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HOLOCENE PROXY-CLIMATE DATA FROM THE CANADIAN ARCTIC

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Abstract

A review of diverse reports of the Geological Survey of Canada has produced lists of radiocarbon-dated samples from the Canadian Arctic which indicate four climatically significant occurrences during the Holocene: vascular plant range extensions, peat deposits of arctic islands, eolian deposition, and thermokarst and thaw. These data suggest warmer and perhaps wetter summers in the western Arctic during the early Holocene and warmer and/or wetter summers during the mid-Holocene elsewhere in the Canadian Arctic. This interpretation is limited by gaps in the database and by uncertainty about the relationship of each data type to climate.

Résumé

L'examen de divers rapports de la Commission géologique du Canada a permis des listes d'échantillons datés au carbone 14 et provenant de l'Arctique canadien. Ceux-ci révèlent quatre événements climatiquement importants qui se sont produits au cours de l'Holocène : les extensions du domaine des plantes vasculaires, les dépôts de tourbe des îles arctiques, la sédimentation éolienne ainsi que le thermokarst et le dégel. Ces données suggèrent l'existence d'étés plus chauds et partant plus humides dans l'ouest de l'Arctique pendant le début de l'Holocène et d'étés plus chauds ou plus humides pendant le milieu de l'Holocène ailleurs dans l'Arctique canadien. Cette interprétation est limitée par des lacunes à partir de la base de données et aussi par des incertitudes concernant chaque type de donées en fonction du climat.

INTRODUCTION

Quaternary studies by the Geological Survey of Canada (GSC) have produced data on the biological, geomorphological, and glacial history of Canada. The climatic implications of some of these studies are widely known, for example, the oxygen isotope and per cent melt records of high arctic ice cores (Koerner and Fisher, 1981) and the abundance of driftwood of mid-Holocene age in the Queen Elizabeth Islands (Blake, 1972). Other climatically significant discoveries have not become general knowledge, as indicated by their omission from literature reviews and annotated bibliographies on Canada's climatic history (Harington and Rice, 1984; Canadian Climate Program, 1985). This review of GSC reports and publications is an attempt to make some of its proxy-climate data more accessible; it was prompted by the Canadian Climate Program's interest in Canada's climatic history and by widespread concern over the mechanisms and implications of climatic change.

In this review, only data of Holocene age from the Northwest Territories and Yukon Territory have been considered. From this body of work, evidence was compiled of four phenomena that are indicative of climatic change: vascular plant range extensions, eolian deposition, peat accumulation and thermokarst and thaw. This report includes a compilation of these four data types, comments on their relationship to climate, and concludes with some general thoughts on the nature of proxy-climate data.

BACKGROUND

The decision to limit the data search to the Holocene of the Arctic was guided by the great activity of GSC personnel in this area over the last 25 years. A survey of the GSC radiocarbon date lists (I-XXVI) suggests that most dates from the Yukon and Northwest Territories are related to at least one of six phenomena: range extensions of plant and animal species, thermokarst, eolian activity, peat deposits, isostatic rebound, and glacial advance and retreat. The relationship to climate of the last two data types seems either too remote or too controversial to pursue. A search was made through the unpublished GSC 'Plant Macrofossil Reports' by J.V. Matthews, Jr. (1973-1986), the unpublished GSC 'Bryological Reports' by M. Kuc and J. Janssens, and selected GSC papers, memoirs, and Current Research articles for such dates and data additional to those listed in the radiocarbon date lists. Several scientists volunteered unpublished information from their files. A check to this study was made by searching the published portion of the Date Locator File (McNeely, 1985) for relevant entries; another search on this file identified peat samples from the arctic islands which had been dated prior to 1985, but for which dates have not yet been published.

These data are listed in the following tables, whether or not they were eventually published; one exception is the set of thermokarst dates from the western arctic coast, which is described by Rampton (1982, 1988).

VASCULAR PLANT RANGE EXTENSIONS

The northern limits of many plant taxa are determined by summer warmth and are commonly coincident with an isotherm of mean July temperature (Edlund, 1986). Early Holocene sediments from the northern Yukon and Mackenzie Delta yield ample evidence of more northerly distributions for poplar trees and a suite of shallow water and shoreline plants that are now confined to regions south of treeline or are extremely rare along the coastal plain: *Scirpus, Naias, Glyceria, Eleocharis palustris, Sparganium, Potagmogeton praelongus, P. zosteriformis, Nuphar, Ceratophyllum, Ranunculus cymbalaria, Chenopodium, Corispermum, Polygonum lapathifolium, Rumex maritimus, Cicuta mackenziana,* and *Bidens cernua*. There is only limited evidence of mid-Holocene range extensions in the central and eastern Arctic, perhaps because so few early and mid-Holocene organic deposits have been studied from this region (Table 1).

Former range extensions of vascular plants are an excellent form of proxy-climate data because of the availability of good modern distribution maps (Porsild and Cody, 1980), the sensitivity of many taxa to a distinct climatic gradient (summer temperature), the species-specificity of many plant macrofossils, and their abundance in suitable organic deposits. The Terrain Sciences Division of the Geological Survey also has abundant data on subfossil insects and mosses; the climatic significance of these data sets remains to be assessed.

ARCTIC PEAT DEPOSITS

Thick (40-900 cm) Holocene peat deposits have been located on many arctic islands. Most probably derive from wet lowland sedge-moss meadows, but they are now dry with gullies along former ice wedges or are covered by alluvial or eolian silt and sand. Peat accumulation rates appear to have been surprisingly rapid, 0.3-5.0 mm/a, based on the 17 peat deposits with at least two radiocarbon dates. Most of the arctic peat deposits listed in Table 2 are early or mid-Holocene in age. A major period of peat growth appears to have occurred on Ellesmere Island from 7 ka to 2.5 ka, and on Banks Island from 10 ka to 5.75 ka (Figure 1). This discrepancy is interesting, in light of other evidence of warmer early Holocene climates in northwestern North America than in the northeast (Williams and Bradley, 1985; Ritchie, 1987).

Are these relict peat deposits climatically significant? Many workers have assumed that current rates of arctic peat production are negligible and that the thick, gullied peat deposits of the early and mid-Holocene are evidence of a high arctic climate more favourable to peat production than the present climate (Tarnocai, 1978). This idea is consistent with other proxy-climate indications and deserves critical study; however, two other possibilities should also be considered:

1) The preponderance of early and mid-Holocene peat in this survey may reflect a sampling bias against peat deposits that still have a wet surface. Minimum accumulation rates for the six peat deposits with basal dates younger than 2.5 ka (assuming surface = present) range from 0.3 to 1.4 mm/a. Late Holocene peat growth has occurred on the arctic islands.
2) The formerly higher water tables indicated by some relict peat deposits may be due to higher sea levels of the early Holocene, and not to a different climate.

Many more basal than uppermost peat samples from arctic peatbeds have been submitted for radiocarbon dating. This is unfortunate because the cessation of peat growth, if by eolian burial or desiccation, has as much climatic significance as the onset of peat accumulation. One might expect dates of the uppermost peat in a region to coincide with other evidence of the onset of cooler/drier conditions, such as eolian activity. The limited available data are consistent with this hypothesis.

EOLIAN DEPOSITS

The sands and silts of arctic floodplains, glacial outwash plains, and sandy tills are prone to deflation and redeposition on nearby surfaces when they are dry and/or sparsely vegetated (Bird, 1961; Pissart et al., 1977). This occurs both in summer and winter. Large clouds of dust blow off dry, late summer floodplains on Banks Island, and the prominent dark mineral layers in spring snowbanks attest to winter transport. Niveo-eolian deposition has been studied on eastern Baffin Island in sections of finely interbedded peat and sand (Boulton et al., 1976; Andrews et al. 1979). At these sites, an increased proportion of sand to organic matter beginning 3-4 ka has been attributed to a cooler, drier climate following the climatic optimum of the mid-Holocene (Short and Jacobs, 1982).

Table 3 lists several radiocarbon dates on organic horizons buried by eolian sand elsewhere in the arctic. Again, at most sites eolian deposition began within the past 4 ka. The data are insufficient to identify intervals of particularly intense eolian activity within that interval.

Although eolian deposits are probably not a suitable material for deriving absolute estimates of past temperature and precipitation, they are a unique indicator of desiccation and paleowind direction. The data on the initiation of eolian deposition (Table 3) are consistent with the notion of widespread Neoglacial climatic deterioration, but offer little additional insight on climate. A regional investigation of arctic eolian deposits, buried peats, and lake sediments would enable one to compare the responses of these depositional environments to climatic change.

Table 1. Vascular plant range extensions

Sample Locality	Collector	Species	^{14}C age and lab number	References
Sabine Point 69°02N 137°38W	V.N. Rampton	*Populus*	9940 ± 90 GSC-2002	Lowdon and Blake (1976)
Blow River 68°52N 137°05W	J.V. Matthews, Jr.	*Populus* *Potamogeton praelongus*	9360 ± 70 TO-328	 J.V. Matthews, Jr., PMR*84-9
Old Crow Loc. 44 68°13N 140°00W	O.L. Hughes	*Populus*	8270 ± 140 GSC-1329	Lowdon and Blake (1979)
Old Crow Loc. 44 68°13N 140°00W	J.V. Matthews, Jr.	*Cicuta* sp. *Scirpus* sp. *Eleocharis palustris* *Rumex maritimus*	8460 ± 120 GSC-2605	Lowdon and Blake (1979) J.V. Matthews, Jr., pers. comm., 1987
Old Crow Loc. 32 68°03N 139°49W	O.L. Hughes	*Scirpus* sp. *Eleocharis palustris* *Chenopodium* sp. *Polygonum lapathifolium*	8100 ± 160 GSC-1243	Lowdon and Blake (1979) J.V. Matthews, Jr., pers. comm., 1987
Stokes Point 69°22N 138°48W	J.V Matthews, Jr.	*Scirpus* sp.	7510 ± 100 GSC-3747	J.V. Matthews, Jr., pers. comm., 1987
Hungry Creek 65°34N 135°31W	O.L. Hughes	*Scirpus* cf. *validus*	8980 ± 90 GSC-2341	J.V. Matthews, Jr., PMR 76-11 O.L. Hughes, pers. comm., 1987
Upper Porcupine 66°57N 137°42W	O.L. Hughes	*Scirpus* sp. *Eleocharis palustris* *Naias flexilis*	9190 ± 90 GSC-2461	Lowdon and Blake (1980) J.V. Matthews, Jr., PMR 77-3
Eagle River 67°06N 137°03W	J.V. Matthews, Jr. N.W. Rutter	*Naias flexilis* *Glyceria* sp. *Bidens cernua* *Ceratophyllum demersum* *Potamogeton zosteriformis*	9970 ± 160 GSC-3133	Blake (1984) J.V. Matthews, Jr., PMR 80-12
Corkery Creek 63°51N 135°38W	O.L. Hughes	*Scirpus validus*	9000 ± 90 GSC-4020	O.L. Hughes, pers. comm., 1987 J.V. Matthews, Jr., PMR 85-16
Liverpool Bay 70°05N 128°24W	V.N. Rampton	*Populus*	9020 ± 80 GSC-1989	Lowdon and Blake (1978)
Richardson River 67°48N 116°11W	D.E. Kerr	*Eleocharis* sp. *Myriophyllum* sp.	6100 ± 80 GSC-4009	D. Kerr, pers. comm., 1987 J.V. Matthews, Jr., PMR 83-19
Tuktoyaktuk Pingo 69°04N 134°19W	J.R. Mackay	*Nuphar polysepalum*	6730 ± 80 GSC-1797	Lowdon and Blake (1979) M. Kuc, BR*209
Dome Bay 78°28N 102°37W	D.A. Hodgson	*Carex* sp. (not *stans*) *Salix* sp.	7500 ± 90 GSC-2572	J.V. Matthews, Jr., PMR 77-6 D.A. Hodgson, pers. comm., 1987
Temperance Bay 78°20N 97°45W	D.A. Hodgson	*Salix* sp.	6900 ± 100 GSC-2624	J.V. Matthews, Jr., PMR 83-15 D.A. Hodgson, pers. comm., 1987
Dartmouth Bight 75°39N 99°20W	W. Blake, Jr.	*Vaccinium uliginosum* *Salix pseudopolaris* *Ranunculus trichophyllus* var. *eradicatus*	9210 ± 170 GSC-180	Blake (1964) Dyck et al. (1965)
Skraeling Island 78°55N 75°39W	W. Blake, Jr.	*Potamogeton filiformis*	6650 ± 70 GSC-3391	J.V. Matthews, Jr., PMR 82-1 Blake (1982)

* PMR unpublished Geological Survey of Canada Plant Macrofossil Report
BR unpublished Geological Survey of Canada Bryological Report

Table 2. Holocene peatbeds (>40 cm thick) of the arctic islands

Peatbed Locality	Dated level thickness (cm)	Growth (cm from uppermost peat)	^{14}C age and lab. number	Substrate/ rate (mm/a)	basin type	Surface of peat	Reference
Banks Island							
Muskox River 75°49N 120°20W	200	200	1440 ± 40 GSC-2286	>1.4	glacial outwash		Lowdon and Blake (1980) Vincent (1983)
Ivitarak River 73°12N 120°04W	~420	400	9770 ± 80 GSC-2127		depression in till	gullied polygons	Lowdon and Blake (1980) Vincent (1983)
Woon River 74°10N 121°07W	50	50	3050 ± 90 GSC-2387		river terrace		Lowdon and Blake (1980) Vincent (1983)
Bernard River 73°26N 123°42W	>410	400	8970 ± 140 GSC-2776			gullied polygons	Lowdon and Blake (1980) Vincent (1983)
Big River 73°31N 124°07W	>500	500	7800 ± 70 GSC-2160		depression in till	gullied polygons	Lowdon and Blake (1980) Vincent (1983)
N. Stewart Pt. 72°31N 119°16W	130	130	2130 ± 70 GSC-2324	>0.6	deep gully in marine silt		Lowdon and Blake (1980) Vincent (1983)
Stewart Pt. 72°16N 119°43W	100	60-100 30	9360 ± 90 GSC-2723 7600 ± 90 GSC-2656	0.3	depression in till		Lowdon and Blake (1980) Vincent (1983)
Kellet River 71°56N 123°14W	250	250 60	9820 ± 220 I-197 6940 ± 110 GSC-10	0.6	depression in till		Dyck and Fyles (1962) Vincent 1983
Masik River 71°35N 123°29W	400	400	9730 ± 150 GSC-1525		river terrace		Lowdon et al. (1977) Kuc (1973)
Thesinger Bay 71°57N 125°14W	110	110	6490 ± 60 GSC-3216			30 cm fine sand	Blake (1983) French et al. (1982)
Dissection River 73°17N 119°32W	~200	near base	8530 ± 110 GSC-2284		gravelly sand	shallow cover of colluviated till	Blake (1987) Vincent (1983)
Big River 72°29N 123°42W	83	base	6520 ± 150 GSC-2610		glaciofluvial terrace		Vincent (1983)
Big River 72°28N 123°53W	110	base	2510 ± 60 GSC-2636	>0.4	meander scar		Vincent (1983)
Prince Patrick Island							
Mould Bay 76°19N 119°21W	184	184	4270 ± 140 GSC-1194		round depression	gullied polygons	Kuc (1971)
Mould Bay 76°19N 119°21W	300	300	8460 ± 150 GSC-364		terrace	deeply gullied	Kuc (1971)
Melville Island							
Sherard Valley	40	40	9040 ± 160 GSC-1708		marine delta		Barnett (1973)
Purchase Bay 75°28N 115°53W	~250	base	7890 ± 70 GCS-4187		sandy depression		D.A. Hodgson, pers. comm., 1987
Bathurst Island							
Scoresby Hills 75°50N 98°02W	~250	top	8420 ± 80 GSC-1887		valley floor	peat mounds overlain by sand-silt	Lowdon and Blake (1975) W. Blake, Jr., pers. comm., 1987
Scoresby Hills 75°45N 98°18W	326	326 9-12	6510 ± 150 GSC-253 1170 ± 150 GSC-402	0.6	large meltwater channel	ice-cored mound	Lowdon et al. (1967) Blake (1974)

Polar Bear Pass 75°45N 98°28.5W	>150	top	2870±50 GSC-1876			thin veneer of alluvium	Lowdon and Blake (1980)
Polar Bear Pass 75°44N 98°28W	–	top	2760±70 GSC-1883			thin veneer of alluvium	Lowdon and Blake (1980)
Dartmouth Bight 75°38N.5 99°20W	264	261-264 17-21	9210±170 GSC-180 7820±140 GSC-233	1.7	depression on ridge		Dyck et al. (1966) Blake (1964,1974)
Walker River 75°57N 77°52W	>150	top	7100±140 GSC-201	>0.6	river terrace	thin colluvium	Dyck et al. (1965)
Goodsir Inlet 75°40N 97°40W	130	25 78	5830±70 GSC-2355 6160±90 GSC-2317	1.6	depression with small temporary stream	gullied polygons	C. Tarnocai, pers. comm., 1987
Ellef Ringnes Island							
Dome Bay 78°27N 102°37W	150	140-150	7500±90 GSC-2572		delta surface	gullied polygons	D.A. Hodgson, pers. comm., 1987
Ellesmere Island							
Lake Hazen 81°49N 71°18W	>235	225-235 35-40	4980±70 GSC-3451 3260±70 GSC-3540	1.1	stream valley	10 cm till-like material	Blake (1985) Gould (1985)
Tanquery Fiord by McDonald River 81°24N 76°10W	210	210	4060±130 GSC-374		–	4.3 m of outwash	Lowdon et al. (1967) Hattersley-Smith and Long (1967)
Tanquery Fiord, by Rollrock River 81°30N 76°10W	400	400	6480±200 SI-468		–		Hattersley-Smith and Long (1967)
Oobloyah Bay 80°54N 82°17W	~225	180	4190±130 GSC-105		gravel of glacial valley		Dyck and Fyles (1963)
Strathcona Fiord 78°33N 82°20W	275	275	7680±150 GSC-175		till, upland depression	30-60 cm colluvium	Dyck and Fyles (1964)
Slidre River north 79°56N 84°35W	~250	30-36	4950±60 GSC-2005		stream valley	15 cm of sand/silt	D.A. Hodgson, pers. comm., 1987
Slidre River south 79°54N 84°38W	~180	~30	3970±80 GSC-2039	~1.4	terrace of stream valley		D.A. Hodgson, pers. comm., 1987
Makinson Inlet 77°50W 81°W45	900	890-900 0-10	5180±260 GSC-2909 2590±150 GSC-3191	3.5	glacial valley	gullied, thin cover of outwash and till	Lowdon and Blake (1981)
Carey Islands, north 76°44N 73°00W	260	250-260 15-18	6300±140 GSC-2368 4390±140 GSC-2415	1.2	hollow on plateau above sea cliff	gullied	Brassard and Blake (1978) Blake (1987)
Carey Island, central 76°43N 73°11W	104	99-104 15-20	8940±90 GSC-2440 7230±80 GSC-2558	0.5	valley	peat mound	Blake (1987) Brassard and Blake (1978)
Devon Island							
Truelove Lowland 75°40N 85°37W	170	170	2450±90 I-3231	>0.7		high-centre polygons	Jankovska and Bliss (1975) Barr (1971)
75°38N 84°28W	–	base	4300±95 S-430			high-centre polygons	Barr (1971)
75°38N 84°26W	–	base	6900±115 S-428			high-centre polygons	Barr (1971)

Table 2. Continued

Locality	Peatbed thickness (cm)	Dated level (cm from uppermost peat)	^{14}C age and lab. number	Growth rate (mm/a)	Substrate/ basin type	Surface of peat	Reference
Cornwallis Island							
Intrepid Bay 75°05N 96°09W	75	75	6590 ± 100 GSC-2532			high-centre polygon	Lowdon and Blake (1979)
Eleanor Lake 75°23N 94°47W	110	110	4670 ± 60 GSC-2476			high-centre polygon	Lowdon and Blake (1979)
Eleanor Lake 75°23N 94°42W	130	130	1700 ± 40 GSC-2321	>0.8		high-centre polygon	Lowdon and Blake (1979)
Resolute 74°46N 95°06W	125	125	5410 ± 50 QL-1741	0.3		palsa	Washburn (1983) Washburn and Stuiver (1985)
		20-25	1680 ± 60 QL-1739				
Somerset Island							
Stanwell-Fletcher L. 72°58N 94°57W	135	135	6280 ± 80 GSC-2339	5.0	gravel and sand of stream valley	gullied polygons	Lowdon et al. (1977)
		32	6070 ± 100 BGS-337				
Creswell Bay 72°53N 93°37W	230	225-230	7590 ± 80 GSC-2583	1.3	laminated sand and silt	gullied, eroding polygons	Blake (1987)
		180-188	7250 ± 70 GSC-3250	0.4			
		90-96	5100 ± 90 GSC-3257	0.2			
		0-3	1320 ± 60 GSC-2945				
Creswell River 73°00N 93°00W	120	75	5700 ± 80 GSC-3082	1.5	depression	gullied polygons	C. Tarnocai, pers. comm., 1987
		120	6010 ± 80 GSC-3077				
Creswell River 73°03N 93°15W	170	170	4580 ± 80 GSC-2439		fine sand	11 cm of fine sand over dissected peat polygons	A.S. Dyke, pers. comm., 1987
Prince of Wales Island							
73°46N 97°46W	102	100-102	8655 ± 230 S-2888	0.8	small depression in marine sand	degraded high-centre polygons	A.S. Dyke, pers. comm., 1987 Hooper, 1986
		5-7	7430 ± 210 S-2889				
Boothia Peninsula							
Pelly Bay 68°05N 90°09W	~200	base	4530 ± 120 GSC-32		marine terrace		Dyck and Fyles (1963)
Lord Lindsay River 70°06N 95°33W	132	130-132	4750 ± 60 GSC-3277	0.5		high-centre polygons	A.S. Dyke, pers. comm., 1987
		5-8	2080 ± 60 GSC-3282				
Wrottesley Valley 71°04N 95°37W	~130	138-144	4580 ± 70 GSC-3279	0.4	depression in till on broad valley floor	eroding high-centre polygons	A.S. Dyke, pers. comm., 1987
		0-7	1240 ± 70 GSC-3331				
Victoria Island							
Richard Collinson Inlet 72°38N 113°41W	~60	60	2200 ± 75 GSC-19	>0.3	marine terrace		Dyck and Fyles (1962)
central 70°59N 110°04W	~800	base	9120 ± 100 GSC-4193	1.4	depression in glaciolacustrine silt	dry	D. A. Hodgson, pers. comm., 1987
		~600	9180 ± 100 GSC-4202				
		top	4730 ± 80 GSC-4206				

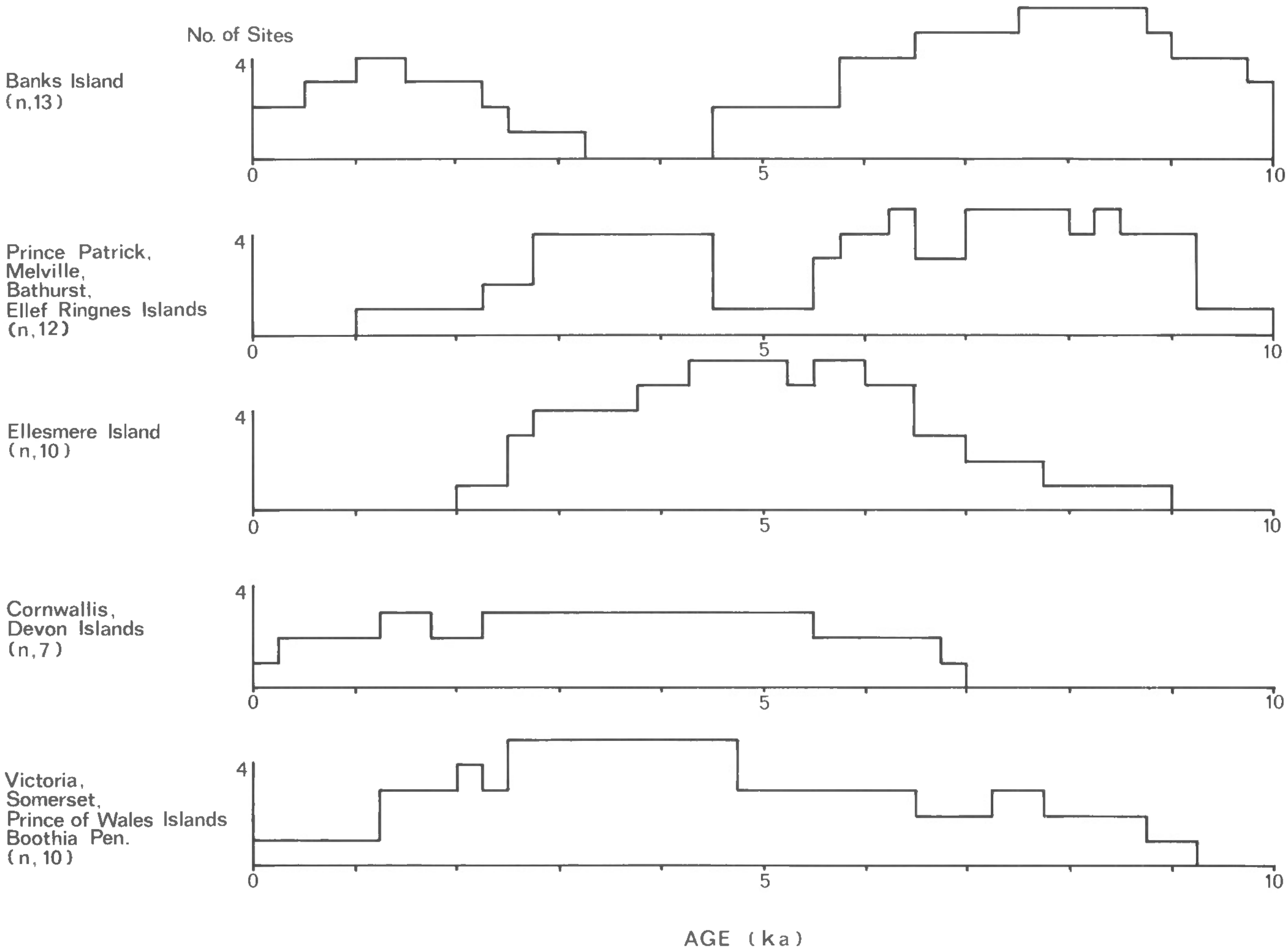

Figure 1. An estimate of regional differences in the timing of Holocene peat accumulation on the arctic islands. Each histogram shows the number of sites accumulating peat during each 250 year interval of the last 10 ka years. The number (n) of radiocarbon-dated peat deposits in each region is indicated. Where the uppermost (or lowermost) peat is of unknown age, its age is arbitrarily assumed to be 2 ka younger (or older) than the peat layer that was radiocarbon dated. A few sites (e.g., Polar Bear Pass on Bathurst Island) emerged from the sea less than 2 ka prior to the uppermost peat date; peat growth at these sites is assumed to have commenced upon emergence. In the 17 arctic peat deposits with both upper and lower peat layers dated, the average duration of peat growth is about 2.7 ka.

THERMOKARST AND THAW

Thermokarst results from melting of ground ice accompanied by local collapse of the ground surface and subsequent formation of depressions. Oriented lakes with steep, eroding shorelines are modern examples of ongoing thermokarst activity. Sediments in such thaw lakes appear to differ from those in other lacustrine sequences in their layered concentrations of terrestrial plant remains (Rampton, 1982). Thermokarst deposits can therefore be recognized in exposures. Studies of such thermokarst deposits show that thawing and collapse were widespread in northwestern Canada between 10 ka and 8 ka, especially along the Beaufort Sea coast (Rampton, 1982, 1988; French and Harry, 1983; Table 4).

Thermokarst activity may be expected to increase in a landscape of ice-rich surficial materials where summers are growing warmer (or possibly winters are becoming snowier) and in which permafrost is therefore degrading. The early Holocene summers in northwestern Canada were therefore warmer than they had previously been. Moreover, because active layers were deeper then than now, summers were warmer than at present (Mackay, 1978; Burn et al., 1986).

The absence of data marking a similar thaw interval in the remainder of the Canadian Arctic is puzzling, as thermokarst lakes occur at least as far north as Bathurst Island. Perhaps warming was insufficient to initiate thawing elsewhere, or collapse did not occur because less ground ice was present. It is also possible, however, that thermokarst deposits have simply not been studied in the central and eastern Arctic.

Table 3. Organics buried by eolian deposits

Sample locality	Collector	^{14}C age and lab. number	Dated material	References
Chapman Lake 64°52N 138°19W	O.L. Hughes	10900 ± 150 GSC-311	prominent silt layer in lake sediment	Dyck et al. (1966) Terasmae and Hughes (1966)
McQueston River 63°38N 137°06N	O.L. Hughes	1590 ± 150 GSC-565	soil overlain by loess	Lowdon and Blake (1968)
Hayes River 67°13N 92°05W	R.D. Thomas	980 ± 70 GSC-2522	peaty soil overlain by sand	Lowdon et al. (1977) Thomas (1977)
Amer Lake 65°33N 97°37W	B.C. McDonald	2540 ± 130 GSC-1086	peat beneath sand-peat layers	Lowdon et al. (1971)
Coppermine River 66°50N 116°21W	D.A. St-Onge	3210 ± 60 GSC-2998	peat overlain by dunes	Blake (1983) St-Onge (1980)
Liverpool Bay 70°01N 129°29W	V.N. Rampton	3280 ± 130 GSC-1268	detritus overlain by eolian sand	Lowdon and Blake (1978) Rampton (1988)
Bernard River 73°15N 121°40W	J-S. Vincent	5800 ± 180 GSC-2242	twiggy peat overlain by eolian sand	Pissart et al. (1977)
Sachs River 71°58N 124°58W	J-S. Vincent	8430 ± 120 GSC-2419	peat layer beneath sand	Pissart et al. (1977)
Thomson River 73°51N 119°49W	J-S. Vincent	3790 ± 90 GSC-2119	willows overlain by eolian sand	Pissart et al. (1977)
Thomson River 73°42N 119°56W	A. Pissart	3460 ± 80 GSC-2124	willows overlain by eolian sand	Pissart et al. (1977)
Dundee Bight 75°58N 96°17W	L.A. Dredge	710 ± 50 GSC-2454	willow exposed by deflation	Lowdon and Blake (1978)
Millut Bay 64°40N 67°33W	A.S. Dyke	1790 ± 80 GSC-2084	soil overlain by eolian sand	Lowdon and Blake (1979)
Pilik River 71°21N 77°19W	D.A. Hodgson	2650 ± 130 GSC-1071	peat bed overlain by stratified sand	Lowdon et al. (1971)
Aktineq Glacier 72°53N 78°52W	R.N.W. DiLabio	450 ± 70 GSC-2597	peat layer within eolian sand unit	Lowdon and Blake (1978)
Paulatuk 69°21N 124°06W	J.R. Mackay	1030 ± 140 GSC-1251	peat in eolian sand	Lowdon et al. (1971)
Mason River 69°55N 128°26W	V.N. Rampton	8650 ± 80 GSC-2029	peaty layer in middle of 0.6 m thick loess deposit	Lowdon and Blake (1978)
Mountain River 65°15N 128°34W	O.L. Hughes	940 ± 50 GSC-2504	spruce stump near base of 19 m thick cliff top dune	Lowdon and Blake (1979)
Warden's Grove 63°40N 104°26W	B. Gordon	810 ± 130 GSC-1689	spruce stump overlain by approx. 2 m eolian sand	Lowdon et al. (1974)

Table 4. Organics dating thermokarst or ice wedge collapse

Sample locality	Collector	^{14}C age and lab. number	Dated material	References
Sabine Point 69°04N 137°48W	D.G. Harry	8980 ± 90 GSC-3914	wood at base of mudflow deposit that thaw-truncates ice below	Blake (1987)
Sabine Point 69°04N 137°48W	D.G. Harry	11,000 ± 100 GSC-3986	detritus at base of thermokarst lake sediment	Blake (1987)
King Point 69°05N 137°55W	D.G. Harry	7770 ± 90 GSC-3987	peat directly over fossil ice wedge (maximum age of thaw event)	Blake (1987) Harry et al. (1985)
Old Crow Flats 67°54N 139°26W	W. Pettapiece	6020 ± 140 GSC-2225	detrital layer at base of thermokarst lake sediment	Lowdon et al. (1977)
Old Crow Basin 67°56N 139°16W	J.V. Matthews, Jr.	10,400 ± 180 GSC-2773	peat in ice wedge pseudomorph	Blake (1984)
Bell Basin 67°12N 137°41W	J.V. Matthews, Jr.	8890 ± 90 GSC-3134	redeposited peat mat in thermokarst lake sediment	Blake (1984)
		8710 ± 80 GSC-3161	organic pod 1 m above GSC-3134 in organic silt	
Horton River Pingo 68°29N 123°16W	B.G. Craig	3,050 ± 150 GSC-397	intercalated peat and silt layers exposed in pingo crater	Dyck et al. (1966)
Erly Lake Pingo 68°14N 122°38W	R.J. Fulton	10,800 ± 150 GSC-1139	moss peat mat in lake sediment	Lowdon et al (1971)
Grandview Hills 67°06N 131°13W	O.L. Hughes	9560 ± 120 GSC-2298	wood at base of thaw pond sediment	Lowdon and Blake (1979)
Norman Wells 65°29N 126°34W	R.J. Fulton	8880 ± 150 GSC-1099	peaty layer in thermokarst lake sediment	Lowdon et al. (1971)
Escape Rapids 67°35N 115°27W	M.A. Guerts	9150 ± 100 LV-1452	wood at base of thaw lake sediment	Guerts (1985)
Thesinger Bay 71°57N 125°14W	D.G. Harry	6490 ± 60 GSC-3216	base of peatbed that grew during thaw event	Blake (1983) French and Harry (1983)
Thesinger Bay 71°57N 125°13W	D.G. Harry	8560 ± 210 GSC-3292	twigs at base of thermokarst lake sediment	Blake (1983) French and Harry (1983)
Thesinger Bay 71°57N 125°25W	H.M. French	9490 ± 80 GSC-2364	wood in thaw lake sediment	French and Harry (1983)
Thesinger Bay 71°53N 124°59W	J-S. Vincent	8240 ± 140 GSC-2246	base of thermokarst lake sediment	French and Harry (1983) Lowdon and Blake (1980)
Satellite Bay 77°22N 116°35W	A. Pissart	7090 ± 150 GSC-854	detritus in ice wedge pseudomorph	Lowdon and Blake (1968)
Yukon Coastal Plain		14 dates		Rampton (1982)
Tuktoyaktuk Coastlands		36 dates		Rampton (1988)

CONCLUSIONS

The four data types compiled in this study reflect different aspects of Holocene climate in the Canadian Arctic. Thermokarst and range extensions of plant species are probably indicators of summer warmth (perhaps also snow depth), and are widely evident in early Holocene sediments of the western Arctic; elsewhere, such data are rare. Eolian activity and peat accumulation are more likely related to moisture conditions, in an inverse manner. A major period of peat accumulation appears to have occurred in the early Holocene in the western Arctic and in the mid-Holocene on the eastern islands. Evidence of eolian activity during the last 4 ka is sparse but pervasive.

In summary, these data are consistent with paleoclimatic interpretations of the low arctic which are based primarily on pollen studies (Ritchie, 1987; Williams and Bradley, 1985) — that is, warmer early Holocene summers in the west and a mid-Holocene optimum in the east. Moreover, they provide scattered glimpses of environmental history from the arctic islands, a vast region whose pollen stratigraphy remains unknown (except for Baffin Island), and from which we have little other evidence of Holocene terrestrial conditions.

The climatic significance of the data identified in this report is limited by its uneven geographic and temporal distribution, and by uncertainty about the relationship of each data type to climate. In general, processes that respond to a climatic gradient in a quantifiable and predictable way are most suitable for reconstructing past climates. Increased efforts to understand the climatic significance of the many sorts of phenomena that geologists study will lead to data collection of more climatic significance. Such data will also be useful in predicting effects of future climatic change.

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