A Holocene lacustrine record of environmental change in northeastern Prince of Wales Island, Nunavut, Canada

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A core from Prince of Wales Island in the central Canadian Arctic was analysed for pollen and sediment characteristics. From 9200 yr BP to 7000 yr BP, the landscape supported a pioneer vegetation under cold conditions, with relatively high sediment input to the lake. Between 7000 and 4000 yr BP there was a period of high pollen concentrations, more abundant Cyperaceae and Dryas on the landscape and finer sediment input. In the last 4000 years, climate cooling is indicated.

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Little is known about the postglacial vegetation history of large portions of the Canadian High Arctic. In the central arctic, pollen diagrams have been published only from Somerset Island (Gajewski 1995). Pollen diagrams are available from Banks Island (Gajewski et al. 2000) in the west, and Ellesmere (Hyvärinen 1985) and Baffin Islands to the east (e.g. Andrews et al. 1979; Jacobs et al. 1997; Mode 1997; Short et al. 1985; Williams et al. 1995).

Holocene climate changes in the Canadian High Arctic have been interpreted from a variety of proxy-climate records (Ovenden 1988), including ice cores (e.g. Bourgeois et al. 2000; Fisher et al. 1995; Koerner & Fisher 1990) and fossil whalebone (Dyke et al. 1996b) or marine mollusc (Dyke et al. 1996a) distributions. Results generally indicate warmer conditions in the early to mid-Holocene and cooling during the past several thousand years (Bradley 1990). Dyke et al. (1996b) suggest that outflow from the melting ice sheets contributed to keeping the inter-island channels free of pack ice, and this would have contributed to maintaining these warmer conditions. A cooling in the late Holocene is noted from many regions, but the timing of this is not well established (Bradley 1990).

We analysed a lake sediment core from a small lake on Prince of Wales Island in the central Canadian Arctic Archipelago (Fig. 1). The purpose of this study is to document the Holocene environmental history of this part of the island and to determine if it was similar to that of nearby Somerset Island.

The bedrock of Prince of Wales Island is primarily limestone or dolomite with a band of sandstone and conglomerate along the eastern side. The easternmost tip of the island, as well as Prescott Island, is Precambrian gneiss (Dyke et al. 1992). Highest vegetation cover is found on the eastern part of the island, in areas underlain by non-carbonate rock (Dyke et al. 1992). The transition between the high- and mid-arctic ecological districts is found in the northern part of the Island, trending northwest–southeast between Ommanney Bay and Browne Bay (Woo & Zoltai 1977).

Prince of Wales Island was deglaciated from the northwest to the southeast between approximately...
11000 and 9000 yr BP (all ages are given in uncalibrated \(^{14}\)C yr BP). Most of the island was submerged following retreat of the ice and only uplands in the north and east remained above sea level (Dyke et al. 1992). The oldest dates of emergence are around 10000 yr BP from Russell Island and the northernmost part of Prince of Wales Island (Dyke et al. 1992).

Site PWWL (73°34.5’N; 98°29.0’W; 110 m a.s.l.) is located in the Allen Lake region of northeastern Prince of Wales Island (Fig. 1). The underlying bedrock consists of conglomerate sandstone and siltstone (Woo & Zoltai 1977) and there are sandstones to the east and carbonates to the west (Dyke et al. 1992). The region surrounding the lake was deglaciated between 10000 and 9600 yr BP, but was submerged and a bone date of 9285 ± 135 was reported from approximately the same altitude as the lake (Dyke et al. 1992). Woo & Zoltai (1977) place the Allen Lake region in the High Arctic vegetation zone, which is a polar desert characterized by sparse vegetation and low species richness. Locally, the vegetation is relatively dense compared to typical high arctic vegetation, and includes areas of peat accumulation. A distinguishing feature of the vegetation immediately around the lake is an abundant population of *Saxifraga oppositifolia*.

**Methods**

Cores were collected on 10 July 1995 in 4.3 m of water from an ice surface using a 5-cm diameter Livingstone corer. The uppermost section was cored in a clear plastic tube fitted with a piston to sample the sediment–water interface. The top 4.5 cm of the interface was subsampled at the field station, and the remainder of the cores stored at 4°C in plastic wrap and aluminium foil.

In the laboratory, the cores were X-rayed on a GE DXD525 machine with Fuji Super HR-S 30 X-ray film. Ninety 1-g wet samples were analysed for particle size using a Malvern Mastersizer E with a 0.1–600 \(\mu\)m sample cell. Sample dispersion was achieved by the removal of organic material with hydrogen peroxide (29–32%) and the addition of 1–3 ml of sodium pyrophosphate (10 g/l). One \(3 \text{cm}^3\) of sediment was burned at 500°C for 3 h to estimate the organic content, and another 3 h at 950°C to estimate the carbonate content (Bengtsson & Enell 1986).

Four \(3 \text{cm}^3\) of sediment was processed for pollen using standard methods (Faegri & Iversen 1975), including 10% HCl, hot 10% KOH, HF and acetolysis with final storage in silicon oil. Tablets of *Lycopodium* were added prior to processing to enable the calculation of pollen concentration (Stockmarr 1971). Samples were also desegregated in warm sodium pyrophosphate and passed through a 7-\(\mu\)m sieve to remove the clay-sized particles. Pollen concentrations were very low and it was difficult to obtain sufficient pollen sums. For each level, multiple slides were counted until (a) a sum of over 300 grains was achieved, (b) 10 slides were counted, or (c) there was no more material.

**Results**

The sediment consisted of 160 cm of inorganic lake sediment with several moss layers (Fig. 2). Mosses were
also found embedded in the ice. Loss on ignition was very low, remaining below 4% and decreasing to negligible levels below 100 cm (Fig. 2). Carbonate content, estimated by ignition at 950°C increased slightly below this level.

Five samples of moss fragments were submitted for AMS radiocarbon dating (Table 1). The uppermost sample was contaminated by bomb carbon and not used. Only the uppermost metre could be dated. The lower sediment contained little organic matter, and, indeed, only two samples could be successfully counted for pollen from this sediment.

Mosses submitted for dating are poorly preserved, but identification revealed that they are characteristic of wetland environments. Scorpidium scorpioides (Hedw.) Limpr was present in every sample and constitutes the sample collected from the surficial sediment and lake ice. This emergent and calciphile species grows in fens and bogs, or at the edges of lakes and ponds. The next most common component is aquatic and belongs to the Drepanoclados group (possibly Warstorfa exannulatus (Schimp. in B.S.G.) Loeske). Calliergon sp. fragments are also present in some of the samples.

Grain-size results were aggregated to present the

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Age (yr BP)</th>
<th>Lab number</th>
<th>Moss</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0–1.0</td>
<td>$-560 \pm 60$</td>
<td>TO-7938</td>
<td>Scorpidium scorpioides (Hedw.) Limpr.</td>
</tr>
<tr>
<td>12.5–15.0</td>
<td>$1560 \pm 90$</td>
<td>TO-7939</td>
<td>Drepanoclados group and Calliergon sp.</td>
</tr>
<tr>
<td>41.0–42.0</td>
<td>$2600 \pm 80$</td>
<td>TO-7940</td>
<td>Drepanoclados group</td>
</tr>
<tr>
<td>73.0–75.0</td>
<td>$4140 \pm 80$</td>
<td>TO-7941</td>
<td>Drepanoclados group and Calliergon sp</td>
</tr>
<tr>
<td>91.0–92.0</td>
<td>$6480 \pm 140$</td>
<td>TO-7942</td>
<td>Drepanoclados group and Calliergon sp</td>
</tr>
</tbody>
</table>

**Fig. 3.** Percentage pollen diagram from lake PWWL. Total pollen concentration (grains/ccm) based on all pollen excluding aquatics.
relative volume size distribution of sand, silt and clay (Fig. 2). In general, there is a relative increase in clays above 100 cm. Below 100 cm, silt is the most important component of the sediment and the clay proportion decreases. Small peaks of over 20% sand are found throughout the core.

Pollen concentrations were low in the bottom of the core, in sediment corresponding to the lower organic matter, higher carbonate content, and higher silt amounts. Concentrations increased before 6500 yr BP and decreased again after 4000 yr BP (Fig. 3).

The percentage pollen diagram shows few changes during the past 6500 years. Poaceae pollen was higher prior to 6500 yr BP, as was pollen of *Papaver*. Cyperaceae and Saxifragaceae pollen decreased between 3500 and 500 yr BP, when several other taxa, notably *Saxifraga oppositifolia*, Brassicaceae and Poly-podiaceae increased. Tree and shrub pollen, transported from the low-arctic tundra and forests to the south remained more or less constant, except for a long-term decrease in *Betula* pollen.

**Discussion**

Dating sedimentary sequences is difficult in the arctic due to low organic content of most lake sediments, presence of Tertiary coal deposits in some regions and extensive carbonate bedrock in the region (Gajewski et al. 1995). With the exception of ice cores, chronologies are frequently insecure. The samples in this site were large and all were based on moss layers in the sediment. Thus, the chronology is probably more secure than that of sites RS36 and RS29 from Somerset Island (Gajewski 1995). However, dates on aquatic fossils can be significantly older than those on terrestrial material taken from the same stratigraphic level (MacDonald et al. 1991) and the chronology of this site may suffer from this problem.

The sediment from the base to around 90 cm was apparently deposited in 2500 years; the time between the presumed emergence from the sea (Dyke et al. 1992) and the lowest radiocarbon date in the core. There is considerable variability in the grain size of the sediment and this corresponds to the presence of light and dark layers seen in X-rays of arctic sediment cores. The presence of several layers with high sand content suggests episodes of increased runoff into the lake. The change in sedimentation regime from more silty to more clayey sediment between 120 and 100 cm corresponds to an increase in pollen concentration and changes in several pollen percentages; for example, a decrease in Poaceae and *Papaver* and an increase in Cyperaceae and *Dryas*. Because of the extremely low organic content, relatively coarse sediment of the lower unit and small pollen sums, the pollen concentrations are less reliable in this portion of the sequence. At Somerset Island, highest concentrations are found in the oldest sediments (Gajewski 1995), and this was interpreted as the time of maximum warmth. The high Poaceae and *Papaver* pollen percentages along with low concentrations and silty sediment suggests relatively colder conditions on Prince of Wales Island. A similar zone was found on Ellesmere Island, interpreted as a reflection of pioneer vegetation by Hyvärinen (1985). This may help explain the higher silt content, due to more slopewash and sediment input into the lake.

By 6500, *Dryas* and Cyperaceae pollen increased and the pollen concentrations increased nearly threefold. The clay content increased, although there were still some peaks with relatively large sand amounts. Today, pollen of *Dryas* and Cyperaceae is widely distributed, but is particularly abundant in the mid-arctic (Ritchie et al. 1987). Pollen concentrations at Prince of Wales are lower than on Banks Island, and it is doubtful that true mid-arctic vegetation was growing around the site.

After 4000 yr BP, Cyperaceae pollen decreased, while Poaceae, *Saxifraga oppositifolia*, Brassicaceae and Ranunculaceae increased. These changes are slight, but suggest a cooling of the region, as these plants are characteristic of high-arctic vegetation. This cooling is seen elsewhere in the central arctic (Bradley 1990). There was no significant change in the sediment at this time.

The pollen diagram from PWWL on Prince of Wales Island does not show large changes in the Holocene as was also observed on Somerset Island (Gajewski 1995). However, on Somerset Island, an initial pioneer or cold phase was not recorded. Future work can determine if this difference is due to some local factor or climate differences between the sites.

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**References**


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