« Plant and Insect Fossils from the Mayo Indian Village Section (Central Yukon) : New Data on Middle Wisconsinan Environments and Glaciation »

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PLANT AND INSECT FOSSILS FROM THE MAYO INDIAN VILLAGE SECTION (CENTRAL YUKON): NEW DATA ON MIDDLE WISCONSINAN ENVIRONMENTS AND GLACIATION*

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ABSTRACT The Mayo Indian Village Section in central Yukon contains the Mayo Till, representing the Wisconsinan McConnell Glaciation, underlain by fluvial sediments with rare detrital organics. Previous ^{14}C dates from the till or underlying sediments have failed to adequately define the age of the McConnell Glaciation. A new accelerator date (29.6 ka BP) on seeds of *Corispermum hyssopifolium* from subtill deposits shows that the McConnell Glaciation is probably Late Wisconsinan in age and that it correlates with the Kluane Glaciation (Kluane Lake area), McCauley Glaciation (Snag-Klutlan region) and the glaciation represented by "Till D" at the Tom Creek Section (Liard Plain). This conclusion and a new date on Old Crow tephra mean that the Reid, Mirror Creek and possibly Shakwak glaciations are of Illinoian age. Plant fossils (pollen and seeds) and insect fossils from detrital organics associated with the 29.6 ka BP date portray an essentially treeless environment. Even though typical low arctic plants such as heaths, shrub birch and alder are rare to absent, both pollen and macrofossils suggest a climate no colder than present low arctic tundra, although, it was probably drier. Spruce may have survived in the region, but only as small groves rather than as a riparian forest.

RÉSUMÉ *Les plantes et les insectes fossiles de la coupe du village indien de Mayo (centre du Yukon): nouvelles données sur la glaciation et les environnements du Wisconsinien moyen.* La coupe du village indien de Mayo renferme le Till de Mayo, témoin de la Glaciation de McConnell datant du Wisconsinien, sous lequel se trouvent des sédiments fluviatiles comprenant des matériaux organodétritiques rares. Les datations au ^{14}C du till et des sédiments sous-jacents obtenues antérieurement n'avaient pas permis de dater avec précision l'âge de la Glaciation de McConnell. La nouvelle date de 29,6 ka obtenue par accélérateur sur des graines de *Corispermum hyssopifolium* provenant des dépôts sous-jacents au till indique que la Glaciation de McConnell date probablement du Wisconsinien supérieur et qu'elle correspond aux glaciations de Kluane (Kluane Lake) et de McCauley (région de Snag-Klutan) et à la glaciation représentée par le «Till D» dans la coupe de Tom Creek (Liard Plain). À partir de cette conclusion et grâce à une nouvelle datation sur le tephra de Old Crow, on peut croire que les glaciations de Reid, de Mirror Creek et probablement de Shakwak sont d'âge illinoien. Les fossiles de végétaux (pollen et graines) et d'insectes trouvés dans les sédiments organodétritiques associés à la date de 29,6 ka BP témoignent d'un milieu en grande partie dépourvu d'arbres. Même si les végétaux caractéristiques du bas Arctique comme les Éricacées, l'aulne et le bouleau arbustif sont rares ou absents, le pollen et les macrofossiles laissent entrevoir un climat qui n'était pas plus froid que le climat actuel de la toundra du bas Arctique, mais probablement plus sec. Les épinettes ont peut-être survécu dans la région mais seulement sous forme de bosquets et non de forêt riparienne.

ZUSAMMENFASSUNG *Pflanzen- und Insektenfossile aus dem Profil des indianischen Dorfs Mayo (Zentral-Yukon): neue Daten zur Umwelt und Vereisung im mittleren Wiskonsinium.* Das Profil aus dem indianischen Dorf Mayo, Zentral-Yukon, enthält das Till von Mayo, das die McConnell-Vereisung im Wiskonsinium bezeugt und unter dem sich Flusssedimente mit seltenem organischem Erosionsmaterial befinden. Frühere ^{14}C-Daten von dem Till oder darunter liegenden Sedimenten führten nicht zu einer adäquaten Bestimmung des Alters der McConnell-Vereisung. Ein neues, mit Hilfe eines Beschleunigers auf Samen von *Corispermum hyssopifolium* in den Ablagerungen unter dem Till gefundenes Datum (29.6 ka v.u.Z.) zeigt, dass die McConnell-Vereisung möglicherweise im späten Wiskonsinium stattfand und mit den Vereisungen von Kluane (Kluane-See-Gebiet), McCauley (Snag-Klutlan-Gebiet) und dem durch das "Till D" repräsentierten Profil von Tom Creek (Liard Plain) korreliert. Diese Folgerung und ein neues Datum auf dem Tephra von Old Crow bedeuten, dass die Vereisungen von Reid, Mirror Creek und möglicherweise Shakwak dem Illinoium zugeordnet werden können. Pflanzenfossile (Pollen und Samen) und Insekten-fossile aus organischem Erosionsmaterial, das mit dem 29.6 ka v.u.Z. Datum in Verbindung gebracht wird, zeichnen eine im wesentlichen baumlose Umwelt. Auch wenn typische Pflanzen der unteren Arktis wie Heidekraut, Buschbirke und Erle selten bis nicht vorhanden sind, belegen sowohl Pollen wie Makrofossile ein Klima, das nicht kälter war als das gegenwärtig in der Tundra der unteren Arktis herrschende, wenn auch möglicherweise trockener. Fichten haben wohl in dem Gebiet überlebt aber nur in kleinen Wäldchen und nicht als Uferwald.

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INTRODUCTION

Stewart River is one of the major tributaries to the Yukon River in the central part of Yukon Territory. Exposures of till and glaciofluvial gravel referable to the McConnell Glaciation, one of two late Pleistocene glaciations recognized in the area, are found intermittently along the Stewart River from the town of Mayo (Fig. 1) to a point just upstream from the McConnell moraine (Hughes, 1987). One such exposure, the Mayo Indian Village Section (named for the abandoned Indian Village that lies on the opposite bank and hereafter referred to as MIV Section), is located on the right bank of Stewart River, 2.4 km downstream from Mayo at 63°36′N; 135°56′W (Hughes *et al.*, 1987a). At the MIV Section McConnell age till, here named Mayo Till, is exposed more or less continuously along the length of the exposure.

A detrital organic zone beneath the till and at the base of the section contains autochthonous plant material suitable for an accelerator (AMS) ^{14}C date. The stratigraphic and chronological significance of this date and the environmental implications of the fossils associated with it are discussed in this paper.

REGIONAL AND LOCAL SETTING

GLACIAL HISTORY

Stewart River is within the Stewart Plateau section of the deeply dissected Yukon Plateau (Bostock, 1948). Bostock (1966) recognized four major advances of the Cordilleran Ice Sheet in central Yukon: Nansen (oldest), Klaza, Reid and McConnell (youngest). Reid and McConnell glaciations, both of late Pleistocene age (Hughes, 1986), were defined from moraines and other ice-marginal features that mark the maximum positions of the Cordilleran Ice Sheet during the late Pleistocene. The Nansen glaciation was inferred from glacial till in the upper reaches of Nansen Creek, west of Carmacks, and the Klaza glaciation from a glacial diversion of drainage into the head of Klaza River. Thus the Klaza, Reid and McConnell glaciations are based on morphostratigraphy alone and lack formally designated corresponding lithostratigraphic units. In the case of both Reid and McConnell glaciations, tills clearly associated with their definitive terminal moraines occur in exposures near the type morphostratigraphic localities. The MIV Section is near the morphostratigraphic locality for the McConnell Glaciation (Fig. 1).

CLIMATE AND VEGETATION

The Mayo region falls within the Central Climate Region of the Yukon (Wahl *et al.*, 1987) which is characterized by a sub-arctic continental climate. This means the area experiences large annual and daily temperature ranges, low relative humidity and low to moderate precipitation (300-400 mm), most of which falls in the summer (Wahl and Goos, 1987). Mean annual temperature at Mayo is −4°C. The 15°C mean daily July isotherm passes through Mayo, which is the most upstream site within a relatively warm trough that follows the Stewart and Yukon Rivers toward the northwest and the Alaskan border (Wahl *et al.*, 1987, Fig. 8)

Mayo and the MIV Section fall within the Ecoregion 13 (Mayo Lake-Ross River) of Oswald and Senyk (1977). The Mayo area is characterized by typical northern mixed deciduous and conifer forests, with regional tree line at between 1370

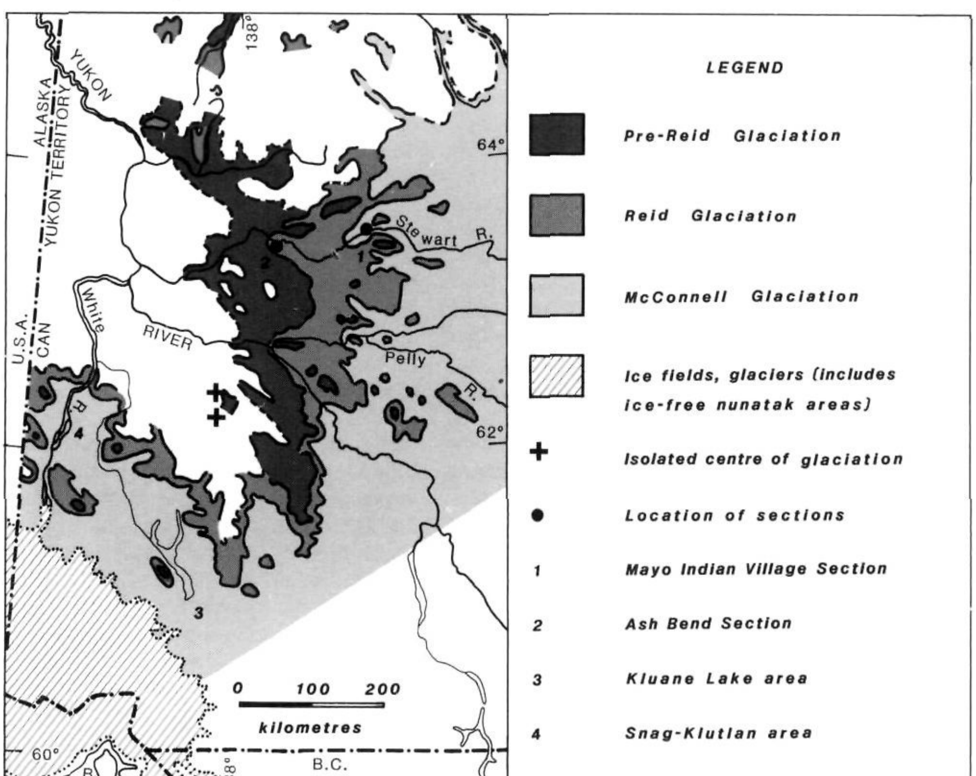

FIGURE 1. Map of central Yukon showing the limit of the McConnell Glaciation and sites mentioned in the text (except Liard Plain).

Carte du centre du Yukon montrant les limites de la Glaciation de McConnell et les sites mentionnés dans le texte (sauf Liard Plain) and 1400 m formed mostly by *Picea glauca* (white spruce). *Abies lasiocarpa* (alpine fir) occurs rarely in the Mayo area, but where present, it rather than spruce forms tree line. Despite the fact that sites downstream and north of Mayo probably have slightly warmer summer temperatures, Mayo marks the northern distributional limit for several species of plants and birds (Burn and Morlan, 1987).

METHODS

Sediment samples studied for pollen analysis were collected from a 6.25 m stratigraphic exposure of Unit 1 near the base of the section (Fig. 2). A $ZnBr_2$ heavy liquid processing technique was employed to concentrate fossil pollen. Because sedimentation rates are unknown, no effort was made to calculate influx values. The relative percent pollen diagram in Figure 4 is based on a sum that includes only identifiable pollen.

Plant and insect macrofossils were isolated from the sieved residue (0.425 mm opening) of sediment samples taken at the 4.7 m level of Unit 1. Approximately 10 kg of sediment was processed. For comparison, plant and insect remains from a sample of modern river detritus were extracted in the same way as the fossils.

THE MIV SECTION

Hughes, in company with H. S. Bostock, first visited the exposure in 1960 when it was much slumped and vegetated. Wood collected at that time from the base of the till yielded the first (I(GSC)-180), Table I) of five "greater than" dates which have been obtained on wood within or beneath Mayo Till. By 1985, when the present authors studied the section, it was well exposed for a length of about 1000 m. The representative section shown in the photo of Figure 3 and diagrammatically in Figure 2 was measured about 800 m downstream from the upper end of the exposure. At this point, Unit 1, containing a rare zone of organic detritus, was exposed and the overlying units readily accessible. The section is slumped and overgrown beginning about 200 m downstream from the point of measurement.

STRATIGRAPHY

Unit 1 (Figs. 2 and 3), which extends to about 5 m above river level, consists of dark brown to dark grey brown organic silt which grades upward into fine grained sand with lenses of organic detritus. The overlying sediments imply rapid deposition, hence Unit 1 is presumed to represent overbank flood plain sediments or fill in an abandoned channel deposited shortly before glaciation of the valley. Organic debris in Unit 1 is rare, being found mostly at only one station where it marks the dipping bedding planes of small scours and depressions.

Unit 2a, 17 m thick, consists of gravel near the base overlain by trough crossbedded sand and minor silt, suggesting glaciofluvial sedimentation. Unit 2b consists of 3 m of fine grained sand and silt with wavy bedding, scattered pebbles, and intercalated lenses of stony diamicton. It was probably deposited in a small ice-marginal pond. The glacio-fluvial gravel of Unit 2c, with cobbles up to 20 cm at the base, fines upward to a

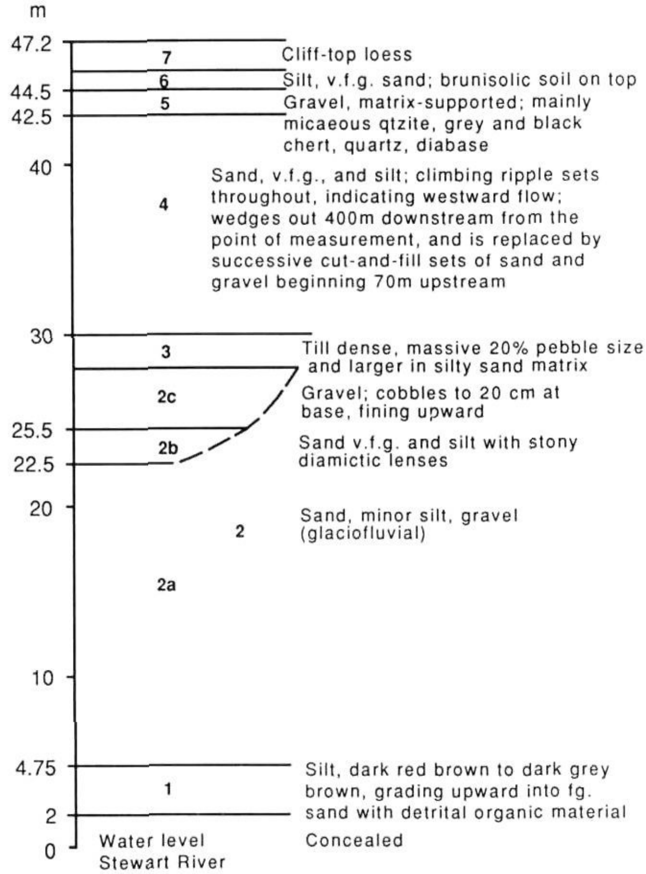

FIGURE 2. Stratigraphy of the Mayo Indian Village section. See Figure 4 for detail on the stratigraphy of Unit 1.

Stratigraphie de la coupe du village indien de Mayo. La figure 4 donne le détail de la stratigraphie de l'unité 1.

pebble gravel. Both units 2b and 2c wedge out about 70 m upstream from the measured section. Unit 2 contains scattered rounded fragments of wood that are clearly allochthonous and most likely reworked from considerably older deposits. Both Unit 1 and parts of Unit 2 were likely deposited at a time when Stewart River was a braided stream.

Unit 3, here named the Mayo Till, is a dense till with maximum thickness of 2 m and containing about 20 percent pebble to cobble clasts in a silty sand matrix. The dense and structureless character of the till suggests lodgement origin; however, discontinuous partings of silt and sand elsewhere along the exposure indicate that basal melt-out processes were also active during deposition. Downstream from the point of measurement the till is locally greatly thickened, probably due to glacial thrusting. Rounded pieces of wood are found within the till at various stations and like the wood in Unit 2, are probably reworked from older deposits.

Unit 4 includes about 13 m of uniform very fine grained sand and silt with ripple cross-beds indicating general westward flow. The sand was probably deposited in a shallow ephemeral lake occupying a depression in the till surface. It wedges out downstream from the point of measurement, but in the upstream part of the section, is cut out and replaced by channel-fill silt

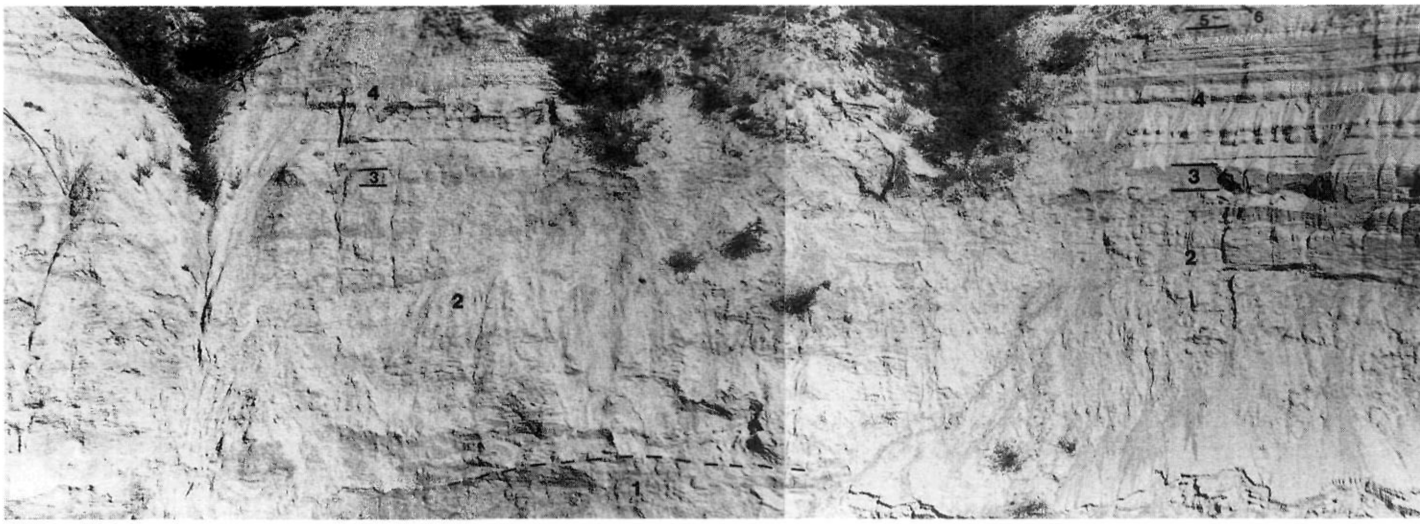

FIGURE 3. Composite photo of the middle portion of the MIV Section (field station 3), showing stratigraphic units numbered as in Figure 2. Unit 1 in the photo is typical of all parts of the section where it is exposed; however, the organics studied for this paper come from a station approximately 120 m further downstream (to the left of the photograph).

Montage photographique de la partie centrale de la coupe de Mayo (MIV, station n° 3) montrant les unités stratigraphiques numérotées comme sur la figure 2. L'unité 1 est représentative de toutes les parties de la coupe où elle est à découvert. Toutefois, les sédiments organiques étudiés ici proviennent d'une station située à environ 120 m en aval (vers la gauche de la photo).

TABLE I

Radiocarbon Dates from the Mayo Indian Village Section

Site	Lab. No.	Age	Material	Stratigraphic Unit	Type of Analysis	Reference
MIV	I(GSC)-180	>35,000	wood	Base of till (Unit 3)	Conventional	Trautman and Walton, 1962
MIV	GSC-331	>46,580	wood	Beneath till (Unit 2)	Conventional	Dyck *et al.*, 1966
MIV	GSC-3931	>42,000	wood (*Picea*)[1]	Beneath till (Unit 2)	Conventional	Unpub.
MIV	GSC-4436	>51,000	wood (*Picea*)[2]	Beneath till (Unit 2)	Conventional	Unpub.
MIV	GSC-4472	>47,000	wood (*Picea*)[3]	Beneath till (Unit 2c)	Conventional	Unpub.
MIV	TO-292	29,600 ± 300	seeds (*Corispermum*)[4]	Unit 1	AMS	This report
Mayo Sect.	GSC-4554	38,100 ± 1330	wood (*Salix*)[5]		Conventional	This report

[1] Identified by R.J. Mott, Unpublished Geological Survey of Canada Wood Identification Rpt. 84-33.
[2] Identified by H. Jetté, Unpublished Geological Survey of Canada Wood Identification Rpt. 87-19.
[3] Identified by H. Jetté, Unpublished Geological Survey of Canada Wood Identification Rpt. 87-20.
[4] Identified by J.V. Matthews, Jr., this report.
[5] Identified by H. Jetté, Geological Survey of Canada Wood Identification Rpt. 88-4.

and sand, which in turn is succeeded by at least two more channel-fill sets consisting mainly of sand and gravel.

Overlying Unit 4 is 1.5 m of gravel (Unit 5) and 1.5 m of fine sand and silt (Unit 6) with a thin brunisolic soil in the upper part. All three were probably deposited by a shifting glacial stream that succeeded the ephemeral lake responsible for Unit 4. The section is capped by up to 2 m of cliff-top loess probably only a few hundreds or thousands of years in age.

CHRONOLOGY

Details on all ^{14}C dates from the MIV Section are presented in Table I. Wood from the base of Unit 3 has yielded a conventional radiocarbon date of >35 ka; whereas wood samples from near the top of Unit 2 have yielded four conventional dates ranging from >42 to >51 ka BP. The probability that all five of the dated wood specimens had been redeposited from some unknown source, and hence that the dates do not define the age of the enclosing sediments, was the stimulus for a search for specimens which had not been redeposited, but the only other datable material from the sub-till part of the section is the detrital debris found in Unit 1. The problems associated with dating such material are well documented (Nelson *et al.*, 1988). The only meaningful dates are those on the autochthonous components of the organic detrital horizon, and since these are usually a minor component of the total sample, accelerator or AMS dating is the only feasible approach.

As noted above, the sedimentary facies of the pre-glacial units suggests that Stewart River of that time was transitional into or had become a braided stream. This implies abundant bare sand bars and a wide scantily vegetated flood plain. Bug seed, *Corispermum hyssopifolium*, grows at such sites in the Yukon today (Porsild and Cody, 1980 and JVM collections). Its seeds occur amongst other remains of plants and insects from the detrital organics in Unit 1 and we reasoned that they were likely autochthonous and hence would yield the most accurate date for the time of deposition of Unit 1. Approximately a dozen well preserved *Corispermum* seeds with a total dry weight of 7.4 mg were submitted to the Isotrace laboratory (University of Toronto) for AMS dating. They yielded a date of 29,600 ± 300 years BP (TO-292). Although we are aware that single AMS dates in this time range must be accepted with caution, the date is supported by a conventional ^{14}C date from a nearby section (see below and Table I, Mayo Section). Thus, we assume, for purposes of this discussion, that TO-292 accurately represents the age of both the *Corispermum* seeds and the 4.7 m level of Unit 1. If so, TO-292 is the youngest finite date from beneath till of McConnell age in central Yukon. Klassen (1987) reports a finite date of 23,900 ± 1140 BP (GSC-2811) beneath a till thought to be a McConnell equivalent in the southern Yukon (see below).

PALYNOLOGY

In spite of its relatively coarse texture and inorganic nature, Unit 1 sediments, except for several sterile horizons, proved to be surprisingly rich is pollen. The basal sediments yielded little pollen, and indeterminate pollen percentages in the diagram (Fig. 4) range from 18-70 percent.

The pollen record is dominated by *Artemisia* (20-50%), Gramineae (15-30%), and Cyperaceae (10-21%). *Picea* ranges from 2-18%, the highest value being in the basal sample, in which *Betula* also reaches its 9% maximum. Throughout the sequence, *Pinus, Alnus* and *Salix* occur in trace quantities, while there is a variety of herbaceous taxa, most noteworthy the Chenopodiaceae-*Amaranthus* type which ranges from 3-7%, and is at 4% at the 4.7m level where the dated seeds of the chenopodiaceous plant, *Corispermum hyssopifolium*, were found.

Modern flood plain vegetation in Alaska and Yukon includes grasses (*e.g.*, *Arctagrostis latifolia, Deschampsia* sp., *Poa alpigena*), *Artemisia Tilesii, Corispermum, Epilobium, Plantago* and various species of *Polemonium, Polygonum, Potentilla* and Caryophyllaceae, all taxa documented in this pollen record. The dominance of herbaceous pollen implies open treeless vegetation, but this could mean either upland tundra or the

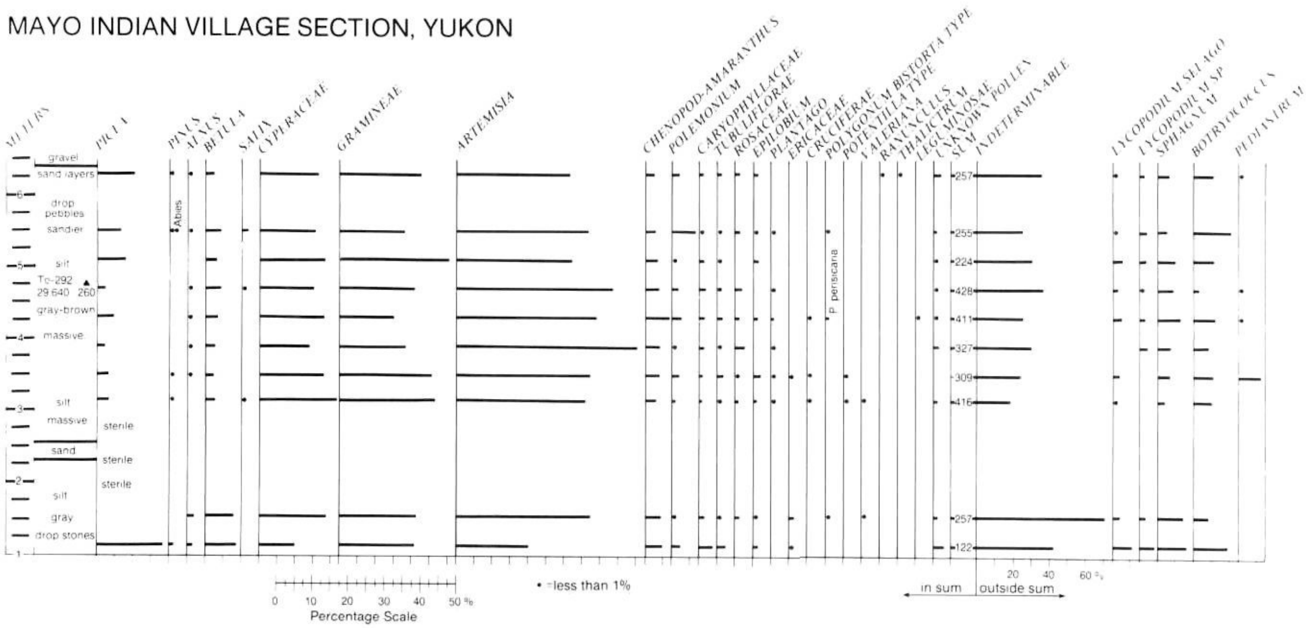

FIGURE 4. Fossil pollen profile from Unit 1 of the MIV Section. The AMS ^{14}C date and macrofossils discussed here come from approximately the same station along the length of the section as the pollen samples. Pollen analysis are by C. E. Schweger.

Diagramme du pollen fossile provenant de l'unité 1 de la coupe de Mayo (MIV). La date au ^{14}C obtenue par accélérateur et les macrofossiles dont on parle ici proviennent à peu près du même endroit le long de la section que les échantillons de pollen. Les analyses polliniques ont été effectuées par C. E. Schweger.

open pioneer vegetation on the flood plain. *Artemisia*-Gramineae-Cyperaceae assemblages similar to those at MIV have been recorded from late Wisconsinan lake sediments of Alaska and Yukon where they represent a unique upland tundra vegetation (Anderson, 1985; Brubaker *et al.*, 1983; Cwynar, 1982; Ritchie, 1982). In contrast, alluvium dated at 29 ka BP from the John River Valley, Alaska has yielded pollen assemblages believed to represent lowland vegetation comprised of mesic meadows rich in Cyperaceae and other herbaceous taxa, as well as *Salix* and *Betula* (Schweger, 1982). In this case it is clear that the pollen was deposited with alluvium on the then broad aggrading flood plain of the Stewart River.

PLANT MACROFOSSILS

Plant macrofossils from the 4.7 m detritus zone of Unit 1 and from comparable modern detritus on the river bank immediately across from the section are listed in Table II. The present distribution of selected plant taxa is shown in Figure 5a.

As indicated in the table, many of the plant fossils represent taxa expected on or near the sandy/gravelly flood plain of a large river. In contrast with the modern river detritus, which is dominated by spruce macrofossils (mostly needles), the fossil assemblage from Unit 1 contains only a single poorly preserved spruce needle, most probably rebedded from an older unit. This supports pollen evidence showing that spruce was virtually absent from flood plain sites at the time of deposition.

Unlike the modern detritus sample, the fossil sample lacks tree birch. It does contain a few fruits of shrub birch, but they are much rarer than in samples from typical shrub tundra. *Alnus* fruits, which are usually abundant in modern alluvial detritus from forest tundra and hypoarctic tundra (Matthews, 1982) are absent altogether in the organic debris from Unit 1 at MIV.

The plant macrofossil assemblage also contains seeds of aquatic plants such as *Potamogeton, Hippuris* and *Myriophyllum*, none of which is typical of active flood plain plant communities. These probably grew in ponds on the stable, vegetated parts of the former flood plain and were flushed into the main river system during spring runoff. Assuming that this was the case, and that the *Hippuris, Potamogeton* and *Myriophyllum* seeds do represent the more stable parts of the flood plain, then the lack of any macroremains of ericaceous plants (matched by near absence of ericaceous type pollen (Fig. 4) is puzzling. Ericoid taxa such as *Ledum, Empetrum,*

TABLE II

Plant Remains from Unit 1 of the Mayo Indian Village site compared with modern alluvial detritus

Taxa	Unit 1 (4.7 m)	Modern
Fungal sclerotia	+	+
Bryophytes	+	+
Pinaceae		
Picea sp.	+ nd	+ + nd,sd
Potamogetonaceae		
Potamogeton filiformis Pers.	+ sd	
P. pectinatus L.	+ sd	
P. Richardsonii (Benn.) Rydb.	+ sd	
Najadaceae		
Najas flexilis Willid.)		+ sd
Gramineae		
Hierochloe odorata (L.) Beauv.*		+ sd
Cyperaceae		
Carex maritima type*	+ sd	
Carex spp.	+ + sd	+ + sd
Eleocharis palustris/uniglumis type		+ sd
Juncaceae		
Juncus/Luzula type*	+ cp	
Salicaceae		
Salix sp.*	+ bd,cp	+ cp,lf
Betulaceae		
Betula glandulosa type	+ sd	
Betula papyrifera type		+ sd
Alnus incana (L.) Moench.		+ sd
Polygonaceae		
Oxyria digyna (L.) Hill	+ sd	
Rumex sp.*	+ sd	
Chenopodiaceae		
Corispermum hyssopifolium L.*	+ + sd	
Caryophyllaceae		
Cerastium sp.*	+ sp	
Melandrium sp.*	+ sd	
Stellaria sp.*	+ sd	
Sagina sp.	+ sd	
Ranunculaceae		
Ranunculus lapponicus L.		+ sd
R. trichophyllus type	+ sd	
R. abortivus L.	+ sd	
R. hyperboreus Rottb.	+ sd	
Papaveraceae		
Papaver sp.	+ sd	
Cruciferae		
Draba type	+ sd	
Rosaceae		
Potentilla sp.	+ sd	
Dryas sp.*	+ lf	
Haloragaceae		
Hippuris sp.	+ sd	
Myriophyllum exalbescens Fern.	+ sd	
Umbelliferae		
Bupleurum americanum Coult. & Rose*	+ sd	
Empetraceae		
Empetrum nigrum L.		+ sd

* = plants expected on or near the active floodplain of a large northern river; + = taxon present; + + = taxon abundant; nd = needle; lf = leaf or leaf fragment; cp = capsule; sd = seed or related structure; bd = bud scale.

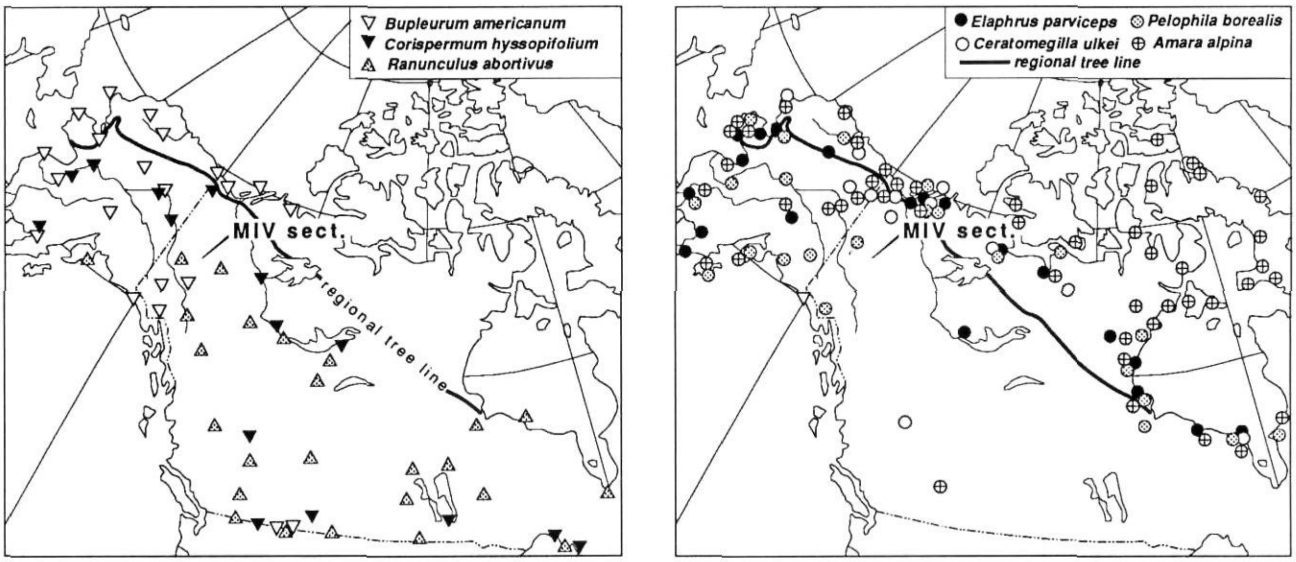

FIGURE 5. Maps showing present distribution of selected plant and insect species recorded from the 4.7 m level of the MIV Section. a) Plant species are represented by triangles. Distribution of *Bupleurum americanum* Coult & Rose generalized from Porsild and Cody (1980); *Corispermum hyssopifolium* Aellen from Porsild and Cody (1980) and Matthews' personal collections; *Ranunculus abortivus* L. generalized from Porsild and Cody (1980). Note that the last species does not occur much north of the fossil locality; whereas, some of the others are found on lowland and alpine tundra. b) Circles represent species of insects. Distribution of *Elaphus parviceps* Van Dyke from Goulet (1983); *Ceratomegilla ulkei* Crotch. from Gordon (1985); *Amara alpina* Payk. and *Pelophila borealis* Payk. from Lindroth (1961-1969).

Cartes montrant la répartition actuelle des espèces de quelques végétaux et insectes observés au niveau de 4,7 m de la coupe de Mayo (MIV). a) Les espèces de végétaux sont illustrées par des triangles. La répartition de Bupleurum americanum *Coult & Rose, généralisée à partir de Porsild and Cody, 1980; de* Corispermum hyssopifolium *Aellen, de Porsild and Cody (1980), et de la collection personnelle de Matthews; de* Ranunculus abortivus, *L. généralisée à partir de Porsild and Cody (1980). À noter que la dernière espèce ne se trouve pas beaucoup plus au nord du site du fossile tandis qu'on retrouve parfois les autres espèces dans les basses terres et la toundra alpine. b) Les cercles représentent les espèces d'insectes. La répartition d'*Elaphus parviceps *Van Dyke de Goulet (1983); de* Ceratomegilla ulkei *Crotch. de Gordon (1985); d'*Amara alpina *Payk. et de* Pelophila borealis *Payk. de Lindroth (1961-1969).*

Vaccinium and *Arctostaphylos* grow on stable flood plain sites today, both within and outside of tree limit. Furthermore, their macroremains are readily incorporated in alluvial sediments as witnessed by seeds of *Empetrum* in the modern detritus assemblage (Table II).

ARTHROPOD FOSSILS

Table III lists arthropod fossils recovered from the 4.7 m level of Unit 1 and Figure 5b the distribution of some key taxa. With the exception of *Harpalus amputatus* none of the positively identified taxa in the list is currently restricted to sites south of tree line and several of them, such as the carabids *Elaphrus parviceps* (Fig. 5b), *Amara glacialis, Pterostichus caribou, P. nivalis* and *Trichocellus mannerheimi* are typically found only above or north of tree line. This signifies a colder climate than at present in the lowlands near Mayo. Some limits on the degree of climatic severity are indicated by the fact that few of the species listed in Table III live at high arctic sites. For example, weevils such as *Notaris* and *Lepidophorus lineaticollis* and the ladybird beetle *Ceratomegilla ulkei* are restricted to low arctic or hypoarctic tundra (Danks, 1981; Gordon, 1985 and Fig. 5b), and the ground beetle *Pelophila borealis* (Fig. 5b) lives near water on rich organic substrata, but does not occur at such sites far beyond tree line (Lindroth, 1961-69). These species indicate that climate in the Mayo area was probably no colder than the contemporary climate of the northern mainland of the Yukon and Northwest Territories.

The carabid beetles *Cymindis* and *Harpalus amputatus* imply dry local sites. The latter is quite rare in the north today, but is common in the prairie regions of western Canada (Lindroth, 1961-69). It occurs today at a few dry sites in the interior Yukon but is not an arctic beetle. Its fossils have been found in fossil assemblages that appear to represent extremely dry tundra (Nelson, 1982). The weevils *Lepidophorus lineaticollis* and *Vitavitus thulius* both thrive at dry sites in Yukon, as long as some vegetation such as willows or *Dryas* are present. Another weevil species, *Connatichela artemisiae*, is also found today in very dry, sandy areas but probably requires the presence of *Artemisia*, its presumed food plant (Anderson, 1984). *Artemisia* pollen is abundant in all pollen spectra.

Beetle species characteristic of dry, scantily vegetated riverbanks are *Amara glacialis, Bembidion sordidum, Bembidion hasti* and perhaps *Bembidion umiatense*. The identification of *Bembidion lapponicum* requires confirmation; nevertheless, all of the species of the subgenus to which it belongs are found on dry, scantily vegetated river banks (Lindroth, 1961-69).

DISCUSSION

PALEOENVIRONMENTS

The high NAP (non arboreal pollen) percentages at the 4.7 m level, presence of tundra beetles such as *Amara alpina*

TABLE III

Arthropod remains from Unit 1 of the Mayo Indian Village Section compared with arthropod fragments from modern alluvial detritus

Taxa	Unit 1 (4.7 m)	Modern
Insecta		
Homoptera		
Psyllidae		+wg
Hemiptera		
Saldidae		
Genus?	+pr	
Coleoptera		
Carabidae		
Pelophila borealis Payk.	+pr	+el
Elaphrus parviceps Van Dyke	+el	
Bembidion lapponicum type*	+el	
B. (Plataphodes) sp.*	+pr,el	
B. hasti C. Sahlb.*	+pr,el	
B. (Peryphanes) sp.	+pr	
B. sordidum Kby.*	+pr	
B. umiatense Lth.	+pr	
Bembidion sp.		+el
Pterostichus. (Cryobius) sp.	+el	+hd
P. (Cryobius) caribou Ball	+pr	
P. (Cryobius) pinguedineus Eschz.	?pr	
P. (Cryobius) brevicornis Kby.	+pr	
P. (Cryobius) nivalis Sahlb.	+pr	
Pterostichus haematopus Dej.	+pr	
Amara alpina Payk.	+pr	
Amara glacialis Mann.*	+pr	
Harpalus amputatus Say	+pr,el	
Trichocellus mannerheimi R. Sahlb.	+hd	
Cymindis sp.*	+hd,pr	
Dystiscidae		
Genus?	+	
Staphylinidae		
Stenus sp.	+hd	
Tachinus instabilis Makl.	+pr	
Silphidae		
Silpha sp.	+pr,el(ff)	
Leiodidae		
Agathidium sp.	+el	
Byrrhidae		
Simplocaria sp.	+el	
Morychus sp.*	+ +pr,el	
Byrrhus sp.	?el	
Curimopsis sp.	+hd	
Coccinellidae		
Ceratomegilla ulkei Crotch.	+pr	
Curculionidae		
Apion sp.	+pr,el	
Connatichela artemisiae Anderson*	+pr,el	
Lepidophorus lineaticollis Kby.*	+el	+hd,pr
Vitavitus thulius Kiss.	+el	
Stephanocleonus type	+el(ff)	
Notaris sp.	?el(ff)	
DIPTERA		
Tipulidae		
Tipula sp.	+ov	
HYMENOPTERA		
Symphyta		
Tethridinidae	?hd	
Apocrita, genus?	+th(ff)	
Ichneumonoidea	+hd	
Formicidae		
Formica sp.		+hd
ARACHNIDA		
Acari		
Oribatei	+	+

* = taxon found on or near bare river shorelines; el = elytron; pr = pronotum; hd = head; ov = ovipositor; lv = larval fragment; th = thoracic fragment; wg = flight wing fragment; ff = fragments.

and absence of spruce macrofossils and bark beetle fossils are a clear indication that a type of tundra environment characterized the lowlands in the Mayo area of central Yukon 29,600 years ago. Vegetation on the flood plain had a xeric pioneering character and this may have been true as well of the more stable floodplain sites and even the uplands. Similar conditions have been documented for other areas of Beringia during Late Wisconsinan time (Giterman *et al.*, 1982; Matthews, 1982; Anderson, 1985).

If, as we conclude, the Mayo area was essentially treeless, with at most small groves of spruce existing only at protected sites (not on the floodplain), then tree line was depressed by about 850 m. Assuming that tree line corresponds approximately with the 10° C July mean isotherm, this implies a mean July temperature at least 5° C lower than today. Other presently forested areas of the Yukon were also treeless at about 29.6 ka BP. Pollen and bryophyte fossils from a site on Silver Creek, near Kluane Lake, show tundra vegetation existed there at virtually the same time as deposition of the 4.7 m level at MIV (Schweger and Janssens, 1982). But because the Silver Creek site is located at a present elevation of 1300 m, it is not the best one to compare with the Mayo region (490 m). Antifreeze Pond, a forested site near the Alaska/Yukon border is located at an elevation of about 750 m. Although its pollen record is marked by date inversions (Rampton, 1971b), the site appears to have been tundra between 27.1 and 31.5 ka BP (Rampton, 1971b).

Even though spruce pollen percentages in Unit 1 are well below the >50% seen in modern samples spruce values from Stewart River valley (Hughes *et al.*, 1981), some of the fossil spectra have as much spruce as surface samples from Old Crow Flats, a forest-tundra region in the northern Yukon (Cwynar 1982; Ovenden, 1982; Schweger and Matthews, 1985). As indicated earlier, this does not mean that the lowland environment at Mayo was exactly analogous to present day forest tundra sites, for if so, one would expect much higher frequencies of *Alnus* and *Betula* (Anderson and Brubaker, 1986; Ritchie, 1974). Furthermore, if riparian forests existed, spruce macrofossils (and probably spruce pollen) would be more abundant. Spruce may have been present in the region 29,600 years ago, but if so, only as small groves at protected sites.

Preliminary evidence from the Mayo Section, an exposure just upstream from MIV and across from the village of Mayo, shows that spruce may have been more abundant in the Mayo area about 38 ka BP. The date (Table I, GSC-4554) comes from an erect willow stump in a horizon which contains spruce needles (Matthews, unpublished) and significant amounts of spruce pollen (Schweger, unpublished). Sand approximately 5 m above the rooted stump contain rare detrital organic zones containing *Corispermum hyssopifolium*, like the Unit 1 organics at the MIV section. If future dating attempts prove this to be so, then the level at MIV equivalent to the 38 ka horizon at the Mayo Section is probably below water level. Perhaps the relatively high percentage of spruce in the lowermost MIV sample represents the end of the time portrayed by the 38 ka organics at the Mayo Section.

Spruce woodland vegetation existed in the northern Yukon Bell Basin between 34-40 ka BP (Hughes *et al.*, in preparation) and in the Bonnet Plume Basin between 37 and 34 ka BP (Hughes *et al.*, 1981, Hughes *et al.*, in preparation).

REGIONAL CHRONOLOGICAL AND STRATIGRAPHIC IMPLICATIONS

The AMS ^{14}C date reported here is the first finite limiting date for the onset of the McConnell glaciation in the central Yukon. The date also provides a minimum age for the end of the nonglacial interval that intervened between Reid and McConnell glaciations. Recognition that the McConnell Glaciation culminated less than 29.6 ka BP also clarifies previously uncertain correlations between Late Quaternary events in central Yukon and other parts of the territory, such as the Kluane Lake region in southwestern Yukon (Denton and Stuiver, 1967), the Snag-Klutlan area of western Yukon (Rampton, 1971a, 1971b) and Liard Plain in southeastern Yukon (Klassen, 1987) (Fig. 6). Details on these revised correlations are as follows:

1. Kluane Lake Region (Fig. 6, columns 4 and 5)

This region was affected by repeated advances of coalescent piedmont glaciers emanating from the St. Elias Mountains (Fig. 1). On the basis of lithostratigraphic units exposed in sections near Kluane Lake, Denton and Stuiver (1967) established a sequence of three glaciations (oldest to youngest: Shakwak, Icefields and Kluane) with intervening nonglacial intervals (Silver and Boutellier — Fig. 6, Column 5). Organic material from sediments of the Boutellier Interval have yielded ^{14}C dates ranging from 37,700 + 1500/−1300 to 29,600 ± 450 years BP, showing that like Mayo Till, Kluane Till was deposited less than 30,000 years ago and indicating essential contemporaneity of Kluane and McConnell glaciations. Prior to the finite date reported here, available ^{14}C dates admitted of two possible correlations of Late Wisconsinan events in the central Yukon with those of Kluane Lake area. The first equated McConnell Glaciation with Kluane Glaciation as Late Wisconsinan events (Fig. 6, columns 1, 4 and 5). The second (Fig. 6, columns 2 and 5) implied that ice advanced over both

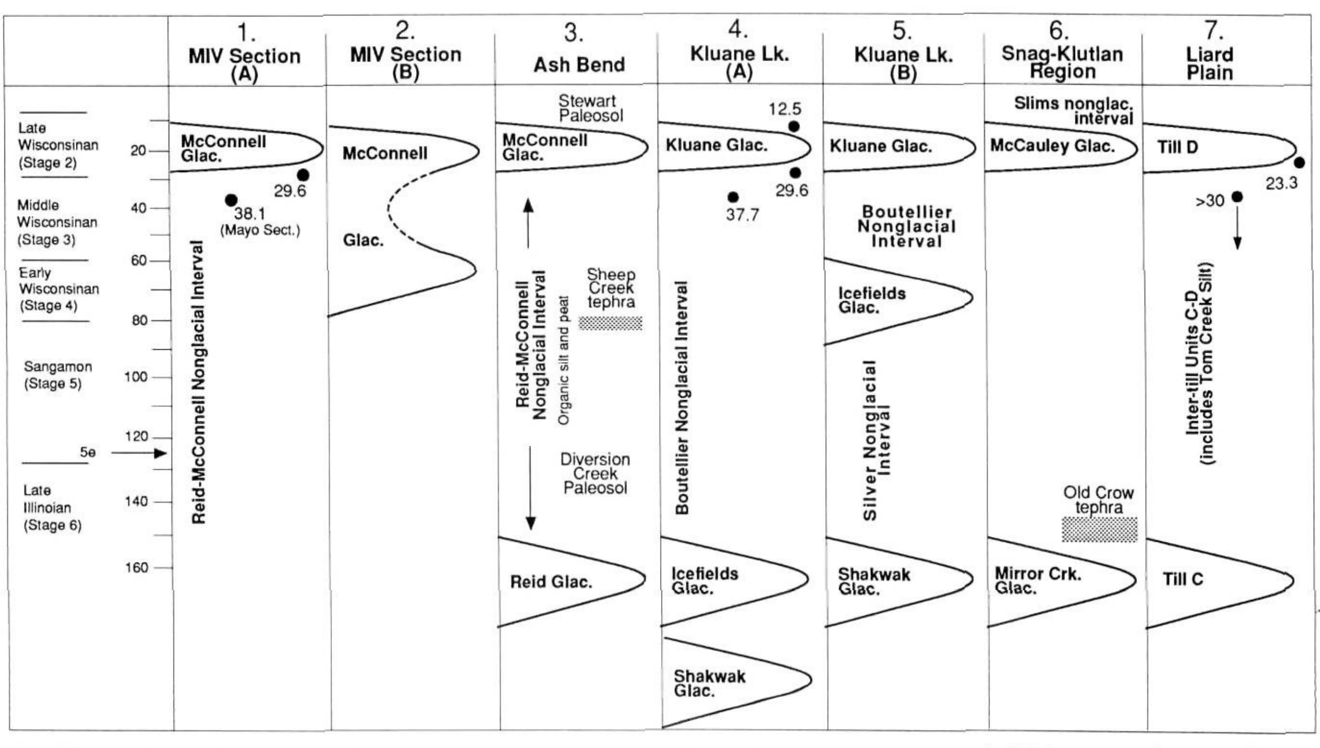

FIGURE 6. Correlation alternatives for comparison of the stratigraphy at the MIV Section with other multiple till sites in the Yukon. See text for details.

Alternatives de corrélation pour établir la comparaison entre la stratigraphie de la coupe de Mayo et celle d'autres sites de till du Yukon. Voir le texte.

areas at a time beyond the range of ^{14}C dating (*e.g.*, presumably during the Early Wisconsinan (?) Icefields Glaciation of the Kluane area) and that subsequent retreat of the St. Elias piedmont glacier left the Kluane area ice free for a period beginning before 37.7 ka BP and continuing through 26.9 ka BP, while there was no demonstratable retreat of the Cordilleran Ice Sheet.

The finite date from the MIV Section reported here shows that the first alternative, essential contemporaneity of McConnell and Kluane glaciations, is the correct correlation. This implies correlation of Reid-McConnell nonglacial interval with Boutellier nonglacial interval, and Reid Glaciation with Icefields Glaciation (Fig. 6, Columns 3 and 4). Note, however, that evidence which would confirm this last correlation is lacking. For example, (1) paleosols comparable to the Diversion Creek Paleosol, which characterizes drift of Reid age in central Yukon (Tarnocai *et al.*, 1985; Smith *et al.*, 1986), have not been reported in drift assignable to Icefields Glaciation; (2) unpublished palynological data by Schweger from the Ash Bend site indicate that the Reid Glaciation was followed by boreal forest conditions that later changed to tundra; whereas, the only palynologic data from the Boutellier nonglacial interval indicate alpine tundra conditions (Schweger and Janssens, 1982); and (3) Sheep Creek tephra, which places the beginning of the Reid-McConnell non-glacial interval before about 75-80 ka BP (Hughes *et al.*, 1987b; Hamilton and Bischoff, 1984) has not been reported from sediments of the Boutellier nonglacial interval. In view of these deficiencies, it is possible that Icefields Glaciation is of Early Wisconsinan age, and that Shakwak Glaciation is equivalent to Reid Glaciation (Fig. 6, columns 3 and 5).

2. Snag-Klutlan Region (Fig. 6, column 6)

In the Snag-Klutlan area, which was also affected primarily by St. Elias glaciers, the only finite date from beneath till of McCauley age is 48 ± 1.3 ka BP(GSC-732) and is suspected of being contaminated by modern rootlets (Rampton, 1971b). Contemporaneity of McCauley Glaciation with McConnell and Kluane glaciations is nevertheless considered likely.

The presence of Old Crow tephra in this region helps in correlation. It was previously dated at 86 ± 8 ka BP (Wintle and Westgate, 1986) but recently was re-dated at approximately 149 ± 13 ka BP (Westgate, 1988). Old Crow tephra overlies Mirror Creek drift and underlies McCauley till which shows that the intervening nonglacial interval in the Snag-Klutlan region represents the Sangamonian and much of Early and Middle Wisconsinan time. Indeed, if the MIV date is correct and the McConnell Glaciation is equivalent to the McCauley, then there is no recognized drift of Early Wisconsinan age in the Snag-Klutlan region.

3. Liard Plain (Fig. 6, column 7)

Unlike the other two regions discussed above, the Liard Plain was covered by Cordilleran glaciers that flowed easterly and southeasterly rather than westerly and northwesterly as in the central Yukon (Hughes *et al.*, 1969). Klassen (1987) documents a nonglacial interval of Middle Wisconsinan age at the Tom Creek Section in the Liard Plain area (Fig. 1). ^{14}C dates on organics in the Tom Creek Silt unit suggest that Cordilleran ice, represented at the site by "Till D", last expanded over that area some time after about 24 ka BP, *i.e.*, nearly 5 ka after deposition of Unit 1 at the MIV Section. This apparent lag in Late Wisconsinan glaciation may reflect the small number of dates currently available, but it is notable that the Late Wisconsinan Donnelly Glaciation of the Alaska Range is also known to have begun shortly after 25 ka BP (Hamilton and Thorson, 1983).

GENERAL CONSIDERATIONS ON DATING AND CORRELATION

Many of the problems discussed in this paper fall within a time frame that is near the upper resolution limit for conventional ^{14}C dating. This problem is not necessarily resolved by recourse to AMS dates. Although in theory, it is possible to obtain finite AMS dates much older than by conventional means, the error factor in AMS dating rises precipitously in samples older than 30 ka BP (Beukens, 1986, p. 7), even when great care is taken to keep background contamination to a minimum. Moreover, the sensitivity of very old samples to modern contamination may be greater for some AMS samples than for conventionally dated samples because of the small size and surface area of the specimens being dated. This is probably especially true for items such as seeds. Clearly there are problems, many of them not quantifiable and possibly not resolvable, with all methods of ^{14}C dating for the time interval discussed here.

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