69-36

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DEPARTMENT OF ENERGY, MINES AND RESOURCES

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SURFICIAL GEOLOGY OF NORTHERN YUKON TERRITORY AND NORTHWESTERN DISTRICT OF MACKENZIE, NORTHWEST TERRITORIES

(Report and Map 1319A)

O. L. Hughes

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ABSTRACT

For discussion of Quaternary geology, the map-area may be considered in three parts: 1) a large area of plain and plateau north of Mackenzie Mountains and east of Richardson Mountains, including also Yukon Coastal Plain, that was overridden by Laurentide ice; 2) the southern part of the map-area, embracing parts of Mackenzie, Wernecke, and Ogilvie Mountains, which experienced repeated advances of valley glaciers; 3) the remaining unglaciated area.

Three advances of valley glaciers are inferred, mainly from geomorphic evidence. Laurentide ice advanced into the area at least twice. Radiocarbon dating indicates that the last advances of both mountain glaciers and Laurentide ice culminated in late Wisconsin time. The preceding advances are presumed to be of pre-Classical Wisconsin or pre-Wisconsin age.

Thick Pleistocene sediments exposed in Bell, Bluefish and Old Crow basins, all in the unglaciated area, include two glaciolacustrine beds intercalated between nonglacial sediments. The glaciolacustrine beds are judged to correlate with the two known advances of Laurentide ice, when drainage, together with turbid meltwater, was diverted into the headwaters of Porcupine River.

RÉSUMÉ

En vue d'étudier la géologie du Quaternaire, la carte peut être divisée en trois parties: 1) une grande étendue de plaines et de plateaux au nord des monts Mackenzie et à l'est des monts Richardson, comprenant également la plaine côtière du Yukon, qui a été recouverte par les glaces Laurentides; 2) la partie sud de la carte, qui englobe des parties des monts Mackenzie, Wernecke et Ogilvie, et qui a subi les avancées répétées des glaciers de vallées; 3) le reste de la région, qui n'a pas subi la glaciation.

L'auteur établit trois avancées des glaciers de vallées, en se fondant principalement sur des preuves géomorphologiques. Les glaces Laurentides se sont avancées dans cette région au moins deux fois. La datation au radiocarbone indique que les dernières avancées des glaciers de montagne et des glaces Laurentides ont été à leur maximum à la fin de l'époque du Wisconsin. L'auteur suppose que les avancées précédentes dataient des époques antérieures au Wisconsin classique et au Wisconsin.

Les épaisseurs de sédiments du Pléistocène exposées dans les bassins Bell, Bluefish et Old Crow, tous dans la région n'ayant pas subi la glaciation, comportent deux lits glaciolacustres intercalés entre des sédiments non glaciaires. L'auteur estime que les lits glaciolacustres correspondent aux deux avancées connues des glaces Laurentides, lorsque l'écoulement des eaux, ainsi que des eaux de fonte turbides, a été détourné vers les sources de la rivière Porcupine.

SURFICIAL GEOLOGY OF NORTHERN YUKON TERRITORY AND NORTHWESTERN DISTRICT OF MACKENZIE, NORTHWEST TERRITORIES

INTRODUCTION

Field work for the present study was carried out in 1962 as part of Operation Porcupine. This operation, under the direction of D.K. Norris, was primarily for the study of pre-Quaternary geology, but also presented an excellent opportunity for broad reconnaissance of the geomorphology and Quaternary geology of the large but little known region of northern Yukon Territory and northwestern District of Mackenzie.

Field work for this reconnaissance consisted mainly of checking air-photo interpretation maps prepared by the writer with the assistance of V.N. Rampton, and in field examination of exposures along major streams and coastal bluffs. Rampton shared all aspects of the field work and was responsible for compilation of the western half of the final map. Valuable observations, especially on distribution of erratics, were contributed by E.W. Bamber, E.W. Mountjoy, B.S. Norford, A.W. Norris, D.K. Norris, R.A. Price, R.M. Procter and G.C. Taylor.

Previous Work

Studies devoted primarily to the geology of the area, were begun by R.G. McConnell (1890, 1891) and continued by Camsell (1906, 1921) and J.J. O'Neill (1924), all of whom made important contributions to the knowledge of its Pleistocene geology. From study of trimetrogon photos, Bostock (1948) defined and named the physiographic elements and was primarily responsible for establishing the maximum limits of Laurentide and valley glaciation as shown for the region on the 1958 Glacial Map of Canada (Geol. Assoc. Can., 1958). These limits were revised in detail as a result of the Operation Porcupine observations. Since 1962 other researchers have contributed further data and observations on the surficial deposits and Pleistocene history of Peel Plain and Anderson Plain, the Mackenzie Delta, and the Yukon Coastal Plain (see Bostock (1964) for physiographic units).

Because of the excellent and extensive studies already published by Mackay (1963), and because also of the logistics involved in carrying out field work in the area, that part of the Yukon-Mackenzie Delta territory lying east of the Delta and north of 69°00'N has, for all practical purposes, been omitted from the present study.

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Regional Setting

The study-area includes parts of the Eastern and Interior systems of the Canadian Cordillera and the northwestern extremity of the Interior Plains Province as defined by Bostock (1948 and 1964). Topography ranges from the locally rugged peaks of the Mackenzie and Wernecke Mountains to the very flat Old Crow Plain and the Mackenzie Delta. The northernmost part of the area lies in the zone of continuous permafrost, the remainder, in the zone of discontinuous permafrost as delineated by Brown (1967).

For discussion of surficial deposits and Pleistocene history, the map-area can be divided into three parts: 1) an area invaded at least once by Laurentide ice from the Canadian Shield; 2) mountain areas in which cirques and valleys were occupied repeatedly by valley glaciers; and 3) the unglaciated area lying outside the maximum limits of either Laurentide or mountain glaciations.

LAURENTIDE GLACIATION

Widespread drift deposits containing rocks derived from the Canadian Shield indicate extensive invasion of the area by Laurentide ice moving generally west and northwest. At its maximum, Laurentide ice reached elevations of 3,500 feet above sea level on the east flank of Richardson Mountains, and of 4,000 feet on the north flank of Mackenzie Mountains. It covered Peel Plateau, Bonnet Plume Basin, the eastern section of Porcupine Plateau, and the Yukon Coastal Plain northwest to Firth River.

That part of the area lying east of the flanks of Richardson Mountains and north of latitude 66°N, exhibits well-preserved landforms typical of plains areas glaciated in late-Wisconsin time. In the peripheral area beyond, glacial landforms are more subdued, suggesting they have been produced by one or more distinctly older Laurentide glaciations, probably early Wisconsin or pre-Wisconsin.

Early Wisconsin or Pre-Wisconsin Glaciations

In some parts of the area, the limit of Laurentide glaciation is defined by subdued but still recognizable moraines and kame terraces, or by ice-marginal channels and spillways. However, especially on mountain slopes, such features are lacking along much of the limit which was then determined from the distribution of glacial erratics of granite, gneiss and volcanic rocks derived from the Canadian Shield.

The limit thus mapped may actually represent a composite of two or more separate early advances. At the edge of maximum glaciation in eastern Porcupine Plateau and southern Richardson Mountains, moraines, meltwater channels and associated glaciofluvial features appear much fresher than along the east side of Richardson Mountains where few such features are preserved. Inland from the Beaufort Sea, meltwater channels and glaciofluvial deposits are moderately well-preserved but moraines are subdued or completely lacking. Such regional differences in preservation of the outermost glacial features may be due to topographic setting and to regional differences in the intensity of weathering processes. However, the possibility that such differences are due to difference in age cannot be discarded.

Stratigraphic evidence from examined sections near the limit of glaciation seem to indicate a single early advance. For example, in numerous exposures along lower Wind and Bonnet Plume Rivers, and along the Peel above the mouth of Snake River, only a single till is exposed; and on Snake River just north of the mountain front and near the limit of Laurentide glaciation, three tills are exposed but without intervening nonglacial sediments or weathering zones. These latter may be either the product of minor fluctuations during a single advance or, in part, the product of valley glaciation. Hence, in western Peel Plateau and eastern Porcupine Plateau, the Laurentide limit would seem to have been established during a single early glaciation. The same appears to be true on the Arctic coast between King Point and Herschel Island where deformation of sediments exposed in coastal bluffs can be satisfactorily explained by a single advance (Mackay, 1959).

During its one or more early advances, the Laurentide ice sheet diverted water from Mackenzie Mountains and upper Peel River into the headwaters of Eagle River through a major channel now occupied in part by Palmer Lake (66°10.5'N, 136°25'W). A second major channel crossed Richardson Mountains and discharged eastward through McDougall Pass, and two lesser streams discharged about 4 and 12.5 miles south of McDougall Pass, respectively.

Thick deposits of glaciolacustrine silt and clay, overlying till of presumed pre-Wisconsin age, are exposed along lower Wind and Bonnet Plume Rivers, and along Peel River between the mouths of Wind and Snake Rivers. In thawing from its permanently frozen state, the silt and clay unit liquifies and forms spectacular mud flows, but is nowhere completely exposed (<u>see</u> distribution of flow slides on accompanying map). Following the retreat of a pre-Wisconsin or early Wisconsin ice sheet, silt and clay were presumably deposited in a glacial lake with an outlet through the Palmer Lake channel. Silt and clay may also have been deposited when drainage was again diverted by Laurentide ice during Wisconsin time. Stratigraphic evidence for two possible ages of silt and clay has not yet been found.

Late Wisconsin Glaciation

Ice-flow patterns related to Laurentide glaciations during the late Wisconsin, indicate westward movement across southern Peel Plain, and deflection of the main ice flow to north-northwest, parallel to the eastern front of the Richardson Mountains. A minor lobe extended southwest to about the junction of Peel and Snake Rivers. Locally, the limits of the former ice sheet are marked by well-preserved moraines that contrast sharply with subdued glacial landforms beyond. Where moraines are lacking, the limit has been inferred from the positions of ice-marginal channels along which streams from the Richardson and Mackenzie Mountains were diverted.

Water flowing out from Mackenzie and Ogilvie Mountains, including such rivers as the Arctic Red, Snake, Bonnet Plume, Wind and Peel were diverted or blocked by the ice sheet. A glacial lake was impounded in Bonnet Plume Basin with an outlet through the Palmer Lake channel. At the maximum advance of ice during the late-Wisconsin, a major channel, about two miles south of "Taylor Lake", carried the diverted drainage of Arctic Red and Cranswick Rivers westward toward Snake River. The major channel in which the present "Taylor Lake" lies, is lower than the Palmer Lake outlet and could not, therefore, have been cut until northward drainage had been re-established along the present course of Peel River.

On the east flank of Richardson Mountains, Barrier River, Stony Creek and parts of Vittrekwa and Road Rivers occupy former major ice-marginal channels. Although the major streams have deepened the channel segments to such an extent that the former levels of some channels cannot be determined, the channel segments appear as remnants of a formerly integrated, ice-marginal channel system that marks a significant ice-marginal position. East of this, glacial landforms are generally well preserved, west of it, they are relatively subdued. Tentatively, the channel system is interpreted as marking the limit of the late-Wisconsin advance against Richardson Mountains.

North of Barrier River, the late Wisconsin limit is tentatively located at moraines in the vicinity of Longstick River and along an ice-marginal channel that extends north from where Willow River turns eastward to the Mackenzie Delta. Wisconsin ice may have reached the coast as far northwest as King Point where a moraine noted by Mackay (1959, Fig. 1) turns seaward and is truncated by the coastline. A well-defined moraine east and north of Sitidgi Lake (68°30'N, 132°45'W) that partially outlines an ice lobe in the Sitidgi basin, had been considered a possible Wisconsin limit but recent field work by J.G. Fyles (pers. comm., 1966) indicates that it probably represents a halt or readvance following the retreat from a late Wisconsin limit lying beyond the area mapped (Mackay, 1963, pp. 21-25).

Laurentide ice moved generally northwestward across the area during the late Wisconsin stage. However, during its retreat, the development of numerous minor lobations controlled by the low relief of Mackenzie Lowlands produced a complicated pattern of ice-flow features. Examples of divergence from northwesterly movement include: westward movement north of Campbell Lake (68°15'N, 133°20'W); northeastward movement to the northeast of this same lake (Mackay, 1963, p. 25); eastward movement near Rengleng Lake (67°43'N, 132°35'W), and southwestward movement near the junction of Peel and Trail Rivers. Major halts or local readvances are inferred from the moraine at Sitidgi Lake discussed above, and from a broad belt of hummocky moraine extending from Peel River north of Fort McPherson, eastward to Big Stone Lake. Locally glacial drift is one hundred or more feet thick in areas of hummocky or ridged moraine near the limit of the late-Wisconsin advance, and in belts of retreatal moraine such as the one at Fort McPherson. In large areas underlain by Lower Cretaceous shale in Peel Plain, and the adjacent northeast margins of Peel Plateau, the till is only a few feet thick except in isolated ridges and patches of moraine.

VALLEY GLACIATION

Valley glaciation occurred mainly in the Mackenzie, Selwyn, and Ogilvie Mountains in the southern part of the area. Minor areas of valley glaciation are also found in the vicinity of Mount Klotz (65°22.5'N, 140°05'W), in Richardson Mountains (at latitude 67°32'N and latitude 67°55'N), and in British Mountains at the Yukon-Alaska border. Evidence for multiple valley glaciation is best displayed around the headwaters of Ogilvie River in the southwestern part of the map-area, and south from there. Since this locality lies beyond the western limit of Laurentide ice, inter-relationships of the

Laurentide ice sheet and valley glaciers do not complicate interpretation of its glacial features. Deposits left by at least three advances are evident. They include:

fresh, sharp-ridged moraines, occurring just south of the map-area (the "last" glaciation of Vernon and Hughes, 1966);

moraines that are subdued but still recognizable ("intermediate" glaciation);

patches of till with little or no characteristic moraine form ("old" glaciation).

Each successive advance was less extensive than the previous one.

Moraines correlated tentatively with the "last" and "intermediate" glaciations are found in many valleys within the mountains of the southeastern part of the map-area. Moraines of the "last" glaciation only are found in Wind, Bonnet Plume and Snake valleys. There is no presently available, stratigraphic evidence by which the ages of the valley glaciations can be correlated with the Laurentide glaciations. However, the relative freshness of glacial landforms of the "last" valley glaciation and those of the late-Wisconsin Laurentide glaciation, together with the radiocarbon data discussed below suggests that the two glaciations were approximately contemporary.

Glacial landforms considered as belonging to the "intermediate" valley glaciation and those near the limit of Laurentide glaciation are all relatively subdued, suggesting early or pre-Wisconsin age. Terminal moraines of the "intermediate" valley glaciation have not been identified in Wind, Bonnet Plume and Snake valleys, nor anywhere within the limit of Laurentide glaciation along the Mackenzie Mountain front. Two possible explanations for this are suggested: first, that during the "intermediate" valley glaciation, glaciers extended down Wind, Bonnet Plume and Snake valleys to form piedmont lobes beyond the mountain front, building terminal moraines that were destroyed by a later advance of Laurentide ice; secondly, that valley glaciers of "intermediate" age were confluent with the Laurentide ice and, therefore, developed no terminal moraines.

Drift containing erratics from the Canadian Shield indicates that probably during this later advance, Laurentide ice extended up Wind, Bonnet Plume and Snake valleys, for several miles south of the northern front of the Mackenzie Mountains. If the ice of the valley glaciers was confluent with the Laurentide ice as in the second explanation offered above, the Laurentide ice must have remained sufficiently thick to extend digitations southward as the valley glaciers retreated.

Distinctive boulders and pebbles of hematite, containing streaks and slabs of red jasper and derived from a major deposit on a tributary of Snake River (65°15'N, 133°00'W), are widely and abundantly distributed across Peel Plateau, decreasing in amounts westward to the limit of Laurentide glaciation, northward along Richardson Mountains and northwestward to Firth River. Much of the hematite may have been transported from its source by streams and later distributed widely by Laurentide ice. However, one block, found at 65°33'N in a gully tributary to Snake River, had a major diameter of three feet and is judged to be so large that glacial rather than fluvial transport would be required to move it. The evidence suggests that a valley glacier extended onto Peel Plateau, at least to 65°33'N, before the last advance of Laurentide ice over the locality, presumably in early Wisconsin or pre-Wisconsin time.

UNGLACIATED AREA

The unglaciated area includes diverse terrains that range from very flat (e.g. Old Crow Plain) through rolling plateaus (Porcupine and Arctic Plateaus) to locally rugged mountain (e.g. Richardson Mountains). It is a unit only in its lack of glacial deposits.

The plateau and lower mountain areas are characterized by broad valleys in which pediment slopes rise gently from the valley axis to meet the steeper valley walls along a rather sharp break-in-slope. Locally, pediments of adjacent subparallel streams merge across low, broad ridge-crests. Along deeply incised stretches of Hart and Blackstone Rivers, and along the Ogilvie River tributary immediately west of Blackstone River, recognizable pediments are either lacking or the pediment remnants are perched high above the present stream. The relationship of these remnants to the modern rivers suggests that erosion kept pace with local upwarping that may have begun during or just after the pediment development. Incised sections of Porcupine River may have had a similar origin or, alternatively, they may represent relatively young channels through which separate drainage basins became integrated into the present Porcupine drainage. In the vicinity of Mount Klotz glacial deposits, the oldest of which are pre-Classical Wisconsin or older, lie on and are clearly younger than the pediment surfaces. Otherwise there is no evidence as to the age of the pediment surface nor of the climatic conditions under which they developed.

Throughout much of the unglaciated area the only surficial deposits are weathered rock or colluvium on slopes, a few feet to tens of feet thick, organic silt and peat in depressions, and, along major streams, fluvial deposits locally exceeding one hundred feet in thickness. However, unconsolidated deposits are both thick and extensive in three basin areas: 1) Bell Basin (Bostock, 1948); 2) Old Crow Basin, coextensive with Old Crow Plain of Bostock (1948); and 3) Porcupine valley between Berry Creek and The Ramparts, called here Bluefish Basin after a small river that enters it from the south. No exposures were studied in Bell Basin, but deposits of sand, gravel, silt and peat up to 152 feet thick were measured along Old Crow River. Similar sediments are up to 190.5 feet thick along Porcupine River below the village of Old Crow. In both these cases the sediments extend below river level and these thicknesses are, therefore, minimal. McConnell (1891, pp. 127D-128D) ascribed the sediments along Porcupine River to the Tertiary. Terasmae, on the other hand, studied pollen from a section (Table 1, measured and collected by the writer) on the south bank of Porcupine River (67°28'N, 139°54'W), and concluded that "The suggested Tertiary age for these beds must be rejected. The pollen assemblages obtained are rather similar to those found in Pleistocene beds elsewhere in this region" (Geol. Surv. Can., Pleistocene Palynology Laboratory Rept. 65-6, 1965).

Porcupine River flows out of Bell Basin through a channel incised in Cretaceous sandstone. Old Crow River leaves Old Crow Plain through a narrow valley cut in granite at the east end of Old Crow Range. The combined Old Crow and Porcupine drainage discharges westward out of Bluefish Basin through the deep canyon called The Ramparts.

The Pleistocene sediments in Old Crow and Bluefish Basins, and probably those in Bell Basin, extend below the bedrock thresholds of the respective basins. The basins, therefore, cannot be entirely erosional, and Tertiary or early Pleistocene warping or faulting must have contributed to their origin. Units 1 and 2 of the section described in Table 1 are judged to be fluviatile and deltaic basin fill; drainage was probably eastward through McDougall Pass in the Richardson Mountains during their deposition. The large logs in Unit 1 suggest a climate at least as warm as that of today, in which white spruce to 15 inches diameter are common on the Porcupine flood plain and a few trees even attain 20 inches diameter. The cryoturbation layer in Unit 2 indicates that sedimentation was at least partially subaerial, and that climatic conditions were sufficiently severe to permit invasion of the sediments by permafrost.

Unit 3 appears to be of glaciolacustrine origin, deposited when Laurentide ice advanced westward against the Richardson Mountains and onto Peel Plateau blocking eastward drainage through McDougall Pass and forming a vast lake that discharged westward at The Ramparts. Drainage from the southwestern part of the map-area, together with sediment-laden meltwater from the Laurentide ice sheet, was diverted into this lake via the Palmer Lake channel.

With retreat of the Laurentide ice, eastward drainage resumed and normal lacustrine, deltaic and fluviatile sedimentation (Units 4 and 5) continued in the basins. A readvance of the Laurentide ice re-established the glacial lake with an outlet at The Ramparts at about 1, 180 feet, and Unit 5 was deposited. Well-defined shorelines peripheral to Old Crow and Bluefish Basins, at elevations between 1, 180 and 1, 000 feet, probably relate to this second glaciolacustrine stage and record the gradual down-cutting of the outlet at The Ramparts. Although shorelines were not recognized in Bell Basin, the basin would, by this interpretation, have been inundated during both glaciolacustrine stages.

By the time McDougall Pass (ca. 1, 030 feet) again became ice-free, the outlet at The Ramparts had been eroded down to a level below that of the pass and westward drainage was permanently established. Drainage of the basin lakes was followed by local deposition of fluvial and shallow-water lacustrine sediments and by widespread peat development (Units 7 and 8). Porcupine River is today incised as much as 185 feet below the general level of Bluefish Basin.

RADIOCARBON DATING AND CHRONOLOGY

In northern Yukon Territory and northwestern District of Mackenzie, samples older than the range of the radiocarbon dating method have been obtained from localities that lie within the limits of Laurentide glaciation. Just east of the small Arctic coast harbour at King Point, Y.T., organic and marine sediments are overlain by till, which is itself overlain by sand and silt. Wood from the organic sediments has been dated as older than 51, 100 years (GSC-151-2; Dyck et al., 1966, p. 21). Peat from the silt four feet above the till was dated at 9, 510 ± 170 years B.P. (GSC-159: Dyck and Fyles, 1963, p. 8). In an exposure along Rat River, N.W.T. (67°39.5'N, 135°28'W), till overlying gravel, is overlain by at least 40 feet of silt with peaty and woody layers. Organic silt from 30 feet above the till has been dated at greater than 38, 300 years B.P. (GSC-204; Dyck et al., 1965, p. 15). Thirty feet of slumped sediments overlying the exposed section probably include sediments of a later (probably late Wisconsin) Laurentide glaciation. In a section at Eskimo Lakes (68°45'N, 133°16'W), described by Mackay (1963, p. 17) and

TABLE 1

Section on south bank of Porcupine River

Unit No.	Description	Bed thickness (feet)	Cumulative thickness (feet)
9	Silt.	1.5	190.5
8	Peat, mostly unhumidified, with wood.	3.0	189.0
7	Silt, grey-brown, with twig and wood lenses, thin peaty layers.	17.5	186.0
6	Clay, silty, dark grey; sediments thawing and flowing; poorly exposed.	17.5	168.5
5	Silt and very fine grained sand, dark grey to grey-brown; gravel lens one foot thick in middle.	37.0	151.0
4	Silt, grey-brown, with lenses of gravel and of twigs and wood; bedding in upper three to four feet, highly convoluted by cryoturbation.	20.5	114.0
3	Silt, clayey, dark brown-grey, massive; markedly jointed, with iron-stained jointed surfaces; overlies unit 2 disconformably.	41.5	93.5
2	Bedded silt, sand and fine gravel, grey-brown to yellow-brown; abundant twig and wood layers in lower twenty-five feet; upper four feet highly convoluted by cryoturbation.	40.0	52.0
1	Course sands and gravel with silt lenses; grey, in part oxidized dull red-brown; partly cemented; contains abundant spruce (?) logs to twenty inches diameter.	12.0	12.0

examined by the writer, organic silt with peat near the top is overlain by 75 feet of gravel and 6 feet of surface peat. The peat was dated at greater than 50,900 years B.P. (GSC-329) and wood from the base of the surface peat at 7,120 ± 140 years B.P. (GSC-371; Dyck et al., 1966, p. 22). Peat collected by Mackay (1963, p. 15) from a similar section on East Channel of Mackenzie River was dated at greater than 44,000 years B.P. (L522A; Broecker and Olson, 1961, p. 166). Using this radiocarbon data, paleobotanical evidence (Terasmae, 1959) and mammal remains in correlative deposits, Mackay concluded that the organic deposits at the Eskimo Lakes and East Channel sites and elsewhere are interglacial. The Eskimo Lakes locality is within an area of outwash deposited when an ice front stood at the Sitidgi Lake moraine. Although no till overlies the organic sediments, observations by J.G. Fyles (pers. comm., 1966) suggest that the locality was glaciated subsequent to deposition of the non-glacial sediments, and that the Sitidgi Lake moraine and associated outwash relate to a late halt or readvance.

On the west side of Snake River (65°41'N, 133°26'W) a sequence on a bedrock bench about 150 feet above the river, shows organic silt overlying 10 feet of boulder gravel and overlain by 55 feet of gravel. Wood from the base of the silt was dated at greater than 31,000 years B.P. (GSC-181, Dyck et al., 1965, p. 15). If no erosional disconformity exists above the silt, it would suggest that the locality has not been glaciated during the last 31,000 years and that the maximum advance of Laurentide ice on Peel Plateau and the intermediate advances of valley glaciers, took place more than 31,000 years ago. Mackay (1963, p. 41) reported two radiocarbon dates, 7,400 ± 200 years B.P. (GSC 16) and 8,200 ± 300 years B.P. (GSC-25; Dyck and Fyles, 1963, pp. 8, 9), that are minimal for the deglaciation that followed the last Laurentide ice advance in the Eskimo Lakes area and at Inuvik, respectively. The earlier date (9,510 ± 170 years B.P.) for deglaciation of King Point, obtained from the previously mentioned peat sample (GSC-204; Dyck and Fyles, 1964, p. 7) is compatible with these in view of the greater distance of that locality from the centre of ice dispersal. The same applies to the date 9,970 ± 180 years B.P. (GSC-147, Dyck and Fyles, 1964, p. 7) for wood collected by the writer from late-glacial or postglacial sediments near the upper limit of late Wisconsin glaciation on the east flank of the Richardson Mountains north bank of Rat River (67°43.5'N, 135°50.5'W). A sample dated 8,780 ± 160 years B.P. (GSC-97, Dyck and Fyles, 1963, p. 28) was collected by the writer from above glaciolacustrine sediments on the south bank of Peel River, 3.5 miles downstream from the mouth of Wind River. The uppermost sediments at least were probably deposited when Laurentide ice dammed Peel River, probably late-Wisconsin time, forming a lake that, at its maximum level, discharged northward via the Palmer Lake outlet. If the uppermost lacustrine sediments in the section on Porcupine River at 67°28'N, 139°54'W (Table 1), can be interpreted as glaciolacustrine, then the date of 10,740±180 years B.P. (GSC-121; Dyck and Fyles, 1964, p. 6) for peat immediately above the sediments is minimum for the last discharge of meltwater from the late-Wisconsin Laurentide ice through either the Palmer Lake outlet or across McDougall Pass. This date would, therefore, be minimum for the late-Wisconsin maximum.

Minimum ages for moraines referred to the intermediate advance of valley glaciers have been obtained by dating lowermost organic material, obtained by boring, from permanently frozen bogs within the moraine areas. Two such dates are 12,550 ± 190 years B.P. from "Gill" Lake (65°28'N, 139°42'W), (GSC-128; Dyck and Fyles 1964, p. 6), and 13,780± 180 years B.P.

from near Chapman Lake, Dawson map-area, (64°51.5'N, 138°19'W), (GSC-296; Dyck, et al., 1966, p. 20), as no till was recovered at either locality to prove bottom of the nonglacial deposits, the dates are minimum for the respective moraines. Nevertheless, these dates would seem to be much younger than the moraines in view of the relationships on Peel Plateau where valley moraines of intermediate age appear to be older than the drift of the Laurentide maximum that has been dated at greater than 31,000 years. There is the possibility that moraines referred to the intermediate advance of valley glaciers belong to more than one age.

A minimum age for the maximum of the "last" glaciation in the Mount Klotz area is provided by a sample from the bottom of a bog impounded by the outermost of a series of "young" moraines and dated at 6,670 ± 140 years B.P. (GSC-192; Dyck et al., 1965, p. 15). However, a sample from a bog that postdates a moraine of the "last" glaciation in North Fork Pass, Dawson map-area, was dated at 11,250 ± 160 years B.P. (GSC-470; Lowdon and Blake, 1968, p. 231) suggesting that the young moraines of the Mount Klotz area may be considerably older than 6,670 years.

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