSC Wood Identification Report No. 83-28 by R.J. Mott) overlying weathered beach(?) gravel and underlying two tills, exposed in a coastal cliff on the Gulf of St. Lawrence shore, east of Green Point, 5.5 km west of Mabou town, Cape Breton Island, Nova Scotia (46°05.37'N, 61°28.58'W), at an elevation of 2 m. Collected 1981 by D.R. Grant.

Comment (D.R. Grant): The sample was dated primarily to give a maximum age for the overlying till which was produced by the regional ice sheet out of the Gulf, and to give a maximum age for the beach gravel tentatively referred to the last interglacial. The date and the paleoecological interpretation of temperate climate (R.J. Mott, personal communication, 1983) support assignment of the beach and peat to stage 5e, and of the red till to stage 4 (Grant and King, 1984). Work continues on the correlation of this bed with nearby GSC-3317, (>53 000, this list) and other subtill peats in the region. Date is based on one 5-day count in the 5 L counter at 4 atmospheres.

GSC-2212. Campbell 11 200 ± 110

Peat (sample GS/70-316; 185.0 g) underlain by surface till and overlain by 2 m of sand (outwash?) at an elevation of approximately 10 m; the bed is exposed in a coastal cliff along the Gulf of St. Lawrence (George Bay), 0.5 km south of Campbell Station, Inverness County, southwestern Cape Breton Island, Nova Scotia (45°50.25'N, 61°29.70'W). Collected 1970 by D.R. Grant.

Comment (D.R. Grant): The pollen assemblage (unpublished GSC Palynological Report No. 75-12 by R.J. Mott) is dominated by shrubs and willow and matches basal L-zone (open tundra, more than 10 000 years ago in Nova Scotia as defined by Livingstone (1968; cf. also Mott, in press). J.V. Matthews, Jr. (unpublished GSC Fossil Arthropod Report No. 1-75) described an assemblage linked to small cold streams and ponds, and noted one species of ground beetle (**Elaphrus lapponicus** Gyll.) whose southern limit is now in Labrador and along the north shore of the Gulf of St. Lawrence. A few coal fragments were observed in the peat. Thus, if the date is reliable, the deposit represents early late-glacial conditions just prior to an abrupt flood of fluvial sand, resulting either from the re-appearance of unvegetated slopes or by reactivation of an ice lobe in George Bay emanating from the Late Wisconsinan glacier over southern Cape Breton Island (D.R. Grant, Surficial geology and Quaternary history of Cape Breton Island, Nova Scotia; unpublished manuscript). Both imply some sort of abrupt climatic deterioration.

Comment (W. Blake Jr.): Upon oven drying the sample weight decreased from 238.5 to 185.5 g. A few twigs were separated out prior to dating. Pretreatment included a cold NaOH leach for five minutes. Date is based on two 1-day counts in the 5 L counter.

Brookside Series

Peat underlain by sand and overlain by silt and stony mud (till?) exposed in a gully in the slope on the north side of highway 311, 1 km east of the junction with the road to Brookside, Colchester County, central Nova Scotia (45°24.09'N, 63°14.35'W), at an elevation of approximately 53 m. Collected May 1979 by G.J. Beke, then Nova Scotia Soil Survey, Truro, Nova Scotia; now Agriculture Canada, Lethbridge, Alberta.

GSC-2930. Brookside (I) 11 100 ± 100

Peat (sample IV Omb; 23.9 g dry) at 190 to 196 cm below the surface.

GSC-3849. Brookside (II) 11 700 ± 110

Peat (sample VI Ofb; 70.0 g dry) at 242 to 250 cm depth in a 253 cm-thick section.

Comment (D.R. Grant): This organic horizon is one of several in Nova Scotia and surrounding areas that date from the period 10 000 to 12 000 BP and which are buried by mineral sediment of varying origin. This occurrence represents the onset of postglacial vegetation and the transition from shrub tundra to open spruce woodland (unpublished GSC Palynological Report No. 79-16 by R.J. Mott). The deposit accumulated in a small wet depression with sedge fen border (unpublished GSC Plant Macrofossil Report No. 82-23 by J.V. Matthews, Jr.). Fossils are of those expected in emergent aquatic vegetation, but the climate was distinctly colder than at present (unpublished GSC Fossil Arthropod Report No. 82-24 by J.V. Matthews, Jr.). The upper sample (GSC-2930) dates the abrupt cessation of organic accumulation when the site was buried by colluvium. This material was interpreted by Beke et al. (in press) as sheet wash resulting from reactivation of devegetated till slopes during a climatic deterioration, as possibly by a fire.

Comment (W. Blake, Jr.): The original damp sample used for GSC-2930 weighed 348.0 g. The dated material is the >40 mesh fraction after the sample had been picked and screened for plant macrofossils and fossil anthropods. J.V. Matthews, Jr. also reported (personal communication, 1979) that a few mosses and sedge stems were present, but no coal or other contaminants were seen. Date for each sample is based on one 3-day count in the 5 L counter.

GSC-1259. Gilbert Cove 14 100 ± 200
$\delta^{13}C = -18.7‰$

Marine algae (sample GS 69/152; 23.8 g) at the base of 4 m of oxidized silty sand under 2.5 m of pebble gravel, which in turn overlies 0.6+ m unoxidized grey silty clay exposed in the Bay of Fundy shore cliff in Gilbert Cove, 16 km southwest of Digby, Nova Scotia (44°29.15'N, 65°57.00'W), at an elevation of 4 m. The algae occur as thin seams a few millimetres in thickness. Collected September 1969 by D.R. Grant and J.G. Fyles.

Comment (D.R. Grant): The organic detritus was identified by M. Kuc as mainly marine algae of the type usually found attached to boulders at tide level (personal communication, 1969). Marine limit, and the upper level of the sand/gravel veneer comprising the host sediment, reaches 35 m in this area. Hence the organic bed relates to the highest deglacial paleoshore, and the dated sediment marks the bottomset or earliest part of the Late Wisconsinan marine submergence in the Bay of Fundy (Grant, 1980, p. 43). Together with comparable shell dates from southern

New Brunswick, GSC-2573 (14 400 ± 530 BP; GSC XIX, 1979, p. 5) and GSC-3354 (13 900 ± 620 BP; GSC XXIII, 1983, p. 10), this age determination shows that the Bay of Fundy was evidently open at that time, if indeed it was ever closed by Late Wisconsinan glaciers.

Comment (W. Blake, Jr.): See comments by V.N. Rampton regarding additional marine shell samples from the Mispec Bay and Sheldon Point areas of New Brunswick (this list). The macroscopic algae (largest pieces were 3 to 6 mm in size) in this sample were quite broken down, perhaps by transport, but the microscopic algae were well preserved. NaOH leach was omitted. Sample was mixed with dead gas for counting. Date is based on one 3-day count in the 2 L counter.

Salmon River Series

Marine gastropod and pelecypod shells from a 3 m-thick sand bed enclosed in a sequence of three tills, exposed in a Gulf of Maine (Bay of Fundy) coastal cliff 0.8 km north of the mouth of Salmon River, Digby County, Nova Scotia (44°03.50'N, 66°10.50'W), at an elevation of 6 to 9 m a.m.s.l.

GSC-1440. Salmon River 38 600 ± 1300
$\delta^{13}C = +0.8‰$

Intact marine gastropods (samples GS/67-140 and GS/70-451; 100 g; **Atractodon** (formerly **Neptunea) stonei;** identified by A.H. Clarke, Jr., then National Museum of Natural Sciences, Ottawa). Collected 1967 through 1970 by D.R. Grant. Two determinations were made:

GSC-1440. Outer fraction 37 500 ± 1300

Outer fraction of shells (21 to 60%) after outermost 20% was removed by HCl leach. Date is based on two 1-day counts in the 5 L counter.

GSC-1440. Inner fraction 38 600 ± 1300
$\delta^{13}C = +0.8‰$

Inner fraction of shells (61 to 100%). Date is based on one 3-day count in the 5 L counter.

GSC-1701. Salmon River >36 000

Marine pelecypods (sample GS/71-75; 80.7 g; **Placopecten magellanicus;** identified by A.H. Clarke, Jr.) in intimate association with the dated species documented above. Collected 1971 by D.R. Grant. Two determinations were made:

GSC-1701. Outer fraction >37 000

Outer fraction of shells (0 to 50%). Because of the small sample size the normal HCl leach to remove the outermost 20% of shell material was omitted. Date is based on one 3-day count in the 5 L counter.

GSC-1701. Inner fraction >36 000

Inner fraction of shells (51 to 100%). Date is based on one 3-day count int he 5 L counter.

Comment (D.R. Grant): The gastropod is an extinct species and is associated with a varied assemblage of temperate molluscs; this led Clarke et al. (1972) and Wagner (1977) to infer water conditions as warm as, and possibly warmer than, at present and to postulate a Sangamonian age. Stratigraphically the bed was originally thought to overlie the lowest (red) till, and in view of finite U/Th ages of 35 000 to 44 000 years (W.S. Broecker, Lamont-Doherty Geological Observatory, Palisades, New York, personal communication, 1972), later authors (e.g., Nielsen, 1974) assigned a Middle Wisconsinan age. After further detailed stratigraphic study of this and related exposures, however, the sand bed is now understood to have been glaciotectonically emplaced within the upper part of the lower shell-bearing till; elsewhere similar shelly sands and silts, locally weathered, underlie the red till. Hence the Salmon River Sand (**Atractodon** bed) predates the oldest till and is re-assigned a last interglacial age on paleoecological grounds; the radiocarbon dates are once again considered minimal. This latter view is supported by the nonfinite age on an associated species. In summary there remains no conflict between the preferred stratigraphic assignment to a nonglacial interval prior to the first glacial advance (elsewhere known to postdate the last warm period) and the paleoecological correlation with type Sangamonian beds of similar character elsewhere on the Gulf of Maine coast (Gustavson, 1976). Further U/Th and amino acid analyses are planned to confirm this hypothesis.

Comment (W. Blake, Jr.): The shells used for GSC-1440 were in pristine condition (hyaline interior; finely ornamented exterior); a single fragmented whole shell plus parts of three others sufficed for dating. For GSC-1701 a single valve >14 cm wide and 14 cm high was used. It was clean and free of pitting and encrustations.

New Brunswick

GSC-3284. St-Louis-de-Kent 12 600 ± 140
$\delta^{13}C = -23.7‰$

Collagen fraction portion (sample 265RM (= NMC-36170); 831.1 g) of a vertebra of balenopterid cf. **Balenoptera acutorostrata** (identified by F.C. Whitmore, Jr., Smithsonian Institution, Washington, D.C.) from the base of a 2 to 4 m-thick clay unit in a fresh ditch excavated near the south bank of Kouchibouguacis River about 1.5 km west of St-Louis-de-Kent, New Brunswick (46°43.4'N, 64°59.6'W), at an elevation of approximately 8 m. Other exposures in the area suggest that clay overlies bedrock and is capped by thin sand. NaOH leach was omitted from sample pretreatment. Collected August 1980 by V.N. Rampton, Terrain Analysis and Mapping Services, Ltd., Carp, Ontario.

Comment (V.N. Rampton): Dates of 18 570 ± 500 BP (S-1969; Rampton and Paradis, 1981a) and 11 830 ± 950 BP (S-1969(B), Rampton et al., 1984) were obtained on another fragment of the same bone at the Radiocarbon Dating Laboratory of the Saskatchewan Research Council, Saskatoon. GSC-3284 and S-1969(B) taken together suggest that the area was submerged to over 8 m elevation around 12 500 years BP. The incorrect age obtained for S-1969 led Rampton and Paradis (1981a) to report, probably erroneously, that much of the New Brunswick Lowlands were deglaciated by 18 000 years ago. Because of the relatively small size of this bone sample the NaOH leach was omitted. After the 831.1 g of sample was treated with 3 N HCl and distilled water rinses, only 10.1 g of collagen remained for burning. Sample was mixed with dead gas for counting. Date is based on one 3-day count in the 5 L counter.

Mispec Bay Series

Marine pelecypod shells from a sand and gravel pit adjacent to Mispec Bay, approximately 10 km east of Saint John, New Brunswick (45°13.7'N, 65°57.1'W), at an elevation of ca. 30 m. The shells were presumably recovered from the same site as those collected by J.R. Bélanger in 1976 (see comments for GSC-2573, 14 400 ± 530 BP, and GSC-2640, 12 800 ± 120 BP; GSC XIX, 1979, p. 5).

GSC-3167. Mispec Bay (III) 13 000 ± 200

Pelecypod shells (sample PM 952; 15 g; **Portlandia arctica siliqua** (Reeve), identified by M.F.I. Smith, National Museum of Natural Sciences, Ottawa; **Mya arenaria, Mya truncata, Macoma calcarea, Hiatella arctica, Balanus** sp., and **gastropods** noted in sample by W. Blake, Jr.) from 3 m of sand underlying an estimated 10 m of sand and gravel (thickness correctly given in Rampton et al. (1984), incorrectly in Rampton and Paradis (1981b)) and overlying clay. Many pelecypods were paired. Collected September 1980 by S. Paradis, Terrain Analysis and Mapping Services Ltd., Carp, Ontario. Date was incorrectly reported as GSC-2167 in Table 1 of Rampton and Paradis (1981b).

GSC-3579. Mispec Bay (IV) 12 800 ± 140
$\delta^{13}C = +0.6‰$

Pelecypod shell fragments (samples 81-125RC-5, -5a; 19.7 g; **Mya** sp., probably **M. arenaria**, identified by W. Blake, Jr.) from the base of 3.5 m of contorted clay and silt underlying 10.5 m of silt and sand, coarsening upwards. Sample unit is underlain by clay and till. Collected October 1981 and June 1982 by V.N. Rampton.

Comment (V.N. Rampton): GSC-2573 and GSC-2640 (both in GSC XIX, 1979, p. 5), together with GSC-3167 and GSC-3579, suggest that the lower sands at this locality were deposited about 12 900 years ago and that sea level was more than 40 m above present at that time (Rampton et al., 1984). The area was likely deglaciated well before 13 200 BP and GSC-2573, which dated at 14 400 ± 530 BP, may have been obtained on a shell fragment reworked from an earlier period of submergence.

Comment (W. Blake, Jr.): The sample used for GSC-3167 comprised 40 left valves and 40 right valves (+ fragments); not all the valves were pairs. All the **Portlandia** valves were greater than 1.5 cm in length, and the maximum size was 1.9 x 1.3 cm. None had periostracum, but many retained good internal lustre; most valves were cleaned in an ultrasonic bath. For GSC-3579 the sample was composed entirely of fragments of **Mya** sp. (probably **M. arenaria**, as truncated posterior ends typical of **Mya truncata** were not present); the largest fragments measured 2.5 x 2.0 cm, most retained some periostracum, but none had lustre or pitted surfaces. **Macoma calcarea** was also present in the sample. Because of the small size of both samples, only the outer 10% of shell was removed by HCl leach. Both samples were mixed with dead gas for counting. Each date is based on one 3-day count in the 2 L counter.

GSC-3552. Durham Centre 12 500 ± 130
$\delta^{13}C = +1.5‰$

Shell fragments (sample 82-397R1a; 27.0 g; **Mya** sp., probably **Mya arenaria**, identified by W. Blake, Jr.) from the base of a 40 cm-thick silty diamicton and the top of an underlying 40 cm-thick clay unit on the coast directly north of Durham Centre, New Brunswick (47°55.5'N, 66°02'W), at an elevation of approximately 1 m. The diamicton is overlain by 2 m of gravel and sand. Collected August 1982 by V.N. Rampton and S. Paradis.

Comment (V.N. Rampton): This date, in combination with GSC-3485 (12 300 ± 220 BP, this list) from the base of a diamicton and GSC-2839 (12 500 ± 360 BP) and GSC-3450 (12 000 ± 100 BP; both in this list) from gravels overlying the diamicton indicate that a glacier readvance into the Goldthwait Sea in Baie des Chaleurs occurred ca. 12 400 BP (Rampton et al., 1984).

Comment (W. Blake, Jr.): The entire sample was fragmented; the largest pieces were up to 2.5 cm in diameter. All fragments were <1 mm thick, with good internal lustre and well preserved periostracum. After adhering sand was washed away in distilled water, the sample was air dried. All pieces utilized had the typical **Mya** hinge area; because no fragments had the truncated posterior end typical of **M. truncata**, it seems likely that the sample represents **M. arenaria**. Date is based on one 4-day count in the 2 L counter.

GSC-3557. Sheldon Point 13 100 ± 160
$\delta^{13}C = +0.8‰$

Shell fragments (sample GB-82-4; 20.5 g; **Hiatella arctica**; identified by W. Blake, Jr.) from reddish diamicton near the crest of the working face in a large pit at Sheldon Point near Saint John, New Brunswick (45°13.5'N, 66°06.5'W), at an approximate elevation of 45 m. Diamicton overlies gravel and sand and is capped by interbedded silty clay, sand and gravel containing a few shelly layers. Collected August 1982 by N.R. Gadd.

Comment (V.N. Rampton): If the diamicton is till, this date plus GSC-3354 (13 900 ± 620 BP; GSC XXIII, 1983, p. 10) from same diamicton indicates that an active glacier was present at this site near Saint John ca. 13 200 years ago (Rampton et al., 1984). If diamicton has been re-worked by marine wave and current action, these dates give only a minimum date for deglaciation of the site. N.R. Gadd (personal communication, 1982) noted interstratified thinner diamicton beds (less than 8 cm thick) and marine clay and silt at other localities within the pit. Because of the small sample size, only the outer 10% of shell was removed by HCl leach. Sample was mixed with dead gas for counting. Date is based on one 5-day count in the 2 L counter.

Dickie Cove Series

Marine pelecypod shells from a wave-eroded sea cliff on the southeast shore of Dickie Cove along the coast of Baie des Chaleurs, New Brunswick (47°57.1'N, 66°07.5'W). Shells collected 1978 and 1979 by R.C. Gauthier, then University of Western Ontario, London, Ontario; now Navacel Enterprises, Ltd., Toronto.

GSC-2839. Dickie Cove (I) 12 500 ± 360
$\delta^{13}C = +1.7‰$

Pelecypod shell fragments (sample C-143; 6.0 g; **Hiatella arctica**, identified by R.J. Richardson, then GSC, now Alberta Geological Survey, Edmonton) from 3 m below the surface of gravels that overlie thin diamicton and marine clays. Sample obtained at an elevation of approximately 15 m.

GSC-3450. Dickie Cove (II) 12 000 ± 100
$\delta^{13}C = +1.1‰$

Pelecypod shell fragments (sample C-143-10; 39.4 g; **Hiatella arctica**, identified by W. Blake, Jr.) from 5 m below the surface of gravels that overlie thin diamicton and marine clays. Sample obtained at an elevation of approximately 13 m.

GSC-3485. Dickie Cove (III) 12 300 ± 220
$\delta^{13}C = +1.4‰$

Barnacle fragments (sample C-447; 12.9 g; **Portlandia** sp.?, **Mya truncata, Hiatella arctica, Macoma balthica, Macoma calcarea, Mytilus edulis, Mya arenaria,** and **Serripes groenlandicus**? associated with barnacle fragments, identified by W. Blake, Jr.) from the base of a 20 cm-thick diamicton overlying silty clay containing abundant fragments of marine algae. Sample obtained at an elevation of approximately 7 m.

Comment (V.N. Rampton): Glaciofluvial or glaciomarine gravels (a) separate marine gravels from which GSC-2839 and GSC-3450 were obtained and (b) diamicton from which GSC-3485 was obtained. Sequence and dates support the hypothesis that a glacier readvance into the Goldthwait Sea in Baie des Chaleurs occurred ca. 12 400 years ago (Rampton et al., 1984). The value obtained for GSC-3450 appears to be anomalously low. No ready explanation for this discrepancy is available.

Comment (W. Blake, Jr.): Sample GSC-2839 also contained barnacle fragments, gastropods, **Mya** sp., and many unidentifiable fragments. Also, a number of **Hiatella arctica** valves, which were particularly thick or especially corroded, were not included in the sample submitted to the laboratory. This sample comprised six left and eight right valves plus 23 fragments. The shells (the largest partial valve was >2.5 x 1.7 cm; the smallest whole valve was 1.4 x 0.7 cm) were pitted, weathered, and somewhat chalky; no periostracum remained and the slight encrustation on some valves was removed by scraping. Sample GSC-3450 comprised 43 left valves and 45 right valves, plus a few fragments. The largest measured 3.5 x 1.7 cm, the smallest (of numerous juvenile individuals) was 1.6 x 0.9 cm. No periostracum was preserved, but most shells retained their internal lustre. The few shells with encrustrations were excluded from the sample. Sample GSC-3485 comprised only well preserved barnacle fragments; maximum length, 3 cm. Because of the size of all three samples, only the outer 10% of shell was removed. GSC-2839 and -3485 were mixed with dead gas for counting, and each date is based on one 3-day count in the 2 L counter. GSC-3450 is based on one 3-day count in the 5 L counter.

GSC-3594. West Branch Reservoir 4500 ± 150

Organics (sample 95R-82-1; 2.6 g; mainly monocot stem and wood fragments; identified by J.V. Matthews, Jr.) from the upper part of a clayey unit underlying 1.8 m of peat. Collected July 1982 from a ditch on the south side of the highway south of West Branch Reservoir, New Brunswick (45°12'N, 66°22.5'W), at an estimated elevation of 41 m by V.N. Rampton.

Comment (V.N. Rampton): Sample was collected to date emergence of area. However, peat accumulation obviously relates to a later event as the site was well above sea level by 12 300 BP (Rampton et al., 1984). NaOH leach was omitted from sample pretreatment. Sample was mixed with dead gas for counting. Date is based on one 3-day count in the 2 L counter.

GSC-2943. Mountain Brook 12 000 ± 180

Marine shell fragments (sample C-218; 20.8 g; **Hiatella arctica;** identified by W. Blake, Jr.) from near the mid-point of 16 m of gravel exposed in a pit about 2 km northeast of Selwood, New Brunswick (47°59.4'N, 66°23.6'W), at an elevation of approximately 32 m. Collected August 1979 by R.C. Gauthier.

Comment (V.N. Rampton): Gravels from which shells were collected show signs of glaciotectonism. This indicates that the area was probably deglaciated shortly before 12 000 years ago, whereas GSC-2727 (this list) indicates that the area was deglaciated just prior to 12 200 years ago.

Comment (W. Blake, Jr.): **Mya truncata** and unidentified gastropods also occur in the sample, but only **Hiatella arctica** (23 right valves plus 18 left valves) was used for age determination; the largest is 3.2 x 1.6 cm. No pitting or encrustations occurred on these aragonitic shells. Adhering mud was scraped off, and although some shells were soft and chalky, most still retained internal lustre. Sample was mixed with dead gas for counting. Date is based on two 1-day counts in the 2 L counter.

GSC-2727. Selwood 12 200 ± 230
$\delta^{13}C = +2.7‰$

Shell fragments (sample C-212; 9.0 g; **Hiatella arctica;** identified by W. Blake, Jr.) from 2 m of gravel in a pit about 0.5 km north of Selwood, New Brunswick (47°59.1'N, 66°24.4'W), at an elevation of approximately 45 m. The gravel is overlain by up to 1 m of interbedded silt and sand. Collected July 1978 by R.C. Gauthier.

Comment (V.N. Rampton): Gravels from which shells were collected are faulted, indicating deposition over ice. Date indicates that the area was probably deglaciated shortly before 12 200 years ago and that relative sea level was more than 45 m at this time (Rampton et al., 1984).

Comment (W. Blake, Jr.): The dated sample consisted entirely of a few whole valves and fragments clearly identifiable as **Hiatella arctica.** Other fragments could not be determined as to species. The largest valve was >3.0 cm long and the smallest (fragile), 1.1 cm. The aragonitic shells were chalky, but a few retained internal lustre. There was no pitting, no periostracum, and no encrustations (although adhering mud was slightly cemented in a few cases, it could still be scraped off). Because of the small sample size, only the outer 10% was removed by HCl leach. Sample was mixed with dead gas for counting. Date is based on two 1-day counts in the 2 L counter.

Québec

GSC-3005. Anse Pleureuse 11 800 ± 240

Marine pelecypod shell fragments (sample AP-11-1; 10.3 g; **Mya truncata;** identified and selected by W. Blake, Jr.) from a large sample including **Macoma calcarea.** The sample was obtained from a 2 m-thick silty diamicton beneath 20 m of stratified sands and gravels exposed in a borrow pit on the east side of Highway 198, 0.7 km south of Anse Pleureuse, Gaspésie, Québec (49°14'18"N, 65°38'55"W), at an elevation of 9 m. Collected July 1979 by B. Hétu and submitted by J.T. Gray, both of Département de Géographie, Université de Montréal, Montréal.

Comment (J.T. Gray): The shell fragments are interpreted as having been incorporated into the basal part of a large outwash delta deposited in contact with the Goldthwait Sea by a northward moving valley glacier originating in the interior of Gaspésie. The date of 11 800 ± 240 BP gives a maximum age for an important advance or stillstand of the ice and is only 1000 years older than the minimum age of 10 890 ± 120 BP (DIC-1810) obtained from **Mytilus edulis** in the upper layers of the overlying stratified sands and gravels (Hétu and Gray, 1981). Other shell samples from similar outwash deltas and frontal moraines in several of the neighbouring valleys are presently being dated to determine the regional significance of this event.

Comment (W. Blake, Jr.): The sample utilized consisted of fragments of 24 valves, all exhibiting the truncated end typical of this species. A few fragments retained traces of periostracum but most exterior surfaces were chalky. Some internal lustre was visible after adhering mud was removed. Because of the small sample size, only the outer 10% was removed by HCl leach. Sample was mixed with dead gas for counting. Date is based on two 1-day counts in the 2 L counter.

GSC-3071. Anse-aux-Naufrages 13 300 ± 110

Marine pelecypod shells (sample AN-1; 48.6 g; **Hiatella arctica,** identified by B. Hétu) from a 5 m-thick glaciomarine silty clay deposit overlying bedrock, and overlain in turn by a 2 m thick unit of beach gravel and sand. The exposure was

situated immediately to the south of Highway 138, at the base of the coastal escarpment 2 km east of Marsoui, Gaspésie, Québec (49°13'21"N, 66°02'30"W), at an elevation of 15 m. Collected July 1979 by B. Hétu and submitted by J.T. Gray.

Comment (J.T. Gray): The shells are indicative of a cold late glacial phase of the Goldthwait Sea. Their occurrence in a silty clay environment indicates deepwater deposition with no subsequent disturbance by glacial overriding, a distinct contrast to the situation in the mouths of the major valleys of the region. The date of 13 300 ± 110 BP furnishes a minimum age for deglaciation of the Gaspésie coast at this location (Hétu and Gray, 1981).

Comment (W. Blake, Jr.): The aragonitic shells are thick (up to 1 cm in places) and massive. All surfaces of the shells were clean, without trace of periostracum or lustre. The sample submitted comprised six right and five left valves, 2.6 to 3.5 cm in length and 1.6 to 2.2 cm in height. Date is based on one 3-day count in the 5 L counter.

GSC-3420. Pointe St-Nicolas >42 000

Wood and other plant debris (sample Pointe St-Nicolas; 37.8 g dry; not identifiable; unpublished GSC Wood Identification Report No. 82-16 by R.J. Mott) in a fluvial sequence (Anse-aux-Hirondelles Formation) exposed in a ravine at Pointe St-Nicolas, Québec, about 15 km west of Quebec City, on the south shore of St. Lawrence River (46°41'53"N, 71°27'24"W), at an elevation of approximately 10 m. The section was cleaned with a shovel, and no rootlets were observed at the time of collection. Collected September 1981 by P. LaSalle, Ministère des richesses naturelles, Québec.

Comment (P. LaSalle): The plant debris has been transported in a fluvial system from the site at which it grew, which may not be too distant. Finite dates (QU-439, 36 560 ± 4600 BP; UGa-463, 28 365 ± 770 BP; both in LaSalle, 1984) had been obtained earlier by the benzene method on samples from the same stratigraphic horizon, but from another part of the ravine exposure. Modern rootlets were visible in the neighbourhood of the collecting site for the finite dates. Despite the removal of all suspicious material, using a binocular microscope, it is assumed that the finite age determinations are the result of contamination by modern material and also possibly because of the memory effect linked to the benzene method itself (Radnell and Muller, 1980). This effect is especially critical for old samples. The new result is compatible with others obtained in the Québec city area (Y-463, >44 000 BP; Karrow, 1957; LaSalle, 1984; and GSC-1539, >39 000 BP; GSC-1473, >37 000 BP, both in GSC XVII, 1977, p. 6) and it seems to confirm the correlation of the Anse-aux-Hirondelles sediments with the St. Pierre beds of the Central St. Lawrence Lowlands (Gadd, 1971; LaSalle, 1984) which are possibly of late Sangamonian age (Fulton et al., 1984).

Comment (W. Blake, Jr.): The largest single piece of wood in the sample, approximately 5 cm long and 3 x 10 mm in cross-section, was not included in the sample submitted to the laboratory. Because of the fine nature of the debris making up this sample, the NaOH leach was omitted. There was no reaction with HCl. Date is based on one 4-day count plus one 3-day count in the 5 L counter.

Ontario

GSC-3706. Navan 11 000 ± 90
$\delta^{13}C = +1.4‰$

Barnacle shells (sample RAB-83-12; 48.1 g; **Balanus hameri**; identified by S.H. Richard) from the base of a grey, stony marine clay unit, about 3 to 4 m below ground level, lying above and in places interfingering with the upper parts of a mostly unfossiliferous unit of ice contact submarine outwash gravels and sands forming the core of the Navan ridge. Exposure of this glaciomarine pebbly clay unit is in an active sand and gravel borrow pit located 3.5 km northeast of Navan, Russell County, Ontario (45°26'40"N, 75°24'00"W), at an elevation of approximately 93 m. Collected 1983 by S.H. Richard.

Comment (S.H. Richard and C.G. Rodrigues, University of Windsor, Windsor, Ontario): GSC-3706 is the second radiocarbon age measurement obtained for shells of the euryhaline, deepwater barnacle **Balanus hameri** from the western Champlain Sea basin. The radiocarbon-dated marine clay beds originated as fine suspended sediment (rock flour) supplied to the marine environment by meltwater issuing from the ice margin. The occurrence of thin strata of well rounded to angular pebbles and stones at various levels in the clay unit is the result of fluctuating discharge of water and sediment. This lithostratigraphy, especially the interfingering of the lower part of the fossiliferous clay unit with the upper part of the underlying unfossiliferous meltwater sand and gravel unit, suggests that the sequence of sediments making up the Navan ridge is a glaciomarine unit deposited in an ice contact outwash delta near the margin of an ice lobe grounded in the Champlain Sea (Richard, 1982). GSC-3706 provides an age for the time of beginning of deposition of the stony marine clay unit forming parts of the centre and sides of the Navan ridge.

Comment (W. Blake, Jr.): The barnacle fragments, up to 5.3 x 3.6 cm in size, were brushed clean of adhering sediment. Some exterior surfaces had black and orange stains, but interior surfaces retained lustre. Date is based on one 3-day count in the 5 L counter.

GSC-3523. Merrickville 11 800 ± 100
$\delta^{13}C = -0.7‰$

Marine pelecypod shells (sample RAB-82-18; 39.6 g; **Macoma balthica**; identified by C.G. Rodrigues and S.H. Richard) from a sand and gravel pit, 4.5 km southeast of Merrickville, Grenville County, Ontario (44°52'35"N, 75°48'10"W), at an elevation of 118 to 120 m. Collected 1982 by C.G. Rodrigues, University of Windsor, Windsor, and S.H. Richard.

Comments (C.G. Rodrigues and S.H. Richard): GSC-3523 provides an approximate age for the arrival of marine water along the southwestern rim of the Champlain Sea basin in the Smiths Falls-Brockville area. The date corresponds closely to GSC-1013 (11 800 ± 210 BP, 104 m) for shells of **M. balthica** from a beach deposit near Maitland, Grenville County, Ontario, and about 29 km south of Merrickville (Henderson, 1970). Comparable dates have been reported by Lowdon and Blake (1979) for shells of **M. balthica** from sands and gravels near the marine limit in the Champlain Valley, GSC-2338 (11 900 ± 120 BP, 101 m) and GSC-2366 (11 800 ± 150 BP, 96 m). Older dates, 12 800 ± 200 (GSC-1859) to 12 100 ± 100 BP (GSC-3110), have been reported from the Clayton area (Richard, 1974, 1978), the Cantley area (Lowdon and Blake, 1973), and the White Lake area (Rodrigues and Richard, 1983) for shells of **M. balthica** from beach deposits north of GSC-3523. The radiocarbon dates indicate that beach deposits near marine limit along the western rim of the Champlain Sea basin are not synchronous and that marine water penetrated into Ottawa valley earlier than into St. Lawrence valley.

Comment (W. Blake, Jr.): This sample comprised many thin intact valves, the largest measured 1.8 x 1.5 cm. Some shells retained internal lustre, but some were chalky and pitted. No periostracum was preserved and no encrustations were present. Because of the small sample size, only the outer 10% of shell was removed by HCl leach. Date is based on one 3-day count in the 5 L counter.

GSC-3322. Atikokan >37 000
$\delta^{13}C = -15.9‰$

Fracture filling of calcium carbonate (sample ATK 24; 37.0 g) collected from a roadcut on Highway 622 near Foresberg Lake, approximately 20 km northwest of Atikokan, Ontario (48°52'N, 92°40'W), at an elevation of 445 m. This surface sample was dry and flaky, with no vegetation, and the calcium carbonate occurred in Archean granite (Eye-Dashwa lakes pluton). Collected August 1981 by D.C. Kamineni, Atomic Energy of Canada Limited, Pinawa, Manitoba (on secondment to GSC, Ottawa).

Two determinations were made:

GSC-3322.	Date is based on one 1-day count in the 2 L counter.	>37 000
GSC-3322.	Date is based on one 3-day count in the 5 L counter.	>37 000

Comment (D.C. Kamineni): The date indicates "that at least some low-temperature fillings are definitely not related to present-day groundwater activity" (Kamineni, 1983).

Comment (W. Blake, Jr.): The sample was given no pretreatment in the laboratory.

Western Canada

Manitoba

Flin Flon Series

A series of lake sediment samples from a core taken in an unnamed lake near Highway 10, 11.3 km east of Flin Flon, Manitoba (54°44'N, 101°40'W), at an elevation of 330 m. Collected July 1972 by R.J. Mott in 9 m of water, using a Livingstone piston sampler.

GSC-2638. Flin Flon, 142.5-162.5 cm 2970 ± 120
$\delta^{13}C = -31.7‰$

Organic lake mud (sample F1; 23.1 g dry) from 142.5 to 162.5 cm below the mud/water interface. NaOH leach was omitted from sample pretreatment. Date is based on two 1-day counts in the 2 L counter.

GSC-2665. Flin Flon, 322.5-342.5 cm 5860 ± 140
$\delta^{13}C = -30.8‰$

Organic lake mud (sample F2; 34.7 cm dry) from 322.5 to 342.5 cm below the mud/water interface. NaOH leach was omitted from sample pretreatment. Sample was mixed with dead gas for counting. Date is based on two 1-day counts in the 2 L counter.

GSC-2689. Flin Flon, 382.5-402.5 cm 7380 ± 130
$\delta^{13}C = -32.0‰$

Organic lake mud (sample F3; 43.9 g dry) from 382.5 to 402.5 cm below the mud/water interface. NaOH leach was omitted from sample pretreatment. Sample was mixed with dead gas for counting. Date is based on one 3-day count in the 2 L counter.

Comment (J.C. Ritchie): A detailed percentage pollen analysis (Ritchie, 1976, 1980; Ritchie and Yarranton, 1978a,b) yielded four distinct pollen zones. The lowest zone is one of the few herb pollen zones recorded in the boreal forest of central Canada. The modern boreal forest became established at the site at about 7000 radiocarbon years ago.

Saskatchewan

William River Dunefield Series

Samples were collected from two bushes and a tree, located on three separate large-scale eolian dunes in the William River dunefield, 10 km southwest of William Point, near the south shore of Lake Athabasca, Saskatchewan (59°02'N, 109°20'W). In all cases, the vegetation was found projecting through the surface of the lower windward (southwest) slope, still in vertical growth position and buried by sand, in the form of truncated accretion and foreset laminae dipping 16° to 29° into the dunes. Modern vegetative growth on the dunes is restricted to the lower leeward (northeast) slopes. The samples represent former northeast-side vegetation which was buried by northeastward migration of the dune and recently exhumed on the eroding southwest slope. Collected August 1981 by P.A. MacLean and submitted by M.A. Carson, both of McGill University, Montreal.

GSC-3351. William River (I) 230 ± 120
$\delta^{13}C = -26.9‰$

Wood (sample C14-#1; 3.6 g; **Populus** sp.; unpublished GSC Wood Identification Report No. 81-36 by R.J. Mott) from a bush projecting through the surface of dune no. 33, at an approximate elevation of 270 m. Sample was mixed with dead gas for counting. Date is based on two 1-day counts in the 2 L counter.

GSC-3361. William River (II) 200 ± 100

Wood (sample C14-#5; 3.6 g; unidentified deciduous species; unpublished GSC Wood Identification Report No. 81-36 by R.J. Mott) from a bush projecting through the surface of dune 17, located 1.0 km west of the site of GSC-3351 and at the same approximate elevation. Sample was mixed with dead gas for counting. Date is based on two 1-day counts in the 2 L counter.

GSC-3382. William River (III) 110 ± 60
$\delta^{13}C = -24.8‰$

Wood (sample C14-#3; 12.0 g; **Betula** sp.; unpublished GSC Wood Identification Report No. 81-36 by R.J. Mott) from dune 16, located 1.2 km west of the site of GSC-3351, and at the same approximate elevation. Date is based on one 1-day count in the 5 L counter.

Comment (P.A. MacLean): When converted to calendar years and used in conjunction with surveyed profiles across the dunes, the dates provide estimates of long-term dune migration rates towards the northeast. These range from 0.3 to 0.6 m/year for the last few centuries, and they are consistent with observed, short-term rates of southwest slope scour and northeast slope accretion (MacLean, 1984; see also unpublished manuscript by M.A. Carson and P.A. MacLean, Development of hybrid aeolian dunes: the William River Dunefield, Northwest Canada).

Alberta

Moore Lake Series

A series of samples was taken from a 918 cm-long core from Moore Lake, Alberta (53°31'N, 110°30'W), at an elevation of 550 m. The core (#II) was collected March 1978 by C. Schweger, University of Alberta, Edmonton, from the northeast part of the lake in a water-depth of 25.7 m. All measurements were taken above the base of the core. No visible tephra layers were present, but shards were detected microscopically at 175.5 cm. The sediments were laminated, carbonate-rich, organic clays with prominent red and white

banding at about 250 and 275 cm. Diatomite layers occurred from 398 to 461 cm. Pollen analysis was carried out by T. Habgood, and limnological and diatom analyses were done by M. Hickman, both of University of Alberta, Edmonton.

GSC-2900. Moore Lake II, 885-890 cm above base — 2140 ± 130; $\delta^{13}C = -31.8‰$

Lake sediment (sample IIML78 (885-890 cm); 10.1 g). Date is based on two 1-day counts in the 2 L counter.

GSC-2907. Moore Lake II, 815-820 cm above base — 2380 ± 140; $\delta^{13}C = -30.6‰$

Lake sediment (sample IIML78 (815-820 cm); 7.0 g). Date is based on two 1-day counts in the 2 L counter.

GSC-2910. Moore Lake II, 515-520 cm above base — 4470 ± 110; $\delta^{13}C = -30.3‰$

Lake sediment (sample IIML78 (515-520 cm); 6.8 g). Date is based on two 1-day counts in the 2 L counter.

GSC-2870. Moore Lake II, 315-320 cm above base — 5800 ± 80; $\delta^{13}C = -27.8‰$

Lake sediment (sample IIML78 (315-320 cm); 23.4 g). Date is based on one 3-day count in the 2 L counter.

GSC-2858. Moore Lake II, 150-155 cm above base — 9250 ± 80; $\delta^{13}C = -26.2‰$

Lake sediment (sample IIML78 (150-155 cm); 28.6 g). Date is based on one 3-day count in the 5 L counter.

GSC-2921. Moore Lake II, 75-80 cm above base — 10 200 ± 160; $\delta^{13}C = -28.4‰$

Lake sediment (sample IIML78 (75-80 cm); 19.3 g). Date is based on two 1-day counts in the 2 L counter.

GSC-2856. Moore Lake II, 20-26 cm above base — 11 300 ± 170; $\delta^{13}C = -26.8‰$

Lake sediment (sample IIML78 (20-26 cm); 25.0 g). Date is based on two 1-day counts in the 2 L counter.

Comment (C.E. Schweger): Spruce and birch pollen were abundant 11 300 ± 170 years ago (GSC-2856), suggesting that late glacial boreal forest had pioneered the stagnant ice moraine of this area. GSC-2858 (9250 ± 80 BP) and GSC-2870 (5800 ± 80 BP) bracket an interval for which there is strong evidence of a lower lake level. During this time spruce and birch pollen declined in abundance while **Artemisia** and grass pollen increased and the halophytic aquatic **Ruppia** became established. Further discussion of the climatic significance of this interval is presented in Schweger et al. (1981).

Comment (W. Blake, Jr.): NaOH leach was omitted from the pretreatment of each core increment. All samples were mixed with dead gas for counting, except GSC-2858 and -2870.

GSC-3775. Peace River Delta — 8780 ± 80; $\delta^{13}C = -24.1‰$

A stump (sample DGS-83-1; 11.5 g dry; **Picea** sp.; unpublished GSC Wood Identification Report No. 84-2 by R.J. Mott), was recovered 4 m below ground surface in the most distal part of the Late Pleistocene Peace River Delta deposited into glacial Lake McConnell (Craig, 1965). The site is 120 km south of Fort Smith, Northwest Territories, on the left bank of Peace River, Alberta (58°56'N, 111°38'W), at an elevation of 221 m. Specifically the date marks the time boundary between glacial Lake McConnell and modern Lake Athabasca. The wood sample was located on the left cutbank of the Peace River 4.5 km upriver from the mouth (northwest end) of the Quatre Fourches channel of the modern Peace River Delta. Located in a cutbank outcrop 5 m above the Peace River surface, the wood was deposited in laminated lacustrine-deltaic sand and silt when Lake McConnell was at about 218 m elevation. Collected September 1983 by D.G. Smith, University of Calgary, Calgary, Alberta.

Comment (D.G. Smith): The date agrees with GSC-3402 (9910 ± 90 BP; GSC XXII, 1982, p. 9), a date on wood from the nearby Late Pleistocene Athabasca Delta. A piece of the stump (GSC-3775) also has been sent to the Amino Acid Laboratory, University of Alberta, Edmonton, for further analysis.

Comment (W. Blake, Jr.): The stump was 13 cm in diameter, wider at the root end. All outside wood cut off. After the damp wood (31.0 g) was dried in an electric oven the weight decreased to 19.3 g. The sample was examined carefully to exclude the numerous rootlets which had penetrated it. Date is based on one 3-day count in the 5 L counter.

Lofty Lake Series

A 294 cm-long core was recovered from Lofty Lake (54°44'N, 112°29'W), 32 km southeast of Lac la Biche, Alberta, at an elevation of 625 m. The core was collected March 1979 by C. Schweger and M. Hickman. A tephra layer, 0.5 mm in thickness, was encountered at 135 cm depth. Fish scales, gastropods, pelecypods, and charophytes were encountered in the upper 184 cm which consisted of marly gyttja gradually merging into organic clays. A horizon of paleosol-like black silty clay peds occurred at 185 to 203 cm. All measurements are taken from the sediment-water interface.

GSC-2876. Lofty Lake, 136-143 cm — 6290 ± 100; $\delta^{13}C = -26.4‰$

Lake sediment (sample LL136-143; 91.3 g) from 1 to 8 cm below a tephra layer. NaOH leach was omitted from sample pretreatment. Date is based on two 1-day counts in the 2 L counter.

GSC-2885. Lofty Lake, 178-184 cm — 8700 ± 90; $\delta^{13}C = -28.3‰$

Lake sediment (sample LL178-184; 46.5 g) from just above a paleosol-like horizon, which in turn overlies coarse sand. NaOH leach was omitted from sample pretreatment. Date is based on two 1-day counts in the 5 L counter.

Comment (C.E. Schweger): These two samples date an interval during which lake levels were greatly lower. Comparisons with other sites in Alberta are made in Schweger et al. (1981). For additional pollen work on sediments from Lofty Lake, see Lichti-Federovich (1970).

British Columbia

Vedder Crossing Gravel Pit Series

Wood samples from two gravel pits on Promontory Road, 3 km northeast of Vedder Crossing, British Columbia (49°04'31"N, 122°06'25"W). Collected September 1982 by M.C. Roberts and N. Calver, Simon Fraser University, Burnaby, British Columbia.

GSC-3593. Vedder Crossing (I) — 30 ± 50

Wood (sample 120, Pit 2-1; **Thuja plicata;** unpublished GSC Wood Identification Report No. 82-55 by R.J. Mott) from a tree branch partially exposed in a massive silty sand

overlying a cobble gravel. This gravel pit contains many sections of the Chilliwack River alluvial fan. The wood was 1.2 m below the ground surface and at an elevation of 22 m.

GSC-3581. Vedder Crossing (II) 530 ± 50

Wood (sample 300, Pit 2-2; **Pseudotsuga menziesii;** identified by R.J. Mott, same report as above) from a log in cobble gravel; this is the unit beneath the massive silty sands in which GSC-3593 was collected. The wood was 3.0 m below the ground surface and at an elevation of 20 m.

Comment (M.C. Roberts): These two dates attest to the recent activity of debris flows in the formation of the Chilliwack River fan. There was the possibility that the fan was formed during immediate postglacial time when considerable amounts of glacial drift were available for transport by Chilliwack River. These dates, however, indicate that the alluvial fan grew during the late Holocene. The possibility remains, nevertheless, that the deeper portions of the fan are early Holocene in age.

Comment (W. Blake, Jr.): Sample 300 was 31 cm long, with a maximum cross-section size of 6 x 5 cm. The wood was yellowish and somewhat punky on the outside (all cut off). Each date is based on two 1-day counts in the 2 L counter.

GSC-3478. Moose Heights 70 ± 60

Humified plant material (sample CIA-82-122; 52.0 g) from colluvial silt exposed in the main scarp of "Big Slide", 11 km north of Quesnel, British Columbia (53°04.7'N, 122°31.0'W), at an elevation of about 640 m. The colluvium, which is up to 4 m thick at the date site, unconformably overlies Pleistocene lacustrine sediments and mantles the wall of Fraser River valley to the north. It was deposited prior to the main phase of Big Slide activity. Collected May 1982 by J.J. Clague.

Comment (J.J. Clague): The surface of the colluvium supports an undisturbed forest that is at least 50 years old; the colluvium is thought to be significantly older than this. Thus, GSC-3478 probably does not date the landslide that produced the colluvium. It is possible that the dated organic horizon is partly or totally a modern root mat. Date is based on one 1-day count in the 5 L counter.

Fraser River Delta Series

The following three samples (GSC-3701, -3798 and -3807) were collected at the base of a brackish water marsh root sequence at the upper tidal flats of the western front of the Fraser River Delta, Vancouver, British Columbia. The purpose of the determinations was to establish the time at which the tidal flats were stabilized and to determine local sedimentation rates. Collected June 1983 by R. Hebda, British Columbia Provincial Museum, Victoria, and J.L. Luternauer.

GSC-3701. Fraser River Delta Marsh (I) Modern

Wood fragments (sample FD83A-3; 11.5 g; coniferous wood too poorly preserved to be determined; unpublished GSC Wood Identification Report No. 83-38 by R.J. Mott) from wet silt 80 to 90 cm below marsh surface at the base of the marshroot sequence, protruding from a tidal creek wall at approximately 2 m above local chart datum (lowest normal water level). Geographic location of sample: 49°09.81'N, 123°11.94'W. Date is based on one 1-day count in the 5 L counter.

GSC-3798. Fraser River Delta Marsh (II) 80 ± 60
$\delta^{13}C = -28.1‰$

Root mat (sample FD83A-1B; 17.7 g; tangle of fossil **Triglochin maritima** roots) from wet silt 80 to 90 cm below clump surface, 10 to 20 cm below general surface of tidal flats, and approximately 3 m above local chart datum (lowest normal water level). Geographic location of sample: 49°09.99'N, 123°12.10'W. Date is based on two 1-day counts in the 2 L counter.

GSC-3807. Fraser River Delta Marsh (III) 310 ± 70
$\delta^{13}C = -27.0‰$

Root mat (sample FD83A-2; 8.0 g; tangle of fossil **Triglochin maritima** roots) from wet silt 80 to 90 cm below clump surface, 10 to 20 cm below general surface of tidal flats, and approximately 3 m below local chart datum (lowest normal water level). Geographic location of sample: 49°09.76'N, 123°12.10'W. Sample was mixed with dead gas for counting. Date is based on two 1-day counts in the 2 L counter.

Comment (J.L. Luternauer): The oldest radiocarbon age in this series (GSC-3807) suggests accumulation of a 60 to 70 cm-high **Triglochin maritima** stack, capped by living vegetation, proceeds at an average rate of ~2.5 mm/year. If the stack is an erosional remnant, the possibility arises that the general surface in this area has degraded 60 to 70 cm in approximately the last 300 years.

GSC-3193. Turbid Creek 3720 ± 60
$\delta^{13}C = -22.7‰$

A single piece of wood (sample CIA-80-137; 11.4 g; **Pseudotsuga menziesii;** unpublished GSC Wood Identification Report No. 81-1 by L.D. Farley-Gill) from diamicton exposed in an erosional bluff bordering Turbid Creek on the south flank of Mount Cayley, 44 km north-northwest of Squamish, British Columbia (50°05.4'N, 123°18.5'W) at an elevation of 615 m. The diamicton containing the dated sample, which is olive-grey in colour, is a debris-flow deposit and is overlain by up to 7 m of similar reddish brown diamicton, also debris flow material. The latter, in turn, is overlain by up to 10 m of rubbly debris deposited during the 1963 Dusty Creek landslide (Clague and Souther, 1982). Collected August 1980 by J.J. Clague.

Comment (J.J. Clague): GSC-3193 provides a date on a large debris flow that swept down Turbid Creek from Mount Cayley, a Quaternary volcano in the southern Coast Mountains. It is not known whether the dated unit is significantly older than the overlying reddish brown diamicton, or whether both were deposited at about the same time (see Clague and Souther (1982) for details on both these prehistoric landslides and the 1963 Dusty Creek landslide).

Comment (W. Blake, Jr.): This single piece of wood was 26 cm long and had a maximum diameter of 5.5 x 2.5 cm. The wood was rounded at both ends, and upon drying it became brittle and split. Date is based on two 1-day counts in the 5 L counter.

GSC-3854. Shannon Creek 10 600 ± 300
$\delta^{13}C = +0.6‰$

Marine pelecypod shells (sample WHM-76-3; 5.0 g; **Nuculana fosse** (Baird); identified by M.F.I. Smith, formerly of the National Museum of Natural Sciences, Ottawa) from a cutbank along Shannon Creek, 3 km south of Squamish, British Columbia (49°40.4'N, 123°09.6'W), at an elevation of 30 m. Some shells were extracted from fresh debris derived from wasting of the slope (initially unoxidized and damp glaciomarine silt with rare stones; no vegetation on the wasting slope); some shells (commonly paired valves) were

picked directly from the enclosing sediment. At the top of the 15 m-high section (above Shannon Creek) the shell-bearing silt is overlain by topset and foreset beds indicating southeastward flow from a former ice front. Collected on several occasions between 1973 and 1979 by W.H. Mathews, University of British Columbia, Vancouver.

Comment (W.H. Mathews): The dated sample was collected from a kame delta (crumbling exposure) marking a sea level at approximately 33.5 ± 0.5 m above that of the present. GSC-3854 dates the time of ice retreat from the head of Howe Sound, when isostatic rebound was as yet incomplete.

Comment (W. Blake, Jr.): The sample also contains fragments of **Macoma** sp. and **Clinocardium** sp. (identified by W. Blake, Jr.), but only **Nuculana fosse** was used for dating. This small sample contained numerous intact valves, the largest one 1.8 cm long and 1.0 to 1.1 cm high. Some shells were characterized by a hard exterior with at least partially intact periostracum; some were more chalky. All shells were <1 mm thick and no good internal lustre was preserved. Because of the small sample size, the HCl leach was omitted. Sample was mixed with dead gas for counting. Date is based on one 3-day count in the 2 L counter.

GSC-3782. UBC Physics Building — 12 200 ± 120
$\delta^{13}C = -3.7‰$

Serpulid worm tubes (sample U.B.C. Phys. Bldg.; 21.3 g) from a fresh excavation made during site preparation for the Physics Building on the University of British Columbia campus, Vancouver, British Columbia (49°17.0'N, 123°15.1'W), at an elevation of 85 m. The sample was extracted from stony marine clay and according to the collector it was "about 7 ft. (2 m) down and below glacial till" (H.C. Gunning, personal communication to W.H. Mathews). Collected 1946 by the late H.C. Gunning; submitted by W.H. Mathews, both of the University of British Columbia, Vancouver.

Comment (W.H. Mathews): The 12 200 ± 120 year age obtained for this sample suggests that the covering material was not till but a glaciomarine diamicton.

Comment (W. Blake, Jr.): The date is compatible with a large number of other dates on marine shells in the Vancouver area (see summaries by Fulton (1971) and Clague (1980, 1981)). The original sample, which had been stored in a cool, dry, dark place (the UBC Department of Geology collections) since 1946, weighed 35.8 g, including the adhering clay. It was soaked for 10 days in distilled water and broken apart to remove clay. The largest 'clump' of tubes measured 6 cm in length, 3.5 cm in diameter. After cleaning, the sample was dried in an electric oven. Because of the small sample size, only the outer 10% of shell material was removed by HCl leach. Sample was mixed with dead gas for counting. Date is based on one 3-day count in the 2 L counter.

GSC-3726. Bowen Island — 12 400 ± 160
$\delta^{13}C = -3.2‰$

Serpulid worm tubes (sample Bolton site, Bowen Is.; 17.9 g) from the surface of a dump from a backhoe pit 2.7 km northwest of Snug Cove dock, Bowen Island, British Columbia (49°23.8'N, 123°21.8'W), at an elevation of 85 m. The pit, dug about 1981, was excavated to a maximum depth of approximately 3 m, and it was nearly filled with water in January 1983. A stony diamicton was exposed in the walls of the pit both above and below the water surface. Collected January 1983 by W.H. Mathews.

Comment (W.H. Mathews): GSC-3726 relates to the retreatal stages of the Late Wisconsinan (Fraser) glaciation, early in the invasion of marine water into the Strait of Georgia, at a time of high relative sea level (>85 m above present), and with clear access to marine organisms, such as serpulid worms, bivalves, and sea lions. Numerous remains of sea lions were unearthed while digging a well adjacent to, and in the same deposit as, the pit from which the shells were derived.

Comment (W. Blake, Jr.): The original 'clump' of worm tubes measured 4 x 2.5 x 2 cm. It was soaked in distilled water for several days, then the tubes were broken open to remove any adhering clay. The sample also contained an intact **Nuculana** plus fragments of **Macoma** sp., **Clinocardium** sp., a pecten, and a gastropod (identified by W. Blake, Jr.). Because of the small sample size, only the outer 10% of shell was removed by HCl leach. Sample was mixed with dead gas for counting. Date is based on one 3-day count in the 2 L counter.

GSC-3681. Balmoral Beach — 30 700 ± 590
$\delta^{13}C = -25.7‰$

A single piece of wood (sample WVS-82-1; 11.9 g; **Picea** or **Larix**, probably **Picea** sp.; unpublished GSC Wood Identification Report No. 83-18 by R.J. Mott) from a 2 m-deep trench excavated into Balmoral Beach, 2 km east-southeast of Comox, British Columbia (49°40.1'N, 124°53.8'W), at an elevation of 0 to 1 m (mean sea level datum). The sample was collected from the upper part of a sandy silt unit which is sharply overlain by about 1 m of crossbedded sand. The sand, in turn, is capped by a thin veneer of littoral gravel directly underlying Balmoral Beach. Balmoral Beach is bordered landward by Willemar Bluff, a sea cliff up to about 70 m high, which exposes thick outwash sand overlain by till. Collected 1982 by W.V. Smitheringale, W.G. Smitheringale & Associates, Ltd., Vancouver.

Comment (J.J. Clague): The dated sandy silt probably is part of the Cowichan Head Formation (Armstrong and Clague, 1977), deposited during the Olympia nonglacial interval. The overlying crossbedded sand, exposed in both the trench and the adjacent sea cliff, is Quadra Sand (Clague, 1976, 1977; Armstrong and Clague, 1977), deposited as outwash in front of or at the margins of glaciers advancing into the Strait of Georgia from the Coast Mountains at the beginning of the Fraser Glaciation. This date agrees well with two previous dates on wood collected from Quadra Sand at Willemar Bluff: 28 800 ± 740 BP (GSC-95, 21 m) and 26 100 ± 400 BP (GSC-53, 36 m; both in GSC II, 1963, p. 49-50). Collectively, the dates indicate that deposition of Quadra Sand began in the Comox area about 29 000 to 30 000 years ago.

Comment (W. Blake, Jr.): The small dry piece of wood was >11 cm long (one end cut) and 2 cm in diameter (circular in cross-section). Date is based on one 4-day count in the 5 L counter.

Queen Charlotte Sound Series

Four samples were extracted from an 8.78 m-long piston core obtained at 192 m depth (below lowest normal water level or chart datum) on the inner-shelf end of a trough in Queen Charlotte Sound, British Columbia (51°29.24'N, 128°29.4'W). The Sound lies off the British Columbia mainland between Vancouver Island and the Queen Charlotte Islands. The purpose of the determinations was to define the age of the lithologic units and local sedimentation rates, but only two samples were large enough to date by conventional means. Collected June 1981 on **CSS Hudson** cruise 81, Phase II, Station 8, by J.L. Luternauer.

GSC-3746. Southeastern Queen Charlotte Sound (II) — 15 200 ± 490; $\delta^{13}C = -1.3‰$

Shell (sample Hud-81, Phase II, Sta. 8, Sec. 3; 5.1 g; unidentified paired pelecypod valves) from gravelly, sandy mud with scattered shell debris at 270.5 to 273.5 cm depth in the core.

GSC-3711. Southeastern Queen Charlotte Sound (I) — 13 600 ± 150; $\delta^{13}C = +0.4‰$

Marine pelecypod shells (sample Hud-81, Phase II, Sta. 8, Sec. 5; 15.6 g; two fragments of a pair of **Macoma nasuta**; identified by K. Conway, Pacific Geoscience Centre, Sidney, British Columbia) from wet cohesive mud at 713.5 to 715.5 cm depth in the same core.

Comment (J.L. Luternauer): The host sediment for the shell fragments from which GSC-3711 was determined is considered to be proglacial mud deposited during the last deglaciation of the area. The coarser and older overlying sediment, from which GSC-3746 was extracted is tentatively interpreted to be a slump deposit.

Comment (W. Blake, Jr.): The pair comprising GSC-3711 was in excellent condition, measuring >5.5 cm in width and 4.5 cm in height. Shell thickness was up to 2 mm. Part of the periostracum was intact and the valves were characterized by good internal lustre. GSC-3746 consisted of paired valves 3.8 x 2.8 cm in size, with both internal and external lustre. Because of the small size of GSC-3711, only the outer 10% of shell was removed by HCl leach, and for GSC-3746 the HCl leach was omitted altogether. Both samples were mixed with dead gas for counting. Each date is based on one 3-day count in the 2 L counter.

GSC-3526-2. Lawn Point — >47 000

A single piece of wood (sample CIA-80-108-3; 45.0 g; **Picea** sp.; unpublished GSC Wood Identification Report No. 82-35 by R.J. Mott) from an 8 m-high coastal bluff at Lawn Point, eastern Graham Island, Queen Charlotte Islands, British Columbia (53°25.7'N, 131°54.7'W), at an elevation of 4 m above mean sea level (1 m above the base of the exposure). The dated sample was collected from till which is underlain successively by ice contact or outwash gravel and by glaciomarine stony clayey silt with lenses of sand. All these units are unconformably overlain by beach gravel that was deposited when the sea was higher relative to the land than today. Collected August 1982 by B.G. Warner, Simon Fraser University, Burnaby, British Columbia, and J.J. Clague. Two determinations were made:

GSC-3526. 11.5 g of wood; standard treatment with NaOH, HCl, and distilled water rinses. Date is based on one 3-day count in the 5 L counter. — >36 000

GSC-3526-2. 45.0 g of wood; treatment as above, but date is based on one 3-day count plus two 1-day counts in the 5 L counter at 4 atmospheres. — >47 000

Comment (J.J. Clague): The age of the surface till on the lowlands of the Queen Charlotte Islands is disputed, but a late Wisconsinan age presently is favoured (see Clague et al., 1982b, for a discussion). GSC-3526 and GSC-3526-2 were obtained in an effort to resolve this issue. Unfortunately, the dates are inconclusive, because the wood probably has been reworked from older sediments and redeposited in the till. Some of the wood may have been reworked from glaciomarine sediments that underlie the till at Lawn Point. Also, the till contains clasts of lignite derived from Tertiary sediments exposed elsewhere on Graham Island, and it is possible that the highly compressed, hard piece of wood that yielded the dates reported here comes from such a source. Wood and marine shells from glaciomarine sediments underlying the till at Lawn Point have yielded dates of >37 000 and >39 000 BP, respectively (GSC-3118 and GSC-2788; Clague et al., 1982b; GSC XXII, 1982, p. 12).

Comment (W. Blake, Jr.): This large flat piece of wood was a dark colour on the surface and slightly damp; it measured 18 x 13 cm and had a maximum thickness of 3.5 cm. All outside wood was cut off. Upon drying in an electric oven its weight decreased from 25.0 to 16.1 g. A second preparation, used for GSC-3526-2, decreased in weight from 179.0 to 61.3 g upon drying.

GSC-3538. Kagan Bay — 8280 ± 110; $\delta^{13}C = +0.4‰$

A single valve of a marine pelecypod shell (sample CIA-82-172; 22.8 g; **Saxidomus giganteus**; identified by W. Blake, Jr.) from littoral sand and gravel exposed in a roadcut and small borrow pit near Kagan Bay, 5 km west-southwest of Queen Charlotte City, British Columbia (53°14.5'N, 132°09.1'W), at an elevation of 17 m above mean sea level. The littoral sediments, about 1.5 m thick at this site, contain abundant shell fragments, lenses of shell hash, and blocks of rock derived from the bedrock face next to the exposure. The littoral sediments are overlain by about 1.5 m of sand, gravel, and rubble, which probably are colluvial in origin. Collected August 1982 by J.J. Clague.

Comment (J.J. Clague): The dated sediments are the highest known postglacial marine deposits on eastern Graham Island, thus GSC-3538 defines the time the sea stood at or near its postglacial limit in this area. A large number of radiocarbon dates on shell, wood, and peat at several sites on Graham and Moresby islands define the pattern of late Pleistocene and Holocene sea level fluctuations in the region (for details on these dates, see Sutherland Brown, 1968; Alley and Thomson, 1978; Clague, 1980; Clague et al., 1982a, b; Mathewes and Clague, 1982; also GSC XI, 1971, p. 301; GSC XXII, 1982, p. 10-14; sea level fluctuations are described by Clague et al., 1982a, b).

Comment (W. Blake, Jr.): Only a single valve was used for dating; it was >6.3 cm long, >5.8 cm high, and 3 to 5 mm thick. There was no encrusting deposit on this valve, but other shells in the collection are encrusted. No lustre nor no periostracum were preserved; no pitting was present. Because of the small sample size only the outer 10% of shell material was removed by HCl leach. Date is based on three 1-day counts in the 2 L counter.

Yakoun River Valley Series

Wood and peat from Pleistocene sediments exposed in a roadcut at Cinola Mine, east-central Graham Island, Queen Charlotte Islands; the date site is 0.7 km north of Yakoun River and 18 km south of Port Clements, British Columbia (53°31.2'N, 132°11.9'W). The sedimentary sequence that yielded the dated samples comprises, from top to bottom, up to 5 m of till, about 15 m of outwash gravel, up to 2.5 m of nonglacial fluvial and organic sediments, and at least 1 m of cobble-boulder gravel and till. The samples were collected and dated to provide a chronology for both the surface drift and the buried nonglacial sediments in Yakoun River valley; the nonglacial sediments have been analyzed for plant macrofossils and microfossils (Warner et al., 1984).

GSC-3518. Yakoun River Valley (I) 3750 ± 60

A single piece of wood (sample CIA-82-167-3; 11.6 g; **Tsuga** sp.?; unpublished GSC Wood Identification Report No. 82-31 by R.J. Mott) from silty sand and sandy silt directly underlying a 55 cm-thick peat bed at 44 m elevation. The dated sediments are part of a nonglacial fluvial-organic unit overlain by outwash gravel and till. Collected August 1982 by J.J. Clague and B.G. Warner.

GSC-3530. Yakoun River Valley (II) 27 500 ± 400

Peat (sample CIA-82-167-1; 40.0 g); the uppermost 2.5 cm of a 55 cm-thick peat bed at an elevation of 45 m. The peat bed is part of a nonglacial fluvial-organic unit overlain by outwash gravel and till. Collected August 1982 by J.J. Clague and B.G. Warner.

GSC-3534-2. Yakoun River Valley (III) 45 700 ± 970

Peat (sample CIA-82-167-2; 116.0 g); the lowermost 3 cm of a 55 cm-thick peat bed at an elevation of 44.5 m. The peat bed is part of a nonglacial fluvial-organic unit overlain by outwash gravel and till. Collected August 1982 by J.J. Clague and B.G. Warner. Two determinations were made:

GSC-3534. 46.0 g (dry) of peat; standard treatment with NaOH, HCl, and distilled water rinses. Date is based on one 3-day count in the 5 L counter. >37 000

GSC-3534-2. 116.0 g of peat; treatment as above, but date is based on two 1-day counts and one 3-day count in the 5 L counter at 4 atmospheres. 45 700 ± 970

Comment (J.J. Clague): GSC-3530, GSC-3534, and GSC-3534-2 are dates on the same peat bed; the first is from the top and the other two are from the base of this bed. The dates are consistent with the stratigraphic relationships at the site and indicate that: (1) the nonglacial period predating the last glaciation on Graham Island began before 45 700 ± 970 BP and ended after 27 500 ± 400 BP and (2) the last advance of glaciers down Yakoun valley and onto the adjacent Queen Charlotte Lowland occurred after 27 500 ± 400 BP. These are the first mid-Wisconsinan dates from the Queen Charlotte Islands and the adjacent northern mainland coast of British Columbia.

The sample that yielded GSC-3518 came from sediments directly underlying the above mentioned peat; the date thus is anomalously young. Although some modern rootlets were observed on the surface of the sample, these were removed prior to processing; furthermore, it seems highly unlikely that the sample could have been contaminated to such an extent that an apparent age of ca. 3750 years would be produced from a sample more than 45 000 radiocarbon years old (GSC-3534-2). An alternative explanation is that the dated wood was bulldozed from nearby Holocene alluvial deposits into the face of the exposure during the construction of the adjacent road. This explanation, although possible, is considered unlikely.

Comment (W. Blake, Jr.): The pieces of dry wood comprising GSC-3518 totalled at least 20 cm in length; the maximum diameter was 2 cm. All adhering silt was scraped off and the wood was 'hard' on cutting. The peat used for GSC-3530 was a single compressed slab approximately 15 x 9 cm in size. Upon drying in an electric oven the weight decreased from 206 g to 170 g. The largest piece of the matted peat used for GSC-3534 and -3534-2 measured 12 x 5 x 0.6 cm. Upon drying its weight decreased from 253 to 189 g. GSC-3518 is based on two 1-day counts in the 5 L counter; GSC-3530 is based on one 3-day count in the 5 L counter.

Northern Canada, mainland

Yukon Territory

GSC-2641. Dominion Creek 12 200 ± 100

Organics (sample NMC-21094; 40.5 g dry; plant stems, seeds, and feces) isolated from the contents of a ground squirrel nest collected at the Ballarat Mines placer operation (63°48'N, 138°41'W) located 13 km from Hunker Creek summit towards the Dominion Creek Road in the Dawson City area, central Yukon Territory, at an elevation of 640 m. Collected by the late H. Schmidt in 1967 and subsequently given to C.R. Harington (Paleobiology Division, National Museum of Natural Sciences, Ottawa); submitted by J.V. Matthews, Jr.

Comment (J.V. Matthews, Jr.): The nest contained a seed cache, insect fossils, and the nearly complete skeleton of a ground-squirrel (**Spermophilus parryi**) that evidently died in its hibernaculum. The exposure from which the nest comes consists of frozen, organic silts (locally called 'mucks') capping auriferous gravels. The exact position of the nest with respect to the surface is unknown but it was found in situ near the silt/gravel contact. The age is in accord with another date (I-3659, 14 870 ± 260 BP) on bones of **Equus** also found near the contact of silts and gold bearing gravels but at another exposure in the same area (Harington, 1977).

Fossilized ground squirrel nests have been found at other sites in the Dawson area as well as in Alaska where several have been dated (Péwé, 1975, Table 13). This is the first date on a ground squirrel nest from the Yukon Territory. Such nests commonly provide a wealth of paleoecological data, and preliminary study of the nest dated by GSC-2641 indicates that it is no exception. In addition to the skeletal remains, the seeds from the seed cache and insects are numerous and exceptionally well preserved. The latter include larvae and adults of carrion beetles which probably occupied the nest after the ground squirrel had died. Among them is the carrion beetle **Silpha coloradensis** Wick., a rare beetle in Alaska-Yukon today.

Comment (W. Blake, Jr.): X-ray diffraction showed that the crystals in the seed cache are gypsum. The portion of the sample dated is the material that floated on water. Date is based on one 5-day count in the 2 L counter.

Twelvemile Bluff Series (II)

Wood and peat samples were collected from the Twelvemile Bluff exposure (informal designation) (67°28'N, 139°54'W), a 55 m-high and 4 km-long river-cut bluff that is known by or includes the following site designations: HH68-228, HH68-3, HH70-1, HH70-2, Porcupine #1 (Lichti-Federovich, 1974); GSC localities C-26 to C-42 (Delorme, 1968); and MiVl-1. The elevation at the top of the bluff is 297 m, and it is located in the Bluefish Basin on the south bank of the Porcupine River, 9.7 km (direct distance) southwest of the village of Old Crow, northern Yukon Territory. All four samples come from Unit 4, a 16 to 18 m-thick sequence of silts and sands that underlies late Wisconsinan glaciolacustrine clays and silts (Unit 5).

GSC-2783. Twelvemile Bluff, Unit 4 >37 000

Numerous small wood fragments (sample MRA-7-17-78-9; 11.5 g) removed from a discontinuous peat located 1.85 m below the base of Unit 5 in Unit 4 at a station immediately downstream from the largest gully that interrupts the section (approximately 0.85 km below the upstream end of the exposure). Collected July 1978 by J.V. Matthews, Jr.

GSC-1189. Twelvemile Bluff, Unit 4 >39 000

Wood and organic detritus (sample HH68-3-5a; 15 g burned) removed from an organic zone located 5.2 m below the base of Unit 5 in Unit 4 at a station (HH68-3) located approximately 0.4 km upriver from the downstream end of the exposure. Collected June 1968 by O.L. Hughes.

GSC-2676. Twelvemile Bluff, Unit 4 >53 000

Wood (sample 2476c; 46.9 g; **Salix** sp.; unpublished GSC Wood Identification Report No. 78-19 by L.D. Farley-Gill) from an autochthonous peat draped into an ice-wedge pseudomorph located 8.3 m below the top of Unit 4 at approximately the same station as the sample collected for GSC-2783. Collected July 1976 by J.A. Westgate, Scarborough College, University of Toronto, Toronto.

GSC-3858. Twelvemile Bluff, Unit 4 >47 000

Unidentified wood fragments (part of sample MRA-7-4-81-4; 66 g) from a fibrous, autochthonous peat located approximately 1.5 m below the base of the glaciolacustrine clay of Unit 5 within Unit 4 at station 81-1; this station is situated approximately 1.9 km downstream from the large gully near which samples for GSC-2783 and GSC-2676 were collected. Collected July 1981 by J.V. Matthews, Jr. and N.W. Rutter.

Comment (J.V. Matthews, Jr.): The glaciolacustrine clay and silt of Unit 5 are equivalent to a similar unit in the upper part of other exposures in the Bluefish and Old Crow basins (Hughes, 1972; CRH-15 series, this list). The near vertical-standing silts and sands of Unit 4 contain several laterally continuous peats and two well defined horizons of ice-wedge pseudomorphs. The lower of these is thought to represent the Koy-Yukon thermal event (Schweger and Matthews, 1984), a period of time when summer climate in the region approached or exceeded present day levels. Both pseudomorph horizons are stratigraphically above Old Crow tephra, which occurs intermittently within the middle part of Unit 4. Old Crow tephra is an important early Wisconsinan marker horizon for east Beringia (Westgate, 1982; Schweger and Matthews, 1984).

The ice-wedge pseudomorph that contained the peat dated by GSC-2676 also contained Old Crow tephra. A pollen sample from the peat (studied by C.E. Schweger, University of Alberta) is dominated by Cyperaceae (sedge) pollen (77%), but also contains 6% **Betula** and 8% Gramineae (grass). The peat yielded an abundance of insect fossils (identified by J.V. Matthews, Jr.). Most represent species that now live in areas of richly vegetated shrub-tundra. Fossils of obligate forest insects were not seen, but the assemblage does contain fragments of ants and other insects not commonly found far beyond the limit of trees. Plant macrofossils (identified by J.V. Matthews, Jr.) are also abundant. Seeds and bractlets of shrub-birch dominate the assemblage, but also present are seeds of **Carex aquatilis**, Wahlenb., **Potamogeton, Menyanthes trifoliata** L. and other taxa typical of poorly drained sites.

A pollen spectrum associated with GSC-1189 (S. Lichti-Federovich, unpublished data) includes (sum=424) 21% **Picea**, 14% **Betula**, 2% **Alnus**, 16% **Salix**, 17% Cyperaceae (sedge), and 9% Gramineae (grass). It comes from a level 1.5 m below a sample that displays the same peak of **Picea** percentages (approximately 60 to 70%) seen in another series of Unit 4 spectra from the downstream end of the exposure (i.e., the sequence published in Lichti-Federovich, 1974).

The peat dated by GSC-2783 is probably stratigraphically above the peak of spruce pollen percentages recorded by Lichti-Federovich (1974). It is at approximately the same level as the upper zone of ice-wedge pseudomorphs; however, it is not clear whether it formed prior to, during, or after the thaw of the wedges. Neither is it clear how GSC-2783 relates to two other dates (GSC-952, 32 400 ± 770 BP and GSC-958, >37 000 BP) that come from a similar level at another part of the exposure (GSC XIX, 1979, p. 30), though it is likely that both are stratigraphically higher in the sequence. A pollen sample from the GSC-2783 peat (studied by C.E. Schweger) contains 32% **Picea**, 7.7% **Betula**, 27.6% Cyperaceae (sedge), 6.2% Gramineae (grass), and 5.2% Ericales. Plant macrofossils (identified by J.V. Matthews, Jr.) reveal an abundance of **Carex** "seeds" (70%), mostly **Carex aquatilis** Wahlenb. plus other wetland taxa such as **Menyanthes trifoliata** L., **Potentilla palustris** (L.) Scop., and **Ranunculus** (cf. **trichophyllus** type). Spruce needles and other fossils of arboreal plants were not observed. Bryophyte fossils (unpublished Fossil Bryophyte Report No. JJ362, by J.A. Janssens, then University of Alberta, Edmonton) include several species of **Drepanocladus** and **Calliergon giganteum** (Schimp.) Kindb. Insect fossils (identified by J.V. Matthews, Jr.) are relatively rare, but include among the dominating aquatic and semi-aquatic component a few fossils of beetles, such as the carabid **Diacheila polita** Fald. which can be collected at mesic tundra sites.

The peat sampled for GSC-3858 occurs intermittently along much of the length of the exposure, but is especially well developed at Station 81-1, where it is the highest organic horizon within Unit 4. The peat is probably stratigraphically above the peat at the upper end of the exposure, dated by GSC-2783, and postdates both the Old Crow tephra and the Koy-Yukon thermal event (see above and Schweger and Matthews, 1984).

GSC-952 (GSC XIX, 1979, p. 30), **Pisidium idahoense** shells from approximately the same stratigraphic position as GSC-3858, has yielded a finite date of 32 400 ± 770 BP. Hence it was expected that the wood from the peat of this sample would also be of finite age. That it is not may mean that an unconformity occurs within the upper metre of Unit 4, a likely contingency since erosion must have occurred as the shoreline of the meltwater lake responsible for Unit 5 transgressed the site.

A preliminary pollen analysis of the GSC-3858 peat (by J.V. Matthews, Jr.) shows a dominance of well preserved Cyperaceae pollen, a finding that is in accord with the abundance of well preserved **Carex** 'seeds' among the plant macrofossils (identified by J.V. Matthews, Jr.). The pollen spectrum (sum=175) also contains 8% **Picea**, 10% **Betula**, less than 1% **Alnus**, 7% grass, and 2% **Artemisia**. Of the insect fossils (identified by J.V. Matthews, Jr.), nearly all represent beetles such as **Stenus, Lathrobium, Helophorus**, and **Blethisa catenaria** Brown that live in poorly drained boreal and forest-tundra sites. Fossils of xerophilous forms such as the carabid **Amara alpina** Payk., the weevil **Lepidophorus lineaticollis** Kirby, and the pill beetle **Morychus** are conspicuously absent, further support for the conclusion that the dated peat is autochthonous.

Other Twelvemile Bluff dates not mentioned above are GSC-199 (>41 000 BP) and GSC-121 (10 740 ± 180 BP; McAllister and Harington, 1969; Lichti-Federovich, 1974).

Comment (W. Blake, Jr.): For GSC-1189 the entire original sample (95 g dry) received the standard treatment with NaOH and HCl, but only a 15 g sample was burned; the date is based on one 1-day count in the 5 L counter. After the original gas was discarded, two additional fractions were burned (30 g and 25 g), but insufficient CO_2 was obtained to carry out a second count at high pressure. GSC-2676 was obtained on wood from a single contorted root. All outside wood and adhering peat was removed. The irregular piece used for dating measured approximately 24 x 10 cm. On drying in an electric oven, the weight decreased from 415 to 136 g. Date is based on one 5-day count in the 5 L counter at 4 atmospheres. For GSC-2783 some of the flattened twigs obtained by sieving on a 10 mesh screen retained their bark and most were characterized by sharp ends; 225 pieces were used, the largest of which measured 4.5 x 1.5 x 0.5 cm. Date is based on one 3-day count in the 5 L counter. GSC-3858 comprised wood fragments isolated by sieving on a 10 mesh screen (>2 mm retained). Some of the wood still had bark, but most of the larger fragments may have been transported (although few pieces displayed rounded ends). Date is based on two 1-day counts plus one 3-day count in the 5 L counter at 4 atmospheres.

'Burnt Hill Bluff' (=HH62-117R) Series

Wood from the HH62-117R or 'Burnt Hill Bluff' (informal name) exposure located on Old Crow River approximately 10 km above its confluence with Porcupine River, northern Yukon Territory (67°36.7'N, 139°44.8'W), at an elevation of 274 m. Collected August 1981 by J.V. Matthews, Jr.

GSC-3392. 'Burnt Hill Bluff' (=HH62-117R) >38 000

A single piece of wood (sample MRA-8-5-83-4; 12.0 g dry; identified as **Picea** sp. by R.J. Mott; unpublished GSC Wood Identification Report No. 82-17). Sample position was 26.6 m below the surface at the top of a 3 m silt lens within gravels, and 12.6 m below the Burnt Hill tephra. The tephra was 30 cm above a prominent paleosol.

GSC-3392-2. 'Burnt Hill Bluff' (=HH62-117R) >51 000

From the same piece of wood used for GSC-3392; 48.5 g dry.

Comment (J.V. Matthews, Jr.): Despite its relatively great depth in the section, the wood was submitted for dating because: (1) an aspartic acid D/L ratio of 0.143 on the wood indicated it might yield a finite age (N.W. Rutter, personal communication, 1981; sample UA-922), and (2) at the time of submission, the Burnt Hill tephra was thought to be equivalent to a mid-Wisconsinan age tephra from interior Alaska. Recent work shows that the Alaskan tephra and Burnt Hill tephra are not equivalent, and pollen analyses of sediments immediately above and below the Burnt Hill tephra suggest that it is early Pleistocene or perhaps even late Tertiary in age (C.E. Schweger, University of Alberta, personal communication, 1983). This conclusion is supported by a study of the paleosol underlying the tephra (C. Tarnocai, Land Resource Research Institute, Agriculture Canada, personal communication, 1983). Since the dated wood comes from 12 m below the tephra and soil, its infinite ^{14}C age is in accord with the new evidence.

Comment (W. Blake, Jr.): The wood used for these determinations was 36 cm long, 8 x 5 cm in cross-section. It was dried in an electric oven. The sample showed no reaction with HCl. GSC-3392 is based on one 3-day count in the 5 L counter; GSC-3392-2 is based on three 1-day counts plus one 2-day count in the 5 L counter at 4 atmospheres.

CRH-11 Series

Wood and peat from sediments associated with the Late Wisconsinan "upper glaciolacustrine unit" (Hughes, 1972) that occurs at the top of the CRH-11 section and at many other sections in the Old Crow and Bluefish basins (see comments for CRH-15, this list). The CRH-11 exposure (67°49.33'N, 139°50.6'W; =HH69-17; Old Crow 6: Lichti-Federovich, 1973; and MkVI-9), at an elevation of 297 m (top), is located on Old Crow River approximately 7.5 km (river distance) downstream from its confluence with Johnson Creek and approximately 34 km north-northeast of the village of Old Crow in northern Yukon Territory.

GSC-2746. CRH-11 (I) >39 000

Wood (sample MRA-7-23-78-16; 11.7 g dry; identified as **Picea**; unpublished GSC Wood Identification Report No. 78-31 by L.D. Farley-Gill) from woody lenses in gravels overlying the upper glaciolacustrine unit and approximately 2-3 m below the top of the section. Collected July 1978 by J.V. Matthews, Jr.

GSC-2559. CRH-11 (II) >40 000

Autochthonous peat (sample MRA-7-23-77-3; 32.2 g; composed of the moss **Drepanocladus vernicosus**; unpublished Bryological Report No. JJ32 by J.A. Janssens, then University of Alberta, Edmonton) from immediately below the lower contact of the upper glaciolacustrine unit. Collected July 1977 by J.V. Matthews, Jr.

GSC-2559-2. CRH-11 (III) >51 000

Autochthonous **Drepanocladus** peat (60.0 g) from the same sample used for GSC-2559, but counted in the 5 L counter at 4 atmospheres.

GSC-2754. CRH-11 (IV) >35 000

Wood (sample MRA-7-23-78-10; 7.3 g dry; identified as **Salix**; unpublished GSC Wood Identification Report No. 78-29 by L.D. Farley-Gill) from a 45 cm-thick subunit of finely bedded sands with clay bands within the lower metre of the upper glaciolacustrine unit. Collected July 1978 by J.V. Matthews, Jr.

GSC-1297 CRH-11 (V) >42 000

Wood fragments (sample HH69-14-4h; 55 g; all probably from **Salix**; unpublished GSC Palynological Report No. 70-7 by R.J. Mott) from fine sand and silt located approximately 1.3 m below the base of the upper glaciolacustrine unit. Collected June 1969 by O.L. Hughes.

GSC-2824. CRH-11 (VI) >38 000

Wood fragments (sample MRA-7-14-78-4; 11.6 g; identified as **Salix**; unpublished GSC Wood Identification Report No. 79-12 by R.J. Mott), extracted from an autochthonous peat exposed immediately below the upper glaciolacustrine unit at a station approximately 500 m downstream from where the other samples in the date series were collected. Collected July 1978 by J.V. Matthews, Jr.

Comment (J.V. Matthews, Jr.): The upper glaciolacustrine unit at CRH-11 is thinner (less than 4 m vs. 7+ m normally) than at other exposures, presumably because much of it has been removed by a stream that crossed the site during the short time interval after the large meltwater lake responsible for glaciolacustrine clays had drained and before

the rivers in the basin had entrenched to their present level (see comment on Old Crow Terrace Series, GSC XIX, 1979, p. 31). Well preserved **Bison crassicornis** bones from the gravels are dated at 11 910 ± 180 BP (I-7765) and 12 460 ± 220 BP (I-3574; Harington, 1977). Furthermore, dates from other localities show that the maximum age for the glaciolacustrine unit is 25 000 to 30 000 years (GSC XIX, 1979, p. 30-32; Morlan, in press). Thus the date of >39 000 BP on the wood of GSC-2746 shows that it is rebedded.

In addition to being thinner than at other exposures, the upper glaciolacustrine unit at CRH-11 also contains subunits not seen elsewhere. For example, the wood dated by GSC-2754 comes from a zone of fine, ripple-bedded sands with organics and clay bands within the lower part of the upper glaciolacustrine unit. However, since inundation of Old Crow Basin by meltwater began no more than approximately 30 000 years ago, the wood dated at >35 000 BP by GSC-2754 must also be rebedded.

The autochthonous **Drepanocladus** peat dated by GSC-2559 and GSC-2559-2 is stratigraphically below GSC-2824 and is truncated by the upper glaciolacustrine unit. The same peat can be traced intermittently along much of the main part of the exposure and, although a significant gap exists in the exposure between the main part and the station of GSC-2824, the GSC-2824 peat is probably the lateral equivalent of the one dated by GSC-2559-2. The wood fragments dated by GSC-1297 (>42 000 BP) are stratigraphically below the dated **Drepanocladus** peat (GSC-2559-2), thus they are actually >51 000 years in age. Moreover, since the highest pollen sample in Lichti-Federovich's (1973) pollen sequence (Old Crow 6) is located below GSC-1297, all of the samples in that study also predate 51 000 years.

Organic sediments associated with GSC-2746 (sample MRA-7-23-78-17) contain insect and plant macrofossils (identified by J.V. Matthews, Jr.). The latter are dominated by 'seeds' of sedge, grass, undetermined Cruciferae, Caryophyllaceae, and Chenopodiaceae (cf. Matthews, 1982, Fig. 1, sample 10). A few needles of **Picea** and **Larix** are present but they, like the dated wood, are probably rebedded from older sediments.

The detrital organics from a silt/sand horizon that is the lateral equivalent of the one yielding GSC-2754 are also rich in insect and plant macrofossils (identified by J.V. Matthews, Jr.). The insects are dominated by the weevil **Lepidophorus lineaticollis** Kby. but also include leafhoppers, several species of **Pterostichus (Cryobius)**, **Amara alpina** Payk., **Trichocellus mannerheimi** Sahlb., **Micralymma**, **Morychus**, and **Chrysolina**. Fossils of aquatic insects are present, but rare. None of the insect fossils refer to species restricted to forested sites. This cannot be said of the plant macrofossils since the assemblage includes a few spruce needles. Nevertheless spruce and the associated boreal biotope components are rare (cf. Matthews, 1982, Fig. 1, sample 13). 'Seeds' of **Carex** and **Potamogeton** are abundant, and the dominant group of plant fossils is the one that represents dry floodplain or upland sites (Matthews, 1982). Macrofossils of plants (identified by J.V. Matthews, Jr.) from the GSC-2824 peat call for a nearly treeless environment in which shrub birches were locally abundant, a conclusion that agrees with macrofossil and pollen evidence associated with GSC-2559-2.

Comment (W. Blake, Jr.): The single piece of wood used for GSC-2746 was 14.5 cm long and 2.3 to 2.7 cm in diameter. All outside wood and adhering silt was cut and scraped away. The peat used for GSC-2559 was oven dried as a large chunk and underwent no other pretreatment. For GSC-2559-2 the peat was sieved on a 40 mesh screen to remove silt, then air dried. The single piece of wood used for GSC-2754 was 10.5 cm long and <2.5 cm in diameter. Adhering silt (along cracks) was scraped off. GSC-1297 consisted of 15 small pieces of wood, up to 2.5 cm diameter; they were not worn, and several were rather twisted (branches?). For GSC-2824 20 pieces of wood were used; the largest was 8 cm long, the maximum diameter was 1.5 cm, the smallest piece was <0.5 cm in diameter. All were dry, some had dark exteriors, none were worn. All samples received the standard treatment with NaOH and HCl. GSC-2754 is based on one 3-day count in the 2 L counter; GSC-2559 and -2824 are each based on one 3-day count in the 5 L counter; GSC-2746 is based on one 4-day count in the 5 L counter; GSC-1297 is based on one 5-day count in the 5 L counter; and GSC-2559-2 is based on one 5-day count in the 5 L counter at 4 atmospheres.

CRH-15 Series

Autochthonous and allochthonous organics from the upper part of the CRH-15 exposure (=HH68-9, Lichti-Federovich's "Old Crow #5", and MlVl-2). The site, a 35 m high river bluff with an elevation of 289 m (top) and approximately 1 km in length, is located in the Old Crow Basin on the right limit of the Old Crow River (67°51.2'N, 139°49.6'W) approximately 74 km (river distance) above the mouth and 1 km above the mouth of Johnson Creek.

GSC-1252. CRH-15 (I) 7610 ± 160
$\delta^{13}C = -25.7‰$

Organic detritus (sample HH68-9-4a; 17.0 g dry) from silt exposed near the base of Unit 4, approximately 0.7 m above glaciolacustrine clay of Unit 3 and 2.3 m below the surface. Collected June 1968 by O.L. Hughes.

GSC-2756. CRH-15 (II) 38 800 ± 2000

Small wood fragments (sample MRA-7-27-78-1; 9.7 g) extracted from an allochthonous peat that partially fills an ice-wedge pseudomorph located approximately 2 m below the base of Unit 3 at Station 9. Wood in the peat includes both coniferous and deciduous types, but all fragments submitted for dating are deciduous and probably from **Salix** (unpublished GSC Wood Identification Report No. 78-45 by R.J. Mott). Collected July 1978 by J.V. Matthews, Jr.

GSC-2574. CRH-15 (III) 41 100 ± 1650

Small wood fragments (sample MRA-7-22-7-1; 11.5 g dry) some with bark, extracted from autochthonous peat located approximately 1 m below the base of Unit 3 in the upper part of Unit 2 at Station 4. All the wood fragments in the dated fraction are from deciduous shrubs, most likely **Salix** (unpublished GSC Wood Identification Report No. 77-51 by L.D. Farley-Gill). Collected July 1977 by J.V. Matthews, Jr.

Comment (J.V. Matthews, Jr.): Like many of the exposures in the Old Crow Basin, CRH-15 can be divided into four major units: Unit 1, clay and clayey silt, exposed at the base of the section; Unit 2, a thick sequence of alluvial and lacustrine sediments, commonly with multiple organic horizons; Unit 3, glaciolacustrine clay and silt; and Unit 4, sand and silt with organic horizons or felted peats. The upper 8 m of Unit 2 contains the Old Crow tephra, an early Wisconsinan tephra found at numerous localities in east Beringia (Westgate, 1982), and above it a prominent disconformity ('disconformity A' of Morlan, 1980) which can be traced over the length of the exposure and which is probably associated with a period of regional warming and erosion (Schweger and Matthews, 1984). Unit 3 clays were deposited between 25 000 and 12 000 years ago (Morlan, in press; CRH-11 series, this list) when Old Crow Basin and

adjacent basins were inundated by glacial meltwater diverted by late Wisconsinan Laurentide ice advancing on the Richardson Mountains (Hughes, 1972). Both GSC-2756 and GSC-2574 are stratigraphically above the tephra and disconformity and within 2 m of the base of Unit 3. Unit 4, from which GSC-1252 comes, consists of sediments deposited after the drainage of the meltwater lake responsible for Unit 3. Thus, according to the latest dates (Morlan, in press) Unit 2 predates 25 000 years and Unit 4 postdates 12 000 years.

All three of the dates have associated paleoecological data. The pollen spectrum of GSC-1252 (Lichti-Federovich, 1973) is dominated by **Betula** (40+%) and Gramineae (grass) (20+%) with slightly less than 10% each for **Picea** and Cyperaceae (sedge). **Alnus** is present but accounts for less than 1%. Except for the high value for grass, these pollen frequencies are comparable with those of similar age at the nearby Polybog site (Ovenden, 1982). Plant macrofossils from the dated level (identified by J.V. Matthews, Jr.) include a few spruce needles and dwarf birch 'seeds', and the insect fossil assemblage is dominated by ants (Formicidae). The allochthonous peat of GSC-2756 contains an abundance of coal fragments and indeterminate pollen (analyzed by C.E. Schweger). Otherwise it is dominated (sum=200) by **Betula** (65%), with Cyperaceae (sedge) accounting for 17%, Gramineae (grass) 7.5%, and **Picea** 4.5%. The fossil insect assemblage (identifications by J.V. Matthews, Jr.), unlike most from the area, is dominated by Diptera (flies) and Cicadellidae (leaf hoppers) rather than Coleoptera (beetles). Although the plant macrofossil assemblage includes a number of common aquatic taxa (e.g., **Potamogeton, Sparganium, Myriophyllum, Carex,** and **Calla palustris** L., it also contains a few species, such as **Eleocharis acicularis** (L.) R.&S. that are rarely seen in northern fossil assemblages. Fossil bryophytes from the peat (unpublished Bryological Reports JJ114-118 and JJ120 by J.A. Janssens) are clearly allochthonous and in terms of taxonomic content are typical of Janssens' Zone 11 type assemblages, being dominated by **Drepanocladus** species (especially **D. lycopodioides** var. **brevifolius**) and other mat-forming fen species (Janssens, 1981).

The peat dated by GSC-2756 is autochthonous. Its pollen flora (analyzed by C.E. Schweger) is co-dominated by grass and sedge (30% each), with 7% **Betula**, 3% **Alnus**, 7.4% **Salix**, and 5.4% Ericales. Of the insect fossils (identified by J.V. Matthews, Jr.) most, such as **Pterostichus (Cryobius) tareumiut** Ball, **Pterostichus ventricosus** Eschz., **P. sublaevis** Sahlb., **P. haematopus** Dej., and **Micralymma**, live today in mesic to xeric tundra. A similar environment is indicated by the plant macrofossils (identified by J.V. Matthews, Jr.), especially by the total absence of fossils of spruce, alder, and birch. Apparently the Old Crow Basin was colder than at present 41 100 ± 1650 years ago.

Comment (W. Blake, Jr.): GSC-2756 was stored damp in a plastic bag, but there was no evidence or smell of mould when the bag was opened. The portion of the sample used was treated by removing all wood fragments which were retained on the 5 mesh screen; then the sample was oven dried. The submitter noted that some of the wood pieces were water worn, but some had the bark still attached and had sharp breaks at the ends. For GSC-2574 the wood was again-concentrated by wet sieving with a 5 mesh screen. Much of the wood was angular with bark intact, suggesting that the pieces represent shrubs. There was no evidence or smell of mould in this sample, either, which was also oven dried after sieving. For GSC-1252 the NaOH leach was omitted, and the sample was mixed with dead gas for counting; date is based on two 1-day counts in the 2 L counter; GSC-2574 and -2756 are each based on one 3-day count in the 5 L counter.

GSC-2792. CRH-70 Exposure >37 000

Organics (excluding wood) in the 0.5 to 4.0 mm sieve fraction, of a peat (sample MRA-7-26-77-10; 32.2 g dry) from the CRH-70 exposure (=MIVI-3) located in the Old Crow Basin at an elevation of approximately 297 m (top) on the left bank of Johnson Creek (67°50.2'N, 139°46.5'W) 3.3 km upstream from its confluence with the Old Crow River. Collected July 1977 by J.V. Matthews, Jr.

Comment (J.V. Matthews, Jr.): The stratigraphy of the CRH-70 exposure is similar to that of others in the basin (see CRH-15 series, this report). The peat is located approximately 2 m beneath the base of Unit 3, which consists of clays and silts deposited between approximately 25 000 and 12 000 years ago when a glacial meltwater lake occupied Old Crow Basin (Hughes, 1972; Morlan, in press; CRH-11 series, this report). The dated peat is approximately 3.2 m above 'disconformity A' (Morlan, 1980) and the Old Crow tephra, the later being an important early Wisconsinan marker horizon for East Beringia (Westgate, 1982; Schweger and Matthews, 1984).

The peat is allochthonous, hence the date may overestimate the time of deposition. Pollen analysis (by C.E. Schweger) shows (sum=200) 26% **Picea**, 3% **Alnus**, 44% **Betula**, 6.5% Cyperaceae (sedge), 5% Gramineae (grass), and 10% Eicales. The plant macrofossil assemblage (identified by J.V. Matthews, Jr.) contains a number of aquatic and shoreline taxa, such as **Potamogeton, Sparganium, Carex aquatilis** Wahlenb., **Myriophyllum**, and **Hippuris vulgaris** L. 'Seeds' of shrub birch are also present, but despite the relatively high percentage of spruce pollen, spruce macrofossils were not observed. The insect fauna of the peat is impoverished and provides little paleoenvironmental information. Bryophytes from the dated peat are poorly preserved as might be expected of an allochthonous deposit. The two samples studied (unpublished Bryological Report No. JJ269, JJ270, by J.A. Janssens, then University of Alberta, Edmonton) contain, among others, several species of **Calliergon** and **Drepanocladus** in addition to **Tomenthypnum nitens** and **Dicranum groenlandicum**, i.e., taxa characteristic of rich to intermediate fens and mires. The dated peat also contained a few postcranial bones of **Bison** (Morlan, 1980). Date is based on one 3-day count in the 5 L counter.

GSC-2773. REM 78-3 section, Old Crow Basin 10 400 ± 180

Woody fragments selected from a sample of a peat horizon (sample MRA-7-29-78-4a; 4.0 g) exposed at the REM-3 section, located in the Old Crow Basin on Johnson Creek (67°55.7'N, 139°15.9'W) approximately 44 km northeast of the village of Old Crow. The peat containing the wood fragments is 3.35 m below the surface at an elevation of approximately 286 m. It is draped into an ice-wedge pseudomorph which intrudes clays deposited in a glacial meltwater lake that indundated the Old Crow Basin (see Hughes, 1972) between approximately 25 000 and 12 000 years ago. Collected July 1978 by C.E. Schweger, University of Alberta, Edmonton, and R.E. Morlan, National Museum of Man, Ottawa.

Comment (J.V. Matthews, Jr.): The peat is overlain by thaw lake sediments; however, it appears to be autochthonous and not part of the thaw lake sequence. Nevertheless, it does contain some small allochthonous coal (or dark amber) fragments, but these account for less than 1% of total organics and were not part of the fraction submitted for dating. The plant macrofossil assemblage from the peat (fossils identified by J.V. Matthews, Jr.) is dominated by shrub birch 'seeds' but also includes **Hedysarum, Arctostaphylos,** and **Carex** sp. Macrofossils of spruce were not noted; however, the volume of sediment analyzed

was small. A pollen sample from the peat (studied by C.E. Schweger) contained too few grains for interpretation. Insect fossils (identified by J.V. Matthews, Jr.) include, among others, carabid beetles that typically occur in tundra biotopes such as **Bembidion dauricum** Motsch., **Pterostichus (Cryobius) tareumiut** Ball, and **Pterostichus haematopus** Dej. Also present are fossils of beetles (e.g., **Donacia, Stenus,** and **Agabus**) that favour poorly drained and aquatic sites as well as the weevils **Apion, Lepyrus,** and **Dorytomus.** None of the insect taxa are restricted to forest sites and in general the combined plant/insect assemblage suggests shrub tundra or possibly forest-tundra with only rare groves of trees.

Comment (W. Blake, Jr.): After sieving on an 80 mesh screen to remove silt, the 'wood fraction' was recovered on a 5 mesh screen and was oven dried; prior to a second, detailed examination. Because of the small sample size the NaOH leach was omitted. Sample was mixed with dead gas for counting. Date is based on two 1-day counts in the 2 L counter.

GSC-3119. Upper Porcupine Section (=HH75-9) 8840 ± 110

Peat sample (MRA-7-11-80-3; 35.0 g dry) from a river-cut bluff section on the left bank of Porcupine River, Yukon Territory (66°56.7'N, 137°42.5'W), at an elevation of 304 m. The locality is within Bell Basin, a thermokarst glaciolacustrine plain similar to those of Bluefish and Old Crow basins. Several other dates have been obtained at this section (GSC XX, 1980, p. 13). This sample (MRA-7-11-80-3) was collected by J.V. Matthews, Jr. in July 1980 at a spot on the upstream part of the section. At that station the thin unit of peaty sediments that caps the exposure and overlies alluvial sands, silts, and glaciolacustrine clays forms a prominent lens of peat 2-3 m in thickness. The dated sample comes from the lowest 10 cm of this peat lens. Macrofossils (identified by J.V. Matthews, Jr.) include mosses, abundant seeds of **Andromeda polifolia** L., seeds of shrub birch, mosses, and a few fragments of ants. Spruce needles were not seen, but the sample examined is small. Preliminary pollen analysis by J.V. Matthews, Jr. (pollen sum=236) shows 86.4% **Betula,** 3.4% Cyperaceae, 6.7% Ericales, 3.4% miscellaneous types, and 37% **Sphagnum** (excluded from sum). Alder was not observed and only a few grains of spruce were seen in a scan of the entire slide.

Comment (J.V. Matthews, Jr.): The date is compatible with GSC-2461 (GSC XX, 1980, p. 13) from the base of an adjacent terrace section which shows that by 9000 BP Bell Basin had drained and Porcupine River was incised nearly to its present level. The absence of spruce macrofossils and presence of only trace amounts of spruce pollen suggest that spruce was either absent or very rare in the area 8840 ± 110 years ago. This finding is in contrast to evidence from another Bell Basin site, near Whitefish Lake, which suggests that spruce grew in the region at least 500 years earlier (cf. GSC-1829, 9530 ± 170 BP; GSC XVII, 1977, p. 16; Hopkins et al., 1981).

Comment (W. Blake, Jr.): The sample submitted weighed 52 g. It was split into two parts and a processed 'wafer' weighing 35.0 g was used. Date is based on two 1-day counts in the 5 L counter.

HHP72-81 Series

Organics from the HHP72-81 exposure (67°12.05'N, 137°41.4'W) located at an elevation of approximately 295 m near the top of a river bluff 48 m high on the east bank of Porcupine River within the Bell Basin, approximately 10.6 km above the mouth of Bell River.

GSC-3134. 8710 ± 80

Organics (sample MRA-7-13-80-9; 26.1 g) in the greater than 0.5 mm sieved fraction of organic silts exposed approximately 3.3 m below the surface of the exposure. Collected July 1978 by J.V. Matthews, Jr.

GSC-3161. 8890 ± 90

Moss fragments (sample MRA-7-13-80-7; 40.1 g dry) in the greater than 0.5 mm sieved fraction of a sample from a redeposited mat of autochthonous moss peat located approximately 1 to 2 m below the level of GSC-3134 within a unit of grey sand.

Comment (J.V. Matthews, Jr.): Only the upper part of the exposure was visible. It consists (from top down) of 3 m of autochthonous 'moss peat', underlain by 30 cm of sandy organic silts containing wood and organic pods (source of GSC-3134), over a 30 cm-thick unit of brown sand possessing at its base a few pebbles and clay peds. The sand truncates the underlying unit, which consists of 2 m of grey sand containing detrital organics, clay balls, and fibrous mats of moss that appear to have been redeposited 'en bloc'. One of these mats of autochthonous organics was the source of GSC-3161. The grey sands are underlain by bedded, relatively inorganic sands, which overlie 4 m of clay and silt above yet another sand unit. Sediments lower than this are obscured.

Since the dated moss mat is thought to have been deposited 'en bloc', and is not likely to have survived more than one such depositional cycle, its age approximates the time of deposition of the sands. This being so, the 8880 ± 90 year age of GSC-3161 is considerably younger than expected. The sample was submitted for dating because it was assumed that it would replicate dates in the range of 13 000 to 16 000 BP from similar sediments in the upper part of the Upper Porcupine Section, upstream from HHP72-81 (GSC XX, 1980; GSC-2553, GSC-2431, p. 13). GSC-3161 rules out such a correlation. The origin of the sands containing the dated sample is uncertain. A fluvial origin appears unlikely in view of evidence from the Upper Porcupine exposure (see comments on GSC-3119, this list) which indicates that Porcupine River was incised nearly to its present level more than 9000 years ago. The grey sand could be nearshore lacustrine sediments of a large thermokarst lake. If so, incorporation of sediment 'en bloc' could result from the formation of thermal niches and subsequent collapse into the lake of blocks of sediment and surface peat, a common shoreline process at the margins of large present day thermokarst lakes of the region.

The organics associated with GSC-3134 consist almost entirely of bryophyte fragments. Bryophyte spores dominate the palynomorph assemblage. A pollen spectrum (analyzed by J.V. Matthews, Jr.) (sum=200) consists of 1% **Picea,** 43.5% **Betula,** 1% **Alnus,** 0.5% **Salix,** 16% Cyperaceae (sedge), 5% Gramineae (grass), 4% Ericales, and 29% miscellaneous pollen, which includes **Typha.** This spectrum, like others from the area (see GSC-3119 and GSC-3133, this list) suggests that spruce was rare to absent in the Bell Basin as late as 8700 years ago, and adds further doubt to the conclusion (GSC-1829, 9530 ± 170 BP; GSC XVII, 1977, p. 16; Hopkins et al., 1981) that spruce was present as early as 9500 years ago. Each date is based on one 3-day count in the 5 L counter.

Rock River Series

Peat and wood samples from the Rock River section (=HH75-1, HH72-96) a 32 m-high river-cut bluff at an elevation of 312 m (top) and located in Bell Basin on the left limit of Rock River (67°14.4'N, 137°03.7'W), 16.2 km above its confluence with Bell River in northern Yukon Territory.

GSC-1773. Rock River (I) >40 000

Wood (sample HH72-96-3; 12.8 g dry; **Picea** sp.; unpublished GSC Wood Identification Report No. 72-54 by L.D. Farley-Gill) approximately 5.5 m above the base of Unit 2b in a zone of ripple-bedded sands and detrital organics bounded above and below by laminated clay. Collected July 1972 by O.L. Hughes.

GSC-2278. Rock River (II) >40 000

Wood (MRA-6-17-75-2A; 11.9 g dry; **Picea** sp.; unpublished GSC Wood Identification Report No. 76-3 by L.D. Farley-Gill) 4.5 m above the base of unit 2b in a 50 cm-thick zone of ripple-bedded sands and detrital organics bounded above and below by laminated clay. Collected June 1975 by J.V. Matthews, Jr.

GSC-2585. Rock River (III) >43 000

Wood fragments (sample MRA-6-14-7s-7; 11.7 g dry; all of them probably **Salix** sp.; unpublished GSC Wood Identification Report No. 77-56 by R.J. Mott), removed from an autochthonous, cryoturbated peat exposed in Unit 1 approximately 80 cm beneath its contact with the glaciolacustrine clay of Unit 2. Collected June 1975 by J.V. Matthews, Jr.

Comment (J.V. Matthews, Jr.): Bell Basin, like Old Crow and Bluefish basins to the northwest, was inundated by glacial meltwater during the late Pleistocene when Laurentide ice advanced to the eastern flanks of the Richardson Mountains (Hughes, 1972; Hughes et al., 1981). The Rock River section portrays the complexity of the meltwater events in the Bell Basin. The section may be divided into five stratigraphic units. The lowest (Unit 1) consists of 5 m of silt containing several laterally continuous peat horizons. The upper one of these, an autochthonous peat, was the source of wood dated by GSC-2585. Unit 2a consists of approximately 5 m of clay, presumably of glaciolacustrine origin, but poorly exposed due to thawing and slumping. Above this, Unit 2b comprises 13 m of alternating beds of laminated clay and fine sands, the latter ripple-bedded and in some cases containing lenses and zones of organic detritus. Both GSC-1773 and GSC-2278 are from this unit. Unit 2c, like Unit 2a, is poorly exposed, but apparently consists of some 8 to 9 m of clay, presumably also of glaciolacustrine origin. Above it is Unit 5, a peat cap of variable thickness.

The fossil insect assemblage associated with GSC-2585 (identified by J.V. Matthews, Jr.) contains, among others, several species of **Pterostichus (Cryobius)**, including **Pterostichus nivalis** Sahlb., **Pterostichus vermiculosus** Men., and a few fragments of the weevil **Lepidophorus lineaticollis** Kirby. The dominant component, however, is typical of aquatic and poorly drained sites (e.g., Chironomidae, Trichoptera, dytiscid beetles, hydrophilid beetles, and many fossils of the staphylinid beetle **Stenus**). Bryophyte fossils from the peat (identified by J.A. Janssens, then University of Alberta, Edmonton, now University of Minnesota, Minneapolis; unpublished Fossil Bryophyte Report JJ33) form a heterogeneous assemblage that includes several species of **Aulacomnium** and **Drepanocladus** as well as **Campylium stellatum** (Hedw.) C. Jens., **Bryum, Hypnum hamulosum** (Breidl.) Podp., **Cinclidium arcticum** (B.S.G.) Schimp., and others. They imply conditions such as might occur today in a calcareous alpine site, a considerable contrast to bryophyte communities currently found in the lowlands. Other plant macrofossils from the peat (identified by J.V. Matthews, Jr.) include **Carex** and 'seeds' and leaves of dwarf birch. Spruce macrofossils were not seen. Thus both insect and plant macrofossils call for tundra conditions. The pollen spectrum from the peat (analyzed by C.E. Schweger) supports this conclusion. Although it is biased by local pollen of Ericales (30.6%), it contains 40.7% **Betula**, 3.2% **Alnus**, 14% Cyperaceae (sedge), 3.2% Gramineae (grass), and only 0.4% **Picea**.

The insect assemblage associated with GSC-2278 includes **Pterostichus (Cryobius), Tachinus, Olophrum, Micralymma**, and many fossils of the weevil **Lepidophorus lineaticollis** Kirby. A few of the insect fossils, such as those of the bark beetles imply the presence of conifers. That spruce grew in the region is also suggested by the plant macrofossil assemblage which contains both spruce needles and seeds. It also contains seeds of dwarf birch, a few seeds which probably represent an arboreal species and seeds of **Alnus crispa**. Paleozoic palynomorphs dominate the pollen assemblage (C.E. Schweger, personal communication, 1979).

Although all three Rock River Section dates are infinite, they have different degrees of stratigraphic significance. GSC-2585 is from an autochthonous peat. Some of the dated wood still retains bark; hence, the date accurately reflects the age of the sediments from which it comes. This is not so for GSC-2278 and GSC-1773, since both are on wood from detrital horizons in which most, if not all, of the wood is rebedded. Therefore, the possibility that the dated wood is much older than the enclosing sediments cannot be ruled out. GSC-2746 (>39 000 BP) from a locality in the Old Crow Basin (CRH-11 series, this list) is an example that shows the degree to which GSC-2278 and GSC-1773 may misrepresent the age of Unit 2b; however, it is unlikely that the sediments enclosing the >40 000 year-old wood in Rock River Unit 2b are as young as the Holocene (as they are in the case of GSC-2746 at CRH-11).

Comment (W. Blake, Jr.): GSC-1773 was wet when received. After oven drying all outside wood was cut off to remove adhering silt and sand. The outside wood was also removed from GSC-2278, which measured 15 x 1.5 x 1 cm and had imbedded sand grains in its surface. For GSC-2585 the wood used (>5 mesh) was recovered by flotation from the silty peat. GSC-1773 and -2278 are each based on one 3-day count in the 5 L counter; GSC-2585 is based on one 4-day count in the 5 L counter.

GSC-3133. HH80-12 (Eagle River) 9970 ± 160

Basal 5 cm of peat (sample MRA-7-9-80-33 and MRA-7-10-80-1; 27.9 g dry) from a 3 m lens of autochthonous peat exposed at the top of a river-cut section on the east bank of Eagle River, Yukon Territory (67°05.8'N, 137°03.2'W). The site is 8 km E15°S of the southern tip of Whitefish Lake (a large lake in the Bell Basin), at an elevation of 320 m. Collected July 1980 by N.W. Rutter, University of Alberta, Edmonton, and J.V. Matthews, Jr.

Comment (J.V. Matthews, Jr.): The section is within the Bell Basin near the downstream end of the Eagle River discharge channel, a throughway for the glacial meltwater that flooded Bell Basin and other basins in the region during Wisconsinan time (Hughes, 1972; Hughes et al., 1981). The dated peat evidently formed after the end of such meltwater activity; hence, the date represents a minimum age estimate for cessation of meltwater influx to Bell Basin. The date agrees with two others (GSC-3119, 8840 ± 110 BP, this list; GSC-2461, 9190 ± 90 BP, GSC XX, 1980, p. 13) which also postdate meltwater flooding of the Bell Basin, but which come from another section (HH75-9).

The dated peat represents material that accumulated in, and grew near, a small sedge-bordered pond which later came to be dominated by mosses. A preliminary pollen analysis of the dated sample (by J.V. Matthews, Jr.) (sum=247) reveals 52.6% **Betula**, 0.8% **Alnus**, 1.2% Ericales, 22.2% Cyperaceae, 1.1% Gramineae, 4% **Artemisia**,

0.4% **Sphagnum**, and 16.5% miscellaneous pollen (including **Salix** and few grains of **Typha**). Spruce was not seen in a scan of the pollen slide. The plant macrofossil assemblage (partially reported in unpublished GSC Plant Macrofossil Report No. 80-12 by J.V. Matthews, Jr.) is dominated by aquatic and semi-aquatic taxa such as **Carex** (several species including **Carex diandra** type), **Potamogeton, Menyanthes trifoliata** L., and **Najas flexilis** (Willd.) R.&S., as well as lesser numbers of other taxa (e.g., **Ceratophyllum demersum** L., **Empetrum nigrum** L., **Potentilla palustris** (L) Scop., **Cicuta, Hippuris vulgaris** L., **Sparganium**, and **Ranunculus trichophyllus** type). 'Seeds' of shrub birch are present but not macrofossils of spruce or alder. Thus both pollen and macrofossils indicate that spruce had not invaded the region by 9970 ± 160 years ago (cf. GSC-3119, this series; Ritchie, 1982; Ovenden, 1982). An especially interesting fossil is an achene of **Bidens cernua** L., a species previously thought to be an introduced weed (Hultén, 1968). Despite its small size, the dated peat sample contained a variety of insect fossils (partially described in unpublished GSC Fossil Arthropod Report No. 80-7 by J.V. Matthews, Jr.). Included are taxa such as **Cyphon, Donacia, Hydrobius, Hydroporus, Stenus, Gymnussa**, and **Gyrinus** that live in and around small northern ponds. Some of the other species (e.g., **Diacheila polita** Fald.) are more typical of mesic tundra. Fragments of dragon flies and ants show that the site was within a region of low-arctic (or hypoarctic) tundra.

Comment (W. Blake, Jr.): The sample was prepared in two batches (20.0 g and 7.9 g) to obtain sufficient CO_2. Date is based on two 1-day counts in the 2 L counter.

Northwest Territories

GSC-3270. Western River 3860 ± 60

Single piece of wood (sample CIA-770001-2; 6.9 g; **Salix** sp.; unpublished GSC Wood Identification Report No. 77-34 by L.D. Farley-Gill) from a bluff along Western River, 75 km south-southeast of Bathurst Inlet, northeastern District of Mackenzie, Northwest Territories (66°17.8'N, 107°05.9'W), at an elevation of about 33 m. The sample was collected from delta foreset beds (mainly sand), 3 m below the top of the bluff. The foreset beds are about 13 m thick and are directly underlain by about 14 m of subhorizontal bottomset beds. Collected July 1977 by J.J. Clague.

Comment (J.J. Clague): GSC-3270 provides chronological control on Holocene sea-level fluctuations in the Western River area. At about 3860 years ago, relative sea level was at least 33 m higher, and probably was 35 to 40 m higher, than it is today at Bathurst Inlet. GSC-3270 is consistent with other radiocarbon dates on Holocene sea levels in the Bathurst Inlet-Western River area summarized by Blake (1963).

Comment (W. Blake, Jr.): The sample comprised fragments of wood from a single piece, of which the largest was 13 cm long and 1.5 cm in diameter. The outside wood was scraped clean to remove adhering sand, although some grains may have been retained in cracks or embedded in the surface. Sample was mixed with dead gas for counting. Date is based on one 3-day count in the 5 L counter.

GSC-3072. Shepherd Bay 8730 ± 230
$\delta^{13}C = +1.7‰$

Marine pelecypod shell fragments (sample CD/AC/209/60; 8.1 g; **Mya truncata**; identified by W. Blake, Jr.) collected from the surface of a till 25.7 km east of the head of Shepherd Bay, District of Keewatin, Northwest Territories (68°58'45"N, 92°56'30"W), at an elevation of 171 m (altimeter measurement). Collected July 1960 by J.D. Aitken for B.G. Craig; submitted 1980 by A.S. Dyke.

Comment (A.S. Dyke): The sample came from a site near to a well defined washing limit at 134 m (altimeter measurement) on a till-mantled hillside immediately beyond a large end moraine. The date provides a reasonable approximation of the age of the marine limit and of the moraine (Dyke, 1984).

Comment (W. Blake, Jr.): The sample consisted of 33 fragments, all exhibiting part of the truncated posterior end typical of this species. The shells had a 'hard' appearance. Most were completely white and clean, but a few had stains, one had a minor amount of pitting, and a few retained traces of periostracum; none had encrustations or chalkiness. The largest fragment was 2.6 x 1.5 cm in size; most pieces were less than 1 mm in thickness and none were thicker than 2 mm. Because of the small sample size only the outer 10% was removed by HCl leach. Sample was mixed with dead gas for counting. Date is based on two 1-day counts in the 2 L counter.

Northern Canada, Arctic Archipelago

Banks Island

Cape Collinson Series

Wood extracted from a 2 to 5 cm-thick organic layer beneath 3 m of sand, gravel, and till and overlying horizontally bedded gravel 21 km northeast of Nelson Head and 12 km southwest of Cape Collinson, Banks Island, Northwest Territories (71°14'20"N, 122°20'20"W), at an elevation of approximately 36 m. The twig layer is separated from the overlying sediments and pinkish grey till (7.5 YR 7/2) by a 5 to 10 cm-thick dark greyish brown clay layer (2.5 YR 3/2) and is underlain by fine sapropel and a light grey-brown, calcareous banded layer.

Collected August 1975 by W. Blake, Jr. Two determinations were made:

GSC-2234. Cape Collinson (I) >39 000
$\delta^{13}C = -29.4‰$

The single largest piece of wood (sample BS-75-296; 5.1 g; **Salix** sp.; unpublished GSC Wood Identification Report No. 75-73 by R.J. Mott) extracted from the organic layer described above. This flattish, well preserved piece was 11.3 cm long and had a maximum width of 3.8 cm. Upon oven drying its weight decreased from 15.2 to 5.5 g.

GSC-2234-2. Cape Collinson (II) 53 100 ± 1560

Wood (sample BS-75-296; 47.0 g) from the same organic layer described above. This larger collection of flattened wood was extracted from the organic layer in the field, then air dried, and finally oven dried. Bark was preserved and rootlets were attached. All pieces were less than 11 cm long and less than 1.5 cm maximum width. On additional oven drying the weight of the whole sample decreased from 129 to 81 g.

Comment (W. Blake, Jr.): Although the organic unit containing the twigs gave the impression of a pond deposit (cf. Vincent, 1982), no diatoms were found (unpublished GSC Diatom Report No. 75-19 by S. Lichti-Federovich). Among Coleoptera remains in this layer were **Pterostichus (Cryobius)** sp., **Dyschirius** sp. representing Carabidae ("ground beetles"), **Euaesthetus** sp. representing Staphylinidae; with the Hymenoptera were several fragments of an unknown parasitic wasp. J.V. Matthews, Jr. (unpublished GSC Fossil Arthropod Report No. 76-16) commented, "**Dyschirius** and **Euaesthetus** are genera which are not expected to occur on Banks Island..., so the presence of fossils of these two genera, though rare, likely shows that the sediments represent a climate warmer than at present, probably an interglacial."

Pollen analysis showed that birch pollen dominated, and some of these pollen were the dwarf birch, **Betula glandulosa** (unpublished GSC Palynological Report No. 79-6 by R.J. Mott).

The organic layer is assigned by Vincent (1982, 1983, 1984) to the Cape Collinson Interglacial and the surface till is the Jesse Till. A third age determination, on a sample of **Salix** and **Betula** wood (unpublished GSC Wood Identification Report No. 77-24 by L.D. Farley-Gill) collected by J-S. Vincent in 1974 and 1977 gave a value of >61 000 BP (QL-1230; Vincent, 1982, 1983).

GSC-2234 was mixed with dead gas for counting. Date is based on one 3-day count in the 5 L counter. GSC-2234-2 is based on one 5-day count in the 5 L counter at 4 atmospheres.

Victoria Island

GSC-3527. Worksop Point — 9880 ± 150
$\delta^{13}C = +0.8‰$

Marine pelecypod shells (sample HCA-82-10-7-2; 26.7 g; **Hiatella arctica** whole valves (one pair) and fragments; identified by D.A. Hodgson) from the surface of marine/deltaic silt at an elevation of 41 m, underlain by bouldery gravel, likely till, and overlain by gravel beach or deltaic topset deposits at 45 m elevation, 6 km south of Worksop Point, Victoria Island, Northwest Territories (72°49.75'N, 111°56'W). Collected July 1982 by J. Bednarski, then GSC, now University of Alberta, Edmonton, and D.A. Hodgson.

Comment (D.A. Hodgson): The shells were deposited when sea level was at 45 m elevation or higher. Strandlines in the vicinity overlie Winter Harbour Till to at least 50 m elevation, and possibly to 59 m. The date is the oldest for sediments postdating deposition of Winter Harbour Till by the Viscount Melville Sound Ice Shelf on the southern shores of Viscount Melville Sound (Hodgson and Vincent, 1984) and is similar in age or slightly older than the oldest dated shells (GSC-282, 9670 ± 150 BP; GSC VI, 1967, p. 191) in marine sediments overlapping the same till unit to the north, on Melville Island.

Comment (W. Blake, Jr.): Nearly all the shells in this sample exhibited some encrustations; some valves, not used, were completely covered by a hard, thin, brown encrustation. All the valves submitted were washed twice in distilled water and air dried. Those selected had minimal amounts of encrustations, and these were removed by scraping. No periostracum remained, the shells were not pitted, and some had internal lustre. Most shells were <1 mm thick, all were <2 mm. The largest whole valve was 3.9 x 2.1 cm in size, but some fragments came from larger valves. The sample used comprised one whole and eight partial right valves, three whole and 13 partial left valves, plus three additional fragments. Date is based on two 1-day counts in the 2 L counter.

GSC-3511. Natkusiak Peninsula — 11 800 ± 100
$\delta^{13}C = +0.2‰$

Marine pelecypod shells (sample HCA-82-5-7-4; 47.5 g; **Hiatella arctica** whole valves and fragments; identified by D.A. Hodgson) from the base of a slightly stony sandy unit, overlying thin till and ice sculptured rock, at 105 m elevation, in a river bank rising to 120 m, on the Wynniatt Bay side of Natkusiak Peninsula, Victoria Island, Northwest Territories (72°52'N, 110°20'W). Collected 1982 by J. Bednarski.

Comment (D.A. Hodgson): The shells were collected from marine or basal deltaic sediments from a marine event which followed strong northwest glacial flow over Natkusiak Peninsula. Sea level at the time the molluscs lived was at an elevation of at least 120 m; marine or deltaic deposits occur nearby up to 135 m elevation. The deposits predate deposition of Winter Harbour Till on the shores of Natkusiak Peninsula (Hodgson and Vincent, 1984).

Comment (W. Blake, Jr.): The shells, all robust and at least 1 mm in thickness (2 mm at hinge), were washed twice in distilled water and air dried. The sample submitted comprised two whole right valves (largest 4.8 x 2.6 cm) plus six fragments, three whole left valves plus 12 fragments. No periostracum remained; no internal lustre was present; some valves had some translucency; and the shells had a minimal amount of encrustations. Date is based on one 4-day count in the 5 L counter.

Somerset Island

GSC-3745. McClure Bay — 8780 ± 110
$\delta^{13}C = +0.7‰$

Marine pelecypod shells (sample SW-10-81; 27.7 g; **Hiatella arctica**; identified by W. Blake, Jr.) from an old surface exposure on a raised beach at the base of a residual granite exposure east of McClure Bay, western Somerset Island, Northwest Territories (73°38'N, 95°32'W), at an elevation of 90 m. Collected July 1981 by S.H. Watts, Sir Sandford Fleming College, Lindsay, Ontario.

Comment (S.H. Watts): The age obtained is consistent with other dates reported on shell and bone material from raised beaches at 80 to 90 m a.s.l. on Somerset Island (Dyke, 1979, 1980, 1983). This value suggests that minimal subaerial weathering has occurred in nearly 9000 years in the immediately adjacent, fresh looking granite outcrops. Highly weathered and grus-covered exposures less than 20 m above this beach level clearly escaped postglacial marine inundation. The degree of weathering preserved in these upper granitic outcrops could reflect longterm subaerial breakdown in a near marine environment during pre-Late Wisconsinan time. Late Wisconsinan glaciation did not modify these exposures to any recognizable degree. Scattered erratics present are also highly weathered and may predate Wisconsinan glaciation.

Comment (W. Blake, Jr.): The sample also contains fragments of **Mya truncata** and **Balanus balanus**, but only **Hiatella arctica** was used for dating. Only the best preserved shells were utilized, but all exhibited chalkiness, none had the periostracum preserved, and only a few had traces of internal lustre. Most shells retained good external ornamentation; particularly worn and thick shells were avoided. The sample used for dating comprised nine whole left valves (plus 8 fragments) and two whole right valves (plus 6 fragments). The largest valve measured 3.8 x 1.9 cm and the smallest, 2.6 x 1.4 cm. Most of the shell material used was 1 mm or less in thickness. Adhering mud and some algae were scraped and washed off. No encrustations or pitting occurred on the shells used, but others in the collection were in extremely poor condition. Date is based on two 1-day counts in the 2 L counter.

GSC-2554. Cape Anne — 9210 ± 80

Plant fragments (sample DCA-77-H98; 55.5 g dry) from a bed of peat with grey sand inclusions, 5 km south-southwest of Cape Anne, Somerset Island, Northwest Territories (74°02'30"N, 94°46'30"W), at an elevation of about 100 m. The peat overlies grey sand with peat inclusions and is overlain by 63 cm of red stony diamicton capped by 67 cm of red sand with marine shell fragments. Collected 1977 by A.S. Dyke.

Comment (A.S. Dyke): The stratigraphy above was exposed in a pit excavated below frost table with an electric jackhammer. "The site was ice free at the time of plant growth, but whether the overlying 'till' represents a readvance or simply a period of solifluction is not known. The uppermost unit, red sand with shell fragments, could be a marine sediment, slope wash deposit, or eolian deposit... Cryoturbated terrestrial plant fragments (including **Salix arctica**) from an earth hummock near the north shore of the Aston Bay... (Zoltai et al., 1978) yielded an age of 9480 ± 190 years (BGS-333). Both dates on terrestrial plant material overlap with the oldest dates on marine shells and whale bones (from this area) and confirm the reliability of radiocarbon dates on marine organisms in establishing deglacial chronologies" (Dyke, 1983, p. 28). GSC-2554 contained fossils of **Carex** sp., **Draba** sp., **Saxifraga oppositifolia** L., **Papaver** sp., and **Ranunculus** sp. (not **R. sulphureus**), as well as several heads of larval chironomidae, other Diptera fragments, **Daphnia** ephippia, and moss fragments. "All of the plants recorded above occur on Somerset Island today" (unpublished GSC Plant Macrofossil Report No. 80-13 by J.V. Matthews, Jr.). Both GSC-2554 and BGS-333 are interesting in that they indicate that plants and insects colonized the coastal fringes of the island as soon as land became available upon deglaciation or emergence.

Comment (W. Blake, Jr.): The BGS-333 date referred to (9480 ± 190 BP, terrestrial plant fragments at 53 m elevation), although in the same general age range as several other age determinations in the northwest part of Somerset Island, is anomalous in that dates on marine shells show that sea level at the time was well above the level at which the peat occurs (cf. GSC-3745, 8780 ± 110 BP, at 90 m, this list). For GSC-2554, wet sand with organic plant fragments and stems was wet sieved in distilled water. Three fractions were separated from a 1.358 kg portion of the bulk sample (some original bulk sample was not used). Approximately 87 g of dried coarser organic material was obtained on the #35 screen, and from this fraction 55.5 g of sample was picked out for dating. Tiny woody stems, which may be willow, were seen in the sample but were not common. No coal, charcoal, amber, or rootlets were noticed. Date is based on one 4-day count in the 5 L counter.

Melville Island

Marine shells, driftwood, and peat were collected from central Melville Island, on and adjacent to Dundas Peninsula (mainly on the Viscount Melville Sound shore). Dates are grouped into series predating and postdating deposition of Winter Harbour Till on southern Dundas Peninsula. These age determinations are listed and discussed in Hodgson et al. (1984), together with all previously published radiocarbon dates from central Melville Island. The age of Winter Harbour Till is also discussed in Hodgson and Vincent (1984).

Pre-Winter Harbour Till Series

GSC-3249. Cape Clarendon (I) 11 700 ± 100
$\delta^{13}C = +0.5‰$

Marine pelecypod shells (sample HCA-80-15/8-4; 50.0 g; **Hiatella arctica**, mainly pairs; identified by D.A. Hodgson) on marine sandy silt, exposed west of the river, 1.5 km west-northwest of Cape Clarendon, Melville Island, Northwest Territories (74°30.7'N, 111°42.0'W), at an elevation of 58 m. Collected August 1980 by D.A. Hodgson and J-S. Vincent.

Comment (D.A. Hodgson and J-S. Vincent): This is the oldest finite date of immediately pre-Holocene age reported from Melville Island. The related sea level likely exceeds 82 m, the elevation at which slightly younger shells (GSC-3111, 11 400 ± 130 BP; this list) were collected. The shell-bearing marine silt is overlain upslope by Winter Harbour Till. These are the only dated shells from Melville Island from stratigraphically below Winter Harbour Till, and thus they provide a maximum age for deposition of the till by the Viscount Melville Sound Ice Shelf (Hodgson and Vincent, 1984). Nevertheless, geological evidence from elsewhere on the shores of Viscount Melville Sound indicates that the till was deposited ca. 10 000 years ago. Therefore, a late Wisconsinan sea covered the south coast of Melville Island for more than 1000 years prior to deposition of the till.

Comment (W. Blake, Jr.): The aragonitic shells were, in general, well preserved, although some light encrustations (or discolorations) were present on the shells used. Individuals with heavier encrustations or Fe stain were not submitted. The sample comprised 11 left plus 14 right valves; the two intact valves measured 4.8 x 2.4 cm and 4.3 x 2.6 cm. Date is based on one 3-day count in the 5 L counter.

GSC-3113. Shellabear Point 11 500 ± 260
$\delta^{13}C = +0.5‰$

Marine pelecypod shells (sample HCA-80-7/7-3; 14.0 g; **Hiatella arctica** whole valves and fragments; identified by D.A. Hodgson) from shell concentrations on gravelly sand, 13 km west-southwest of Shellabear Point, Liddon Gulf, Melville Island, Northwest Territories (74°49'N, 113°42'W), at an elevation of 56 m. Collected July 1980 by D.A. Hodgson and J-S. Vincent.

Comment (D.A. Hodgson and J-S. Vincent): The shells are likely from a nearshore or beach environment, at or close to the Late Wisconsinan marine limit in Liddon Gulf. This is the highest shell collection from this area. Hodgson et al. (1984) indicated that adjacent coastal areas were depressed for at least 1000 years before ice of the Viscount Melville Sound Ice Shelf reached its Late Wisconsinan limit on southern Dundas Peninsula.

Comment (W. Blake, Jr.): Most of the collection was lightly to heavily encrusted, and some valves had spots of lichens and holes (pitting). The sample submitted for dating consisted of four intact valves, two right and two left, plus four left valve fragments; all of these were free or nearly free of encrustations, and although they had no lustre, all were characterized by good external ornamentation. The largest valve measured 4.7 x 2.4 cm and the smallest, 3.7 x 1.8 cm. The sample was mixed with dead gas for counting. Date is based on two 1-day counts in the 2 L counter.

GSC-3111. Cape Clarendon (II) 11 400 ± 130
$\delta^{13}C = +1.4‰$

Marine pelecypod shells (sample HCA-80-15/7-11; 26.8 g; **Hiatella arctica** whole valves and fragments; identified by D.A. Hodgson) from marine sandy silt overlain by 1 m or less of Winter Harbour Till, exposed in a shallow flowslide, 5.5 km northeast of Cape Clarendon, Melville Island, Northwest Territories (74°32.7'N, 111°32.5'W), at an elevation of 82 m. Collected July 1980 by D.A. Hodgson and J-S. Vincent.

Comment (D.A. Hodgson and J-S. Vincent): These are the highest shells of finite age from Dundas Peninsula, though GSC-3249 (11 700 ± 100 BP, this list) is slightly older. Thus 82 m is the minimum elevation reached by the sea predating deposition of Winter Harbour Till by the Viscount Melville Sound Ice Shelf on southern Melville Island.

Comment (W. Blake, Jr.): The aragonitic shells submitted for dating comprised 11 right valves (5 whole, 6 fragments) and 8 left valves (4 whole, 4 fragments), and the largest valve was 3.9 x 2.1 cm. All valves were characterized by good external ornamentation, but no real

internal lustre. No pitting or encrustations were present; some valves had chalky exterior surfaces. Date is based on two 1-day counts in the 2 L counter.

GSC-338. Nias Point 10 380 ± 160

Marine pelecypod shells (sample FG-64-51b, site 7/21I; 47.3 g; **Hiatella arctica** whole valves and fragments; identified by J.G. Fyles) from within sand exposed in the eroded face of a delta whose top surface is at an elevation of 49 m, 9.5 km southeast of Nias Point on the south shore of Hecla and Griper Bay, Melville Island, Northwest Territories (75°30.4'N, 110°15'W), at an elevation of 44 m. Collected July 1964 by J.G. Fyles.

Comment (D.A. Hodgson): These shells date a delta surface only 6 m below the elevation (55 m) of the highest delta remnants found around the southwest shore of Hecla and Griper Bay.

Comment (W. Blake, Jr.): The outer 30% of shell material was removed by HCl leach. Date is based on two 1-day counts in the 5 L counter.

GSC-3122. Bridport Inlet 10 200 ± 100
$\delta^{13}C = +0.8‰$

Marine pelecypod shells (sample HCA-80-21/7-2; 27.0 g; **Hiatella arctica** whole valves, fragments, one pair; identified by D.A. Hodgson) within silty sand, overlain by 1 m of delta topset gravels at an elevation of 48 m, along a creek 5 km southwest of Polynia Lake, Bridport Inlet, Melville Island, Northwest Territories (75°04.3'N, 108°47'W). Collected July 1980 by D.A. Hodgson and J-S. Vincent.

Comment (D.A. Hodgson and J-S. Vincent): The sample dates a sea level at or slightly higher than 48 m and may predate or be contemporaneous with the Viscount Melville Sound Ice Shelf that deposited Winter Harbour Till.

Comment (W. Blake, Jr.): The aragonitic shells submitted for dating comprised 13 left valves and 11 right valves; none were whole as even intact valves had a hole close to the hinge. All shells were thin, most <1 mm, all <2 mm. The largest valve was 4.4 x 2.4 cm; an intact pair (not used) was 5.3 x 2.7 cm. No pitting, lustre or encrustations were present. Date is based on one 3-day count in the 2 L counter.

Post-Winter Harbour Till Series

GSC-666. Parry Point (I) 8960 ± 140

Marine pelecypod shells (sample FG-66-70e, site 2-1-8; 42.7 g; **Astarte** sp., **Portlandia** sp., **Mya** sp. and **Hiatella arctica;** identified by J.G. Fyles) within a 3 m-thick sand unit exposed in a gully cut in beach material (pebbly sand) at an elevation of 9 m, 2 km north of Parry Point, Melville Island, Northwest Territories (74°48'N, 110°38'W). Collected August 1966 by J.G. Fyles.

GSC-668. Parry Point (II) 8700 ± 160

Marine pelecypod shells (sample FG-66-70d, site 2-1-8; 26.8 g; **Astarte** sp., **Portlandia** sp., and **Hiatella arctica;** identified by J.G. Fyles) from the same location and elevation as GSC-666 (this series). Collected 1966 by J.G. Fyles.

Comment (D.A. Hodgson): Sea level at the time of shell deposition is unknown for both these samples. Nearby shells related to a sea level of at least 25 m elevation dated 9620 ± 150 BP (GSC-665; GSC VII, 1968, p. 242). The highest beaches overlying Winter Harbour Till near Parry Point are at 30 to 35 m elevation. GSC-666 is based on one 4-day count in the 5 L counter; GSC-668 is based on one 3-day count in the 2 L counter.

GSC-663. Parry Point (III) 5750 ± 130

Marine pelecypod shells (sample FG-66-70a, site 1-1-8; 75.1 g; **Astarte** sp.; identified by J.G. Fyles) thinly scattered in very fine sand and silt on the wing of a delta whose surface is at 7 m, close to R.C. Scott's grave, immediately north of Parry Point, Melville Island, Northwest Territories (74°47.5'N, 110°39'W), at an elevation of 3 m. Collected August 1966 by J.G. Fyles.

Comment (D.A. Hodgson): Whether or not the shell-bearing sediments underlie the 7 m delta surface is unknown. Date is based on one 3-day count in the 5 L counter.

GSC-3403. Hecla and Griper Bay 8530 ± 90
$\delta^{13}C = -25.8‰$

Wood (sample HCA-80-30/7-13; 11.5 g; **Picea** sp.; unpublished Wood Identification Report No. 80-30 by L.D. Farley-Gill), part of a log 6 to 8 cm in diameter, >1 m long, excavated from freshly undercut frozen silty clay in the southwest corner of Hecla and Griper Bay, Melville Island, Northwest Territories (75°31.5'N, 111°07'W), at an elevation of 1 m. The wood is overlain by 7 m of silt, sand, and gravel, exposed in a river bank whose top elevation is at 8 m. Collected July 1980 by D.A. Hodgson and J-S. Vincent.

Comment (D.A. Hodgson and J-S. Vincent): The log is driftwood which entered the Arctic inter-island channels from the Arctic Ocean, sank, and was buried by sediments from a receding shoreline or a prograding delta. Local marine limit is at an elevation of 55 m (see GSC-338, this list).

Comment (W. Blake, Jr.): This age determination is one of the oldest for driftwood in the Queen Elizabeth Islands (Blake, 1972); to my knowledge the oldest date obtained so far is one of 8915 ± 115 BP (S-2211) from Clements Markham Inlet, northern Ellesmere Island (Stewart and England, 1983). The sample had a strong sulphurous smell; the adhering yellowish silt and outer hard and crusty wood was cut away prior to drying in an electric oven. Date is based on two 1-day counts in the 5 L counter.

GSC-3175. Cape Providence 2920 ± 60

Wood (sample HCA-80-17/7-6C; 11.4 g; **Salix** sp.; unpublished Wood Identification Report No. 80-43 by R.J. Mott) from a single bush preserved beneath 2 m of organic-rich sand exposed in a stream bank, at the foot of a 100 m-high colluvium-mantled slope, 6 km northeast of Cape Providence, Melville Island, Northwest Territories (74°29'N, 112°12'W), at an elevation of 66 m. Collected July 1980 by D.A. Hodgson and J-S. Vincent.

Comment (D.A. Hodgson and J-S. Vincent): The collectors hoped the sample would date from the immediate postglacial period in the early Holocene.

Comment (W. Blake, Jr.): The bush was 25 cm long with many twisted and contorted branches, and fine debris wedged into crevices between branches. The presence of much bark, fragile branches, and partial roots suggested little transport. Maximum stem diameter was 1.5 cm, and the width of the bush was approximately 20 cm. Some wood surfaces are rusty and cracked. Upon oven drying the sample (wood only) decreased in weight from 44.8 to 38.9 g. All outside wood was removed. Date is based on two 1-day counts in the 5 L counter.

Ellesmere Island

Leffert Nunatak Series

Marine pelecypod shells and crustose coralline algae from the surface of an ice-cored lateral moraine on the south side of Leffert Glacier, Ellesmere Island, Northwest

Territories (78°40.0'N, 75°06'W), at elevations between 165 m and 180 m (altimeter determinations). Four age determinations have been made:

GSC-3472. Leffert Nunatak (I) 2540 ± 50
$\delta^{13}C = -2.4‰$

Crustose coralline algae (sample BS-82-145; 58.0 g dry) from the top and sides of a single large boulder. Collected June 1982 by W. Blake, Jr.

GSC-3515. Leffert Nunatak (II) 2280 ± 140
$\delta^{13}C = +0.5‰$

The single largest pelecypod valve (sample BS-81-205; 8.5 g; **Astarte borealis** var. **arctica**; identified by I. Lubinsky, University of Manitoba, Winnipeg, Manitoba) from the till comprising the moraine; it measured 4.5 x 4.0 cm, was 1.5 mm thick at the outer edge and up to 5 mm thick at the hinge. Collected July 1981 by W. Blake, Jr.

GSC-3793. Leffert Nunatak (III) 2880 ± 70
$\delta^{13}C = +1.4‰$

Marine pelecypod shell fragments (sample BS-82-143; 48.5 g; **Mya truncata**; identified by W. Blake, Jr.) from the surface of, and slightly embedded in, the till comprising the moraine. The sample consisted of 25 fragments of left valves, and 25 fragments of right valves (not necessarily pairs); all were characterized by the truncated posterior end which is typical of the species. The largest pieces show that some robust valves were >3.4 cm long and >2.7 cm high. Most valves are 2 to 3 mm thick in the hinge area and at the posterior ends; relatively few valves are <1 mm thick. Collected June 1982 by W. Blake, Jr.

GSC-3932. Leffert Nunatak (IV) 2410 ± 60
$\delta^{13}C = -2.2‰$

Crustose coralline algae (sample 84-BS-228; 30.0 g) from a different boulder than that from which sample BS-82-145 (= GSC-3472) was collected. The sample was cleaned in distilled water to remove adhering silt. The largest pieces measured 3.0 to 3.5 cm in diameter; most crusts are less than 2 mm in thickness, but in bulbous parts the thickness may be up to 5 mm. Collected July 1984 by W. Blake, Jr.

Comment (W. Blake, Jr.): The age determinations on different materials give consistent results and show that, "Leffert Glacier, a major outlet glacier draining eastward from the central Ellesmere Island Ice Cap, has advanced more than 7 km from the position that it occupied approximately 2000 radiocarbon years ago" (Blake, 1984). Because of the small size of GSC-3515, only the outer 5% of shell was removed by HCl leach; sample was mixed with dead gas for counting. GSC-3472 is based on one 3-day count in the 5 L counter; GSC-3515 is based on one 3-day count in the 2 L counter; GSC-3793 is based on three 1-day counts in the 5 L counter; and GSC-3932 is based on one 3-day count in the 2 L counter.

Alexandra Fiord Series

GSC-2611. Alexandra Fiord, shells (I) 16 700 ± 280
$\delta^{13}C = +1.5‰$

Marine pelecypod shells and fragments (sample BS-77-207; 26.7 g) from the surface of gravel bars along the central stream in the Alexandra Fiord Lowland, about 2 km south of the former R.C.M.P. post, Alexandra Fiord, Ellesmere Island, Northwest Territories (78°51.7'N, 75°47'W), at an elevation of 70 to 75 m (altimeter) (72-79 m by stereotope plotting, G. Mizerovsky). Collected July 1977 by R.J. Richardson, then GSC, now Alberta Geological Survey, Edmonton, and W. Blake, Jr.

GSC-2989. Alexandra Fiord, shells (II) 8450 ± 490
$\delta^{13}C = -0.8‰$

Fragments of marine pelecypod shells (sample BS-79-204; 3.8 g; **Macoma calcarea**; identified by W. Blake, Jr.), from the surface of gravel bars along the central stream in the Alexander Fiord Lowland, approximately 1 km south of the former R.C.M.P. Post, Alexandra Fiord, Ellesmere Island, Northwest Territories (78°52.4'N, 75°46'W), at an elevation of 40 to 42 m (altimeter determination). Collected July 1979 by W. Blake, Jr. and E.W. Blake.

GSC-2835. Alexandra Fiord, peat 4520 ± 60
$\delta^{13}C = -27.9‰$

Peat (sample BS-77-202; 27.8 g) exposed in the bank of a stream approximately 2.4 km south of the former R.C.M.P. post, Alexandra Fiord, Ellesmere Island, Northwest Territories (78°51.6'N, 75°47'W), at an elevation of 87 m (steretope plotting by G. Mizerovsky). The 5 cm-thick peat layer was overlain by 30 to 40 cm of sandy debris containing angular pebbles, and the peat appeared to be at the top of a buried soil profile approximately 30 cm thick. Collected July 1977 by W. Blake, Jr.

Comment (W. Blake, Jr.): GSC-2611 is far too old for the elevation at which it occurs, that is, well preserved **Mya truncata** shells at 50 m near the head of Alexandra Fiord are 7000 ± 70 BP (GSC-3288; Blake, 1982a; GSC XXII, 1982, p. 18). Also, determination of amino acid ratios, in a collection upstream of the site where the collection used for GSC-2611 was made, indicated that shells of varying age were present (both **Mya truncata** and **Hiatella arctica**). GSC-2989 may be correct, for older Holocene shell samples occur along the outer coast to the east (e.g., GSC-3103, 8930 ± 100 BP at 50 m beside Alfred Newton Glacier; Blake, 1981; GSC XXI, 1981, p. 18), but the dated sample also may contain a mixture of 'old' shells with Holocene shells (making the age appear too old for shells at 40 to 42 m), since the collection site lies downstream of the site at which GSC-2611 was collected. The peat used for GSC-2835 contained several heads, elytra, and pronota of a predaceous diving beetle (tentatively referred to **Hydroporus morio** by D.J. Larson, Memorial University of Newfoundland, St. John's; cf. unpublished GSC Fossil Arthropod Report No. 78-7 by J.V. Matthews, Jr.). Remains of ?**Atheta** sp. (a rove beetle), wasps, chironomids, and spiders are also represented, in addition to **Carex** achenes and specimens of an unidentified reticulate seed (all listed in the same report by J.V. Matthews, Jr.). Since the writer collected living **Hydroporus morio** in a pond at the former Alexandra Fiord R.C.M.P. post, it would appear that the local climate was at least as favourable as today some 4580 to 4460 years ago (c.f. also Blake, 1981; Bergsma et al., 1984). The peat used for dating was from a damp sample (Bag 1); on drying in an electric oven its weight decreased from 240 to 150 g.

GSC-2611 is based on two 1-day counts in the 2 L counter. For GSC-2989, because of the small sample size (11 left valves, 4 right valves, all including the hinge area and all shells (aragonitic) less than 0.5 mm in thickness; some white, others with a bluish tinge), only the outer 5% of shell material was removed with HCl leach; sample was mixed with dead gas for counting. Date is based on two 1-day counts in the 2 L counter. GSC-2835 is based on two 1-day counts in the 5 L counter.

GSC-2843. Eastern Judge Daly Promontory — 7960 ± 150; $\delta^{13}C = +1.4‰$

Marine pelecypod shells (sample JDS-7-78; 12.4 g; **Mya truncata**; identified by W. Blake, Jr.) from along the east coast of Judge Daly Promontory, 17 km southwest of Cape Defosse, Ellesmere Island, Northwest Territories (81°08'N, 66°23'W), at an elevation of 66 m. The shells were found in situ within silt and sand foreset beds (5 m below the surface) that rise to a former relative sea level of at least 85 m a.s.l. (England et al., 1981). Collected July 1978 by R.S. Bradley, University of Massachusetts, Amherst, Massachusetts, and J. England, University of Alberta, Edmonton, Alberta.

Comment (J. England): Shorelines dating to approximately 8000 BP are known to extend to about 120 m a.s.l. at Cape Baird, 55 km to the northeast of GSC-2843 (England, 1983). Because the postglacial isobases rise to the southeast across Judge Daly Promontory (England, 1982), it is likely that GSC-2843 dates a relative sea level higher than 85 m. Because scree is accumulating on the local 85 m beach terrace, it is not known whether higher shorelines have been buried; therefore, it is likely that GSC-2843 represents a maximum age for the 85 m sea level.

Comment (W. Blake, Jr.): **Hiatella arctica** was also present in the sample and **Portlandia arctica** was stated to be in the collection by the submitter (J. England), although none was received by the laboratory. The **Mya truncata** shells were all well preserved, with nearly intact periostracum, no pitting or encrustations, and some internal lustre. The **Mya** used included one intact right valve (4.5 x 3.4 cm) plus three partial left valves (the biggest is >4.5 cm long and one of the nearly intact left valves appeared to pair with the right valve). Because of the small sample size, only the outer 10% of shell was removed by HCl leach. Sample was mixed with dead gas for counting. Date is based on two 1-day counts in the 2 L counter.

GSC-3179. Chandler Fiord — 7870 ± 270; $\delta^{13}C = +1.0‰$

Marine shells (sample DL-CF-80-S2-4; 7.5g; **Portlandia arctica**; identified by J. England, University of Alberta, Edmonton, Alberta) in situ in marine silt at the head of Chandler Fiord, Ellesmere Island, Northwest Territories (81°41'N, 69°08'W), at an elevation of 65 m. The sample occurs in silt that laterally underlies a prominent gravel terrace marking the local marine limit at 83 m a.s.l. Collected July 1980 by D. Lemmen, University of Alberta, Edmonton, Alberta; submitted by J. England.

Comment (J. England): During the last glaciation ice from the Grant Land Mountains (35 km to the northwest) terminated at the head of Chandler Fiord. This sample indicates the time of the onset of deglaciation and the age of the 83 m marine limit. This sample takes precedence over a previous ^{14}C date of 7340 ± 180 BP (GSC-1812, England, 1978; GSC XIX, 1979, p. 45) on marine shells from nearby silts.

Comment (W. Blake, Jr.): These well preserved shells, 0.5 to 1.3 cm in length, were characterized by periostracum on some valves and good internal lustre on all. Because of the small sample size, only the outer 10% of shell was removed by HCl leach. Sample was mixed with dead gas for counting. Date is based on two 1-day counts in the 2 L counter.

Mount Beaufort Series

GSC-2840. Mount Beaufort (I) — 410 ± 50

Peat (sample BLP-1-78; 28.0 g dry) from 10 to 20 cm beneath a surface cover of silt in a prominent basin adjacent to Robeson Channel and 3 km northeast of Mount Beaufort, Ellesmere Island, Northwest Territories (81°54'N, 63°20'W), at an elevation of 83 m. The peat appears to be in situ and the uppermost 10 cm of a 20 to 30 cm-thick layer was dated. Sample collected July 1978 by J. England and R.S. Bradley.

Comment (J. England): This sample was collected approximately 33 m below the local marine limit (at 116 m a.s.l.) in a large basin formerly occupied by the sea. It was thought that the silts overlying the peat were of marine origin because they are similar to other marine silts nearby. Apparently this is not the case and although the upper part of the peat represents the local accumulation of vegetation at approximately 410 BP, the overlying material has been deposited by solifluction. The climatic significance of the sample is difficult to assess because the local area is poorly drained and similar vegetation is accumulating today. Date is based on two 1-day counts in the 5 L counter.

Comment (W. Blake, Jr.): Information on the lake sediments in 'Beaufort Lakes' is available in Retelle (1983) and Retelle and Bradley (1983).

GSC-3041. Mount Beaufort (II) — 8090 ± 120; $\delta^{13}C = +2.2‰$

Marine shells (sample BL-4-78; 12.3 g; **Mya truncata**; identified by W. Blake, Jr.) collected in situ at an elevation of 90 m in silt and sand that laterally underlie a marine limit beach at 116 m a.s.l. The shells occur in a prominent lowland immediately north of three unnamed lakes (81°53'N, 63°20'W) and 3 km northeast of Mount Beaufort, Ellesmere Island, Northwest Territories. Collected July 1978 by J. England and R.S. Bradley.

Comment (J. England): These shells indicate that the sea remained at marine limit until approximately 8100 years ago. In the Archer Fiord/Lady Franklin Bay area, some 35 to 70 km to the southwest, dates on shells related to marine limit range from 8000 to 11 000 BP, indicating the presence of a full glacial sea beyond the last ice limit (England, 1983). Another sample, collected from the same terrace and at the same elevation as sample GSC-3041, dated 8255 ± 215 BP (S-1990; England, 1983).

Comment (W. Blake, Jr.): The sample submitted to the laboratory comprised 10 **Mya truncata** fragments (the largest >4 cm high), 9 of which included the typical truncated posterior end and one fragment that could be no other species because of its size and shape. These aragonitic shells had a somewhat 'hard' appearance, no periostracum, some staining, and slight encrustations. On the other hand there was no chalkiness and some internal lustre persisted. Sample was mixed with dead gas for counting. Date is based on one 3-day count in the 2 L counter.

GSC-3002. James Ross Bay — 8300 ± 300; $\delta^{13}C = +1.8‰$

Marine pelecypod shells (sample JRB-3-79; 7.1 g; **Hiatella arctica**; identified by J. England) from along the east bank of the James Ross River, 10 km south of its mouth in James Ross Bay, Ellesmere Island, Northwest Territories (82°44'N, 64°48'W). Collected at 66 m a.s.l. from the foreset beds of an expansive delta whose surface is at 78 m a.s.l. (England, 1983). Collected June 1979 by J. England.

Comment (J. England): This sample is considered to date the outer edge of the prominent 78 m delta. The local marine limit, approximately 4 km farther south, is at an elevation of at least 90 m and dates 9825 ± 460 BP (S-1984, England, 1983).

Comment (W. Blake, Jr.): The sample submitted was composed of whole valves and fragments. All these aragonitic shells were thin (<1 mm thick) and fragile; some had the ligament intact. A few valves were heavily iron stained or encrusted, but these were not used. The largest intact valves (a pair) measured 3.2 x 1.4 cm. Because of the small sample size, only the outer 10% was removed by HCl leach. Sample was mixed with dead gas for counting. Date is based on two 1-day counts in the 2 L counter.

Clements Markham Inlet Series

Driftwood samples from three sites along the inner south shore and inland of the head of Clements Markham Inlet, Ellesmere Island, Northwest Territories.

GSC-3031. Clements Markham Inlet (I) — 2180 ± 60; $\delta^{13}C = -25.1‰$

Wood (sample W-CMI-79-32; 11.3 g; **Picea** sp.; unpublished GSC Wood Identification Report No. 79-67 by L.D. Farley-Gill) imbedded in marine silt at an elevation of 5.5 m below a prominent ice-pushed ridge on a raised delta lip at 7 m a.s.l. The driftwood log was found along the inner south shore approximately 2.5 km east of the 'horizontal central point' in Clements Markham Inlet (NTS 120 F, 120 G; 1:250 000 map sheet) (82°39'N, 67°46'W). Collected July 1979 by T.G. Stewart, University of Alberta, Edmonton, Alberta.

GSC-2973. Clements Markham Inlet (II) — 4660 ± 60; $\delta^{13}C = -24.8‰$

Wood from a driftwood log (sample W-CMI-79-19; 11.6 g; **Larix** sp.; unpublished GSC Wood Identification Report No. 79-65 by L.D. Farley-Gill) lying on a well developed beach berm approximately 4 km southwest from the head of Clements Markham Inlet (along Clements Markham River) and approximately 1 km southeast into a small side valley (82°34'N, 68°43'W), at an elevation of 22.5 m. Collected July 1979 by T.G. Stewart.

GSC-2975. Clements Markham Inlet (III) — 7800 ± 80; $\delta^{13}C = -27.2‰$

Wood from a driftwood log (sample W-CMI-79-4; 11.3 g; **Picea** sp.; unpublished GSC Wood Identification Report No. 79-64 by L.D. Farley-Gill) found at an elevation of 72 m at the top of a gully eroded into Holocene marine silts which are draped against the bedrock valley wall. The collection site is 5 km south of the spit where the river draining Piper Pass enters Clements Markham Inlet. Collected July 1979 by J. Bednarski, University of Alberta, Edmonton, Alberta.

Comment (T.G. Stewart): These three samples form part of a suite of driftwood samples and associated radiocarbon dates used to infer Holocene sea-ice variations along northern Ellesmere Island (Stewart and England, 1983). Though GSC-2975 obviously had moved downslope from its original place of deposition, it was the highest, and thus oldest, driftwood found in 1979 and gave an estimate on the beginning of postglacial driftwood penetration into Clements Markham Inlet. This date has been superseded by S-2211, 8915 ± 115 BP (sample collected in 1981), which is currently the oldest dated Holocene driftwood from the Queen Elizabeth Islands. GSC-2973 is likely in its original stratigraphic position as another dated driftwood sample at a slightly lower elevation, 21 m a.s.l., dated 4215 ± 75 (SI-4763). GSC-3031 is slightly lower in elevation than a similarly dated sample from Clements Markham Inlet reported by Crary (1960; L-261B, 2190 ± 150 BP), but both samples are inferred to relate to the same relative sea level at 7 m.

Driftwood penetration into Clements Markham Inlet is controlled by the presence of multi-year landfast sea ice which presently blocks the inlet mouth and is removed only in the warmest summer seasons. Thus the elevational distribution of driftwood below the marine limit serves as proxy data for inferring ablation season warmth during the Holocene. Three periods of driftwood abundance and sparseness are recognized. Period 1 extends from initial driftwood entry approximately 8900 BP until 4200 BP. During this period driftwood penetration increased with the greatest abundance at 6000 to 4200 BP. During Period 2 (ca. 4200 to 500 BP) driftwood is sparse; it increases significantly in Period 3 (<500 BP). GSC-3031 and L-261B, as well as other dates at ca. 1000 BP, likely indicate climatic amelioration within Period 2 but the present driftwood data are not sufficient to closely define these. Blake (1972, 1975) has reported similar driftwood abundance periods.

Comment (W. Blake, Jr.): GSC-3031 was >27 cm long and measured 3.5 x 2.0 cm in cross-section. GSC-2973, a more weather-beaten piece, was 23.5 cm long and had a maximum diameter of 4.5 cm. GSC-2975, as received by the laboratory (cut) was 17.5 cm long and its maximum cross-section size was 6.0 x 3.5 cm; its surface was cracked and weathered buff. The outside wood was removed from all three samples by cutting and scraping. GSC-2975 and -3031 are each based on two 1-day counts; GSC-2973 is based on one 2-day count, all in the 5 L counter.

Alaska

GSC-3050. Usuktuk R. — 37 000 ± 990; $\delta^{13}C = -20.6‰$

Right horncore with partial frontal region (sample USGS M1422; 121.0 g) of a mature male saiga antelope (**Saiga tatarica** (L.); determined by C.A. Repenning, United States Geological Survey, Menlo Park, California) from a sand bar of Usuktuk River (sometimes spelled "Esuktuk"), Alaska (approximate coordinates: 69°58.4'N, 156°33'W). The site is 150 km south of Barrow at an elevation of approximately 48 to 61 m. Collected 1978 by D.C. Linck, U.S. National Park Service, Alaska Archeological Survey, Anchorage, Alaska; submitted by J.V. Matthews, Jr. via C.A. Repenning.

Comment (J.V. Matthews, Jr.): This age determination represents the first direct radiocarbon date on a North American saiga fossil. The date shows that saiga antelope occupied Alaska and probably other parts of east Beringia during the latter part of the mid-Wisconsinan Boutellier Interval as redefined in Hopkins (1982). Whether saiga also lived in east Beringia during the succeeding Duvanny Yar Interval (Hopkins, 1982), when climate peaked in severity, remains to be determined, but dates associated with saiga fossils in east Siberia suggest this possibility (Schweger et al., 1982). The dated specimen is mentioned in two recent reviews of Quaternary mammals (Harington, 1980, 1981), and its age is plotted along with those of other east Beringia ungulate fossils in Figure 2 of Matthews (1982).

Comment (C.R. Harington): The specimen is the ninth known from North America, and the second reported from the Arctic Slope of Alaska; it is not far from the locality of a metacarpal (USNM "RSFVL 75-30") from the bank of Kuk River (Harington, 1980). It appears to be deeply iron stained for a Late Wisconsin specimen, and may be older. With the specimens from Kuk River and Baillie Island, Northwest

Territories, it adds credence to a suggested late Pleistocene migration of saigas eastwards across Bering Isthmus to northwestern Canada along the Arctic Slope. In size, the specimen compares most closely with that from Gold Hill, Alaska (F:AM 30407).

Comment (W. Blake, Jr.): Because of the small sample size, the NaOH leach was omitted. The sample was treated with 3N HCl and distilled water rinses to recover the collagen; 12.9 g was burned and 45.3 cm of CO_2 was produced. Date is based on one 4-day count in the 5 L counter.

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* Two fractions dated of same sample.
** Same CO_2 counted in two counters.