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Post-Glacial Vegetation History of the Ittlemit Lake Basin, Southwest Yukon Territory

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ABSTRACT. The pollen record of a 240 cm peat profile in the Ittlemit Lake area in southwest Yukon Territory presents a vegetation development history of the last 9000 radiocarbon years. Spruce migrated into the area at least 9000 radiocarbon years ago. From 9000 yr BP to approximately 5000 yr BP the area supported a sparse *Picea-Salix-Betula* forest-tundra vegetation. By 5000 yr BP local environmental change created a different habitat primarily affecting the local taxa. *Alnus* invaded the general area shortly after 5000 yr BP. A local *Betula*-dominated community replaced the previous Cyperaceae-dominated one at about 3000 yr BP. A Cyperaceae-dominated community again occupied the area at about 1900 yr BP. Although the local community changed several times, the present regional forest-tundra vegetation has had little change during the last 9000 radiocarbon years.

Key words: pollen analysis, paleovegetation, southwest Yukon

RÉSUMÉ. Le relevé des pollens dans un profil de tourbe de 240 cm venant de la région du lac Ittlemit dans le sud-ouest du Territoire du Yukon représente l'histoire de l'évolution de la végétation des derniers 9 000 ans (radiocarbone). L'épinette a fait son apparition dans la région il y a au moins 9 000 ans (radiocarbone). De 9 000 à 5 000 ans environ avant notre ère, la région possédait une végétation clairsemée de forêt-toundra composée de *Picea-Salix-Betula*. Environ 5 000 ans avant notre ère, un changement dans l'environnement local a créé un nouvel habitat, ce qui a d'abord affecté les taxons locaux. Peu après 5 000 ans avant notre ère, toute la région a été envahie par *Alnus*. Environ 3 000 ans avant notre ère, une communauté locale à dominance de *Betula* a remplacé la communauté précédente à dominance de cypéracées. Une communauté à dominance de cypéracées a de nouveau occupé la région environ 1 900 ans avant notre ère. Bien que la communauté locale ait changé plusieurs fois, la végétation existante de forêt-toundra de la région n'a subi que peu de modifications au cours des derniers 9 000 ans (radiocarbone).

Mots clés: analyse pollinique, paléovégétation, sud-ouest du Yukon

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INTRODUCTION

The Ittlemit Lake area, southwest Yukon, Canada, is situated between Aishihik Basin and Ruby Range (Bostock, 1948). Palynostratigraphic examination of this area is of special interest because the area is highly elevated and therefore sensitive to environmental changes. During the last few decades, extensive investigations of the late Quaternary environmental history have been carried out in northern Yukon and adjacent Alaska and Northwest Territories (Ritchie, 1984a, 1985; Ager, 1983; Ager and Brubaker, 1985; Hills and Sangster, 1980; Cwynar, 1982), while records from the region between Ruby Range and Tintina trench in southwest-central Yukon Territory still remain fragmentary and rare. In the Ittlemit Lake area, no palynological data have been reported.

During the last glaciation, Ittlemit Lake area was covered by a cordillera ice lobe (Hughes *et al.*, 1969; Dewez, 1988), which left extensive ice-contact deposits in the area. Paleovegetation and paleoclimatic investigations in the area are primarily aimed at determining whether the modern vegetation pattern of a subalpine-tundra and boreal forest in the region has had a long history during the post-glacial time or experienced severe variations. Further, as post-glacial migration routes of spruce have been widely discussed during the last decade (Ager, 1983; MacDonald, 1984), the arrival time of spruce in the study region is also of interest. This paper presents the results of pollen analysis in the Ittlemit Lake area, filling a geographic gap for palynological investigations in the southwest Yukon. The study emphasizes the relationship between pollen records and local environmental conditions, since the site is situated in a small basin at a relatively high elevation. Vegetation in such an environment is a function not only of climatic conditions but also of geomorphological processes and landform development.

THE STUDY AREA

Samples of a peat profile were collected from a wet peatland near the northwestern end of Ittlemit Lake at 61°13′35″N lat., 137°12′53″W long., at an elevation of 1180 m a.s.l. (Fig. 1). The core site is located at the southwestern end of a flat lowland near the northwestern end of Ittlemit Lake, which is an old glacial channel in the mountain area. A series of moraine ridges is scattered on the slope east of the lowland area and in adjacent gullies.

The present vegetation in the area is classified as a sparse white spruce (*Picea glauca*) forest-tundra. An obvious vertical zonation of vegetation cover on the northeast- and southeast-facing slopes was observed. Forest-tundra on the foot of slopes consists of 5% *Picea glauca*, 50-70% *Betula glandulosa*, 5-10% *Salix glauca*, and 15-20% Ericaceae, estimated empirically. With increased altitude, forest-tundra is replaced at about 1220 m by high shrub-tundra that consists of about 60% *Betula glandulosa*, 20% *Salix glauca*, and 15% *Ledum groenlandicum*. Low shrub-tundra occurs at about 1370 m and consists of approximately 40% *Betula glandulosa*, 40% *Salix glauca*, and 15% *Vaccinium* sp. The shrubs in this zone are less than 0.5 m high. *Dryas* tundra occurs above *ca.* 1460 m and consists of 60% *Dryas hookeriana* and 30% bare ground. Compositae, *Saxifraga* sp., *Betula* sp., and *Salix* sp. are also present. In the lowland area, spruce forest-tundra covers the well-drained glacial deposits, while an *Eriophorum* sp. dominated community occupies all wet ground. *Betula*

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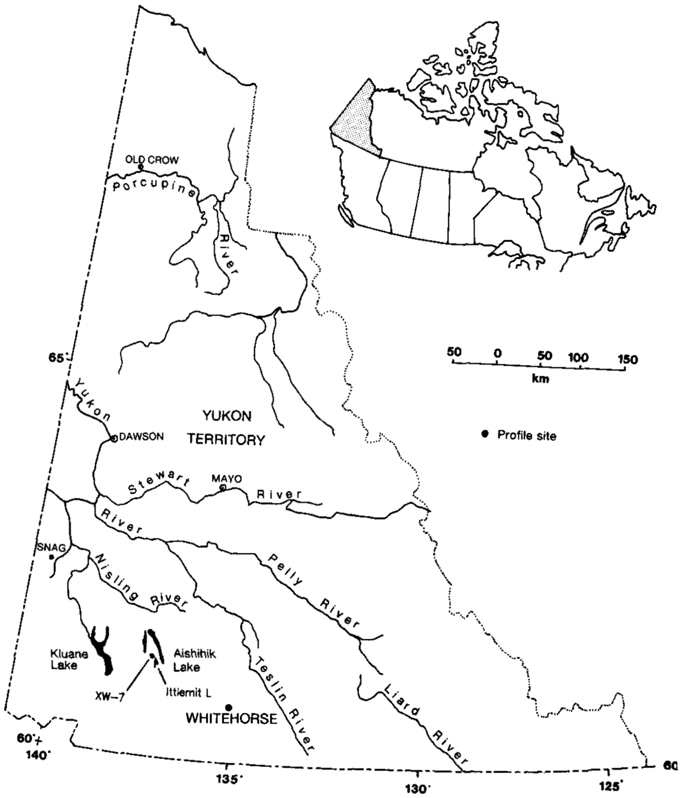

FIG. 1. Location map of the study area. The core site is marked as XW-7.

glandulosa or *Salix glauca* patches occupy all moderately drained areas. At the core site, *Eriophorum* sp. covers about 80% of the ground. *Betula glandulosa* patches exist only a few metres away from the core site. *Salix glauca* and *Potentilla fruticosa* are also present in the vicinity. No tree birch was observed during any of the three field seasons.

METHODS

The seasonally unfrozen peat deposits were trenched down to the occurrence of permafrost and collected as a monolith using a 38 cm × 5 cm × 4 cm plastic tray. This monolith was then subsampled in the laboratory at 5 cm intervals. The frozen sediments were raised by means of a modified CRREL Ice-Coring Auger (Veillette and Nixon, 1980). The cores were scraped clean of possible contamination, photographed, cut into 2.5 cm segments, and then sealed in labelled plastic bags.

In the laboratory subsamples of 2 cm^3 of sediments were taken every 5 cm and treated using standard preparation procedures (Faegri and Iversen, 1975) for pollen analysis. The exotic marker suspension method (Benninghoff, 1962; Matthews, 1969; Maher, 1972) was used to determine pollen accumulation rates (PARs). At least 200 terrestrial pollen grains were counted for each sample. *Betula* pollen grain diameters were measured at certain levels to distinguish the arboreal (*Betula papyrifera*) and shrub (*Betula glandulosa*) types, although there is a considerable size overlap according to modern reference collections (Ives, 1977).

RESULTS

Sediment Stratigraphy

The sediments in this profile consist basically of organic peat with variable mineral content and humification. White River volcanic ash grains (1230 yr BP) are scattered at the 20 cm horizon. Extensive ice lenses occur between 40 and 43 cm. At the 63 and 83 cm horizons, the peat becomes woody, with long fibres. Below 131 cm mineral content starts to increase. From 154.5 to 206.5 cm, the sediments change to an organic silt, with extensive ice lenses between 177 and 180 cm and fine sands between 182 and 185.5 cm. Fibrous peat occurs from 206.5 cm down to an occurrence of coarse sand containing organic material at 222-226 cm. Organic silt with ice lenses occurs between 226 and 234 cm, and fibrous peat occurs between 234 and 238 cm. At the bottom of the profile, organic fibres with sand occur from 238 to 240 cm. The detailed stratigraphy is presented with the pollen diagrams.

Radiocarbon Dates and Sedimentation Rates

Four core segments were submitted for ^{14}C dates. The stratigraphic positions of dated samples are approximately similar to the changes of pollen spectra so that the chronology of events reflecting environmental variation can be estimated more accurately. The results of the dating are listed in Table 1. Sedimentation rates were determined using these four ^{14}C dates (Fig. 2). The results (Table 2) were used to determine the absolute pollen accumulation rates. Because ice lenses in this profile are extensive and the content of ice varies throughout the section, the thicknesses of ice lenses were modified prior to the calculation of sedimentation rates and sample volumes were calibrated before the determination of PAR values (Wang, 1989). Full discussion of this calibration and related methodology has been presented in previous studies (Wang, 1989; Wang and Geurts, 1989).

TABLE 1. Results of ^{14}C dates, Ittlemit Lake area peat core

Lab number	Sediment interval (cm)	^{14}C dates (yr BP)	Material
UQ-144	55.0 - 13.0	490 ± 170	peat
UQ-144	468.0 - 74.0	2950 ± 100	peat
UQ-144	3149.0 - 154.5	5000 ± 100	peat
UQ-137	4232.0 - 240.0	8850 ± 200	peat

TABLE 2. Sedimentation rates deduced from the relation of ^{14}C dates *vs* depth, Ittlemit Lake area peat core

Core interval (cm)	Time interval (yr BP)	Mean sedimentation rate (cm/yr)
0.0 - 9.0	0 - 490	0.01837
9.0 - 71.0	490 - 2950	0.02443
71.0 - 153.0	2950 - 5000	0.03829
153.0 - 236.0	5000 - 8850	0.02088
236.0 - 240.0	8850 - 9031*	0.02088

*Extrapolated.

Pollen Stratigraphy

The results of pollen analysis are represented on a relative pollen frequency (pollen percentage) diagram (Fig. 3) and a pollen accumulation rate diagram (Fig. 4). Three numerical procedures — i.e., CONISS (Grimm, 1987), ZONATION (Gordon and Birks, 1972), and CONZONE (Wang and Geurts, 1988; Wang, 1989) — were employed to zone the pollen diagrams with a data matrix of pollen and spore percentages, including the most abundant types: *Picea*, *Alnus*,

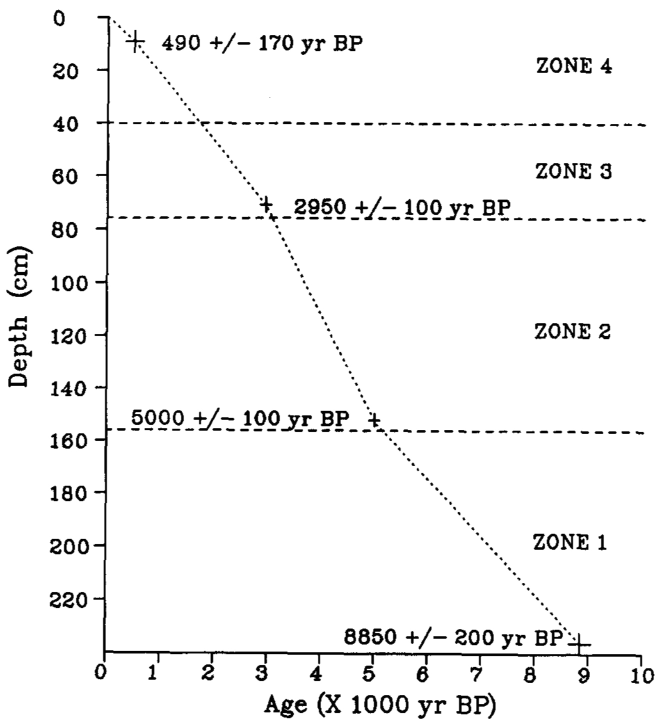

FIG. 2. Relation of ^{14}C dates *vs* depth. Pollen zone boundaries are also shown (see Figs. 3 and 5 for zonation details).

Betula, *Salix*, Rosaceae, *Juniperus*, Ericaceae, Gramineae, Cyperaceae, *Lycopodium*, *Dryopteris*, and *Equisetum*. Four major site pollen zones were recognized (Fig. 5). Measurement of pollen size suggests that *Betula* pollen in this profile was from dwarf birch (*Betula glandulosa*) (Fig. 6).

Zone 1 (157.0–240.0 cm): Zone 1 is characterized by high *Picea* (36-46% and 150-370 grains·cm^{-2}·yr^{-1}) and shrub pollen (22-46%). *Betula* is the most dominant shrub in the pollen spectra (20-30% and 90-175 grains·cm^{-2}·yr^{-1}). *Salix* values are consistently around 2-5%, its highest occurrence in the profile. Rosaceae percentages range from zero in one sample to 6%, *ca.* 2% in most cases. *Alnus* is only occasionally observed. Cyperaceae are the most abundant herb type (14.4-25.6% and 52-163 grains·cm^{-2}·yr^{-1}). Gramineae percentages are consistently around 5%. Other taxa are not significantly represented. In the pteridophyte group, *Lycopodium* (*ca.* 4%) and *Equisetum* (0-7.8%) reach their maximum in zone 1.

Zone 2 (76.5–157.0 cm): The most striking feature of zone 2 is the rise of *Alnus* pollen (*ca.* 8% and up to 260 grains·cm^{-2}·yr^{-1}) and the high value of Cyperaceae (*ca.* 30% and 440 grains·cm^{-2}·yr^{-1}). *Picea* is lower in percentage (19.4-34.4%) but higher in PAR values (165-820 grains·cm^{-2}·yr^{-1}) than before. *Juniperus* has its best occurrence in this zone (*ca.* 1-2% in most samples). Rosaceae decrease somewhat (*ca.* 1.5%). *Salix* (0-4%) and Gramineae decrease and Ericaceae (*ca.* 1-2%) increase in comparison with those in zone 1. *Betula* value is from 11.4 to 42% and 80-800 grains·cm^{-2}·yr^{-1} in PARs.

Zone 3 (40.0–76.5 cm): Picea experiences a small decrease in this zone (13-31% and 120-650 grains·cm^{-2}·yr^{-1}), while the *Alnus* value is similar to before (4-10%). *Betula* increases

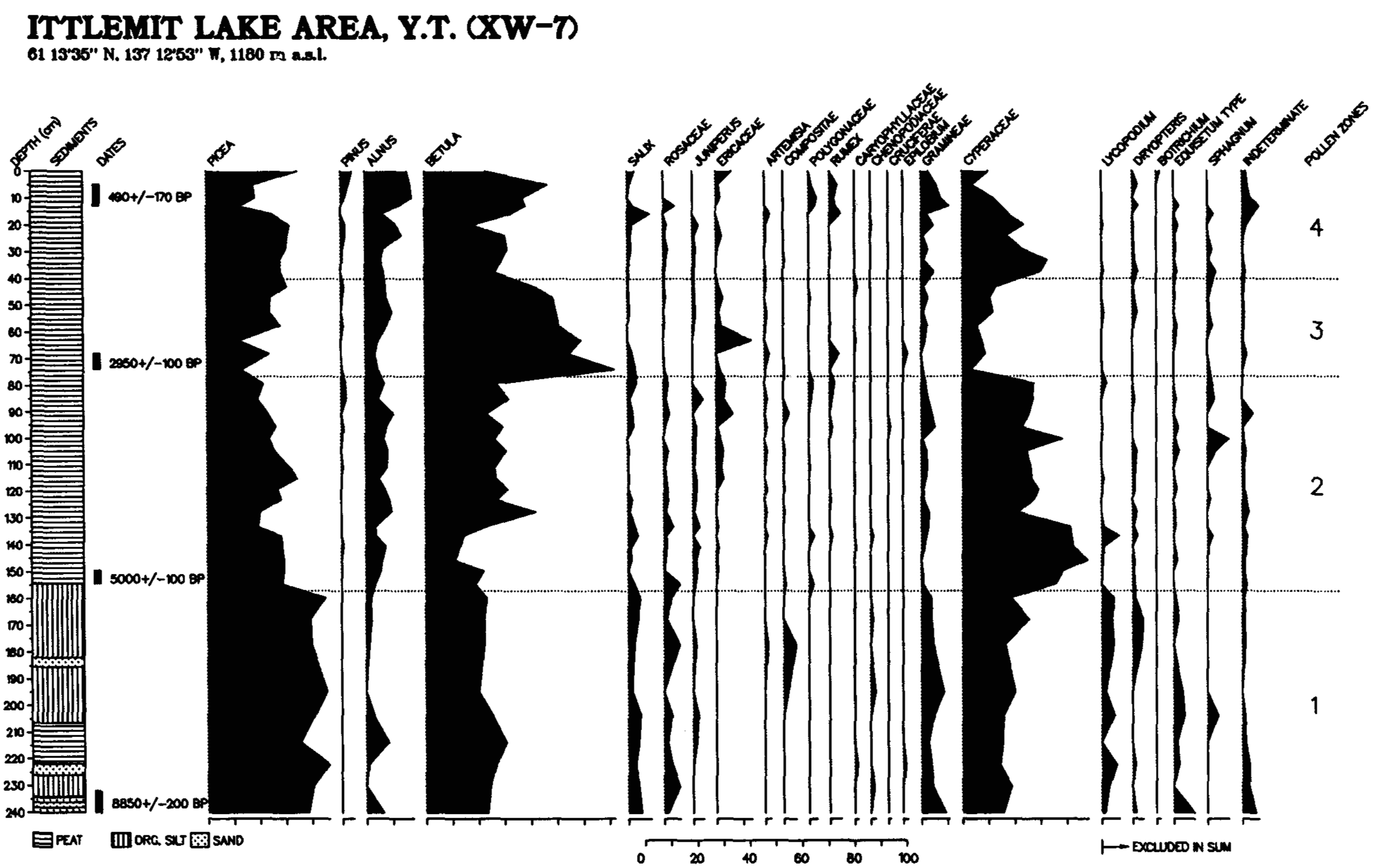

FIG. 3. Pollen percentage diagram, Ittlemit Lake area peat core.

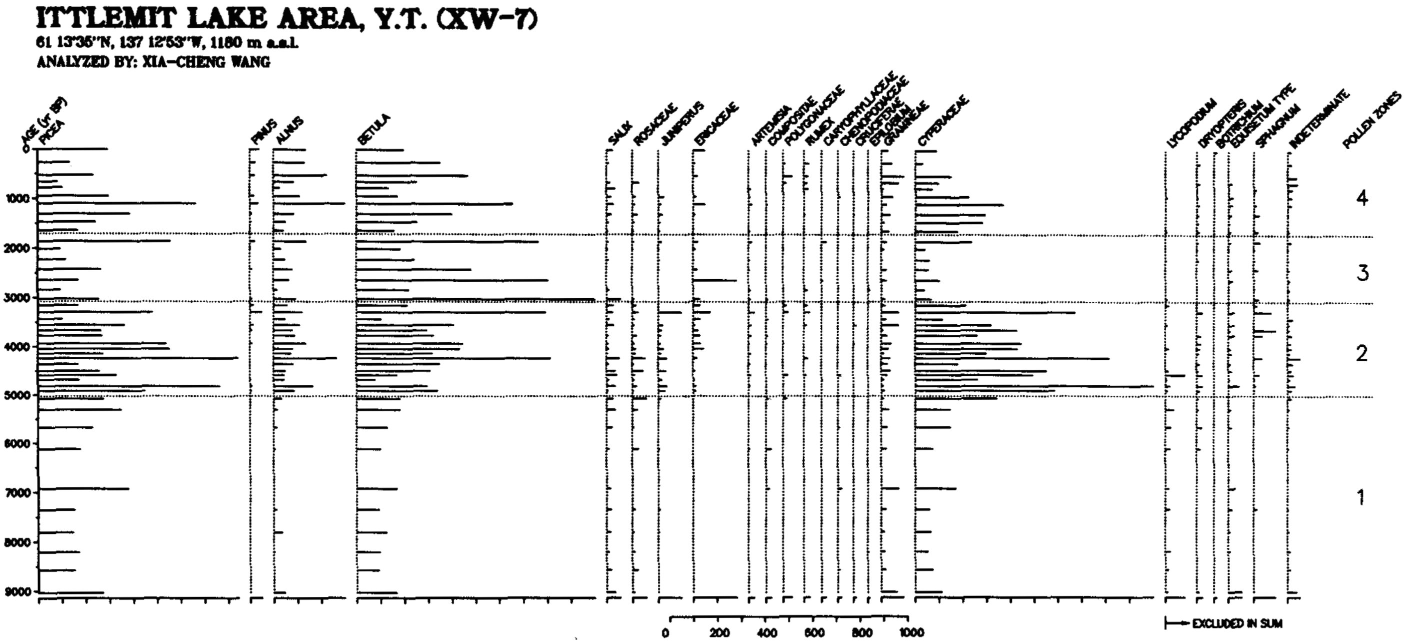

FIG. 4. Absolute pollen accumulation rate (grains·cm^{-2}·yr^{-1}) diagram, Ittlemit Lake area peat core.

significantly (42-75% and 270-1330 grains·cm^{-2}·yr^{-1}), compensating the dramatic decrease of Cyperaceae (3.4-12.9% and 35-230 grains·cm^{-2}·yr^{-1}). No other taxa are significantly represented in this zone.

Zone 4 (0-40.0 cm): Zone 4 is characterized by a rise of Cyperaceae (10-32.5% and 50-440 grains·cm^{-2}·yr^{-1}) and *Salix* (0-8.8% and up to 30 grains·cm^{-2}·yr^{-1}) and a decrease of *Betula* (18.4-47% and 80-465 grains·cm^{-2}·yr^{-1}). Gramineae percentages are higher than before, especially in the top part of the zone, where values reach 11%. *Rumex* occurs extensively in the top few samples (*ca.* 2.5%). *Alnus* experiences a large increase in the upper part of the zone (12-18% and *ca.* 350 grains·cm^{-2}·yr^{-1}). *Pinus* occurs irregularly, ranging from 0.4 to 1.8% in the first peak and from 1.55 to 4.4% in a second peak. *Picea* values, however, are similar to before.

PALEOENVIRONMENTAL RECONSTRUCTION

*Zone 1 (*ca. *9000 BP–*ca. *5000 BP):* During this time interval the Ittlemit Lake area supported a forest-tundra vegetation in which *Salix*, *Betula*, and Rosaceae were important components. As an alternative to this forest-tundra interpretation, high *Picea* percentage in zone 1 may also suggest that an open spruce forest existed in the area during this time interval. Although *Picea* pollen accumulation rates in this zone are too low to support the open forest interpretation, there is no doubt that spruce arrived in the Ittlemit Lake area at least by 9000 yr BP, as suggested by the high *Picea* percentage. It is interesting to note the discrepancy of *Picea* values between the pollen percentage diagram and pollen accumulation rate diagram. This may suggest that *Picea* pollen is severely overrepresented on the percentage diagram. In this zone, *Picea* is the only tree taxon, and high tree pollen percentages compensate the low value of shrubs and herbs. As previous studies have indicated, dwarf birch is a prolific pollen producer, and in north Yukon and N.W.T. 2-3% dwarf birch ground cover may cause 13-28% of *Betula* pollen in adjacent lake sediments (Ritchie, 1977:Table 6, 1982:Table 1, 1984a:135). Although the pollen records recovered from lake sediments and peat may not be directly comparable (Ritchie, 1974; Birks, 1977; Kay and Andrews, 1983), these figures may give a rough estimate of the *Betula* pollen representation factor in general. The approximately 20% *Betula* pollen found in this zone suggests a limited ground cover of dwarf birch in the area from about 9000 to about 5000 yr BP. In contrast to the overrepresentation of *Betula* pollen, *Salix* is usually underrepresented regionally (Farley-Gill, 1980). Three to four percent willow pollen in the pollen spectra has been considered as evidence for the presence of this shrub at the sampling site (Janssen, 1966). Thus, the consistent occurrence of *Salix* pollen with a value around 5% is a significant representation of this taxon and indicates that willow occurred widely in the area during the zone 1 time interval. Rosaceae, requiring an open habitat, is another taxon with significant representation in the pollen spectra. As the result of low pollen production within the shrub and herbaceous community, consisting of taxa such as *Salix* and Rosaceae, *Picea* pollen may be strongly overrepresented. This may explain the discrepancy

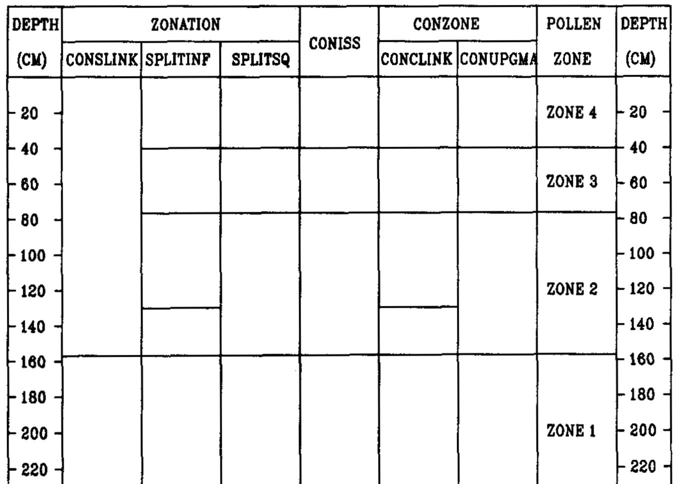

FIG. 5. Comparison of numerical and empirical zonation results.

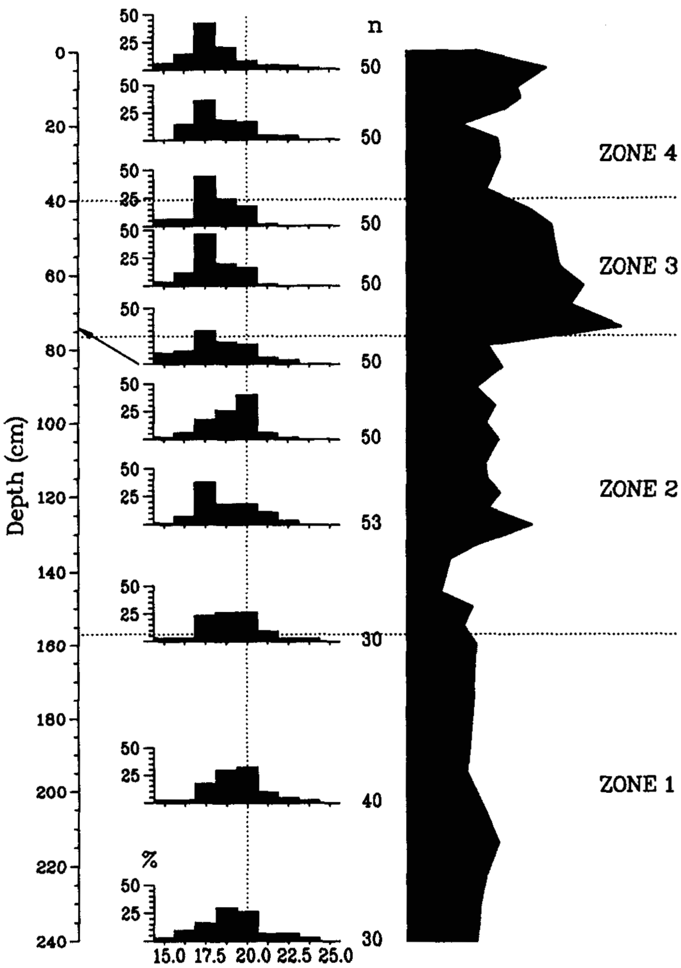

FIG. 6. *Betula* pollen grain-size measurements. Pollen zone boundaries and *Betula* pollen percentages are also shown for easy comparison.

between *Picea* pollen percentage and pollen accumulation rate. Therefore, an interpretation of a forest-tundra vegetation is likely more valid.

Zone 2 (5000–3000 yr BP): There is again a discrepancy between *Picea* percentages and accumulation rates. While *Picea* percentages decrease in zone 2, the *Picea* pollen accumulation rate increases. The *Betula* pollen accumulation rate increases, while its percentages remain the same as in zone 1. Also, the rise of *Alnus* and Cyperaceae pollen percentages are simultaneously accompanied by the increase in pollen accumulation rate. As a result of most taxa having increased accumulation rates, the total pollen accumulation rate is 2-3 times higher than in zone 1. The most striking feature in this zone is the great increase in the Cyperaceae percentages and the rise of *Alnus* and *Juniperus*. Selected pollen ratios (Fig. 7) also show this increase of Cyperaceae. Although zone 2 falls into the same time range as pollen zone 6 at Antifreeze Pond, about 210 km northwest of the Ittlemit Lake (Rampton, 1971), the pollen spectra in these two sequences are not very similar. Clearly, pollen records in lake deposits may be quite different from those in peat. However, both sites have comparable *Picea*, *Betula*, and Gramineae percentages. The prime difference relates to the Cyperaceae curves, i.e., there is much higher representation of Cyperaceae in the Ittlemit Lake area. The increase in *Alnus* percentages occurred at Antifreeze Pond about 5700 yr BP, about 700 years earlier than at Ittlemit Lake, although the values at Antifreeze Pond are much higher than those at Ittlemit Lake. Other differences include greater representation of shrubs such as *Juniperus* and Ericaceae in the Ittlemit Lake area. Although zone 6 at Antifreeze Pond was described as a spruce forest, this interpretation is not applicable to the Ittlemit Lake area. The consistent representation of *Juniperus* pollen in this zone indicates that an open habitat existed in this area, since this taxon is unable to persist in shaded environments (Ritchie, 1984b).

Surficial pollen investigations in southwestern Yukon (Wang, 1989) and Coppermine Valley in the Northwest Territories (Geurts, 1983) indicate that *Picea* pollen in forest samples should be higher than 40-50% in moss polsters. It is relevant to interpret the pollen spectra of zone 2 as a forest-tundra vegetation with shrub components differing from those in zone 1. *Salix*, Rosaceae, and Gramineae were apparently less important than before. A limited population of *Alnus* probably invaded the general area about 5000 yr BP. At first *Juniperus*, then later Ericaceae, became important components of the vegetation. Although a slight decrease of spruce pollen percentage in comparison to zone 1 was recorded, *Picea* might actually have a greater abundance or more efficient pollen production than before, as suggested by the increase of spruce pollen accumulation rate in this zone. However, this change in regional vegetation components was probably of limited magnitude. Within a general background of regional (*Picea*) and local (shrubs) components, Cyperaceae abundance changed significantly. The increase of Cyperaceae by about 20% indicates a deterioration of local drainage conditions or an increase in soil moisture at the sampling site and vicinity. It was this change in the moisture regime that allowed for development of the peat deposits after the zone 1 time interval. More significant representation of *Sphagnum*, a typical bog plant, also favours such an interpretation.

Zone 3 (3000–1900 yr BP): Pollen spectra of zone 3 are very similar to those of zone 2 except for the remarkable decrease of Cyperaceae and the associated increase of *Betula*, with a value of about 30%. Changes in pollen accumulation rate follow the change in percentage. This resemblance between percentage and accumulation rate data implies a real change of pollen rain composition. Decreased *Picea vs Betula* ratio and increased *Picea vs* Cyperaceae and *Betula vs* Cyperaceae ratios directly illustrate this change (Fig. 7). Since *Picea* values show no obvious difference from before, it is concluded that the regional vegetation component did not

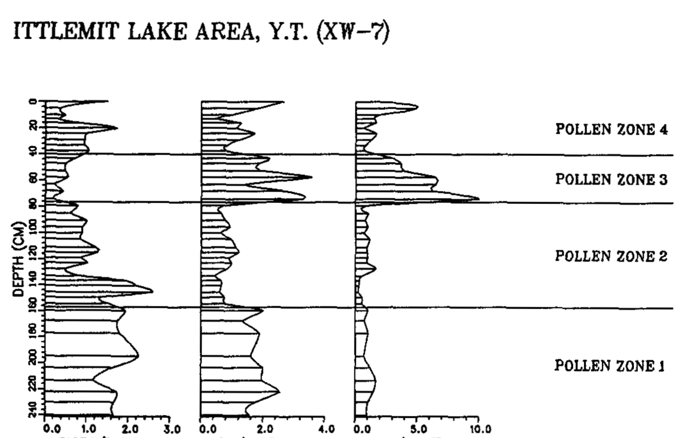

FIG. 7. Selected pollen ratios, Ittlemit Lake area peat core.

change significantly. The only variation that occurred in zone 3 was the invasion of *Betula* into the site, which reflects an improvement in the drainage condition at the sampling site. The area was still under forest-tundra vegetation, as before. Similar pollen spectra have also been found in zone 3b at Mackintosh Creek–HB1 diagram in southwest Yukon (Beaudet, 1986) and upper zone 3b of Birch Lake Core II at Tanana Valley in eastern Alaska (Ager, 1975). The former has been interpreted as a forest-tundra vegetation, and the latter as part of Middle Tanana Valley forest. However, it must be kept in mind that the birch pollen in Middle Tanana Valley was considered to be from tree *Betula*, compared with the dwarf birch of the Mackintosh Creek and Ittlemit Lake areas.

Zone 4 (1900 yr BP–present): Pollen zone 4 represents a vegetation pattern similar to zone 3 and typical of a forest-tundra. The components of this vegetation, however, have undergone a modification by slight replacement of certain local taxa. Increased Cyperaceae in the lower part and *Rumex* and Polygonaceae in the top part of the zone suggest that the site returned to a wetland at approximately 1900 yr BP. *Salix* shrubs increased in distribution shortly after the beginning of this wet episode. Both percentage and accumulation rates of *Alnus* increased after about 800 yr BP, indicating either an increase in distribution density of this taxon in the area or more efficient pollen production, reflecting favourable climatic or ecological conditions.

DISCUSSION

The pollen records provided above present a clear picture of changing local landscape in the Ittlemit Lake area over the last 9000 radiocarbon years. The pollen sequence suggests that spruce arrived in this area at least 9000 yr BP. This suggestion is supported by both percentage and accumulation rate data. During the interval between 9000 and 5000 yr BP, the area was covered by a sparse *Picea-Salix-Betula*-Gramineae forest-tundra vegetation. Because the pollen production of *Salix* and herbs is very low, the *Picea* pollen percentage is severely overrepresented in zone 1 and therefore causes a discrepancy between percentage and accumulation rate data. By 5000 yr BP, local environmental change created a different habitat for this forest-tundra vegetation cover that primarily affected the local taxa. The importance of *Salix*, Rosaceae, and Gramineae in the vegetation decreased. Cyperaceae, *Juniperus*, and Ericaceae became more important. Increased accumulation rate values for many taxa suggest an improvement of the pollination environment for most plants in the area. *Alnus* invaded the general area shortly after 5000 yr BP. A rise of *Alnus* pollen in both percentage and accumulation rate data in the middle Holocene is a common feature of many pollen sequences in northwest North America (Ritchie, 1984a,b; Rampton, 1971; Ager, 1975; Matthews, 1974; MacDonald, 1984; etc.). However, this event occurred about 1000 to 2000 years later in the Ittlemit Lake area than at most other places, and the values of both percentage and accumulation rates are much lower in the Ittlemit Lake area. An increase of *Alnus* pollen percentage from 15 to 25% at about 4500 yr BP in the Jenny Lake area in southwest Yukon (Stuart *et al.*, 1989), about 60 km southwest of Ittlemit Lake, is consistent with the record of Ittlemit Lake area in chronology, except for the higher value in the Jenny Lake area. Previous studies have shown that *Alnus* pollen is usually overrepresented in pollen spectra, especially at high altitude sites (Campbell, 1987; Wang, 1989). It is apparent that the *Alnus* pollen record in the Ittlemit Lake profile reflects a sparse regional distribution of alder rather than a local colonization. Beginning around 3000 yr BP, a *Betula*-dominated local community replaced the previous Cyperaceae-dominated one, causing a change of shrub constituents in the vegetation. This *Betula*-dominated forest-tundra phase lasted for about 1100 years and was again replaced by the Cyperaceae-dominated community around 1900 yr BP. Associated with the increase of Cyperaceae, *Salix* became more important than before. Gramineae and *Rumex* also increased somewhat about 800 yr BP. A further increase of *Alnus*, associated with an increase of *Pinus* pollen, occurred at about 500 yr BP, which corresponds to the advance of glaciers in the St. Elias Mountains (Denton and Karlén, 1973). However, the regional forest-tundra environment has not changed significantly during the last 1900 radiocarbon years.

The discontinuous occurrence of *Pinus* pollen peaks in the profile is interesting and provides some climatic information. A previous study (MacDonald and Cwynar, 1985) demonstrates that *Pinus contorta* migrated into the Kettlehole Pond (60°04′N, 133°48′W) area near the border of Yukon and British Columbia by 2490 yr BP and invaded the Cinquefoil–Dwindling Pond (61°05′N, 135°30′W) area by 1100 yr BP and the Two Horsemen Pond (60°51′N, 135°45′W) area by 520 yr BP in southwest Yukon Territory, both about 100 km south-southeast of Ittlemit Lake. The nearest pine trees at present are located about 55 km east and 75 km southeast of the Ittlemit Lake area (Geurts, 1986:55, Fig. 19). Apparently the pine pollen peaks in the Ittlemit Lake pollen profile are exotic due to long-distance transportation, as suggested by their low values. The first peak with a value of about 5% and 50 grains·cm^{-2}·yr^{-1} occurred at about 3000 yr BP, which is approximately the same as the arrival time of pine at Waterdevil Pond in northern British Columbia (MacDonald and Cwynar, 1985). As reported from Baffin Island (Nichols *et al.*, 1978), exotic pollen peaks have been interpreted as paleowind evidence. During the pollination period of pine in May and June (Bassett *et al.*, 1978), high mean monthly wind speeds and dominant SE and S winds in the area (Fig. 8) are favourable for transporting pine pollen

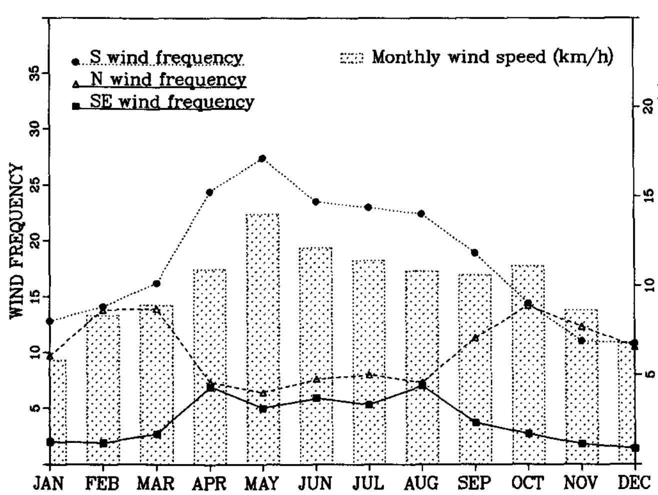

FIG. 8. Mean annual wind directions and speeds at Aishihik Station, southwest Yukon Territory (data from Environment Canada, 1982; after Wang, 1989).

to the Ittlemit Lake area. Airborne pollen records from the Gladstone Creek area, southwestern Yukon Territory (Lagarec and Geurts, 1984), reveal that low pressure and meridional circulation of air masses are favourable conditions for the transportation of airborne pollen to the Aishihik-Kluane area. A previous study (Geurts, 1988) indicates that short-term pollen spectrum fluctuations are a result of changes in pollen production, which is affected by dominant weather and atmospheric circulation systems. These isolated *Pinus* pollen peaks in this study might suggest that the favourable pollination condition of pine is also favourable for transporting the pollen to the study area.

It has long been believed that the southwest Yukon was supporting an open grassland vegetation during much of the Holocene (Johnson and Raup, 1964; Workman, 1978). Such a hypothesis, however, has recently been challenged by the pollen records of the Jenny Lake profile (Stuart *et al.*, 1989). Pollen records presented in this paper indicate that spruce migrated into the Ittlemit Lake area at least 9000 yr BP and a spruce forest-tundra vegetation has been established in the Ittlemit Lake Basin since then. Such a conclusion is consistent with the findings of the Jenny Lake profile and not in favour of the open grassland hypothesis.

CONCLUSION

In conclusion, the regional forest-tundra vegetation in the Ittlemit Lake area has experienced little change during the last 9000 radiocarbon years, while the local environment developed through several stages. From 9000 to approximately 5000 yr BP, the vegetation in the area was a spruce forest-tundra. A local Cyperaceae-dominated community developed in the area from 5000 to 3000 yr BP. *Alnus* invaded the general region shortly after 5000 yr BP, although its pollen values are much lower than at other northern localities. A *Betula*-dominated community developed at the site at about 3000 yr BP, and a Cyperaceae-dominated community has been significant since 1900 yr BP as a response to a wetter condition. Discontinuous occurrence of *Pinus* pollen peaks from about 3000 yr BP reveal a frequent occurrence of favourable weather and atmospheric circulation conditions for pine pollen production and transportation in the region.

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