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Article abstract

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PALYNOLOGY OF SIX MIDDLE AND LATE HOLOCENE PEAT SECTIONS, BAFFIN ISLAND

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RÉSUMÉ *Palynologie de six tourbières de l'Holocène moyen et supérieur, île de Baffin.* Six sites localisés dans le nord de la péninsule de Cumberland ont fait l'objet d'analyses polliniques. Le présent article a pour objectif de combler le manque de données pollenanalytiques dans le haut Arctique canadien. Les auteurs présentent douze diagrammes polliniques, qui indiquent que le dépôt pollinique du dernier millénaire a été dominé par le groupe des Graminées. Cette situation est bien différente de celle qui prévaut dans les assemblages polliniques plus anciens qui, entre 2500 et 2000 ans et entre 5000 et 4000 ans BP, sont caractérisés par une plus grande diversité et comprennent des quantités appréciables de pollen d'Éricacées et d'arbustes (saules). Un pic prononcé du pollen de saule apparaît sur les diagrammes vers 2500 BP.

ABSTRACT Palynological investigations were undertaken at six sites on the northern Cumberland Peninsula, Baffin Island. Pollen assemblages from the Canadian High Arctic are rare, and the purpose of this paper is to expand this record. Twelve pollen diagrams from the six sites are presented. They suggest that over the last 1000 years, the pollen rain has been dominated by pollen of the graminoid group. This contrasts with earlier pollen assemblages between 2500 and 2000 years BP and between 5000 and 4000 BP which were typically more diverse and included significant quantities of heath and shrub (willow) pollen. A pronounced willow peak is evident on the diagrams and dates from *ca.* 2500 BP.

ZUSAMMENFASSUNG *Palynologie von sechs Mittel- und Spätholozän Torfmoorschnitten, Baffin Insel.* Palynologische Forschungen wurden an sechs Stellen auf der nördlichen Cumberland Halbinsel, Baffin Insel, vorgenommen. Pollenansammlungen aus der kanadischen Polargegend sind selten und der Zweck dieser Forschungsarbeit ist, diese Aufzeichnungen zu erweitern. Zwölf Pollendiagramme der sechs Stellen werden vorgelegt. Sie zeigen, dass in den letzten 1000 Jahren, die Ablagerungen von Pollen aus der Gräsergruppe vorherrschen. Das kontrastiert mit früheren Pollenansammlungen zwischen 2500 und 2000 Jahren v. u. Z. und zwischen 5000 und 4000 v. u. Z., welche in typischer Weise mannigfaltiger waren und bedeutsame Quantitäten von Heide- und Busch (Weide) pollen enthielten. Ein ausgeprägter Weiden-Höhepunkt ist offensichtlich in den Diagammen und Daten von *ca* 2500 v. u. z..

INTRODUCTION

Pollen assemblages from high arctic environments in Canada are rare (Fig. 1). HEGG (1963) has published a diagram from Axel Heiberg Island, and Janovska and BLISS (1977) have reported on a diagram from Devon Island. NICHOLS (1975), BOULTON *et al.* (1976) and ANDREWS *et al.* (1979) have described peat profiles from Cumberland Peninsula, Baffin Island, and finally, BARTLEY and MATTHEWS (1969) and TERASMAE *et al.* (1966) have presented a series of pollen spectra from northern Ungava. All these profiles extend back to about 2500 BP with the northern Ungava record extending the record back to around 4000 BP. There is thus a paucity of basic data with which we can assess the Holocene changes of pollen accumulation over a complex mosaic of tundra. It is for this reason that we present our data from six short terrestrial sections, originally collected only for ^{14}C dating as part of glacial geological studies, from sites along the northern coast of Cumberland Peninsula, Baffin Island (Fig. 1 and 2). Our data will add to a sparse body of extant knowledge and will be valuable for assessing changes in pollen accumulation and assemblages in a series of buried peats and soils that extend back to the last interglacial and even older Pleistocene interglacials (*cf.* TERASMAE *et al.*, 1966; MILLER, ANDREWS, and SHORT, 1977). Similar sediments have been recently collected from the cliff sections northeast of Kivitoo, northern Cumberland Peninsula (NELSON, 1978).

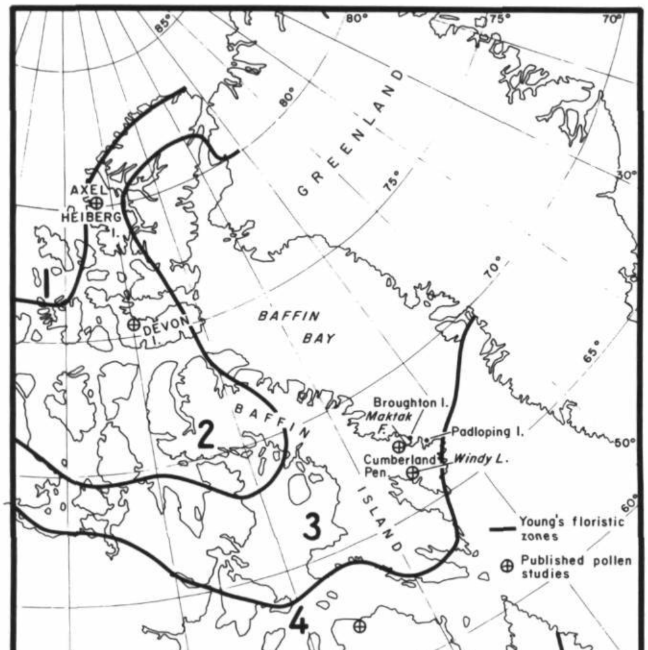

FIGURE 1. Location map of published pollen studies referred to in text and Young's floristic zones for the Eastern Canadian Arctic.

Cartes de localisation des sites étudiés dont les résultats sont déjà publiés et auxquels nous faisons référence, et les zones floristiques de l'est de l'Arctique canadien selon Young.

BACKGROUND

Northern Cumberland Peninsula is a typical fiord coast. The fiords cut through the highlands and continue inland as deep glaciated valleys. Elevations reach a maximum of about 1800 m a.s.l. near the fiord heads, whereas, the fiord dephts are ≤ 400 m.

The area has had a long and complex glacial history. This history as currently understood is summarized by NELSON (1978) and DYKE (1977). It is important to note that during the late Foxe (Wisconsin) glacial maximum, glacier termini lay well inland of the outermost coast and thus extensive areas around the fiord mouths were ice free. It is even probable that parts of the continental shelf were dry land (ANDREWS, 1975). The Holocene history is summarized by MILLER (1973), DYKE (1977) and DAVIS (1980) who described evidence for a local

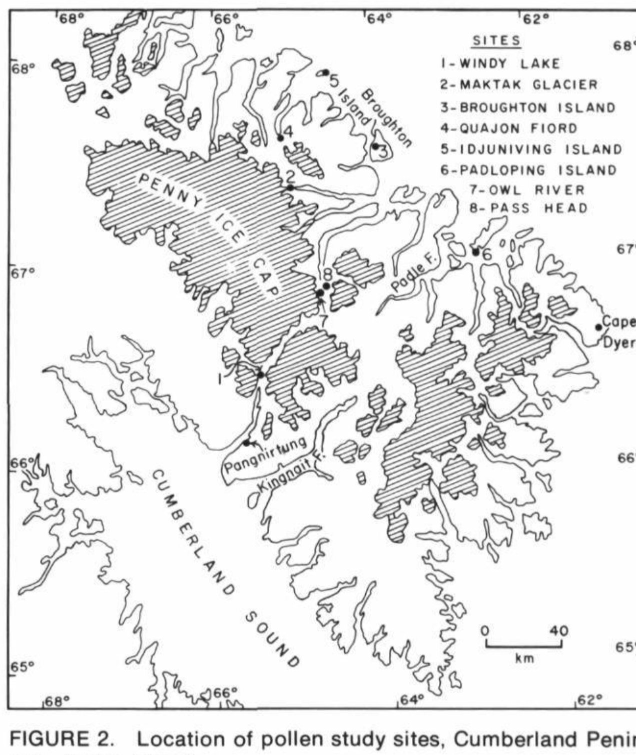

FIGURE 2. Location of pollen study sites, Cumberland Peninsula, Baffin Island.

Carte de localisation des sites de recherches palynologiques, péninsule de Cumberland, île de Baffin.

thermal optimum from about 8000 to 5000 (?) BP which was followed by a series of climatic fluctuations evidenced by the fluctuations of the margins of small cirque glaciers as well as the larger outlet glaciers (*cf.* BOULTON *et al.*, 1976).

CLIMATE

The climate of northern Cumberland Peninsula is middle to high arctic in character. The annual average temperature at the DEW Line site on Broughton Island is −11°C (Table I). Summers are cool and precipitation is low. The number of growing degree days (see Table I) is only 22. Fogs are common in the summer and these are trapped beneath the regional inversion that is a common feature of the coast up to an altitude of about 500 m.

There is a significant climatic gradient from the outer coast to the fiord heads some 50 km inland (Fig. 2). The extent of this gradient is not known but preliminary climatic data suggests that summer temperatures may average 1 to 3°C *warmer* at the fiord heads than on the outer coast.

VEGETATION

A valid and useful way of comparing the northern polar flora has been proposed by YOUNG (1971). He divides the tundra into four floristic zones (Fig. 1) and characterizes each by a climatic parameter *a*, the sum of the average summer monthly temperatures >0°C. The value of *a* for Broughton Island (Table I) is 10.5 which places the site within Young's zone 2, an area traditionally called high arctic (YOUNG, 1971, p. 91). However, because the weather station at Broughton is at 581 m a.s.l., the coastal lowlands and fiord heads would be somewhat warmer in summer and would probably classify as zone 3, an area transitional between high and low arctic tundra.

Although it is common to subdivide the arctic latitudinally (Fig. 1), the same general effect occurs during a vertical transect. SCHWARZENBACH (1975) was the first to delimit a series of floristic zones in the center of Cumberland Peninsula based on the altitudinal limits of the flora.

The inventory of the flora of northern Cumberland Peninsula is incomplete. The distribution of *Betula* (birch) is important for this study. *Betula nana* and *Betula glandulosa* both occur on Cumberland Peninsula, but as restricted outliers. The main concentration of *Betula* covers a few square kilometers in the low pass between Padle Fiord and Kingnait Fiord (see Fig. 2) (SCHWARZENBACH, 1975). However, small outliers covering a few square meters occur on the large island 30 km south of Broughton Island and at the head of an adjacent fiord. These outliers occur in sheltered, southfacing sites. LAFARGE (1975) collected 86 vascular plants between Maktak Fiord and Broughton Island, and this total has subsequently been enlarged (K. HON, personnal communication, 1975). The largest number of species belong to the Gramineae (grass) family (12) followed by Cyperaceae (sedge) (9), and Ericaceae (heaths) (9).

TABLE I

Temperature and precipitation data from Broughton Island and Padloping Island, N.W.T., Canada

	Broughton Island	Padloping Island
Elevation (m)	581	
Period of record	1959-1969	
Mean June temperature (°C)	− 0.6	
Mean July temperature (°C)	5.0	
Mean August temperature (°C)	3.6	
Mean September temperature (°C)	− 1.9	
Mean summer temperature (°C) (June, July, August)	2.6	
Mean annual temperature (°C)	−11.0	
Growing Degree Days*	22	
Mean May precipitation (cm)	3.1	T]
Mean June precipitation	3.1	.6
Mean July precipitation	7.17	1.93
Mean August precipitation (cm)	2.24	.89
Summer precipitation (cm) (May, June, July, August)	9.61	2.88
Mean total annual precipitation (cm)	30.5	22.3
Young's (1971) summer index a**	10.5	
Young's zone	2	

* The sum of daily average temperatures above 5°C

** The sum of mean monthly temperatures above 0°C

T = Trace

POLLEN PREPARATION AND COUNTING

The chemical treatment of the samples was conventional (FAEGRI and IVERSEN, 1975) and included sieving (250 mm screen) to remove coarse organics, caustic soda, acetolysis, and hydrofluoric acid, with prolonged boiling times; the reaction times were increased to allow for the reduced boiling point at the altitude of the laboratory and the intractability of arctic peats (*cf.* NICHOLS, 1975). Pollen concentration was calculated using the dry weight method (JØRGENSEN, 1967); the STOCKMARR (1971) exotic additive method was also employed with the sediments from Padloping, Pass Head, and Owl River. Pollen taxa were identified using the INSTAAR reference collection. The Ericaceae group may include members of the Ericaceae, Empetraceae, and Pyrolaceae.

Two types of pollen diagrams were prepared: 1) the conventional relative percentage diagram and 2) a pollen concentration ("absolute") diagram based on the dry weight of samples. For Baffin Island pollen samples, a standard count of 100 grains, excluding local over-representative peat forming taxa (Cyperaceae, Ericaceae, and *Sphagnum),* give statistically reliable pollen estimates (NICHOLS, 1975, p. 54; ANDREWS *et al.*, 1980: Tables 2 and 3). This total is smaller than the usual standard count for this laboratory (300 grains) because of the sparseness of the pollen in the intractable sediment and because local pollen production is derived from a very few plant taxa. Commonly, a count of a whole slide will total less than 100 grains, and it is necessary to scan additional slides to increase the values of exotic taxa, especially *Picea* (spruce) and *Pinus* (pine), to statistically reliable totals related to "absolute" values. These scan values for spruce and pine are included in the pollen concentration diagrams, and labeled either *Picea*/Scan *Picea* or *Pinus*/Scan *Pinus.* Data reduction is largely handled by computer programs (ECCLES *et al.*, 1979). ANDREWS *et al.* (1979) describe the application of life form and diversity measures to an arctic pollen diagram; we also use a similar approach (Table III). The diversity measure we use here is Simpson's diversity defined by:

$$S_i = \frac{N\,(N-1)}{\sum\,(n_i\,(n_i-1))}$$

where N is the total number of pollen grains and n_i is the number of grains in the i^{th} taxon. This formula has a lower limit of one and is a measure of the dominance of a pollen sampling interval by a single taxa (when $S_i = 1$).

SITE DESCRIPTIONS AND PALYNOLOGY

Padloping Island:

23.5 cm of organic-rich sediment overlying 10 to 20 centimeters of pebbly sand which in turn lies on bedrock was sampled by G. H. MILLER in 1973. The section is located about 1.5 m above high tide, and is being eroded by high storm tides. A basal date of 2570 ± 75 BP (20-23.5 cm) (SI-2555) (Table 2) is similar to basal dates from several sites throughout the Canadian Arctic (BARTLEY and MATTHEWS, 1969; NICHOLS, 1969) which record the beginning of peat growth. The basal date from the nearby Maktak peat monolith (BOULTON *et al.*, 1976: Figure 2) is also similar (2500 ± 170 BP, Birm-380). The second radiocarbon date from this section, at 8-9 cm, is 250 ± 40 BP (SI-2734); the date was obtained on the $< 125\mu$ fraction which we have found to give the most consistent dates (STUCKENRATH *et al.*, 1979). However, in such shallow sections, the risk of contamination from percolating ground water and/or from fine rootlets is nevertheless possible. Thus the latter date may be too young.

Figure 3 presents the relative (percentage) and pollen concentration (grains/gg dry weight) diagrams. The relative spectrum is dominated by Gramineae pollen with significant and varying amounts of Ericaceae, Caryophyllaceae (pinks), *Salix* (willow), and Cyperaceae pollen. Long-distance exotic pollen — *Alnus* (alder), *Betula, Picea*, and *Pinus* — occur in small percentages. *Betula*, however, is noted only at five levels, and is assumed to be from the dwarf birch populations that occur on Cumberland Peninsula. This result is of interest as *Betula* lives only 30 km south of this site (Figure 2).

Pollen concentration values are generally high at this site, and Gramineae is the dominant taxa. The maximum pollen accumulation is 884×10^3 grains/gg dry weight (g/gdw) at 8 cm, and throughout the section, values range between 10^4 and 10^5 g/gdw. During the growth of the basal peat, the pollen assemblage is characterized by a heath/grass/sedge spectrum which was succeeded *ca.* 2000 BP by a grass/heath/willow assemblage. A short episode with high values of *Salix* pollen occurs between 16 and 18 cm (1800-2000 BP), followed by a grass/sedge assemblage up to 6-8 cm (*ca.* 800 BP). This is followed by a spectrum dominated by grasses and pinks. These data are summarized in Figure 9; two time models are illustrated in this diagram, one based on a linear extrapolation from the basal date using a sedimentation rate of 0.91 cm/100 years (I) and the other based on both ^{14}C dates (II). In summary, the pollen spectra can be subdivided into five zones that indicate a progressive decline in the diversity of the pollen taxa (Table III) and the establishment of a pollen assemblage dominated by grass.

The interpretation of the sequence at Padloping is complicated by its nearness to sea level (Fig. 3). It is known that a marine transgression has occurred over the last 1000 years and that 2500 years ago sea level was probably below present (PHEASANT and ANDREWS, 1973). However, the increasing tendency toward a grass and herb dominated assemblage is not easily explained by sea level variations. An initial favorable period for a relatively diverse high arctic to transitional flora is indicated. This was followed by increasingly mesic conditions, due either to climate or the effect of a build-up of an organic mat over the pebbly substrate, in which grass became dominant but with a significant increase in willow pollen accumulation. During this time (from 23.5 to 16 or 18 cm), small amounts of spruce and pine pollen were entering the area. The major change toward a less diverse pollen assemblage occurs at 12 cm, and the most depauperate assemblage is seen in the upper 3 cm of the section.

BROUGHTON ISLAND

This site lies close to the village of Broughton Island and was sampled from a peat hummock on a low, marshy plain floored by sands. The shallow (20 cm) section consisted of eight centimeters of reddish brown humified peat below twelve centimeters of spongy, unhumified peat. The lower section dates from between 680 ± 90 BP (18-20 cm) and 160 ± 80 BP (12-14 cm) (Table II). The upper fifteen centimeters were analyzed for pollen; samples were processed at 2.5 cm intervals.

The relative pollen spectra (Fig. 4a) is dominated by *Salix* with smaller Gramineae peaks at 7.5 cm and 15 cm. Cyperaceae values are high in the upper half of the diagram after a peak of 1600% at 7.5 cm. Exotic pollen taxa are represented throughout the diagram, but contribute most significantly at the 15– and 5–cm levels.

Pollen concentration is highest in the basal pollen sample (144 x 10^3 g/gdw), and then drops off to low values at 12.5 cm at the unconformity in the peat. With the initiation of new peat growth, pollen accumulation rose slowly to 58 x 10^3 g/gdw (*Salix* = 56 x 10^3 g/gdw) for the surface sample. Exotic "absolute" values peak at 15 cm, 12.5 cm, and 5 cm.

Table III lists the pollen grouped into life-form and moisture preference classes. This records a three-part sequence from mesic (15-10 cm), wet (7.5-2.5 cm), to mesic conditions at the surface. This sequence is paralleled by high shrub pollen percentages in the lowermost and surface samples and by high graminoid counts in the middle (Fig. 9).

IDJUNIVING ISLAND

The Idjuniving Island peat section is exposed in a wave-cut bluff and overlies a Dorset Eskimo site. There has been considerable difficulty in getting a series of ^{14}C dates from this section (Table II); however, the Dorset occupation of the eastern Canadian Arctic which dates between about 2800 and 1000 BP limits the age of this section. Thus, we suggest that the date of 1205 ± 120 BP from 15-18 cm is probably correct. However, the depth of the organic-rich sediment is laterally variable and erosion is causing cliff retreat at this site, thus the date of 850 ± 75 BP from 30-36 cm cannot be easily associated with the original monolith. The date of "modern" from 3-4.2 cm may equally well be 100 or more years old.

The upper ten centimeters of the section were analyzed for pollen and the pollen spectra (Fig. 5) indicated

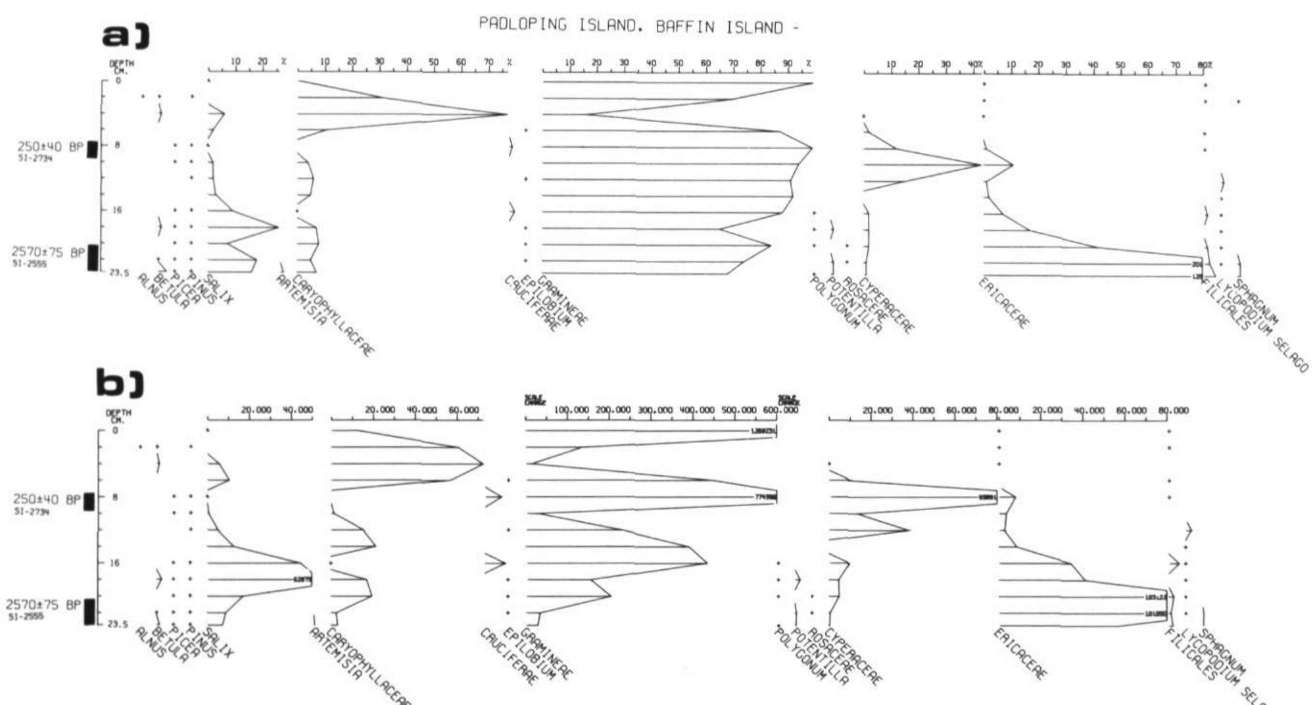

FIGURE 3. Padloping Island. a) Relative data (AP + NAP = 100, excluding Cyperaceae, Ericaceae, and *Sphagnum)* b) Pollen concentration data (numbers per gram oven-dry weight.

Île Padloping. a) Données exprimées en pourcentage pollinique (PA + PNA = 100, en excluant Cyperaceae, Ericaceae et Sphagnum). b) Données exprimées en concentration pollinique (nombre de grains par gramme en poids sec).

TABLE II

Radiocarbon dates and rates of sedimentation on "peats" from sites on Cumberland Peninsula, Baffin Island, N.W.T. (Location on Fig. 2)

Depth (cm)	^{14}C date	Lab no.	Material
Broughton Island			
12-14 cm	160± 80 BP	GaK-3097	>125μ
18-20 cm	680± 90 BP	GaK-3098	>125μ
Idjuniving Island			
3-4.2 cm	"modern"	DIC-331	>125μ
15-18 cm	1205± 120 cm	GaK-1812	>125μ
23-26.5 cm	"modern"	GaK-1681	charcoal
30-35 cm	950± 75 BP	DIC-401	>125μ
Quajon Fiord			
4-7 cm	730± 70 BP	GaK-2792	total organic
11.5-13 cm	1670± 90 BP	GaK-2575	total organic
Padloping Island			
7.5 to 9.5 cm	250± 40 BP	SI-2734	<125μ (average of insoluble
20.5-23.5 cm	2570± 75 BP	SI-2555	>125μ and soluble NaOH treated samples.)
Pass Head Peat			
38-46 cm	3765± 75 BP	SI-2069	<125μ (NaOH insoluble)
95-100 cm	5980± 95 cm	SI-2070	<125μ (NaOH insoluble)
Owl River			
155-160 cm	1870± 90 BP	GIF-3493	>125μ
176-178 cm	2830± 235 BP	DIC-648	>125μ
280-282 cm	2730±1290 BP	DIC-649	>125μ
289-294 cm	2660± 100 BP	GIF-3493	>125μ

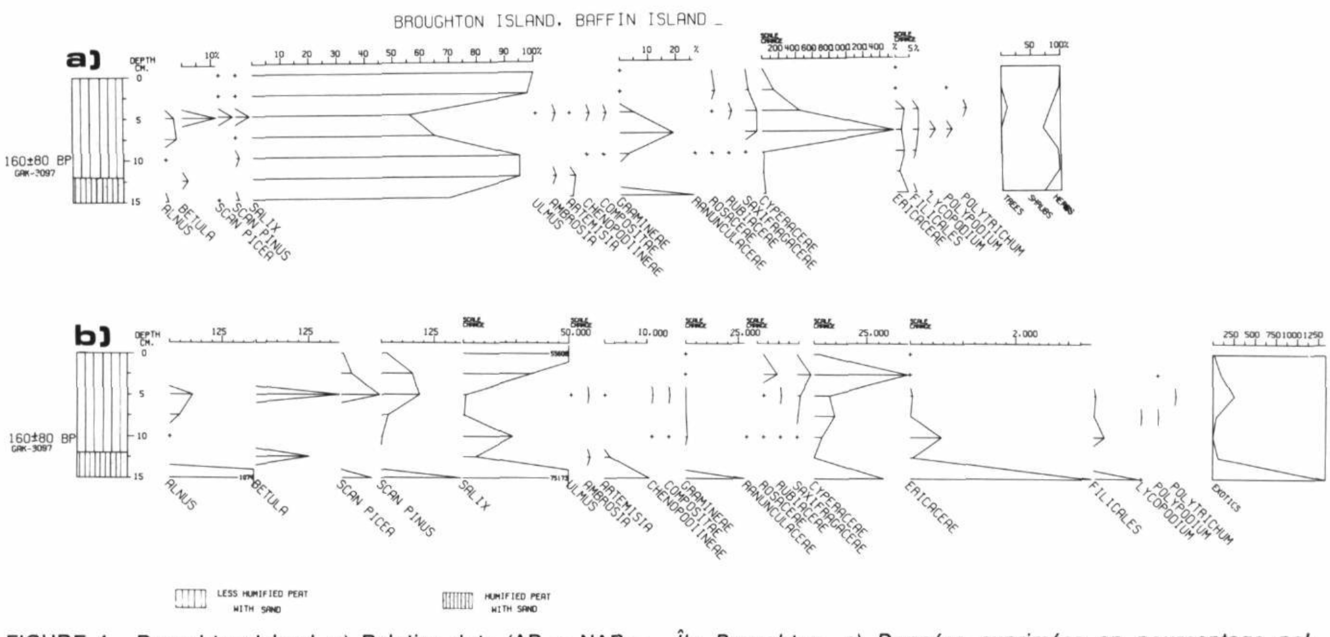

FIGURE 4. Broughton Island. a) Relative data (AP + NAP = 100, excluding Cyperaceae and Ericaceae). b) Pollen Concentration data (numbers per gram ovendry weight).

Île Broughton. a) Données exprimées en pourcentage pollinique (PA + PNA = 100, en excluant Cyperaceae et Ericaceae). b) Données exprimées en concentration pollinique (nombre de grains par gramme en poids sec).

that Gramineae is the dominant taxa; in addition, there are significant numbers of Caryophyllaceae and *Salix* pollen, *Picea* and *Pinus* are consistently present in low numbers, but *Alnus* pollen was observed at only two levels (5 cm and 10 cm) and *Betula* was counted at only one level (5 cm, second preparation). These data are summarized in Table III which records a four-part sequence from a willow (one level only) to willow/grass through a grass/sedge/herb to a grass/willow assemblage at the top of the section.

QUAJON FIORD

In 1969, D. R. Pheasant sampled a shallow depression, interpreted as representing an ephemeral lake basin, at the head of Quajon Fiord for peat and collected at 13-cm thick silty organic-rich monolith. The basal date of 1670 ± 70 BP (11-13 cm) and a date of 730 ± 70 BP (4-7 cm) suggest that peat growth at this site was uniform, averaging 0.72 cm/100 years. The basal date is similar to that of 1600 BP from Saglouc on the northwestern Ungava coast (BARTLEY and MATTHEWS, 1969) which marked the initiation of widespread peat growth in that area. Ten centimeters of peat was analyzed for pollen and covers about 1400 years; samples were taken every 1 cm.

The relative diagram (Fig. 6a) can be divided into two main zones. From 10-6 cm, a willow/grass or willow/sedge spectra dominates; this is succeeded by a decline

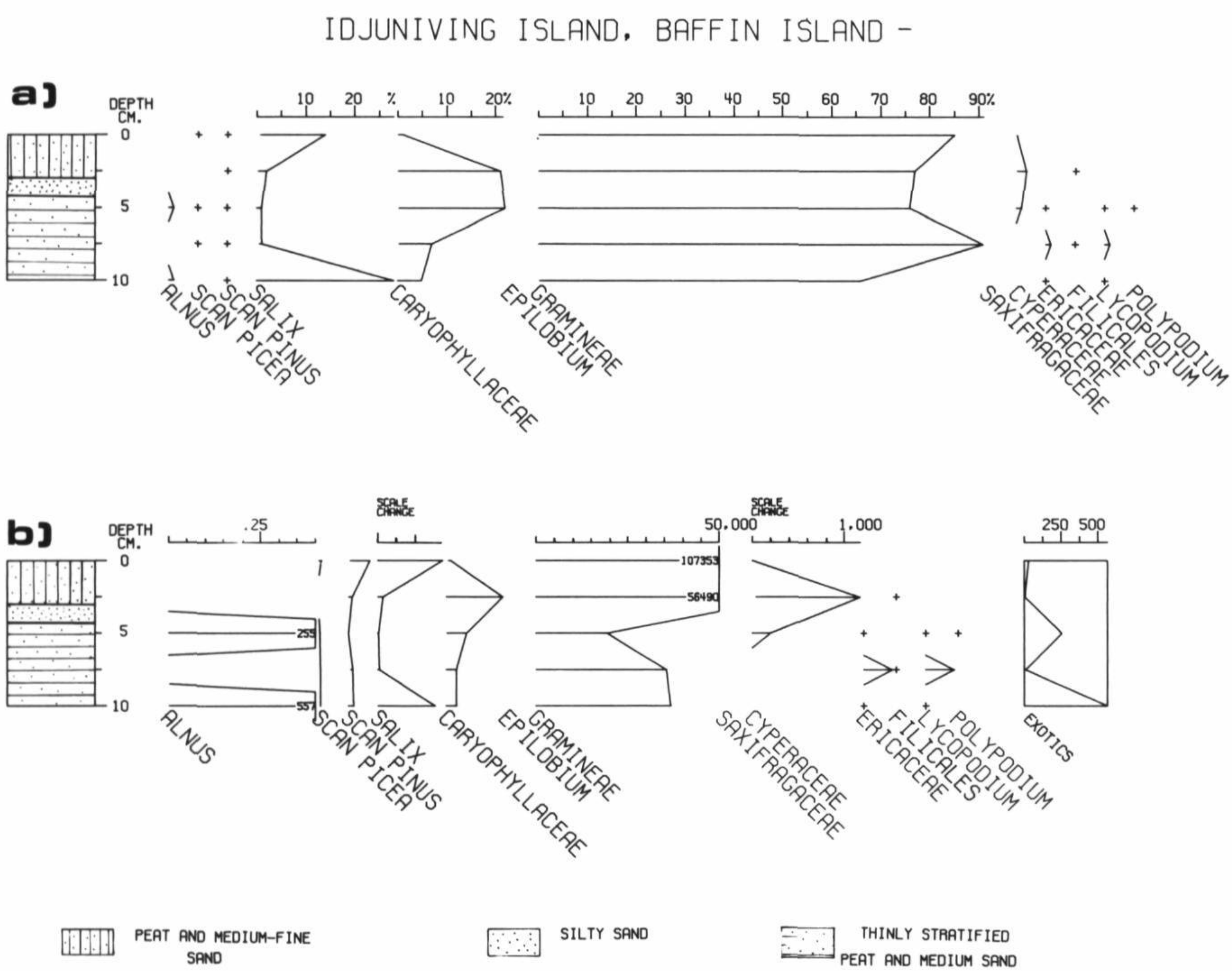

FIGURE 5. Idjuniving Island. a) Relative data (AP + NAP = 100, excluding Cyperaceae and Ericaceae). b) Pollen concentration data (numbers per gram oven-dry weight).

Île Idjuniving. a) Données exprimées en pourcentage pollinique (PA + PNA = 100, en excluant Cyperaceae et Ericaceae). b) Données exprimées en concentration pollinique (nombre de grains par gramme en poids sec).

TABLE III

Life-form, moisture preference, Simpson's diversity (S_i) and pollen accumulation, (grains/dr, dry weight) for the six pollen profiles

Site	Total pollen	% trees	% shrubs	% herbs	% grasses	% exotics	% hydric	% mesic	% xerix	Simpson's diversity index
Padloping										
0 cm	1,282,052	0	0	1.0	99.0	0	0	99.0	1.0	1.02
2	195,435	0	0	31.0	69.0	T*	0	64.0	31.0	1.75
4	93,956	0	7.0	77.0	16.0	0	0	23.0	77.0	1.60
6	525,384	0	2.0	10.8	87.3	0	0	89.2	10.8	1.21
8	884,138	0	.9	.9	98.2	T	0	98.2	1.8	1.036
10	47,134	0	8.4	2.6	89.0	T	0	90.3	9.7	1.251
12	294,319	0	2.6	5.2	91.4	T	0	93.1	6.9	1.193
14	434,679	0	4.9	4.9	90.2	0	0	93.1	6.9	1.22
16	540,246	0	14.7	1.8	82.6	0	0	90.8	9.2	1.42
18	287,773	0	37.0	6.7	56.3	T	0	79.0	21.0	2.18
20	353,565	0	34.0	5.6	59.7	T	0	64.6	35.4	2.10
22	152,329	0	72.3	2.0	24.8	T	.3	30.7	69.0	1.71
23,5	103,680	0	63.4	4.0	30.4	T	.4	38.8	60.3	2.01
Broughton Is.										
0 cm	58,407	0	95.2	0	4.8	0	4.8	95.2	0	1.1
2.5	77,709	.1	41.6	.8	57.4	.1	57.4	42.5	0	1.99
5	8,843	2.6	13.4	1.4	82.1	3.1	81.1	14.8	1.0	1.44
7.5	10,345	.4	4.0	.2	95.0	.5	93.9	5.2	.3	1.11
10	28,875	0	83.8	0	15.4	0	12.8	83.8	3.4	1.38
12.5	6,544	0	94.2	2.9	2.9	1.0	2.9	93.3	2.9	1.124
15	144,165	.9	55.1	.7	42.5	.9	23.1	71.5	4.5	2.065
Idjuniving Is.										
0 cm	178,403	0	10.5	3.0	86.5	0	0	97.0	3.0	1.32
2.5	75,094	0	1.9	30.3	67.8	0	1.0	68.7	30.3	1.81
5	27,108	0	1.9	25.6	72.5	.9	.9	72.5	25.6	1.69
7,5	41,459	0	2.5	9.8	86.7	.6	.6	83.0	10.8	1.31
10	57,323	0	28.2	7.2	64.6	1.0	.4	91.4	7.2	1.99
Quajon Fiord										
0 cm	27,040	.6	2.1	.3	96.7	.6	.6	98.4	.4	1.07
1	59,415	0.0	.6	0	99.4	.1	.2	98.8	.9	1.01
2	3,665	1.3	5.2	0	90.5	1.3	4.6	90	4.1	1.22
3	7,253	1.4	3.5	.7	94.0	1.8	1.1	94.1	3.0	1.13
5	771	19.2	34.6	3.9	26.8	19.2	3.9	49.9	27.0	4.09
6	8,694	.8	22.0	1.3	74.9	1.3	2.6	90.8	5.4	1.64
7	19,255	0.0	24.9	2.4	71.8	2.4	.5	76.1	21.0	1.73
8	14,191	0.0	46.8	1.2	52.0	1.2	4.6	79.8	14.5	2.04
9	2,911	0.0	46.8	0	52.6	0	0	89.0	11.0	2.02
10	1,554	.1	21.3	.9	77.2	1.0	1.4	72.1	25.4	1.56
Pass Head										
67 cm	72,661	1.4	81.4	2	14.6	1.4	9.9	62.9	25.8	1.460
68	74,105	.1	65.0	0	34.2	.1	18.9	69.2	11.9	1.853
69	91,939	0	73.5	0	24.8	0	11.1	83.7	5.1	1.662
70	29,685	.4	56.0	1.1	41.8	.4	19.6	33.6	46.4	2.046
71	51,354	.6	79.4	.9	18.8	1.0	4.8	41.4	52.8	1.503
72	37,208	1.4	56.7	0	39.2	1.4	4.1	63.5	31.1	2.101
73	55,554	.7	52.9	0	45.8	.7	7.7	63.2	28.4	2.045
74	62,824	1.1	72.7	1.6	24.6	1.1	10.4	53.0	35.5	1.698
75	75,911	1.6	82.9	0	14.9	1.6	4.0	28.5	65.9	1.409
76	50,083	1.0	74.8	.6	22.6	1.0	3.8	29.9	65.4	1.636
77	60,817	2.1	62.2	.5	32.6	2.1	8.2	46.9	42.8	2.024
78	82,572	0	55.7	1.1	43.1	0	6.3	57.4	36.2	2.015
79	35,300	0	55.4	2.0	37.1	0	12.4	46.0	41.6	2.237
80	41,736	3.3	62.1	3.6	27.0	3.3	10.8	36.9	49.0	2.168
81	63,263	.6	51.7	1.0	42.3	.6	22.9	46.2	30.3	2.236

Site	Total pollen	% trees	% shrubs	% herbs	% grasses	% exotics	% hydric	% mesic	% xerix	Simpson's diversity index
82	49,786	.6	47.8	1.2	39.1	.6	25.5	59.0	14.9	2.552
83	272,699	0	7.2	.1	20.3	0	87.6	6.4	5.9	1.770
84	44,103	.7	36.8	1.8	50.3	1.0	38.3	27.3	33.4	2.520
85	30,371	1.8	25.7	.7	68.4	1.8	55.8	20.2	22.2	1.871
Owl River										
156 cm	4,879	1.1	4.0	.5	94.4	1.3	83.2	14.8	.8	1.119
157	15,240	.7	14.3	.7	84.2	.9	73.9	23.6	1.5	1.370
158	14,625	.5	5.8	.2	93.2	.5	82.7	15.4	1.5	1.146
159	7,462	.9	4.2	1.1	93.7	.9	87.0	10.2	1.9	1.137
160	7,072	.6	10.3	.2	89.0	.6	81.2	17.5	.7	1.247
161	7,991	.1	39.6	0	60.3	.1	56.1	42.5	1.4	1.921
162	2,887	2.9	18.5	0	78.6	2.9	67.1	28.9	1.1	1.531
163	2,376	3.4	29.6	.5	66.1	3.9	49.7	41.9	4.5	1.904
164	1,678	3.0	13.5	.3	82.6	3.3	69.7	26.2	.9	1.426
165	1,287	2.1	18.7	2.1	75.0	2.1	56.3	41.6	0	1.671
166	1,348	2.6	18.0	.4	78.5	2.6	50.0	46.5	.9	1.541
167	1,854	3.3	35.7	.9	60.1	3.3	55.3	39.6	1.7	2.041
168	5,947	1.6	42.4	1.9	53.5	1.6	37.5	57.8	3.1	2.144
169	951	6.1	59.1	2.5	31.0	6.1	23.8	60.9	9.3	2.225
170	6,452	4.6	8.4	.4	86.7	4.6	66.0	28.4	1.1	1.315
171	5,386	1.1	10.7	1.6	86.4	1.1	76.3	20.3	2.3	1.320
172	9,733	1.3	5.9	1.0	91.5	1.5	88.6	8.7	1.2	1.189
173	6,118	2.1	6.7	1.0	90.2	2.1	74.1	22.3	1.6	1.223
174	3,328	6.6	10.3	1.9	80.4	8.4	59.8	29.0	2.8	1.512
175	1,090	6.6	5.7	0	87.7	6.6	68.7	22.1	2.6	1.288
176	2,805	3.1	5.3	0	91.2	3.1	73.2	23.4	.3	1.196
177	5,251	.6	5.4	0	94.0	1.2	68.7	30.1	0	1.129
178	2,008	1.3	2.0	0	96.0	1.3	82.6	15.4	.6	1.084
214	2,106	1.0	3.0	.3	95.0	1.0	90.5	7.2	1.3	1.108
215	1,983	1.2	1.6	0	96.4	1.2	91.4	6.6	.8	1.076
216	2,150	1.4	9.7	1.4	87.5	1.4	79.3	15.7	3.7	1.289
217	4,003	1.5	3.4	.9	94.1	1.5	86.1	10.6	1.7	1.127
218	2,987	1.1	6.6	.9	91.4	1.3	83.6	13.5	1.5	1.192
219	1,844	3.8	7.6	.7	87.5	3.8	79.9	12.5	3.8	1.293
220	2,807	.4	7.0	1.2	90.2	.5	82.0	11.9	5.6	1.222
221	1,248	2.4	3.8	.8	92.1	2.8	77.6	18.4	1.2	1.175
222	3,086	2.2	3.7	.8	92.1	2.6	77.6	18.4	1.2	1.144
223	1,048	3.2	7.9	0	87.6	3.2	73.6	19.2	4.0	1.291
224	3,759	5.2	7.8	1.0	86.0	5.7	74.6	18.1	1.5	1.335
277	933	15.0	5.0	2.5	75.0	15.0	62.5	12.5	10.0	1.699
278	8,799	1.0	3.2	.6	95.2	1.0	84.0	13.8	1.2	1.101
279	4,420	.5	2.4	0	97.1	1.0	75.5	23.6	0	1.059
280	6,634	.8	2.8	.3	95.9	.8	84.3	14.1	.9	1.086
281	8,899	.7	1.0	.6	97.5	.7	87.5	11.1	.7	1.052
282	8,014	1.4	2.5	.2	95.7	1.4	89.2	8.1	1.3	1.090
283	8,639	2.4	8.0	.7	88.9	2.4	76.4	21.3	0	1.254
284	10,479	.6	3.0	.3	96.0	.6	84.7	12.8	1.9	1.083
285	11,918	.1	.6	.3	99.0	.1	70.7	28.9	.3	1.021
286	19,169	.3	1.7	.3	97.7	.5	93.6	5.7	.2	1.048
287	6,623	2.5	6.1	0	90.0	2.5	44.3	52.6	.6	1.204
288	12,427	0	1.0	0	99.0	0	71.1	28.1	.7	1.020
289	20,990	1.0	9.2	0	89.8	1.0	67.0	32.0	0	1.228
290	12,031	.4	4.5	0	95.1	.4	68.9	29.8	.9	1.104
291	9,575	1.5	12.9	.3	85.2	1.5	65.2	32.0	1.2	1.345
292	32,360	1.1	21.5	0	77.4	1.1	74.8	22.2	1.9	1.550

* Present is scan count only. Percent not computed.

in *Salix* percentages while Gramineae and Cyperaceae values increase. *Betula* percentages are significantly higher in this upper section. This change is correlated on the concentration diagram (Fig. 6b) with a change from large "absolute" pollen accumulation values at 9-6 cm to very low pollen accumulation values from 5 to 2 cm, although very high values for Cyperaceae are recorded at 0 and 1 cm. Exotic values are generally high in this section; the 5-cm level records the influx of very large values for both *Betula* and *Pinus*.

The occurrence of high values of *Betula* pollen in the upper levels may indicate that a limited amount of dwarf birch was present at the head of Quajon Fiord; the values recorded here form a strong contrast with those noted in the previous three sites. Preliminary climatic measurements conducted at the head of Quajon Fiord in 1976 indicate that summer temperatures were warmer there than on Broughton Island. Alternatively, the higher birch and pine numbers may represent exotic pollen masking of a tundra flora of low productivity (RITCHIE and LICHTI-FEDEROVICH, 1967; BIRKS, 1973). In this case, the source for birch pollen would probably be regional. However, we point out that limited birch pollen reached Padloping Island although that site is only a few tens of kilometers from pollinating dwarf birch.

OWL RIVER

A discontinuous peat section was collected by G.H. MILLER in 1973 in a section exposed by the Owl River, North Pangnirtung Fiord. A series of four radiocarbon dates (Table II) is available, but the standard deviations of the three lowermost dates overlap substantially, and this suggests rapid accumulation in the lower part of the section. A similar conclusion was reached by STUCKENRATH *et al.* (1979) in their analysis of a similar section close by (their Site 1). The peat was sampled for pollen analysis at 1-cm intervals and analyzed by A.C. Millington, formerly of INSTAAR.

The basal spectrum of the relative diagram (Fig. 7a) is characterized by a very large *Salix* percentage; except for Cyperaceae, other taxa record only low values. Subsequently, the diagram can be characterized by a Gramineae-Cyperaceae assemblage until about the 170-cm level, when *Salix* values again rise and become an important part of the pollen spectrum. Values for Gramineae and Cyperaceae remain important here, although the latter does register decreased percentages at the base of this section.

Salix values peak in the basal spectrum of the concentration diagram (Fig. 7b), then decrease to very low values while Gramineae and Cyperaceae numbers dominate the basal section of the peat. The middle section of the peat (214-224 cm) is characterized by low

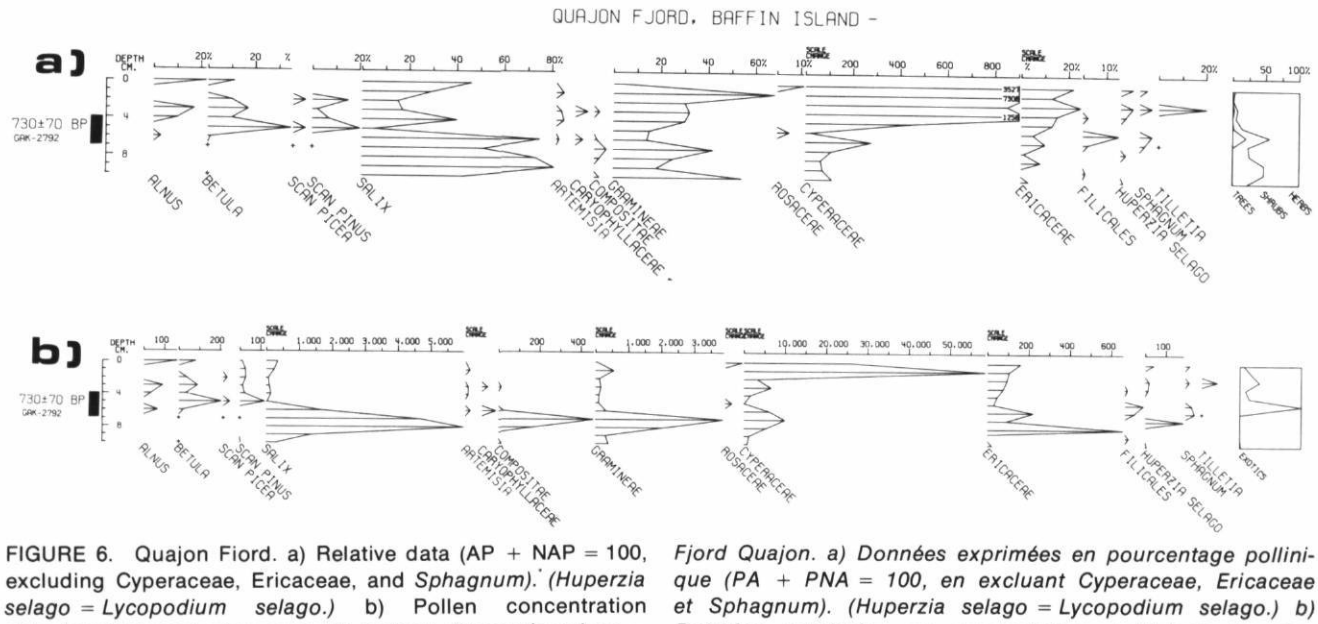

FIGURE 6. Quajon Fiord. a) Relative data (AP + NAP = 100, excluding Cyperaceae, Ericaceae, and *Sphagnum*). *(Huperzia selago = Lycopodium selago.)* b) Pollen concentration data (numbers per gram over-dry weight). *(Huperzia selago = Lycopodium selago.)*

Fjord Quajon. a) Données exprimées en pourcentage pollinique (PA + PNA = 100, en excluant Cyperaceae, Ericaceae et Sphagnum). (Huperzia selago = Lycopodium selago.) b) Données exprimées en concentration pollinique (nombre de grains par gramme en poids sec). (Huperzia selago = Lycopodium selago.)

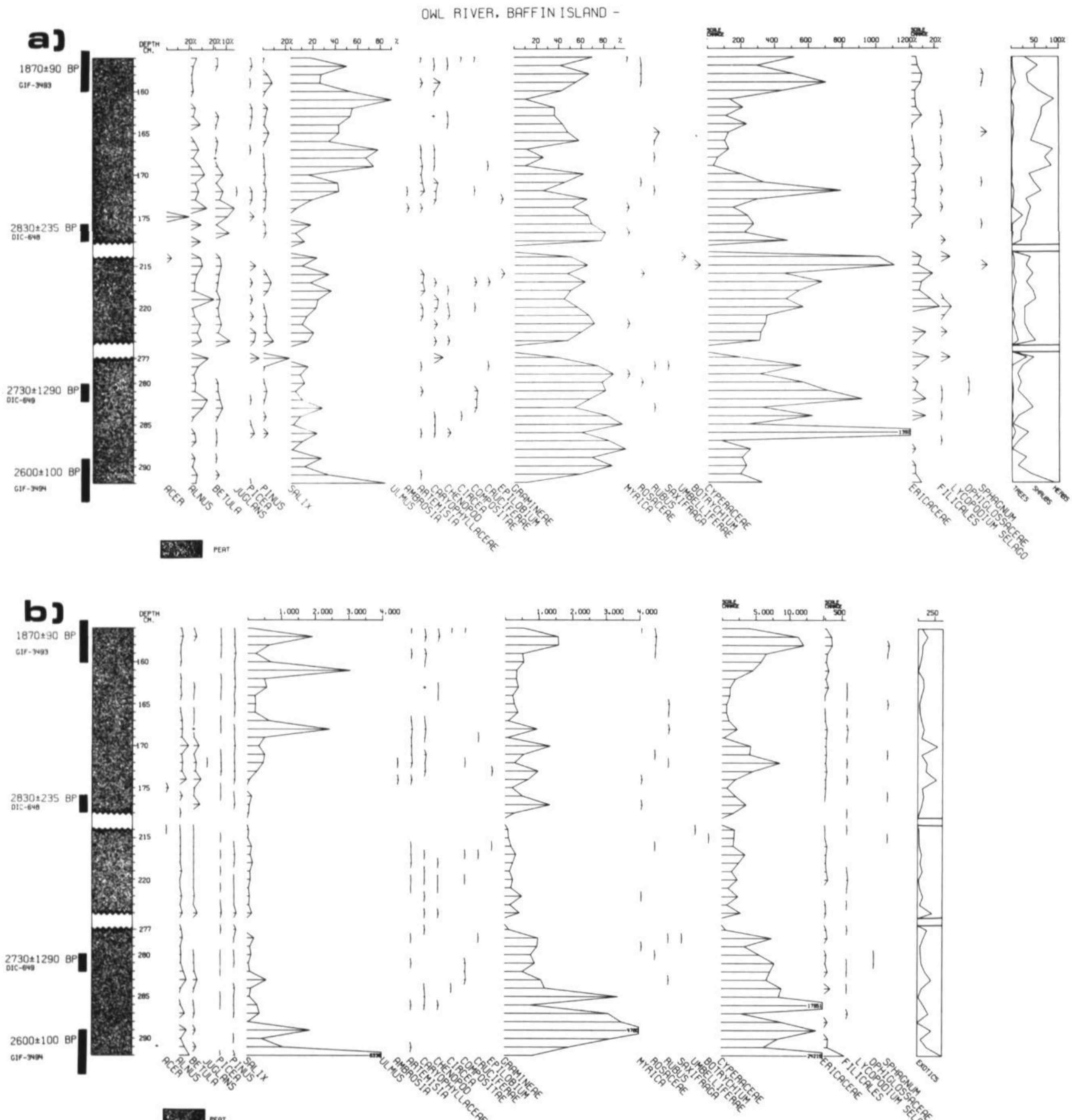

FIGURE 7. Owl River. a) Relative data (pollen sum excludes Cyperaceae, Ericaceae and *Sphagnum*). b) Pollen concentration data (numbers per gram over-dry weight).

Rivière Owl. a) Données exprimées en pourcentage pollinique (les sommes polliniques excluent Cyperaceae, Ericaceae et Sphagnum*). b) Données exprimées en concentration pollinique (nombre de grains par gramme en poids sec).*

values, although Gramineae and Cyperaceae remain the most important taxa. The upper peat section is characterized by a *Salix*-Gramineae-Cyperaceae assemblage. Exotic values are low at this site, but peaks are recorded at the base of the section and again between 170 and 175 cm (*ca.* 2500-2800 BP).

PASS HEAD

The Pass Head peat section (STUCKENRATH *et al.*, 1979: Fig. 4) was collected by G.H. Miller in 1973. The 18-cm thick peat section from 67 to 85 cm was sampled for pollen at 1-cm intervals; ^{14}C dates were collected from organic sections at 38-46 cm (3765 ± 75 BP) and 95-100 cm (5970 ± 95 BP), thus bracketing the peat (Table II).

The pollen spectrum generally describes an increase in shrub cover to the top of the section. The relative diagram (Fig. 8a) can be divided into three main sections with a transition from a grass-sedge-heath-sphagnum zone (85-83 cm) through a grass-heath-willow zone (82-70 cm) to a willow-sedge-grass zone (69-67 cm). The pollen concentration spectra (Fig. 8b) is similar, with very large *Salix* values (>60 x 10^3 g/gdw) in the

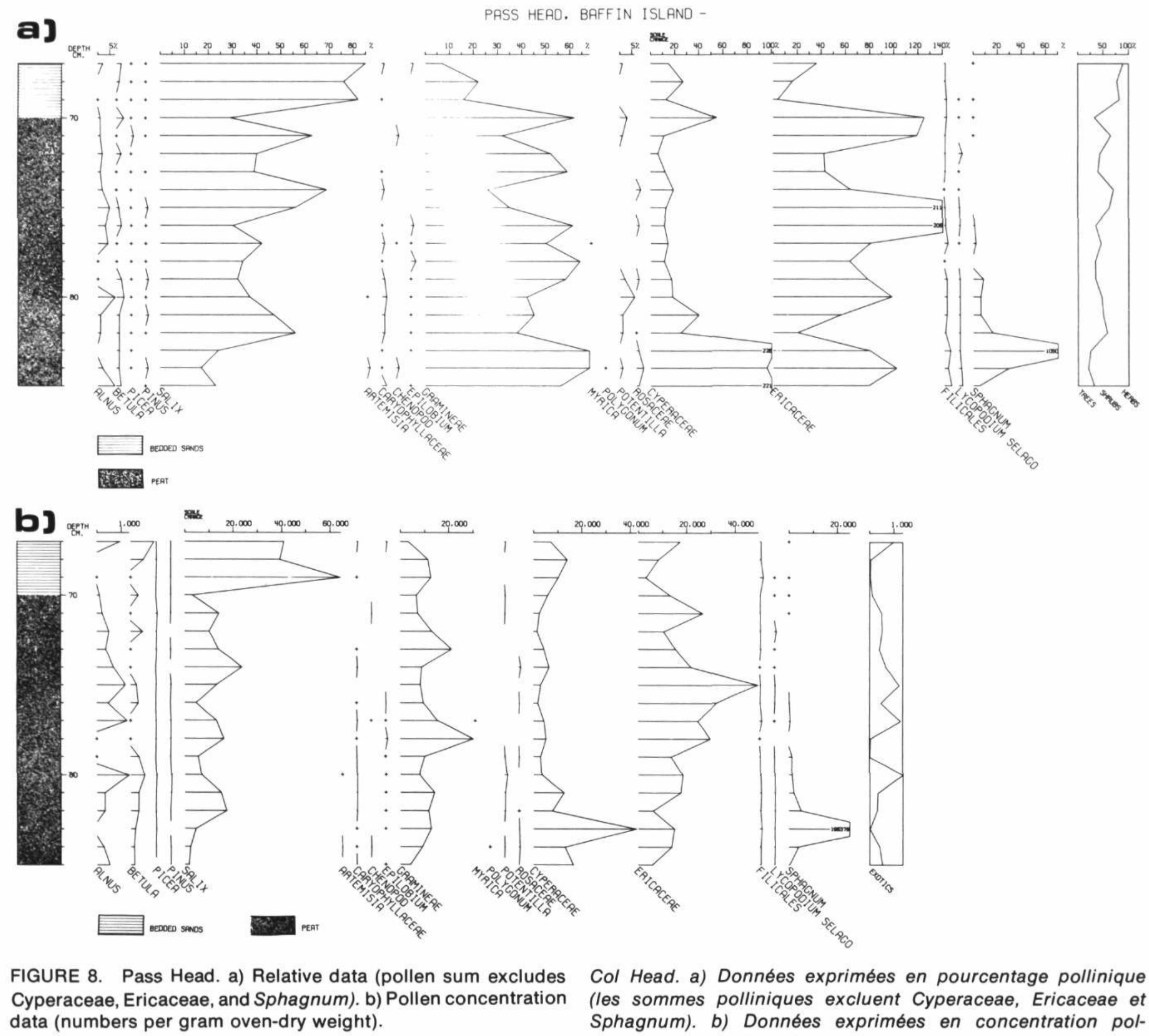

FIGURE 8. Pass Head. a) Relative data (pollen sum excludes Cyperaceae, Ericaceae, and *Sphagnum*). b) Pollen concentration data (numbers per gram oven-dry weight).

Col Head. a) Données exprimées en pourcentage pollinique (les sommes polliniques excluent Cyperaceae, Ericaceae et Sphagnum). b) Données exprimées en concentration pollinique (nombre de grains par gramme en poids sec).

upper zone. Exotic values are low throughout the section, with peaks at 80 cm, 77 cm, and 67 cm.

LIFE FORM AND MOISTURE PREFERENCE

Table III summarizes our six diagrams on the basis of pollen concentration, percentages of Life Form (ANDREWS *et al.*, 1979), percentages of pollen from taxa of a particular moisture habitat, and Simpson's diversity, and provides a convenient summary of the pollen diagrams. Local site conditions are especially noticeable in the Moisture Preference values. They grade from Mesic to Xeric sites, such as Padloping and Pass Head, to Mesic sites (Quajon Fiord), to Hydric sites (Owl River). The diagrams are frequently dominated by a single Life Form, usually Grasses (including Gramineae and Cyperaceae) and Shrubs (mainly *Salix*). Small percentages of Exotic and Tree pollen are found in most diagrams. Simpson's diversity is uniformly low and is close to 1.0 on most sites (Table III). The most diverse pollen spectra is clearly that from Pass Head which does cover part of the local thermal optimum on eastern Baffin Island. However, even in this diagram the maximum diversity is only 2.52. The maximum value recorded in any diagram is 4.09 from 5 cm in the Quajon Fiord diagram. Table III can be compared with values for the Windy Lake peat diagram ANDREWS *et al.* 1979: Fig. 8 and 9). By-and-large the diagrams from the northern coast of Cumberland Peninsula are less diverse than the Windy Lake site possibly reflecting the climatic and vegetational gradient across the Peninsula (Fig. 2).

DISCUSSION

Figure 9 is a summary diagram where we attempt to see if there are any regional trends. An alternative hypothesis would be that each site was responding to *local* site conditions. The importance of the local site is of course apparent in the distinctiveness of the local pollen assemblages. However, we believe that there are some significant broad trends in the data from the sites which are contemporaneous. These trends are reinforced by comparison with the pollen spectra from Maktak Fiord (BOULTON *et al.*, 1976; see Fig. 2) and that from Windy Lake (NICHOLS, 1975; ANDREWS *et al.*, 1979).

The most important trend observed is the transition from the mixed and relatively diverse assemblages that occur between about 2500 and 1500 BP and between 4500 and 5500 BP (Pass Head) and the predominantly

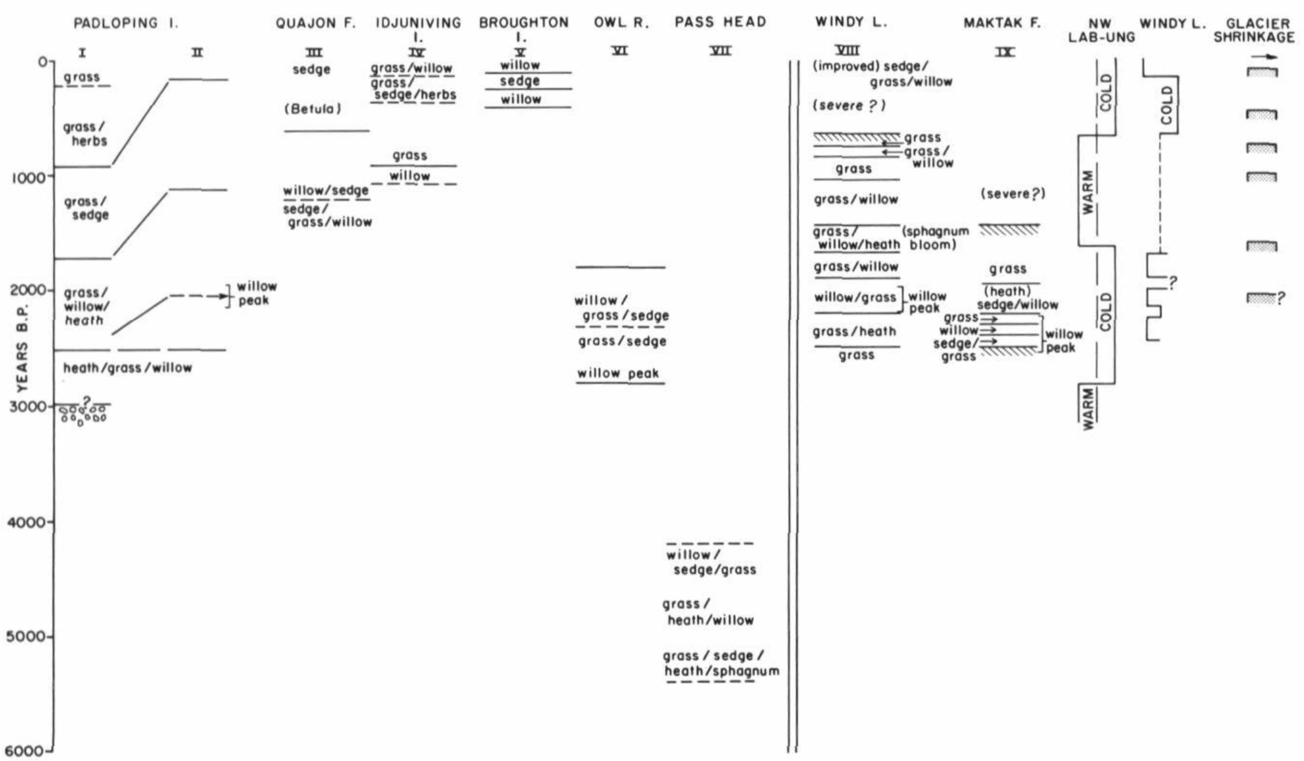

FIGURE 9. Summary diagram comparing the six study sites with published palynological and glaciological data from Baffin Island.

Diagramme de synthèse qui compare les résultats obtenus dans six sites à l'étude et les données de palynologie et de glaciologie déjà publiées sur l'île de Baffin.

grass dominated (sedge at Quajon and Broughton) (Life Form = Graminoid) phase that characterized the last 1000 years. The modern pollen rain from Pangnirtung Pass (ANDREWS *et al.,* 1979: Table IV) suggests that modern conditions most closely approximate those *ca.* 2500 and 2000 BP. However, a comparison of the pollen spectra from the two sites in North Pangnirtung Fiord, Pass Head and Owl River, suggests a climatic deterioration from the local climatic optimum (Pass Head) to the period between 2000 and 3000 BP. The Pass Head diagram records a much greater pollen productivity with higher *Salix* values. The larger *Picea* and *Pinus* values in the Owl River diagram, however, probably reflect the poorer local pollen record rather than warmer conditions.

An intriguing feature in the pollen diagrams from Padloping Island, Owl River, Maktak Fiord, and Windy Lake is a major peak of *Salix* pollen. At Padloping Island and Windy Lake, extrapolation between ^{14}C dates suggests that the willow peaks are contemporaneous. However, the large willow spike in the Maktak diagram dates closer to 2400 BP (on the basis of the sedimentation rate) and that at Owl River closer to 2600-2800 BP. With the errors inherent in dating these thin, organic-rich sediments (STUCKENRATH *et al.,* 1979), it is worth considering whether the latter two willow events are also chrono-correlative. Additional sections are needed to verify or refute our suggestion that these willow peaks represent the same regional environmental event. Because the Maktak peat was overridden by a glacier about 1500 BP, we consider that this section experienced less contamination than the other three, and hence we suggest that the age of the willow event was bracketed between 2200 and 2600 BP. At Sermermiut, West Greenland, FREDSKILD (1967) recorded a willow peak at 2570±BP. Immediately prior to the willow peak at Padloping Island, Windy Lake, and Maktak Fiord the pollen assemblages record significant levels of Ericaceae pollen. In high arctic tundra, heath elements are the climax vegetation for mesic sites (Webber, pers. comm.) and they do not represent disturbed sandy sites. It is notable that heath taxa do not contribute significantly to any of the pollen assemblage zones after about 1500 BP, but pollen from this group is also important in the Pass Head spectrum, which represents pollen accumulation during the local thermal maximum (MILLER, 1973; DYKE, 1977).

Differences and similarities exist between the northwestern coast of Labrador-Ungava (BARTLEY and MATTHEWS, 1969) and the northern coast of Cumberland Peninsula (Fig. 9). The difference may be associated with the location of these two areas with respect to the main 700 mb trough that typically extends south over Baffin Island centered about 75°W (CRANE, 1978). These two areas occur close to the western and eastern limbs of the trough, and the out-of-phase climatic interpretations may thus reflect long-term variations in the mean position of the trough, presumably during the summer months. This is an interesting hypothesis that requires further study.

The pollen assemblages from the six Baffin Island sites can be compared with the basal tundra episode (10,000 to 6700 BP) from Short's Labrador diagrams (SHORT and NICHOLS, 1977; SHORT, 1978a & b). However, the problem of comparing lake records (Labrador) with peat records is complex. In general, the basal Labrador tundra assemblage is characterized by low pollen productivity and low willow values. This contrasts with the more diverse pollen assemblages between 2500 and 2000 BP recorded in the Baffin Island peat sections, and suggests colder and drier conditions prevailed in the early Holocene of Labrador.

CONCLUSION

The six short pollen diagrams from terrestrial, organic-rich sediments on northern Cumberland Peninsula add to our scanty knowledge of mid– and late-Holocene pollen spectra from the eastern Canadian Arctic and from high arctic tundra sites specifically. Over the last 1000 years, the pollen rain has been dominated by pollen of the graminoid group, mainly grass, but sedge at the wetter sites. This phase contrasts with earlier pollen assemblages between 2500 and 2000 BP which were typically more diverse and included significant quantities of heath and shrub (willow) pollen. There is some evidence that a short-lived phase of willow expansion occurred between 2200 and 2600 BP and that this was preceeded by an optimum when heath pollen was important. Terrestrial, organic-rich sediments on Cumberland Peninsula are frequently short, truncated, and not easy to date by radiocarbon. Further research should concentrate on finding longer sections (if available) and coring ponds and lakes so that continuous stratigraphic sections may be obtained (*cf.* DAVIS, 1980).

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