Géographie physique et Quaternaire

A Sixteen Thousand Year Old Organic Deposit, Northern Baffin Island, N.W.T., Canada: Palynology and Significance

Un dépôt organique de 16 000 ans dans le nord de l'île de Baffin : palynologie et importance

Eine 16 000 Jahre alte organische Ablagerung im Norden der Baffin-lnsel, Nord-West-Territorien, Kanada: Palynologie und Bedeutung

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Volume 42, Number 1, 1988

URI: https://id.erudit.org/iderudit/032710ar
DOI: https://doi.org/10.7202/032710ar

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Publisher(s)

Les Presses de l'Université de Montréal

ISSN

0705-7199 (print)
1492-143X (digital)

Explore this journal

Cite this article

Short, S. K. & Andrews, J. T. (1988). A Sixteen Thousand Year Old Organic Deposit, Northern Baffin Island, N.W.T., Canada: Palynology and Significance. *Géographie physique et Quaternaire*, *42*(1), 75–82. https://doi.org/10.7202/032710ar

Article abstract

A 3 m exposure of sediment containing organics was sampled near the settlement of Arctic Bay, Baffin Island, N.W.T. A total of seven radiocarbon dates have been obtained from the deposit. Three dates between 182.5 and 290 cm depth gave radiocarbon ages between 14,185 ± 760 and 16,849 ± 860. A date from 82.5 to 87.5 cm resulted in an age of 8635 ± 565. An apparent reversal in 14C dates may reflect folding of the sediments associated with the downslope creep of the deposit or rapid accumulation of organics. The three basal dates are the first terrestrial sediments from Baffin Island to date from older than ca. 10,000 BP and less than 20,000 BP. Analysis of the sediment for pollen indicated that it is generally sparse. The pollen assemblage is dominated by Salix, Cyperaceae, and Gramineae pollen and exotic pollen types {Pinus, Picea, Betula, and Alnus) occur sporadically throughout the section.

Géographie physique et Quaternaire, 1988, vol. 42, nº 1, p. 75-82, 3 fig., 3 tabl.

A SIXTEEN THOUSAND YEAR OLD ORGANIC DEPOSIT, NORTHERN BAFFIN ISLAND, N.W.T., CANADA: PALYNOLOGY AND SIGNIFICANCE

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ABSTRACT A 3 m exposure of sediment containing organics was sampled near the settlement of Arctic Bay, Baffin Island, N.W.T. A total of seven radiocarbon dates have been obtained from the deposit. Three dates between 182.5 and 290 cm depth gave radiocarbon ages between 14,185 ± 760 and 16,849 ± 860. A date from 82.5 to 87.5 cm resulted in an age of 8635 ± 565. An apparent reversal in ^{14}C dates may reflect folding of the sediments associated with the downslope creep of the deposit or rapid accumulation of organics. The three basal dates are the first *terrestrial* sediments from Baffin Island to date from older than *ca.* 10,000 BP and less than 20,000 BP. Analysis of the sediment for pollen indicated that it is generally sparse. The pollen assemblage is dominated by *Salix*, Cyperaceae, and Gramineae pollen and exotic pollen types (*Pinus, Picea, Betula*, and *Alnus*) occur sporadically throughout the section.

RÉSUMÉ *Un dépôt organique de 16 000 ans dans le nord de l'île de Baffin: palynologie et importance*. Dans les Territoires du Nord-Ouest, près de la localité de Arctic Bay, dans l'île de Baffin, on a échantillonné une coupe de 3 m effectuée dans des sédiments renfermant des matériaux organiques. On en a tiré sept datations au radiocarbone. Entre 182,5 et 290 cm, trois datations font remonter les sédiments entre 14 185 ± 760 et 16 849 ± 860. Entre 82,5 et de 87,5 cm, la datation les fait remonter à 8635 ± 565. L'inversion apparente des dates au ^{14}C pourrait indiquer qu'un plissement des sédiments s'est associé au glissement du dépôt ou à l'accumulation rapide de sédiments organiques. Les trois datations effectuées à la base de la coupe représentent les premiers sédiments terrestres de l'île de Baffin à remonter avant 10 000 BP, soit entre 10 000 et 20 000 BP. L'analyse pollinique des sédiments a révélé que le pollen y est plutôt rare. L'assemblage pollinique est dominé par les pollens de *Salix*, de cyperacées et de graminés; quelques types de pollens exotiques (*Pinus, Picea, Betula*, et *Alnus*) apparaissent de façon sporadique dans toute la coupe.

ZUSAMMENFASSUNG *Eine 16 000 Jahre alte organische Ablagerung im Norden der Baffin-Insel, Nord-West-Territorien, Kanada: Palynologie und Bedeutung*. In der Nähe der Siedlung Arctic Bay, Baffin-Insel, Nord-West-Territorien, wurden Sediment-Proben, die Organisches Material enthalten, aus einem 3 m tiefen Schnitt entnommen. Insgesamt konnten sieben Radiokarbon-Daten aus dieser Ablagerung gewonnen werden. Zwischen 182.5 und 290 cm Tiefe ergaben drei Datierungen Radiokarbon-Alter zwischen 14 185 ± 760 und 16 849 ± 860. Zwischen 82,5 bis 87,5 cm führte die Datierung zu einem Alter von 8635 ± 565. Eine offenbare Umkehrung in den ^{14}C Datierungen mag wohl das Resultat einer Faltung der Sedimente sein in Verbindung mit einem Herunterrutschen der Ablagerung oder einer raschen Anhäufung organischen Materials. Die drei Datierungen von der Basis des Schnitts sind die ersten *Erd*-Sedimente von der Baffin-Insel, die als älter als *ca.* 10 000 v.u.Z. zu datierne sind und weniger als 20 000 v.u.Z. Die Analyse des Sediments in Bezug auf Pollen zeight, daß dieser im allgemeinen spärlich ist. Die Pollen-Ansammlung ist beherrscht von *Salix*-, Cyperaceae- und Gramineae-Pollen und exotische Pollen-Typen *(Pinus, Picea, Betula* und *Alnus)* finden sich sporadisch in dem Schnitt.

Manuscrit reçu le 6 janvier 1987; manuscrit révisé accepté le 9 juillet 1987

INTRODUCTION

Continuous accumulation of organic rich sediment since *ca.* 16,000 BP has preserved a pollen record of high arctic conditions and also provides a constraint on glacial reconstructions for the area. The sediment section is described, its significance discussed, and the first Late Pleistocene pollen diagram from the eastern Canadian Arctic is presented.

Over two decades of research in Arctic Canada has failed to uncover clear, unequivocal evidence for the maximum extent of glaciation during the Late Wisconsinan (late Foxe Glaciation in local Baffin Island terminology) Glaciation (Miller and Dyke, 1974; Dyke *et al.*, 1982; Nelson, 1982; Andrews and Miller, 1984). Several authors have noted that collections of marine shells from various marine and glacial marine facies, especially along the outer coast of eastern Baffin Island, either date from; 1) < 11,000 BP and most commonly less than 10,000 years; or 2) > 40,000 years (Pheasant and Andrews, 1973; Miller *et al.*, 1977; Mode, 1980; Brigham, 1983). This gap in the stratigraphic record has been used to argue for different histories of glaciation (Denton and Hughes, 1981; Andrews and Miller, 1984).

SITE DESCRIPTION AND BACKGROUND

In 1982, as part of a study on Holocene palynology of Arctic North America (Andrews *et al.*, 1981; Diaz and Andrews, 1982; Short and Jacobs, 1982; Short *et al.*, 1985), a field party flew to Arctic Bay, northern Baffin Island (Fig. 1) to sample a 5 m thick exposure, the middle of which had been sampled by G. Falconer in 1961 and dated to 9360 ± 120 (I-1315) (in Andrews and Drapier, 1967). The exposure (72°03′N, 85°02′W, 61 m asl) lies in a valley below King George V Mountain between Arctic and Victor bays. The deep trough of Admiralty Inlet lies 10 km due west and the site is flanked by two fiords that head into Admiralty Inlet (Adams Sound and Strathcona Sound).

Geologically the area is complex with a wide variety of sedimentary and volcanic rocks exposed along the fiords. The rocks range in age from Precambrian to Paleozoic and consist for the most part of sandstones, shales, limestones and dolostones (Thorsteinsson and Tozer, 1970). The dominant lithology around Adams Sound is quartz arenites with a small outcrop of Proterozoic limestone and dolostone occurring to the east of the outcrop.

STRATIGRAPHY, COLLECTIONS, PREPARATION AND RADIOCARBON DATES

The section consisted of 300 cm of sandy "peat" overlying 175 cm of sands and gravels (Table I). The word "peat" is used (*i.e.* Table I) because field observations indicate that the bulk of the section consists of an *in situ* sedge peat. The high inorganic content (Table II) is associated with the influx of sediment, as colluvium and eolian inputs, from the nearby slope. Permafrost was encountered at 60 cm from the present surface and the section sloped steeply below that point. Blocks of sediment were collected back to the permafrost face and transported back to the laboratory. Samples were then taken at 2.5 cm intervals to 150 cm, and at 5 cm from that depth to the base of the section. Modern moss and lichen polsters were collected from the area, including the present surface of the deposit.

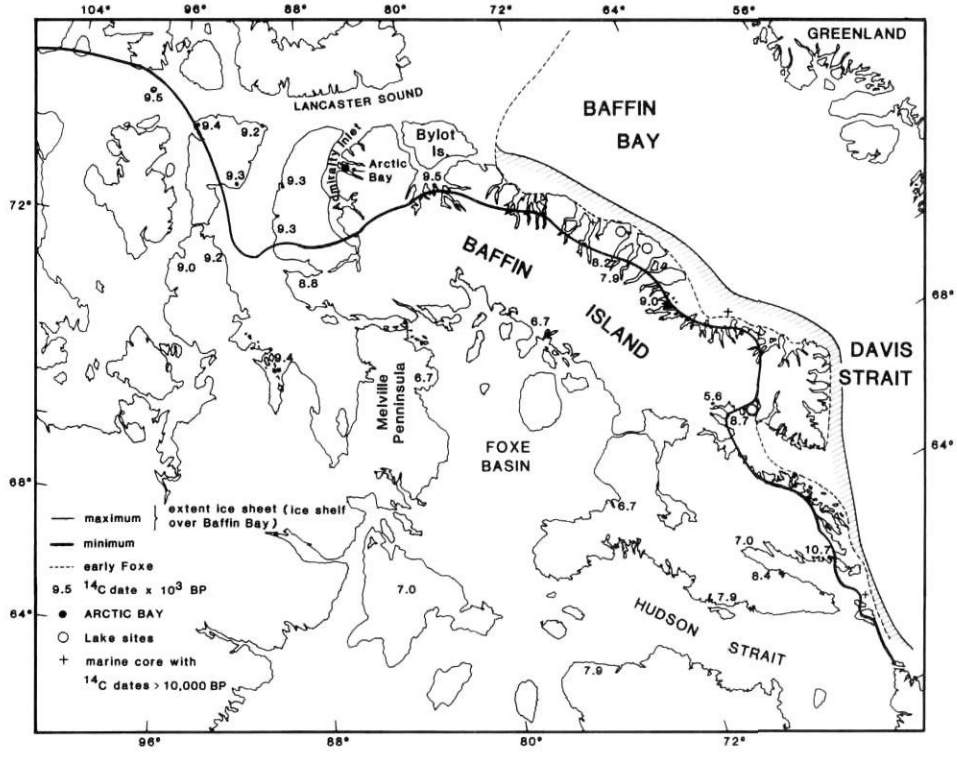

FIGURE 1. Location map showing the location of the Arctic Bay site and suggested Late Wisconsinan ice margins from different authors. *Maximum*: Denton and Hughes, 1981; *minimum*: Dyke, 1983; Andrews and Miller, 1984; Dykes, 1984; *early Foxe*: Klassen, 1982; Andrews and Miller, 1984.

Carte de localisation du site de Arctic Bay et des marges glaciaires proposées par différents auteurs. Limite maximale: *Denton et Hughes, 1981;* limite minimale: *Dyke, 1983; Andrews et Miller, 1984; Dykes, 1984;* limite du Foxe inférieur: *Klassen, 1982; Andrews et Miller, 1984.*

The radiocarbon dates from the Arctic Bay section are reported in Table II and plotted on Figure 2. Prior to submission, all samples were prepared in the INSTAAR Sedimentology Laboratory; organic carbon content ranged from 2 % to 20 %. There was no evidence of carbonate in the samples as the pH of the sediment was < 5.9. The 8635 ± 390 BP (GX-9302) date is from a similar level to that reported by Falconer (Andrews and Drapier, 1967) and thus confirms the early Holocene age for the middle peats. We have obtained three dates from between 182 and 290 cm; these range between 14,185 ± 760 (GX-9304) and 16,849 ± 860 BP (GX-9303), but the dates are in apparent reversed stratigraphic order. Note, however, that at the 95 % confidence level the three basal dates overlap. This may imply that the peat accumulated relatively rapidly (.04 cm/yr). The reversal, however, may represent the folding of the peaty sediments associated with the downslope creep of the deposit from the surrounding valley sides. No evidence for folding was noted although this theory cannot be entirely discounted.

POLLEN RESULTS

Pollen from the peat section was counted at 10 cm intervals. This interval represents approximately 500 years through the 5075 ± 210 BP (GX-9686) date, but in the upper 26 cm the sampling interval represents more than 2000 years. Six modern polsters from the area have also been analyzed. Standard chemical preparation techniques employed at the INSTAAR Palynological Laboratory for arctic sediments were used (Faegri and Iversen, 1975; Nichols, 1975), including caustic soda, acetolysis, and multiple hydrofluoric acid treatments; sodium pyrophosphate was tested on eight reprepared samples. Pollen preservation and density were generally poor. At least 100 grains (excluding the peat-former Cyperaceae [sedges and cottongrasses]) were counted for five of the top seven levels; subsequently, counts ranged as low as 5 grains for an entire slide. Eight samples, levels 0 through 70 cm, were reprepared for comparison with the original counts; except for one level (10 cm), pollen recovery was improved. Percentage values, however, did not generally change nor did diversity (*i.e.*, number of taxa). The pollen count data are summarized in Table III.

Two pollen diagrams were constructed. Because of problems in dating the Arctic Bay section, the pollen data were arranged in both stratigraphic (Fig. 3, Table III) and chronological order. The latter diagram was constructed by assuming that the radiocarbon dates are correct and then rearranging the intervening levels; little "squeezing" of levels had to be done. This scheme suggests a period of slow peat growth, with the accumulation of only 30 centimeters of peat in some 5000 years (levels 150 through 170 cm), between 8000 and 13,000 BP. The stratigraphic sequence will be presented here (Fig. 3); the two diagrams do not present significantly different vegetation histories, particularly in the middle and late Holocene. If the Arctic Bay section accumulated relatively rapidly in the late Pleistocene, as the overlap of the three basal dates suggests, the minor differences seen near the base of the section may not be of great significance. Out of 30 total taxa, the most important local pollen types, plus the four exotic pollen types, are included in the diagram. Mean pollen percentages for the six polsters are indicated on the top line.

Pollen densities are generally low in the modern samples, with 100-counts common. The spectra are dominated by *Salix*, Gramineae (grass family, and/or Filicales (ferns); exotic conifer pollen values are low. These data can be compared to the regional pollen rain of the Clyde region, 650 km to the southeast. *Salix* and Gramineae (*i.e.*, a High Arctic assemblage) dominated the pollen rain in the Clyde area and the latter reached

TABLE I

Stratigraphy, Arctic Bay organic section

0 – 3	Living surface (Gramineae, *Salix*, etc.)
3 – 30	Dark brown sedge and grass peat, high sand content, high rootlet concentration
30 – 110	Dark brown, fine-grained sedge peat
110 – 140	Medium reddish-brown, sandy, fibrous sedge peat
140 – 223	Dark brown, fine-grained sedge peat; pebbles at base
223 – 230	Fine tan sand with rootlets
230 – 240	Medium brown clayey peat with some sand
240 – 255	Coarse reddish-brown sandy, fibrous peat
255 – 260	Fine clayey peat
260 – 290	Coarse sand alternating with lenses of gravel and medium brown sedge peat
290 – 297	Coarse reddish sand
297	Angular gravels

TABLE II

Radiocarbon Dates, Arctic Bay Peat

Depth (cm)	Field No.	Sed Lab No.	Sample Dry WT.	Dated Sample WT.	% Organic Carbon	pH	Date	Radiocarbon Lab No.
0 – 4	AB-5	GRL-615-0	137.6	4.06 g	10.5	3.3	Recent	GX-9685
23 – 26	AB-4	GRL-616-0	50.3	.80	20.4	4.3	5075 ± 210	GX-9686
50 – 57.5	AB-8	GRL-710-0	—	3.16	—	—	6720 ± 390	GX-12852
82.5 – 87.5	AB-1	GRL-587-0	207.1	2.52	8.4	—	8635 ± 565	GX-9302
137.5 – 142.5	AB-7	—	—	—	—	—	7830 ± 230	GX-1029
182.5 – 187.5	AB-2	GRL-588-0	178.5	.63	2.5	—	16,849 ± 860	GX-9303
255 – 260	AB-6	GRL-670-0	161.9	.76	3.75	5.9	15,810 ± 490	GX-10628
280 – 290	AB-3	GRL-589-0	113.6	.54	4.3	—	14,185 ± 760	GX-9304

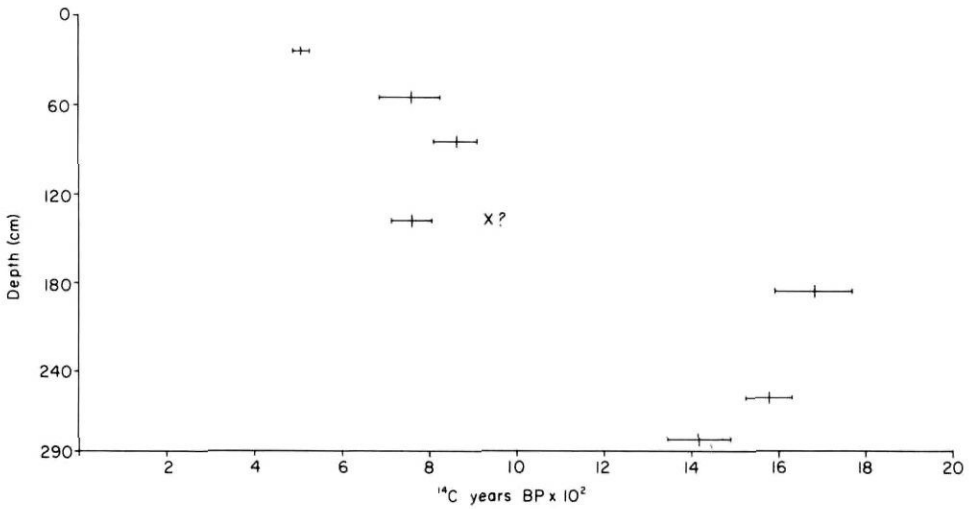

FIGURE 2. Age/depth curve, Arctic Bay peat. Error bars represent one standard deviation. X marks approximate location of Falconer's date.

Courbe âge/profondeur, tourbe de Arctic Bay. Les barres d'erreur représentent une déviation standard. Le x donne la localisation approximative de la date de Falconer.

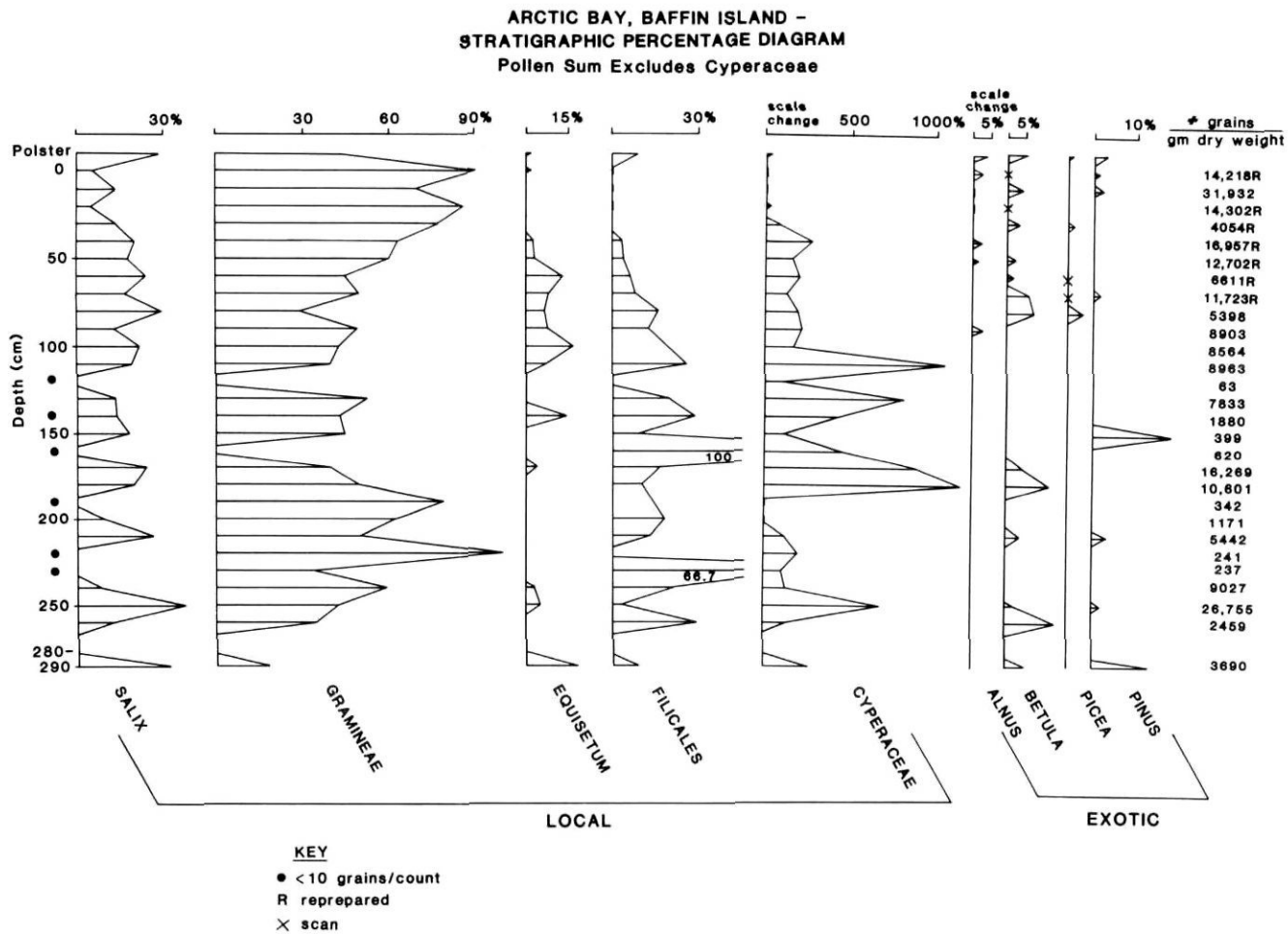

FIGURE 3. Percentage pollen diagram from the Arctic Bay peat site. Levels arranged in stratigraphic order. Includes the most important local pollen types plus the four exotic pollen types. Pollen concentration values (number of grains per gram dry weight) are listed to the right of the diagram. The five levels with less than 10 pollen grains are marked with a circle.

Diagramme pollinique en pourcentage du site de Arctic Bay. Les niveaux sont illustrés par ordre stratigraphique. Le diagramme comprend les types de pollen les plus importants et les quatre types de pollen exotique. Les valeurs de concentrations polliniques (nombre de grains par gramme de poids sec) sont données à la droite du diagramme. Les cinq niveaux ayant moins de 10 grains de pollen sont indiqués par un cercle.

TABLE III

Pollen Data Summary, Arctic Bay Peat

Depth	Count*	No. Traverses	No. Taxa	% Exotic	No. Grains/ gm Dry wt.	No. Exotic Grains/ gm Dry wt.
0 R	200	7.856	10	3	14,218	416
10	106	6.623**	10	4.7	31,932	1465
20 R	200	11.253	10	1	14,302	112
30 R	70	70.8	8	5.7	4,054	91
40 R	85	All***	12	2.3	16,957	110
50 R	101	All	12	6.9	12,702	161
58 R	104	53.45	10	2	6,611	40
70 R	67	All	9	6	11,723	272
80	31	All	9	9.7	5,398	176
90	40	All	11	2.5	8,903	70
100	46	All	7		8,564	
110	15	All	6		8,693	
120	1	18.496	1		63	
130	15	All	6		7,833	
140	7	All	5		1,880	
150	11	All	6	18	399	98
160	1	18.584	2		620	
170	25	All	8	4	16,269	66
180	10	All	7	10	10,601	85
190	5	All	3		342	
200	11	All	5		1,171	
210	30	All	7	6.7	5,442	164
220	1	18.58	2		241	
223-230	3	19.47	3		237	
235-240	37	All	7	2.7	9,027	107
250	61	All	11	3.3	26,755	114
260	17	All	7	11.8	2,459	129
280-290	22	All	8	18	3,690	189

* excluding Cyperaceae
** 40X count (all others are 16X counts)
*** Total number of traverses possible on 16X count = 35.4
R = repreparation

its percentage maximum along a north-south eastern Arctic transect (Mode, 1980; Short *et al.*, 1985). Pollen concentrations in the Clyde area, the lowest for that transect, are comparable to this study. The importance of Filicales in the Arctic Bay modern pollen rain was not observed in the Clyde area.

The fossil spectra are also dominated by local pollen types, primarily *Salix*, Gramineae, Filicales, and Cyperaceae. Gramineae percentages peak in the upper part of the diagram (Fig. 3) and reach a secondary maximum just above the base. *Salix* percentages fluctuate strongly with high peaks in the middle of the section. Large Cyperaceae percentages are recorded before *ca.* 6000 yr BP, contrasting with the low late Holocene and modern values for this group. Pollen concentration values vary widely, reflecting both the stratigraphy of the section (*i.e.*, low values are generally correlated with increased sand content) and the occasional accumulation of very large values of one pollen type. The values, however, are comparable to those reported by Miller *et al.* (1977, Table 9) for Holocene-age organic-rich sediments in the Clyde region to the southeast.

Exotic pollen influx is low (< than 200 grains/gm dry weight) and variable in the Arctic Bay section, especially between 14,000 and 7000 BP. *Betula* (birch), the most common exotic pollen type, presently grows as shrubs *ca.* 1000 km to the southeast and 800 km to the southwest (Porsild, 1964; Porsild and Cody, 1980). *Alnus* (alder), *Picea* (spruce), and *Pinus* (pine) pollen are rare in the section, although occasionally large percentages are registered due to low counts.

DISCUSSION

Preliminary pollen analyses of the Arctic Bay section indicate that the environment of the site has been characterized by a high arctic assemblage dominated by willow and grass. Increased accumulation of exotic birch and pine pollen in the late glacial suggests more frequent advective transport of these grains from southerly sources into an impoverished local vegetation. The sources for pine pollen are presumed to be located some 3400 km to the south or west in the northern United States. It has been suggested that dwarf birch

survived on coastal forelands (nunataks) of the eastern Canadian Arctic during the Late Wisconsinan glaciation (Short, 1978; Davis, 1980; Mode, 1980; Short *et al.*, 1985); this possible source of birch pollen is located approximately 1900 km southeast of the study site. Advection of birch pollen from the west (the Birch Zone of Alaska) may also be proposed as a more distant source.

The increase in sedge pollen between *ca.* 14,000 and 8000 BP suggests an increase in moisture availability at the site. This may indicate a rise in the permafrost level in the region or possibly a greater frequency of North Atlantic derived air masses.

The Arctic Bay sequence can be compared to other pollen records from eastern and southern Baffin Island which date close to this time period where higher-than-present exotic shrub and/or tree values are recorded between *ca.* 10,000 and 8700 yr BP (Miller *et al.*, 1977; Davis, 1980; Mode, 1980; Short *et al.*, 1985). The pollen record of the Devon Island ice core (McAndrews, 1984), 250 km to the northeast, also provides a comparative data set. The late Holocene and last interglacial assemblages are dominated by alder pollen and relatively high pollen concentrations, whereas the early Holocene and Wisconsinan assemblages are dominated by birch and sage (*Artemisia*) and much lower pollen concentrations. In contrast, alder is of little importance in the Arctic Bay site, in pollen samples from recent levels in the Penny Ice Cap (Short and Holdsworth, 1985), and in the modern pollen fallout for central and northern Baffin Island (Elliot-Fisk *et al.*, 1982). Similarly, sage is of little importance in the Arctic Bay section and the Penny Ice Cap. This suggests that different dominant air masses are responsible for the pollen fallout between Baffin Island and Devon Island. However, the importance of birch pollen in the early Holocene samples from Devon Island is similar to the Arctic Bay record, suggesting a closer and hence regional source for this pollen type.

Increased exotic pollen input is again noted after 7000 BP, reflecting the establishment of more continuous vegetation in Keewatin (Nichols, 1974, 1975) and Labrador-Ungava (Short, 1978; Lamb, 1980, 1985). Subsequently, exotic pollen grains are recorded in all levels. A secondary willow episode and minimum grass percentages characterize the pollen spectrum until 5000 BP; this episode may represent the local climatic optimum, a period of environmental stability in northwestern Baffin Island. Subsequently the decrease in sedge pollen and rise in grass pollen suggests a decrease in moisture, at least locally. This correlates with a mid-late Holocene trend to more severe conditions, marked by a change from a diverse, shrub-dominated assemblage to a more impoverished graminoid spectrum, observed in other Baffin Island sites (Miller *et al.*, 1977; Short *et al.*, 1985).

RELATIONSHIP TO LATE FOXE (WISCONSINAN) GLACIAL HISTORY

Figure 1 shows the location of Arctic Bay in relation to two different concepts of the extent and history of the northeastern Laurentide Ice Sheet (Denton and Hughes, 1981; Dyke, 1984). These two views have been succinctly called the "maximum" and "minimum" glacial reconstructions (Denton and Hughes, 1981; Dyke, 1983; Prest, 1984; Dyke, 1984). To the east of Arctic Bay, Klassen (1982, 1985) documents an early Foxe (Wisconsinan) glacial advance that overwhelmed much of Bylot Island and required massive glaciation of Lancaster Sound. However, during the late Foxe glaciation no "foreign" ice impinged on Bylot Island. The maximum extent of late Foxe Glaciation is delimited by a glacial-marine delta and ice contact features at Cape Hatt (Fig. 1) which are associated with a ^{14}C date of 9500 $\pm$ 180 BP (GSC-3318) (Klassen, 1982, 1985; Dyke, 1984). Hence, Klassen's work supports the "minimum" view. This pattern of ice margins and associated ^{14}C dates is dominant along the 1200 km outer coast of Baffin Island; glacial-marine deposits with ^{14}C dates of $>$ 40,000 BP (Miller *et al.*, 1977; Mode, 1980; Nelson, 1982; Brigham, 1983) are overlain at low elevations by early Holocene transgressive facies which are associated with dates of between 10,700 and 9500 BP (Miller, 1980).

In the minimum glacial model, the terrain between the inner moraines of Cockburn age (Falconer *et al.*, 1965; Andrews and Ives, 1978) and the outer early Foxe moraines (Miller and Dyke, 1974; Andrews and Miller, 1984) (Fig. 1) should contain some evidence for ice-free conditions between 10,000 and $<$ 40,000 BP. Attempts to core lakes in this terrain have provided useful Holocene pollen records (Davis, 1980; Mode, 1980), but the oldest sediment recovered has been about 9000 years old. However, only three lakes have been cored to date. Investigation of fiord sediment records within this zone (Fig. 1) have provided evidence, in the form of accelerator dates on *in situ* molluscs and on corrected organic fraction ^{14}C dates, that the outer reaches of several fiords were ice free during the last 12,000 years or more (Andrews *et al.*, 1985) (Fig. 1).

Modelling ice extent and ice history by glacial isostatic theory (Quinlan, 1981, 1985) favors a "minimum" ice margin, but in order to match observed sea level curves the ice sheet remains essentially unchanged between 18,000 and 8000-9000 BP when overall recession and thinning take place. Thus the location of the Arctic Bay section, and cores from selected fiords $\leq$ 14,000 BP, provide important constraints on the position of the late Foxe (Wisconsinan) ice sheet margin. Radiocarbon dates to the east and west of Arctic Bay (Fig. 1) (Dyke, 1983, 1984) record the entry of the early Holocene sea through Lancaster Sound. Dyke (1983, 1984) states that significant deglaciation occurred around 9500 BP. His map of the altitude of the 9300 BP shoreline along the northern margin of the Laurentide Ice Sheet suggests that sea level near Arctic Bay was 60-70 m above sea level. There is no indication in the stratigraphy of the section (located at *ca.* 80 m asl) that it lay below sea level at any time, thus supporting in a general sense Dyke's forecast.

CONCLUSION

The sedge-peat section at Arctic Bay, Baffin Island, indicates that the northeastern margin of the Laurentide Ice Sheet did not extend into Lancaster Sound, at least $\leq$ 16,000 years ago. Pollen data from the deposit suggest that between 12,000

and 16,000 BP there was a regional source for birch pollen. An early Holocene warm period, reported for several other sites in Baffin Island (Short *et al.*, 1985), is registered in the Arctic Bay peat. The mid-late Holocene change to more severe climatic conditions (Miller *et al.*, 1977; Short and Jacobs, 1982; Short *et al.*, 1985) is also supported by this record.

ACKNOWLEDGMENTS

This is a contribution to NSF grants DPP-82-08677 and EAR 84-09915. G. Falconer provided details about the site. E. J. Rowen assisted in the field. W. N. Mode has read and commented on the manuscript. The manuscript has benefited from comments by Dr. A. S. Dyke and an anonymous reviewer.

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