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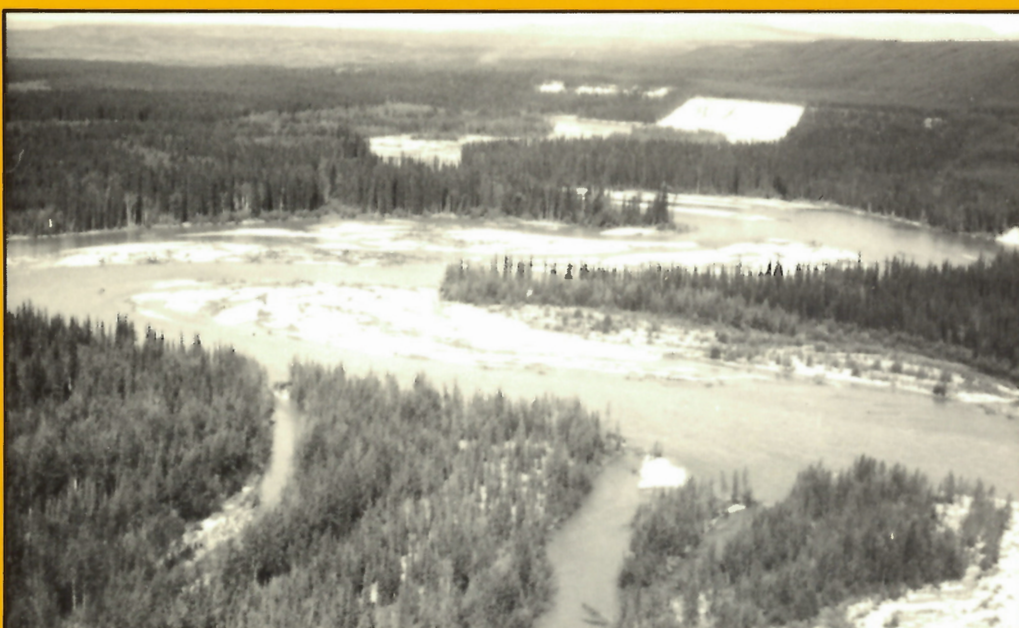
Paper 86-17

THE TERTIARY-PLEISTOCENE STRATIGRAPHY OF THE LIARD PLAIN, SOUTHEASTERN YUKON TERRITORY



R.W. Klassen

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Cover Photo

Aerial view to the northwest across Liard River near the western boundary of the study area. Liard Plain lies between the white bluff and the Pelly Mountains on the horizon. At the bluff, four tills occur, separated by nonglacial sediments. (ISPG Photo 1723-4)

Critical Reader

J.J. Clague

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THE TERTIARY-PLEISTOCENE STRATIGRAPHY OF THE LIARD PLAIN, SOUTHEASTERN YUKON TERRITORY

Abstract

The Tertiary-Pleistocene stratigraphic succession seen along Liard River and its tributaries in southeastern Yukon Territory includes mature gravel and sand of Tertiary age with a characteristic light grey that contrasts with the darker colours of the overlying Pleistocene deposits. Silt and clay along with siltstone, shale, and coal are included in the Tertiary succession.

Four tills designated as Till A, Till B, Till C, and a surface Till D are separated by stratified units designated Intertill unit A-B, Intertill unit B-C, and Intertill unit C-D. It is suggested that these units range in age from Kansan (Till A) to Late Wisconsinan (Till D). This proposal is based mainly on inferred stratigraphic relationships of the Pleistocene deposits to basalt flows dated at about 765 ka, 604 ka, 546 ka, and 232 ka. Two radiocarbon dates, one greater than 30 ka and another of 24 ka, were obtained from a fossiliferous bed (Tom Creek silt) within Intertill unit C-D. Pollen spectra obtained from the Tom Creek silt indicate a herbaceous tundra environment prevailed in this region prior to the Late Wisconsinan glaciation.

Résumé

La série stratigraphique tertiaire-pléistocène le long de la rivière Liard et de ses affluents dans le sud-est du Yukon se compose de gravier et de sable matures du Tertiaire, dont la couleur gris pâle caractéristique contraste avec les couleurs plus sombres des dépôts pléistocènes susjacents. La série tertiaire se compose de limon et d'argile, d'aleurolite, de schiste argileux et de charbon.

Quatre tills désignés till A, till B, till C et till D, ce dernier étant un till superficiel, sont séparés les uns des autres par des unités stratifiées désignées unité interglaciaire A-B, unité interglaciaire B-C et unité interglaciaire C-D. L'âge de ces unités varierait du Kansan (till A) au Wisconsinien supérieur (till D), d'après les liens stratigraphiques déduits existant entre les dépôts pléistocènes et les coulées de basalte qui datent de près de 765 000 ans, de 604 000 ans, de 546 000 ans et de 232 000 ans. La datation au carbone radioactif d'une couche fossilifère (limon de Tom Creek) à l'intérieur de l'unité interglaciaire C-D a donné deux dates, l'une supérieure à 30 000 ans et l'autre de 24 000 ans. L'analyse des pollens extraits du limon de Tom Creek révèle que cette région était une toundra à herbacées avant la glaciation du Wisconsinien supérieur.

INTRODUCTION

General statement

Liard River and its tributaries across the Liard Plain in southeastern Yukon Territory expose a unique succession of sediments and lava flows ranging in age from Tertiary to Pleistocene. A number of sections were studied during reconnaissance mapping of the surficial deposits of this region during the summer of 1977, 1978, 1979, and 1981. Klassen (1978) briefly described several sections and discussed the historical implications of the stratigraphy. This report provides a more detailed account of the stratigraphy and focuses on the Late Tertiary-Pleistocene history based in part on age dates from lavas and organic material and on paleontological and paleomagnetic evidence from late Pleistocene sediments.

Liard Plain is a southeast trending intermontane basin bounded by Cassiar Mountains on the southwest, Yukon and Highland plateaus on the northeast, Pelly Mountains on the northwest, and Rocky Mountains on the southwest (Fig. 1). Liard River follows a southeasterly course along the central part of the Liard Plain; its major tributaries are Rancheria, Frances, and Hyland rivers.

Glacial deposits, consisting mainly of outwash sand and gravel, form the surface southwest of Liard River and a broadly rolling till plain occurs to the northeast of the river (Fig. 2). Ice flow features are found over much of the till plain and indicate that the last glacier flowed mainly in a southeasterly direction.

Previous studies

Brief discussion of, or references to the Tertiary and Quaternary deposits of southeastern Yukon Territory are included in published reports and descriptive notes on maps but the results of detailed studies have not been published. The dearth of information on the Tertiary, and in particular the Quaternary geology of this region, contrasts with the considerable volume and variety of published studies available for western and northern Yukon (see references in Hughes et al., 1972; Hughes et al., 1981).

Dawson (1898, p. 98-99) noted the Tertiary and overlying glacial deposits exposed along Liard River and its tributaries within the Liard Plain. In a report on the surficial geology along the Alaska Highway in northern British Columbia and southeastern Yukon, Denny (1952) included general descriptions of the surficial deposits as well as site descriptions in the vicinity of Watson Lake and along the Alaska Highway in the southeastern Yukon. Denny also discussed some aspects of the late glacial and postglacial history of the region. Gabrielse (1967) mapped ice-flow features in the Watson Lake area and concluded that the entire area was covered by one or more advances of ice. He also mentioned the occurrence of sediments of "intra- or pre-Pleistocene age" beneath till along Liard River and of glacial lake sediments in the northeastern part of the Watson Lake area. The most recent publications consist of the previously mentioned report by Klassen (1978) and surficial geology maps (1:250 000 scale) of the Watson Lake area (Klassen and Morison, 1982) and of the west half of the Coal River area (Klassen, 1983).

Field work

The information presented in this report was obtained as a result of reconnaissance mapping in the Watson Lake and Coal River areas in southeastern Yukon (Klassen and Morison, 1982; Klassen, 1983). The work was part of a larger regional mapping project which includes the Wolf Lake area (Klassen and Morison, 1983), Teslin area (in preparation), Whitehorse area (in preparation), Laberge area (Klassen and Morison, in press) and the east half of the Carmacks area (Klassen et al., in press). The maps are based largely on airphoto interpretation along with areal observations and scattered field checks along helicopter and motor vehicle traverses during the summers of 1977, 1978, 1979, and 1981.

Acknowledgments

The author was ably assisted in the field during the summer of 1977 by E. Thorsteinson and M.M. Lessard. S.R. Morison assisted with much of the airphoto interpretation, map compilation, and field work in 1978 and 1979. The potassium-argon dates made available to the author by J.A. Westgate and R.C. Walter of the University of Toronto provided much of the basis for the proposed chronological framework. Comments and suggestions offered by J.J. Clague in his constructive review of an earlier version of this paper are much appreciated.

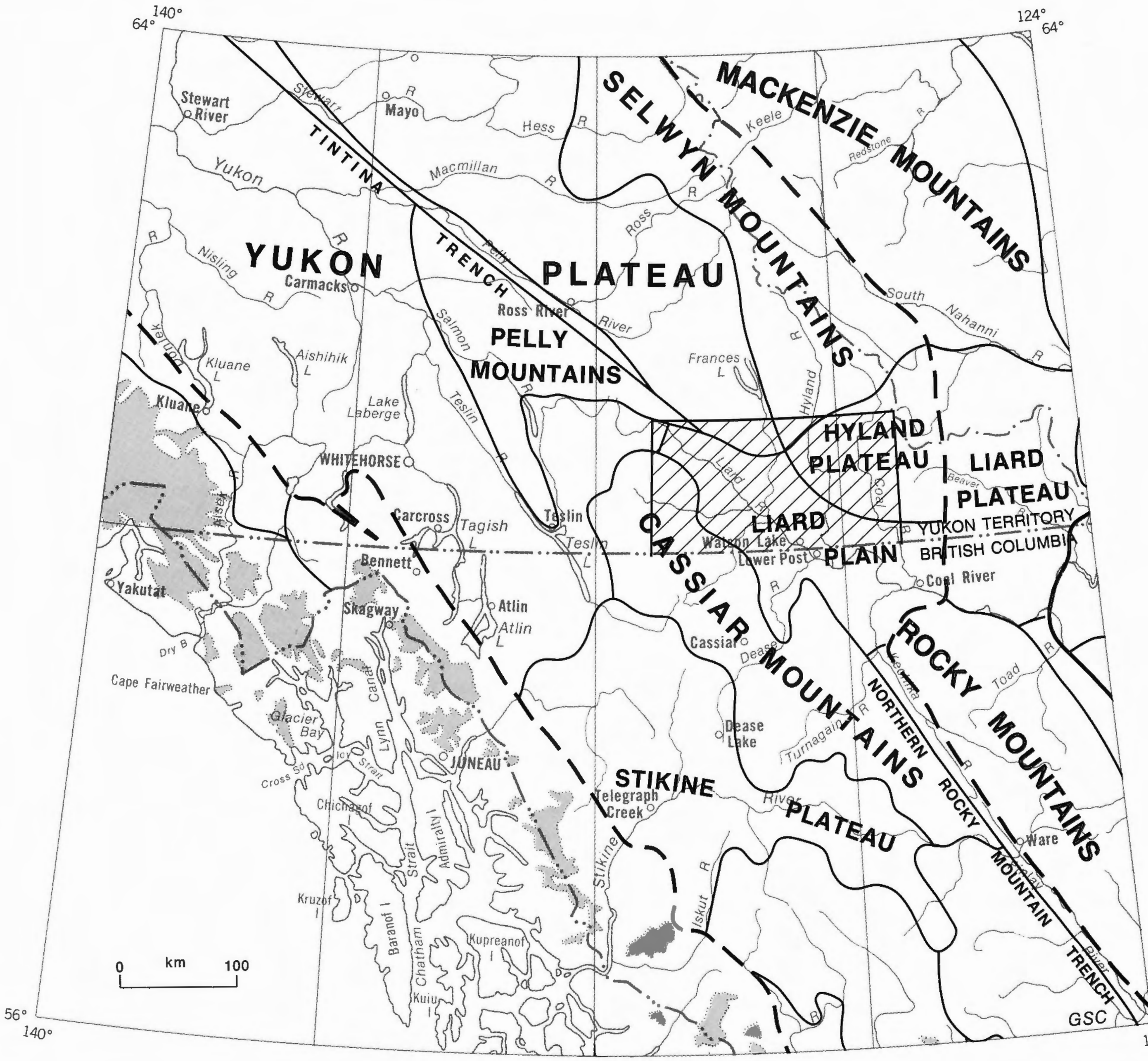

Figure 1. Physiographic map of the Corderilleran Region (Bostock, 1970) in the southern Yukon and northern British Columbia; study area is shaded.

STRATIGRAPHY

The Tertiary-Quaternary stratigraphic succession proposed for the southeastern Yukon is based mainly on four sections in the Liard Plain: two along upper Liard River; one on Tom Creek, a tributary to Liard River; and one along lower Hyland River.

Description of sections

Allan Creek section

A near-vertical bluff about 75 m high (760 m asl at top) along the northeast side of Liard Valley (60°28'32"N, 129°40'32"W), about 62 km northwest of Watson Lake (Fig. 2, 3) airport, is herein named the Allan Creek section after a creek that joins Liard River about 4.5 km upstream. A succession of eight discrete stratigraphic units can be seen along the clean face of this exposure (Fig. 4). The steep face makes all but the lowest unit virtually inaccessible; these units can, however, be reached along a nearby gulley where they are exposed in step-like fashion below the valley rim. The contacts between the units are remarkably well exposed in the face of the bluff and the sediments can be studied along the gully. The section from top to bottom is described in Table 1.

Rancheria River section

The Rancheria River section is located at the downstream end of a partly tree-covered bluff more than 60 m high (700 m asl at top) that forms the northwest side of Liard Valley, about 2 km below the confluence of Liard and Rancheria rivers (60°13'40"N, 129°06'15"W) and about 21 km northwest of Watson Lake airport (Fig. 2). The section includes two exposures about 10 to 15 m above river level that are separated by patches of tree-covered colluvium (Fig. 5, 6, 7). Dawson (1898, p. 99) and Gabrielse (1967) made brief references to this section and inferred a Paleocene, Eocene, or Miocene age for the oldest unit. The section from top to bottom is described in Table 2.

Tom Creek section

This section is exposed in a horseshoe-shaped bluff about 25 m high (650 m asl at top) on the west side of Tom Creek (60°13'42"N, 129°00'24"W), about 5.5 km above the confluence of Tom Creek with Liard River and 17 km northwest of Watson Lake airport (Fig. 2, 8). Undercutting of the bank by Tom Creek has resulted in a fresh, accessible exposure (Fig. 9). The units are described in Table 3.

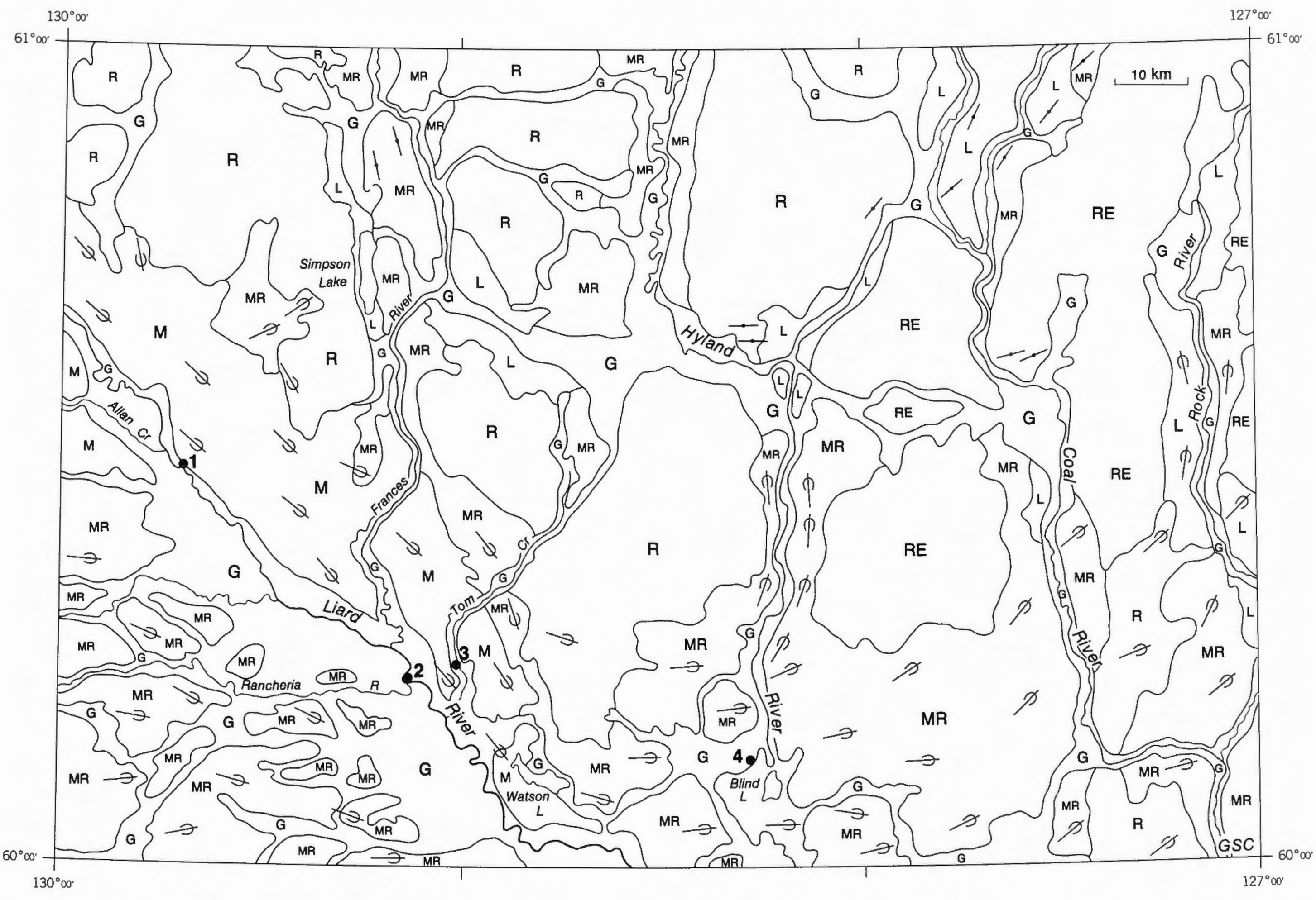

Figure 2. Generalized surficial geology map of the Watson Lake (105A) and west-half Coal River (95D) areas, southeastern Yukon (modified after Klassen and Morison, 1982; Klassen, 1983). Sections discussed in this report: 1. Allan Creek, 2. Rancheria River, 3. Tom Creek, and 4. Hyland River. Legend: G – Glaciofluvial deposits; L – Glaciolacustrine deposits; M – Till plains; MR – Till-veneered bedrock; R – Glaciated mountainous terrain; RE – Older, glaciated mountainous terrain. Symbols show ice flow direction (specific or sense) reflected by drumlinoid features.

Hyland River section

This section is exposed in a cliff about 65 m high (about 700 m asl at top) and 600 m long on the west side of Hyland River (60°07'40"N, 128°16'50"W) (Fig. 2, 10). It is about 2.5 km northwest of Blind Lake and 30 km east of Watson Lake airport. Much of the upper part of the section is nearly vertical and therefore inaccessible without special equipment. Thicknesses given for most units described are estimates based on altimeter readings. The section is described in Table 4.

Figure 3. Aerial view northwest across Liard River towards Allan Creek section that appears as as white bluff in the upper right. ISPG 1723-4.

Figure 4. Allan Creek section viewed from across Liard River. Stratigraphic units are numbered as in Table 1. ISPG 1134-9.

Stratigraphic units

Tertiary sediments

The stratigraphically lowest units described in the Allan Creek, Rancheria, and Hyland River sections (Fig. 4, 5, 6, 7, 10) form the lower part of the river banks within and south of the Watson Lake map area.

These units are composed of gravel, sand, silt, and clay, along with siltstone, shale, and coal. They are distinguished from Quaternary sediments by the predominantly light grey quartz and quartzite lithologies of the gravel and sand which impart an overall light grey tone that contrasts with the brown tone of overlying immature Quaternary sediments. Thin seams of in situ lignite coal which occur in places within the sediments also distinguish the Tertiary deposits from Quaternary sediments.

Thicknesses are about 25 m in the Allan Creek (Fig. 4) section where the lower contact is not exposed, and about 10 m in the Hyland River section (Fig. 10) where the sediments lie between bedrock and younger sediments. The thickest exposure known to the author is in a cliff about 9 km downstream from the confluence of Liard and Hyland rivers (Tatisno Creek; 59°50'N, 128°02'W) south of the study area where some 34 m of gravel, sand, and silt are overlain by 60 m of drift (R.F. Gerath, Thurber Consultants Ltd., Vancouver, personal communication, 1983).

The Tertiary sediments overlie Proterozoic bedrock along Hyland River and underlie drift and lava flows in the vicinity of Liard River and lower parts of its major tributaries in the southeastern part of the Liard Plain. Exposures along the lower parts of Hyland, Rancheria, and Frances rivers suggest that the belt is 60 km wide in the

Figure 5. Basalt overlying Pleistocene gravel in the Rancheria River section. Scale units are in feet. ISPG 1723-20.

Table 1. Stratigraphy, Allan Creek section

Unit No.	Unit Name	Description	Thickness (m)
8	Till D	Till: olive grey (5Y 4/2)[1]; oxidized with greatest oxidation along joint surfaces; moderately stony matrix[2] composed of 41% sand, 41% silt, and 18% clay (one sample); fissile in part; closely spaced joints; pebble fabric (50 elongate pebbles) is strongly oriented NNW to SSE similar to drumlimoid features; rock types are predominantly dark aphanitic varieties including volcanics, foliated metamorphics and granitic types; till is capped by a discontinuous veneer of sand containing an ash bed 1 cm thick; sharp contact with underlying unit	7.5
7	Intertill Unit C-D	Sand and gravel: poorly sorted, fine gravel and sand in upper zone about 1 m thick; most of this unit is covered in accessible part of the section; exposure in cliff face appears to be mainly sand; sharp contact with underlying unit	7.0
6	Till C	Till: very dark grey (2.5Y N3/); unoxidized except along joints; moderately stony matrix composed of 43% sand, 40% silt, and 17% clay (one sample); pebble fabric (50 pebbles) has a strong W-E orientation; rock types are predominantly volcanics with some foliated metamorphics, quartz, quartzite, and granite; sharp contact with underlying unit	2.5
5	Intertill Unit B-C	Clay: dark olive grey (5Y 3/2); massive; scattered bits of organic detritus and shell fragments; putrid odour; samples taken for paleomagnetic measurements show uniformly spaced cyclic fluctuations typical of the small shifts of the magnetic pole within the late Pleistocene; appears to be of shallow lacustrine origin; sharp contact with underlying unit	3.5
4	Till B	Till: grey (5Y 5/1) to olive (5Y 5/4) with somewhat mottled aspect; oxidized; moderately stony matrix 42% sand, 48% silt, 10% clay (one sample); pebble fabric has a SW-NE orientation; rock types are predominantly volcanic and foliated metamorphic with some quartz, quartzite, and types too strongly weathered to identify; sharp contact with underlying unit	2.5
3	Intertill Unit A-B	Silt and sand: overall greyish brown in lower zone to yellowish brown in upper zone; medium to thinly bedded; possible ice wedge cast estimated to be 2 m high occurs just above the till contact; glaciofluvial and/or glaciolacustrine origin; sharp contact with underlying unit	21.0
2	Till A	Till: olive (5Y 5/3); oxidized; stony to moderately stony matrix composed of 60% sand, 35% silt and 5% clay (one sample); fissile and jointed with distinct oxidation stains along joint faces; rock types are predominantly quartzite, quartz, foliated metamorphics and volcanics with some granitic varieties; sharp contact with underlying unit	3.5
1	Tertiary sediments	Sand, gravel, and silt: mostly sand and fine gravel with lenses of silt in the upper zone; thin stringers of lignite occur mainly within the silt; overall colour is a light grey that contrasts with the overall grey to yellowish brown aspect of the overlying units; pebbles are predominantly well rounded quartzite and quartz pebbles along with some volcanics and rare, highly weathered granitic types; current bedding indicates flow in same direction as Liard River; silt lenses, from 1 to 3 m thick, include beds of lignitized tree parts up to 20 cm thick with well preserved wood structures; samples taken by W.H. Poole in 1952 yielded a radiocarbon age of >40 100 BP (GSC-414, Dyck et al., 1966); depositional setting appears to have been riverine; silt and wood accumulated within and adjacent to abandoned channels in the back swamp part of the floodplain.	25.0

[1] Munsell Color chart, moist surface.
[2] Matrix includes that portion of the sample finer than 2 mm.

southeast part of the Watson Lake area and narrows towards the northwest. The distribution of "Eocene" fluvial sediments in the southeastern Yukon mapped by Tempelman-Kluit (1980, p. 1193) is a fair approximation of sediment distribution, although the easterly and southeasterly extent is somewhat greater than that shown.

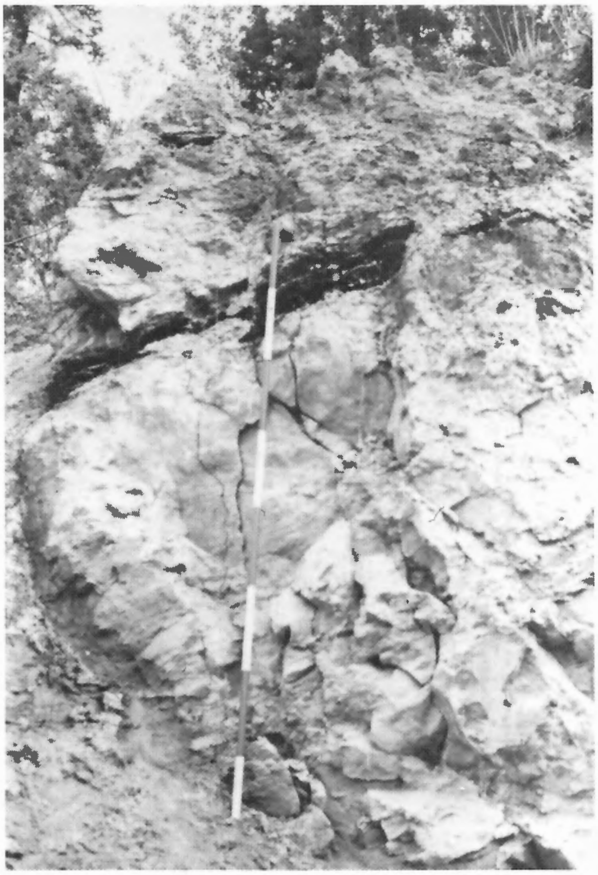

Figure 6. Tertiary siltstone and thin intercalated coal seam underlying Pleistocene gravel (Fig. 5) in Rancheria River section. ISPG 1723-19.

Figure 7. Near vertical Tertiary siltstone beds unconformably overlain by Pleistocene gravel to the right of centre. ISPG 2004-1.

Tertiary sediments were deposited along mature river systems and include channel, overbank, and backswamp types of deposits. The degree of pebble roundness and the highly resistant rock types that make up the gravels indicate multicycle reworking within large channels. Lenticular shaped beds of silt and siltstone intercalated with coal stringers (Fig. 6) most likely accumulated as backswamp deposits and fills in abandoned meanders on ancient floodplains.

Preglacial drainage lines within the Liard Plain apparently were in much the same direction and roughly coincident with the major present day rivers. According to Tempelman-Kluit (1980) this was not so in the southern Yukon west of the Cassiar Mountains. He proposed that Pleistocene glaciations resulted in a reversal of flow directions mainly to the northwest from considerably shorter preglacial routes to the southwest. The mechanism that was thought to have triggered diversion elsewhere in this region – glacier blockage of downstream sections of major rivers – was not operative over most of the Liard Plain where ice advances were generally in the direction of the regional drainage.

Paleontological and radiometric dating evidence indicative of the age of these sediments has not been obtained. The stratigraphic position of these mature, mostly unconsolidated terrestrial sediments is characteristic of Tertiary sediments in other parts of western Canada and they are thus assigned to this period. Dawson (1898, p. 99) suggested a Miocene age for the lignites and "associated clays and soft shales" on the basis of their similarity to the "Miocene of British Columbia". Gabrielse (1967) referred to the steeply dipping beds of this formation as being of Paleocene or Eocene age and Tempelman-Kluit (1980, Fig. 3) designated these sediments as Eocene in age. An unconformity within these sediments (Fig. 7) suggests that units of at least two ages are present. Some deformation may have resulted from disturbances such as landslides or ice thrusting; however, as inferred by Dawson (1898, p. 99) and Gabrielse (1967), the distribution of deformation structures appears to reflect tectonic rather than local disturbances. Some of the uppermost gravels, exhibiting the maturity and lithology characteristic of this formation but lacking the in situ coal beds common to other units, may well be of Pliocene age, as they are similar to the White Channel Gravels of the Yukon Plateau described by McConnell (1905, p. 32-33) and thought by him and later workers (Bostock, 1964; Tempelman-Kluit, 1980) to be of Pliocene age.

Basalt flows

Basalt flows are exposed in places along the banks of Rancheria River, the lower part of Liard River, and at the surface in the vicinity of Watson Lake. The basalt is typically black, vesicular, highly fractured, and blocky where thin (Fig. 5, 11) and distinctly columnar where more than several metres thick. Thicknesses range from about 2 m where the basalt occurs within sand and gravel at the mouth of Rancheria River (Fig. 11) to more than 60 m along Liard River near Watson Lake.

Dawson (1898, p. 99-100) noted the stratigraphic position of the basalt above the coal-bearing beds along Liard River and recognized its surface expression in the flat-topped hills in this region. Along the Alaska Highway, just west of the study area, Lord (1944) mapped basalt flows along the valley bottoms and concluded that they ranged in age from the late Tertiary to the Pleistocene.

The stratigraphic positon of the lava flows is uncertain although they appear to be associated with the lower units of the Pleistocene succession in the Watson Lake area.

Potassium-argon dates on basalts at four localities in this area indicate ages from as old as about 765 ± 49 ka (lab no. 481) to as young as 232 ± 21 ka (lab no. 581; Table 5) indicating an early to middle Pleistocene age. The poorly sorted gravel beneath the basalt in the Rancheria River section (Fig. 5), dated at 545 ± 46 ka (lab no. 2381, Table 5), may be a facies of the oldest of four tills (Till A) in the Allan Creek section for the rock assemblages within the gravel and Till A are similar (Till (A?) of Table 2 and Till A of Table 6). The youngest basalts may therefore be part of the intertill unit beneath Till C in the Allan Creek section (Fig. 4).

Basalt flows probably occur in ancestral valleys throughout much of the study area. Glacial deposits, however, mask the surface expression of the flows that likely are at the periphery of volcanism centred in the Jennings River map area to the southwest. Lava flows and volcanic cones of Tertiary (?) to Recent age occur in this area (Gabrielse, 1968). The lavas in the study area probably originated as fissure type extrusions in this peripheral zone.

Pleistocene tills and intertill sediments

Four tills designated Till A, Till B, Till C, and Till D that are separated by three stratified intertill units designated Intertill unit A-B, Intertill unit B-C, and Intertill unit C-D, are identified in the Allan Creek section (Fig. 4). These units are the basis for the Pleistocene stratigraphic framework proposed for this region. Although the units can be traced some distance upstream from the Allan Creek section, only the two upper tills (C, D) and the sediments separating them (Intertill unit C-D) can be correlated with the units in the Tom Creek section (Fig. 9). The uppermost tills, where present in the described sections, can be correlated on the basis of stratigraphic position and surface morphology.

Lithostratigraphic units

Till A differs from the younger tills in the Allan Creek section in that its texture and the rocks it contains strongly reflect the underlying Tertiary source beds. It is sandier and has a higher percentage of quartz and quartzite rocks than the younger tills (Table 6). The contacts with the underlying Tertiary sediments and the overlying Intertill unit A-B are sharp and appear as nearly horizontal traces indicating a uniform thickness of about 3 m across the face of the section.

Intertill unit A-B is a thinly bedded succession of silt and sand some 15 to 20 m thick (unit 3, Fig. 4). It appears to be devoid of fossils suggesting a probable glaciolacustrine origin. Periglacial conditions may have existed following deposition of the lower part of this unit, providing the structure just above the contact with Till A is correctly identified as a fossil ice wedge (Table 1). Similar sediments some 20 m thick are exposed in places below the confluence of Liard River and Tom Creek suggesting that this unit underlies other parts of the Liard Plain.

Distinctive characteristics of Till B in the Allan Creek section are columnar erosional forms seen across parts of the cliff face (Fig. 4). The rock assemblage differs from Till A in that the percentage of quartz and quartzite rocks is lower and the percentage of volcanic rocks is higher; compared with Till C, however, Till B has a significantly higher percentage of volcanic and foliated metamorphic rocks (Table 6). The contacts with the enclosing intertill units are sharp and nearly horizontal. The SW-NE pebble fabric of Till B suggests that it was deposited as a lodgment or englacial till by a glacier flowing to the northeast.

Figure 8. Aerial view to the northwest of the Tom Creek section. The described part (Fig. 9) is to the right of the cluster of trees. ISPG 1723-10.

Table 2. Stratigraphy, Rancheria River section

Unit No.	Unit Name	Description	Thickness (m)
5	Basalt flow	Basalt: very dark grey (2.5Y N/3) to black (2.5Y N/2.5); markedly vesicular, closely spaced joints result in irregular, blocky face; K-Ar date 545 ± 46 ka (#2381)	2.0
4	Till A(?)	Silt: buff to brown, 'baked' zone along contact with basalt	0.15
3		Gravel: poorly sorted, fine to medium gravel; subrounded to well rounded pebbles; rock types predominantly quartzite, quartz, foliated metamorphics and volcanics along with some granitic varieties	2.0
2		Covered interval	2.0
1	Tertiary sediments	Siltstone: yellowish brown, weakly indurated; jointed; blocky, irregular face; several seams of lignite coal, 15 to 30 cm thick, occur in the upper part; steeply dipping to nearly vertical beds.	3.0

Intertill unit B-C is dense, massive, slightly fossiliferous clay separated from underlying Till B and overlying Till C along sharp contacts. Scattered organic detritus and soft gastropod shells are indicative of nonglacial conditions between the glacial advances that deposited the enclosing tills. Sediments correlative with this unit were not recognized elsewhere in the study area. The results of paleomagnetic analyses of this unit are discussed later in this report.

Till C is unoxidized and its dark grey (2.5Y N/3) colour contrasts with the lighter colours of the other oxidized tills. Its colour also reflects a high clay content apparently derived from the underlying clayey Intertill unit B-C. The rock assemblage characteristic of Till C differs from the other tills (Table 6), particularly its low content of granite rocks. Contacts are sharp and roughly horizontal. The pebble fabric suggests easterly glacier flow similar to flow components of the last glacier across the western part of the Liard Plain (Fig. 2).

Till C is correlated with the oldest till (unit 2) in the Tom Creek section on the basis of stratigraphic position and similar physical characteristics. The rock assemblages in the units in both sections are similar (Table 6). Both units are unoxidized and their pebble fabrics suggest east to southeast ice flow directions similar to ones shown by ice flow features in the surface till in the southern part of the plain (Fig. 2). The continuity of the till plain between the exposure of Till C in the Allan Creek and Tom Creek sections suggests that this unit may underlie much of this part of the Liard Plain.

Table 3. Stratigraphy, Tom Creek section

Unit No.	Unit Name	Description	Thickness (m)
8	Till D	Till: olive (5Y 4/3); oxidized, with strongest oxidation along joints; moderately to fairly stony matrix composed of 49% sand, 39% silt, and 12% clay (one sample); pebble fabric (50 elongate pebbles) is dominantly NNW to SSE similar to drumlinoid features; gradational contact with underlying till	1.5
7		Till: olive grey (5Y 4/2); oxidized, with strong oxidation along closely spaced joints; moderately to fairly stony matrix composed of 34% sand, 41% silt, and 25% clay (average 3 samples); stones smaller than those in overlying unit, elongate pebbles have preferred orientation WNW to ESE; rock types are predominantly light and dark volcanics along with some quartz, quartzite, foliated metamorphics and granitics; sharp contact with underlying silt	4.0
6	Intertill Unit C-D	Silt: dark grey (5Y 4/1); clayey; jointed with oxidation stains along joints; contains small lenses of gravel; lower zone is weakly cemented with limonite; sharp contact with underlying unit; pinches out towards the upstream part of the section	1.0
5		Silt: (Tom Creek silt) very dark greyish brown (2.5Y 3/2); fissile; fairly hard and compact; high in disseminated organic detritus, rare bits of wood; fossiliferous, including herbaceous pollen of grass (Gramineae), sage or worm wood (Artemisia), and sedge (Cyperaceae), along with aquatic plants, megaspores, and insects; unidentified twig fragments from the bottom and upper zone of this unit were radiocarbon dated at greater than 30 000 BP (GSC-2949) and 23 900 ± 1140 BP (GSC-2811; Lowdon and Blake, 1981), respectively; pinches out towards the upstream part of the section where the overlying till is in sharp contact with the underlying gravel (Unit 4); paleomagnetic measurements show uniformly spaced cyclic fluctuations typical of the small shifts of the magnetic pole within the late Pleistocene	2.5
4		Gravel and sand: poorly sorted; strongly stained with limonite, and weakly cemented zones present; rocks are rounded to subrounded; rock types are mainly dark aphanitic volcanics along with quartzites and some granitics	4.8
3	Intertill Unit C-D	Clay: dark grey (2.5Y N/4); massive; greasy	1.2
2	Till C	Till: dark grey (5Y 4/1) in upper zone to olive grey (5Y 4/2) in the lower zone; unoxidized; moderately stony matrix with 48% sand, 46% silt, and 6% clay (one sample) in the lower zone and 59% sand, 35% silt, and 6% clay (average 3 samples) in the upper zone; elongate pebbles have a preferred orientation NW to SE; small lenses of sand from underlying unit occur in lowermost 2 m of till	8.0
1		Sand and gravel: interbedded coarse sand and fine gravel; limonite stained; thin sand beds contain bits of coal and wood.	1.2

Intertill unit C-D in the Allan Creek section consists of sand and gravel separated from Till C and Till D along sharp contacts. A succession of clay, gravel, and fossiliferous silt in the same stratigraphic position in the Tom Creek section is correlated with the unit in the Allan Creek section. The results of paleontological and paleomagnetic studies and radiocarbon dating of the fossiliferous silt are discussed in later sections.

Till D is the till described in the Allan Creek and Tom Creek sections. It averages about 6 m in thickness and is olive grey (5Y 4/2) to olive (5Y 4/3). Descriptions and grain size analyses from the above sections and other exposures in the area (Table 7) indicate that the till is variable in colour and is generally sandy and moderately stony. The two uppermost till units described in the Tom Creek section are included in Till D as the contact between them is gradational and slight differences in their physical properties may in part result from different modes of deposition from the same ice sheet.

Till D overlies Intertill unit C-D and older Pleistocene sediments over much of the Liard Plain (Fig. 2, unit M). This till overlies bedrock in the southwestern part of the study area and occurs along the flanks of the low mountainous terrain bordering the northeastern part of the Plain (Fig. 2, unit MR). Distinctive drumlinoid features oriented to the east and northeast over the Liard Plain and to the north and northeast within the lower parts of the valleys of Hyland, Coal, and Rock rivers, outline the extent and flow directions of the glacier that deposited Till D in the study area.

Laboratory studies of Intertill units B-C and C-D

Samples collected during the course of field work were submitted to specialists for paleontological and paleomagnetic analyses and radiocarbon dating. Pollen and other fossils from Intertill unit C-D (Tom Creek silt) in the Tom Creek section are discussed by R.J. Mott and J.V. Matthews Jr., respectively. Paleomagnetic measurements of samples from Intertill unit B-C in the Allan Creek

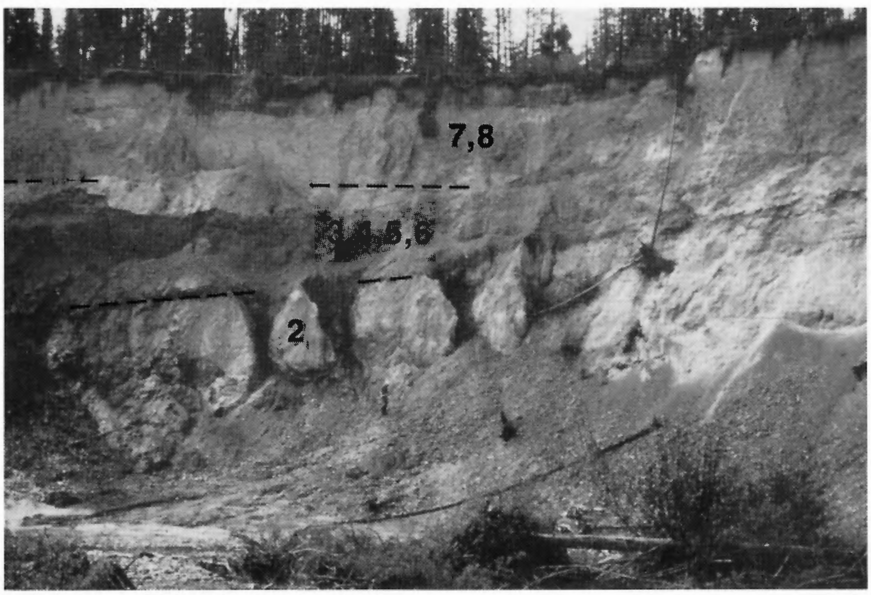

Figure 9

Tom Creek section showing units 2 to 8. Unit 1 is covered. Person in lower centre of photo provides scale. ISPG 1723-6.

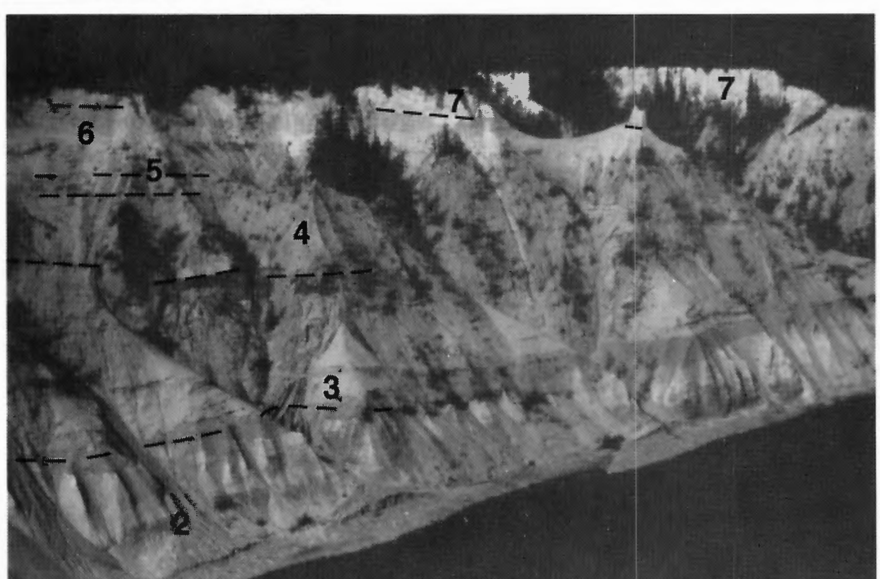

Figure 10

Hyland River section showing units 2 to 7. Unit 1 is exposed to the left of photo. ISPG 1723-16.

section and Intertill unit C-D in the Tom Creek section are discussed by R.W. Barendregt of the University of Lethbridge.

The fossiliferous silt (unit 5) of Intertill unit C-D of the Tom Creek section is rich in organic detritus including pollen, spores, and arthropod remains. This bed is herein named the Tom Creek silt because of the climatic and chronological inferences made on the basis of fossils contained and radiocarbon dates obtained from wood fragments within it.

Palynology of the Tom Creek silt.[1] The pollen spectra of the Tom Creek silt indicates that a herbaceous tundra environment, with local grass sedge meadows, and some willows had developed in this area prior to the last glaciation (Fig. 12). Pollen was preserved mainly on the lower two-thirds of the bed with scattered and poorly preserved grains of similar pollen in the upper third.

Gramineae (grass) is the most abundant pollen taxon, exceeding 37% in all samples. Cyperaceae (sedge) pollen is plentiful as are **Artemisia** (wormwood or sage) and **Betula** (birch). The birch pollen is of small size, indicative of shrub birch species (i.e. **Betula glandulosa, B. nana**). **Salix** (willow) is the only other shrub consistently represented. **Alnus** (alder) pollen is rare as are the tree pollen types **Picea** (spruce) and **Pinus** (pine). A variety of herbaceous pollen taxa comprising mainly upland types are present in small percentages. Pteridophyta (fern) spores, including **Botrychium**, occur in small numbers. **Selaginella** spores are present; however, their preservation is poor and the species cannot be identified. They resemble spores of **Selaginella sibirica**, a common species of the north today. **Potamogeton** (pondweed) and **Myriophyllum** (water-milfoil) pollen attest to the presence of aquatic habitats although boggy areas do not appear to have been abundant judging by the sparseness of **Sphagnum** spores.

Little variation in the pollen spectra is seen throughout the unit, suggesting either a very short time interval was involved or the environment was relatively stable. If any trend is apparent it is the slight increase in shrubs and the decline in some herbaceous pollen types upwards.

Identical modern analogues to the fossil pollen spectra outlined above have not been described. Grasses were probably abundant as suggested by records of pollen assemblages from modern grassland areas where grass pollen is not the most abundant in surface spectra (Lichti-Federovich and Ritchie, 1968; Mott, 1969, 1973). Pollen records from present arctic and alpine environments provide the closest analogies, although they have a distorted representation of tree pollen and/or various shrub or herb taxa (Ritchie and Lichti-Federovich, 1967; Terasmae, 1967; Birks, 1973, 1977, 1980; Ritchie, 1974; Ager, 1975; Bourgeois, 1981). Several mid to Late Wisconsinan sites with grass-sedge-herb pollen spectra have been described from northwestern Canada. The greatest similarity is with

Table 4. Stratigraphy, Hyland River section

Unit No.	Unit Name	Description	Thickness (m)
8		Silt: light brown; clayey; thinly bedded to laminated; glaciofluvial or glaciolacustrine	1.0
7	Till D	Till: pale olive (5Y 6/3, dry); stony with boulders; sandy matrix 87% sand, 7% silt, and 6% clay (one sample); forms steep face of cliff, and hoodoos on bluff outliers	5.0
6		Sand and gravel: glaciofluvial	12.0
5	Till B(?)	Till: olive (5Y 5/3); sandy; stony; jointed	5.0
4		Sand and gravel: glaciofluvial(?)	12.0
3		Sand: silty or gravelly in part; thinly bedded; contains lens up to 3 m thick of coarse detrital coal; individual pieces of coal to 30 cm across; dark brown of coal unit contrasts with light brown of enclosing sand; minor beds of detrital coal occur elsewhere within this unit	15.0
2	Tertiary sediments	Gravel: light grey; lower zone about 1 m thick is strongly iron stained and cemented; well rounded, pebble to cobble sizes; rock types are predominantly white quartz, quartzite, and dark aphanitic types including volcanics; bed of lignite coal 20 to 80 cm thick and continuous for some 60 m, occurs about 1 m above the cemented lower zone, original wood structures are well preserved in the coal; the upper zone of the gravel forms a steep face below the contact with the overlying sand and makes it readily identifiable along Hyland River south of this locality; the maturity of the gravel and coal seams within it indicates a probable Tertiary age for this unit	10.0
1	Proterozoic bedrock	Argillite: dark grey to brown; thinly bedded in part with some sulphur-stained beds; beds up to 1 m thick in places are brownish and have blocky aspect reflecting numerous vertical joints; beds dip in a general southerly direction although minor folding is evident; exposure is continuous for about 60 m along downstream part of section; similar outcrops farther downstream are assigned to the Proterozoic (Gabrielse, 1967).	5.0

[1] From unpublished GSC Palynological Report No. 78-5 and 80-4 by R.J. Mott.

assemblages recovered from Antifreeze Pond in the Snag-Klutlan area of southwestern Yukon that date between about 13 500 and 31 500 BP (Rampton, 1971), and lake sites in northern Yukon dating from about 15 000 to 30 000 BP (Cwynar and Ritchie, 1980). At these sites, grasses, sedges, and birch pollen are dominant, and many of the herbaceous taxa seen in the Tom Creek profile are represented whereas tree and shrub pollen other than birch are scarce. The upper parts of sections along Porcupine and Old Crow rivers in the Yukon, studied by Lichti-Federovich (1973, 1974), have similar pollen assemblages that may date from the mid Wisconsinan interval. A grass-herb-shrub pollen spectrum was also found in north-central British Columbia in sediments associated with mammoth remains that date from the mid Wisconsinan Olympia Interglaciation (Harington et al., 1974).

Figure 11. Basalt flow (blocky unit from centre right) above a gravel that may be correlative with the Pleistocene gravel in the nearby Rancheria River section. Another gravel bed separates the basalt from a till that here forms a terrace surface. ISPG 1723-11.

Plant macrofossils of the Tom Creek silt[1]. The presence of abundant Characeae, **Ranunculus batrachium** type, **Potamogeton** and **Hippuris** suggests that most of these samples formed in a lake or pond (Table 8). Many of them were clayey and contained clay peds in the examined residue. Most also contained macrofossils of aquatic animals.

A peculiar feature of those samples yielding more than a few fossils is the rarity of **Carex** achenes. Normally pond or lake samples from the north contain abundant **Carex**, representing the emergent shoreline zone, and only a few seeds of **Ranunculus batrachium** type. In this case **batrachium** type achenes dominated. One sample contained 23 **batrachium** type achenes and only one **Carex**; while most of the others contained no **Carex** fossils at all. It is possible that the rarity of **Carex** and abundance of **Ranunculus** indicates that the sediments were deposited far from shore in a large lake, an oligotrophic lake, or in a small lake which had a barren shoreline or other characeristics which inhibited development of shoreline vegetation. A large lake seems most likely.

Table 5. Potassium-argon dates on basalt flows of the Liard Plain southeastern Yukon (J. Westgate and R.C. Walter, University of Toronto, personal communication, 1983)

Lab No.	Age (ka)	Location	Comment
481	765 ± 49	60°04'N, 128°49'W	outcrop, Alaska Highway
2481	604 ± 39	60°05'N, 128°54'W	bluff, cast bank Liard River
2381	545 ± 46	60°14'N, 129°06'W	Rancheria River section
581	232 ± 21	60°09'N, 129°41'W	outcrop, Alaska Highway

Table 6. Pebble counts in tills and gravels at the Allan Creek and Tom Creek sections. Percentages are based on one count of about 50 pebbles from each unit.

Unit	Rock Types (% of Total Counted)					
	Quartzite	Quartz	Volcanic	Foliated Metamorphic	Granitic	Others
Liard River Channel (Allan Ck. sec.)	9	9	31	35	9	7
Till D (Allan Ck. sec.)	4	11	48	19	17	1
Till C (Allan Ck. sec.)	9	18	52	14	5	2
Till C (Tom Ck. sec.)	14	14	42	12	9	9
Till B (Allan Ck. sec.)	12	14	32	22	14	6
Till A (Allan Ck. sec.)	23	19	21	24	11	2
Tertiary sediments (Allan Ck. Sec.)	46	35	12	3	3	1

[1] From unpublished GSC Plant Macrofossil Report No. 78-9, 80-9, 80-10, 90-11 by J.V. Matthews, Jr.

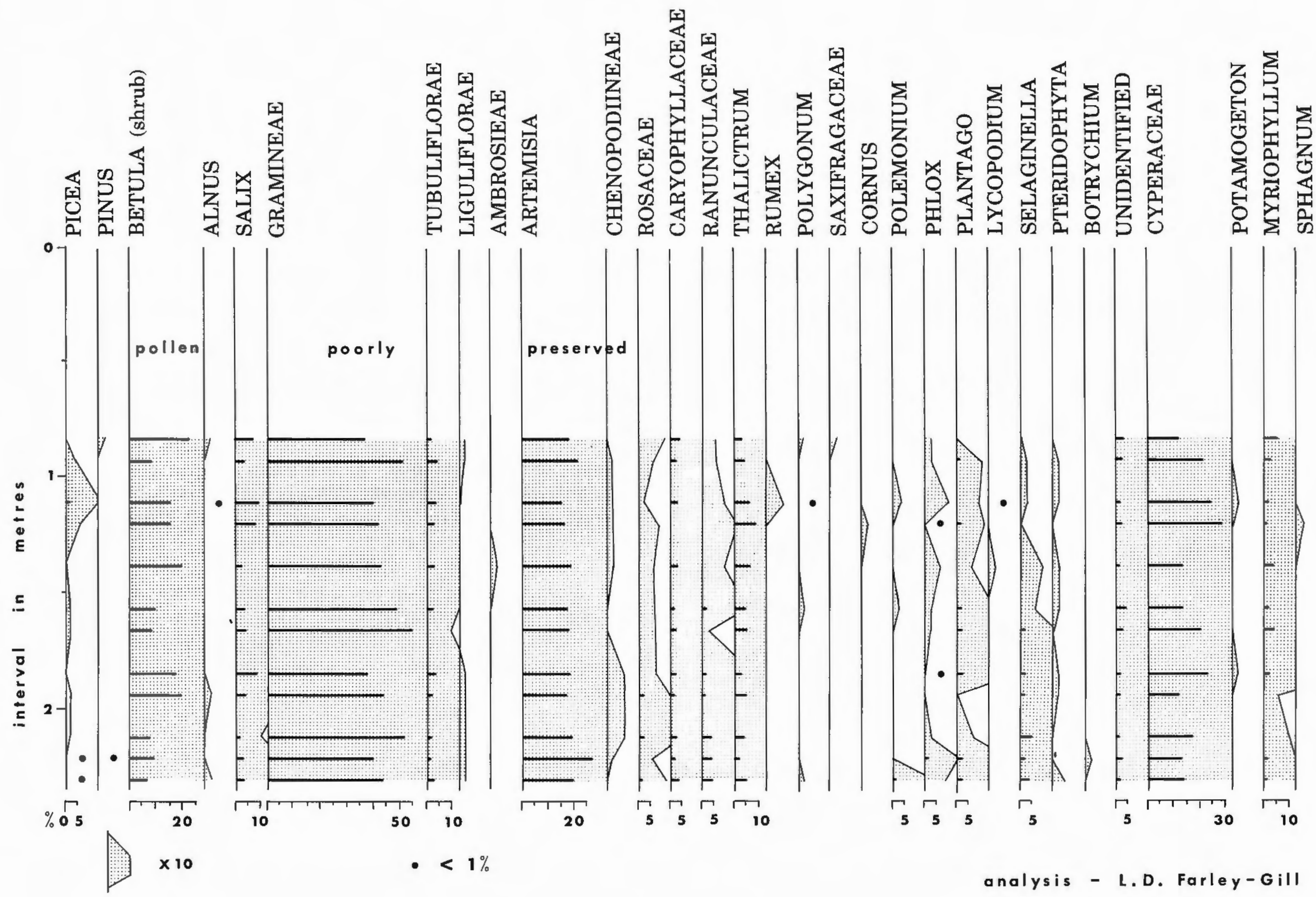

Figure 12. Pollen diagram of the Tom Creek silt.

Table 7. Physical properties of the surface till on the Liard Plain

Grain Size (%)							Colour	Location	Sample No.	Comments
Bulk Sample				Matrix <2 mm						
gravel	sand	silt	clay	sand	silt	clay				
46	22	22	10	41	41	18	olive brown (2.5Y 4/4)	60°29'N, 129°41'W	15-77	thickness 7.5 m; Allan Creek section
25	40	31	4	54	41	5	olive (5Y 4/3)	60°18'N, 129°26'W	13A-77	bank of Liard River near Meister River
24	28	30	18	37	41	22	olive grey (5Y 4/2)	60°14'N, 128°00'W	21-78	thickness 6 m; Tom Creek section
19	27	33	21	33	41	26	as above	as above	22-78	as above
40	20	25	15	33	42	25	as above	as above	22-77	as above
32	35	25	8	49	39	12	olive (5Y 4/3)	as above	20-78	upper zone of unit
32	41	19	8	60	28	12	yellowish brown (10YR 6/4)	60°77'N, 129°01'W	36-78	road cut across drumlin
45	22	23	10	40	41	19	olive (5Y 4/3)	60°07'N, 128°48'W	35-78	as above
27	44	27	2	60	37	3	olive grey (5Y 4/2)	60°04'N, 128°43'W	12-77	road cut, till plain
				47	34	19	dark greyish brown (2-5Y 4/2)	59°58'N, 128°04'W	6-78	as above
68	29	2	1	89	7	4	pale olive (5Y 6/3 dry)	60°08'N, 128°17'W	31-77	thickness 5 m; Highland River section
36	30	24	10	49	36	15	Average			

Arthropods and Bryozoa of the Tom Creek silt[2]. Most of the identified fossils are indicative of aquatic conditions (Table 9). Beetles typical of richly vegetated shorelines were rare, but so too are the fossils indicative of bare, clayey or silty shorelines. Mandibles of tadpole shrimp (**Lepiduris**) were rather abundant in some samples. These animals usually occur in ephemeral ponds where the O_2 level is too low to support fish (or which freeze to the bottom in winter). This seems to constrain the suggestion of a large lake inferred from plant macrofossils. However, the rarity of Dytiscid fossils (**Colymbetes** was represented only by fragments and it is the genus most likely to colonize temporary ponds) seems to show that the lake, whatever its size, did not have a well developed emergent vegetation zone. The residue and its fossils from a sample nearest the bottom contact do not contain the dominant aquatic component present in most other samples.

Radiocarbon dates from the Tom Creek silt. Parts of small twigs too compressed and decomposed to identify were recovered from the contact of the Tom Creek silt and underlying sand and gravel unit and from the upper zone of the silt. A radiocarbon date of >30 000 BP (GSC-2949) from the lower material and a finite date of 23 900 ± 1140 BP (GSC-2811) upper material (Table 3) suggest that the Tom Creek silt was deposited during an interval of at least 6 ka duration.

Paleomagnetic record of Intertill unit B-C and Tom Creek silt. Paleomagnetic measurements were taken from samples of the Tom Creek silt in the Tom Creek section and Intertill unit B-C in the Allan Creek section. The sediments show no major excursions or reversals and the small scale signatures of the plots obtained (Fig. 13, Table 10) may provide useful information for correlation purposes only when more data is available from this region.

Table 8. Plant macrofossils, Tom Creek silt

Family - Genus	Occurrence
Characeae (Stone warts) **Chara** and/or **Nitella** - oogomia	9 samples, middle and upper zones
Isoetaceae (quillwarts) **Isoetes**? - megaspores	4 samples, upper zone
Najadaceae (pondweed) **Potamogeton** sp. - fruits	3 samples, upper zone
Cyperaceae (sedges) **Carex** - achenes	3 samples, middle and upper zones
Betulacea (birch) **Betula** sp. - bractlet	1 sample, upper zone
Ramunculaceae (buttercup) **Ranunculus** sp.; **batrachium** type - adenes more than one species represented	7 samples, middle and upper zones
Haloragidaceae (water milfoil) **Hippuris vulgaris** L. - fruit	2 samples, middle and upper zones

Samples were obtained by pushing or gently tapping the open ends of plastic, 2 cm cubes into the sediments. The direction of magnetic north was marked on the positioned cube. Four samples were taken at a 6 cm spacing along horizons that in turn were spaced at 30 cm vertical intervals.

The samples show the characteristic magnetization to be of a single component and well represented by the direction of the remanent magnetization measured after

Table 9. Arthropod and Bryozoa fossils, Tom Creek silt

Fossils	Occurrence
Arthropods	
Crustacea	
Cladocera (ephippia)	11 samples, lower and middle zones
Notostraca	2 samples, upper zone
Lepiduris sp. - mandibles	
Ostracoda	2 samples, upper zone
Insecta	
Coleoptera (beetles)	2 samples, upper and lower zones
Carabidae (ground beetles)	
Bemidion sp.	
Pterostichus (**Cryobius**) sp.	
Trichocellus mannerheimi	
Dytiscidae (diving beetles)	6 samples, middle and upper zones
Colymbetes sp.	
Hydrophilidae (water scavenger beetles)	2 samples, upper and lower zones
Staphylinidae (rove beetles)	2 samples, upper and lower zones
Olophrom boreale (Payk)	
Micra lymma sp.	
Aleocharinae	
Tachyporus sp.	
Silphidae	2 samples, middle and upper zones
Silpha sp.	
Curculionidae (weevils)	2 samples, lower and upper zones
Lepidolphorus lineaticollis Kirby	
Trichoptera (caddis flys)	1 sample, upper zone
Diptera (flys)	3 samples, lower, middle and upper zones
Chironomideae	
Xylophagidae	1 sample, lower zone
Xylophagus sp.	
Hymenoptera (wasps, ants, bees)	1 sample, lower zone
Ichneumonoidea	
Bryozoa	
Cristatella - statoblasts	2 samples, upper zone

[2] From unpublished GSC Fossil Arthropod Report No. 78-10 and 80-5 by J.V. Matthews, Jr.

demagnetization (Fig. 13). The inclination and declination profiles show a regular cyclic fluctuation; the increasing inclination values at horizons 3, 6, and 8 of Allan Creek (Table 10) correspond to easterly shifts in the declination profile. The cyclic fluctuations are typical of those produced by the small but regular movement of the non-dipole field and probably represent several thousand years. The Tom Creek profiles show less fluctuation, possibly indicating that these sediments were deposited more rapidly than the Allan Creek sediments.

Tertiary-Pleistocene events

A broad framework of Tertiary-Pleistocene events inferred for this region includes early Tertiary tectonism followed by a long interval of relative stability during which fluvial erosion formed a mature, low relief landscape. A climate, milder than the present one, accelerated the weathering of less resistant sediments and the growth of vegetation on the extensive backswamp parts of river valleys. Volcanism that was centred in the Cassiar Mountains to the southwest of the Liard Plain (Fig. 1) extended into parts of the Liard Plain probably as early as the Late Tertiary. Dated lava flows indicate that intervals of volcanism occurred during the mid-Pleistocene and the early part of the late Pleistocene (Table 5).

The stratigraphic relationship of the dated lava flows to the till units is rather uncertain (Fig. 14). The age of about 545 ka (Table 5) from the lava in the Rancheria section which

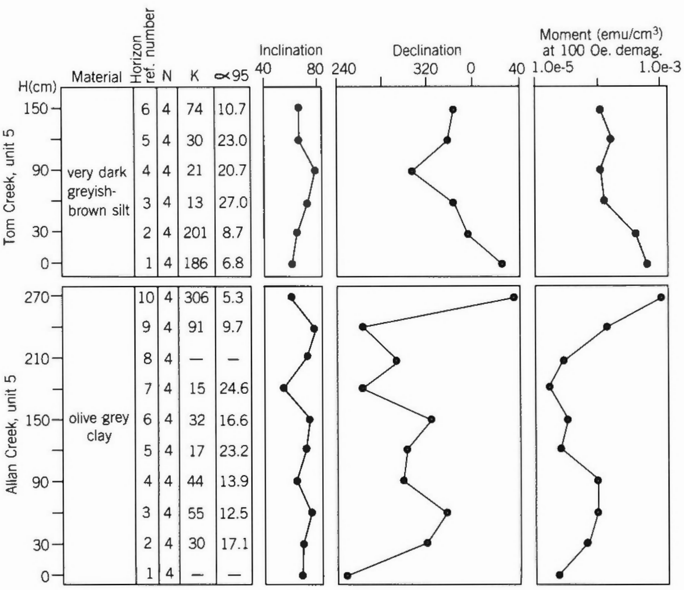

Figure 13. Plots of paleomagnetic measurements of samples of the Tom Creek silt and Intertill unit B-C in the Allan Creek section. Symbols used: N – number of separately oriented drive-core specimens; K – precision parameter; ∝95 – radius in degrees of 95% zone of confidence.

^{14}C (years BP)	K-Ar (ka)	CHRONOSTRATIGRAPHY Stage	LITHOSTRATIGRAPHY Main unit	LITHOSTRATIGRAPHY Material	EVENT
		LATE WISCONSINAN	Till D	olive till olive grey till	Glaciation
23 900 ± 1140 BP (GSC-2811) >30 000 BP (GSC-2949)		MID WISCONSINAN	Intertill unit C-D	Tom Creek silt gravel clay	Non glacial
		EARLY WISCONSINAN (?)	Till C	dark grey till	Glaciation
		SANGAMONIAN (?)	Intertill unit B-C	fossiliferous clay	Nonglacial
	•232 ± 21				Volcanism
		ILLINOIAN (?)	Till B	olive till	Glaciation
		YARMOUTHIAN (?)	Intertill unit A-B	silt and sand	Nonglacial
	•545 ± 46				Volcanism
		KANSAN (?)	Till A	olive till	Glaciation
	•604 ± 39				
	•765 ± 49	PRE-KANSAN (?)			Volcanism
		PLIOCENE	Tertiary sediments	quartz and quartzite gravel and sand, coal	Preglacial

•suggested stratigraphic position of dated lava flows

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Figure 14. Composite section of the Teritary and Pleistocene stratigraphy of the Liard Plain, southeastern Yukon. Stage chronology after Fenton (1984).

Table 10. Magnetic remanence of sampled horizons in the Tom Creek silt and Intertill unit B-C in the Allan Creek section

	Horizons	# Specimens	AF demagnetizing field (oersteds)	Inclination (degrees)	Declination (degrees)	Virtual Geomagnetic Pole lat.	Virtual Geomagnetic Pole long.	Moment (emu/cm^3)
Allan Creek Unit 5	10	4	300	66.2	40.3	64.3	329.8	.19E-03
	9	4	100	80.0	260.7	52.5	197.8	.25E-04
	8	4	100	76.0	295.0	62.0	168.0	.47E-05
	7	4	100	61.1	262.5	32.3	169.8	.30E-05
	6	4	100	71.7	326.7	72.4	142.5	.66E-05
	5	4	300	71.9	292.8	56.3	164.7	.42E-05
	4	4	300	65.4	297.8	52.8	148.9	.11E-04
	3	4	100	78.5	338.9	78.2	188.9	.18E-04
	2	4	100	74.0	320.0	70.5	157.2	.99E-05
	1	4	100	71.7	246.5	-	-	.48E-05
Tom Creek Unit 5	6	4	100	67.4	341.5	75.5	104.5	.13E-04
	5	4	100	63.8	338.3	74.6	111.6	.39E-04
	4	4	100	79.8	305.0	66.1	187.1	.11E-04
	3	4	100	74.3	341.5	80.9	150.7	.18E-04
	2	4	100	69.3	355.6	82.2	770.1	.58E-04
	1	4	100	61.2	25.8	66.1	357.7	.73E-04

appears to be stratigraphically higher than the oldest till (Till A) suggests an interval of glaciation of about mid-Pleistocene age or older. The youngest dated basalt records volcanism that occurred about 232 ka, substantially earlier than the Late Wisconsinan glaciation that deposited the surface till (Till A). The radiocarbon dates of greater than 30 ka and about 24 ka from the Tom Creek silt suggest that the interval between the last two glaciations (Till C and Till D) was the mid Wisconsinan. The abundance of grass pollen suggests that the climate of this region was somewhat cooler than that at present and similar to modern arctic and alpine climates.

The extent and flow directions of the Late Wisconsinan glacier in the study area are indicated by the glacial deposits and streamlined landforms that occur over much of the area (Fig. 2). Late Wisconsinan ice covered all of the area with the possible exception of the higher mountainous terrain in the northeastern part (Fig. 2, unit RE). A piedmont glacier that flowed mainly to the southeast across the Liard Plain included distinctive sublobes that diverged to the north and northeast up the valleys of Hyland, Coal, and Rock rivers (Fig. 2). Here, glacial lakes (Fig. 2, unit L) formed and spilled eastward along the ice margin towards the front of the main glacier east of the study area.

The piedmont glacier over the Liard Plain was nourished mainly by ice from the Cassiar and Pelly mountains to the west. South-flowing ice lobes from the Selwyn Mountains to the north probably did not coalesce with the ice lobes that flowed up Hyland, Coal, and Rock river valleys at this time; this is suggested by the occurrence of extensive glaciolacustrine deposits beyond the latter lobes (Fig. 2), although the lakes may have formed later during deglaciation. Part of the Hyland Plateau may in fact have remained ice free throughout Late Wisconsinan time, as the surfaces in this part appear somewhat more dissected and lack the distinct glacial features evident on the terrain to the south (Fig. 2, unit RE). The pre-Wisconsinan(?) surface shown north of the map area on the Glacial Map of Canada (Prest et al., 1967) may extend farther south than shown and may include the part of the Hyland Plateau in the study area.

During deglaciation extensive belts of outwash were deposited southwest of Liard River (Fig. 2) as the glacier retreated upslope towards the northwest. Meltwater was ponded in the main and tributary valleys of Frances, Hyland, Coal, and Rock rivers. During the early stages, spillways drained these lakes eastward across the low mountainous terrain in the east-central part of the study area.

Deglaciation of the Liard Plain was likely complete by 10 ka. Although radiocarbon dates have not been obtained from the surface of the Liard Plain, the intermontane Shakwak Valley in the southwestern Yukon has yielded several surface dates on shells and organic matter ranging from about 10 to 12 ka (Lowdon and Blake Jr., 1973, p. 28).

REFERENCES

Ager, T.A.
1975: Late Quaternary environmental history of the Tanana Valley, Alaska; Ohio State University, Institute of Polar Studies, Report No. 54, 117 p.

Birks, H.J.B.
1973: Modern pollen rain studies in some arctic and alpine environments; in Quaternary Plant Ecology, ed. H.J.B. Birks and R.G. West; Blackwell Scientific Publications, Oxford, p. 143-168.

1977: Modern pollen rain and vegetation of the St. Elias Mountains, Yukon Territory; Canadian Journal of Botany, v. 55, p. 2367-2382.

Birks, H.J.B. (cont.)
1980: Modern pollen assemblages and vegetational history of the moraines of the Klutlan Glacier and its surroundings, Yukon Territory, Canada; Quaternary Research, v. 14, p. 101-129.

Bostock, H.S.
1964: Geology of McQuesten, Yukon Territory; Geological Survey of Canada, Map 1143A.

1970: Physiographic regions of Canada; Geological Survey of Canada, Map 1254A, scale 1:5 000 000.

Bourgeois, J.
1981: Étude palynologique dans la vallée du Grizzly Creek (Yukon); thèse de maîtrise non publiée, Université d'Ottawa, 84 p.

Cwynar, L.C. and Ritchie, J.C.
1980: Arctic steppe-tundra: a Yukon perspective; Science, v. 208, p. 1375-1377.

Dawson, G.M.
1898: Report on an exploration in the Yukon District N.W.T. and adjacent northern portion of British Columbia 1887; Geological Survey of Canada, Publication No. 629.

Denny, C.J.
1952: Late Quaternary geology and frost phenomena along Alaska Highway, northern British Columbia and southeastern Yukon; Geological Society of America Bulletin, v. 63, p. 883-922.

Dyck, W., Lowdon, J.A., Fyles, J.G., and Blake, W. Jr.
1966: Geological Survey of Canada radiocarbon dates V; Geological Survey of Canada, Paper 66-48.

Fenton, M.M.
1984: Quarternary stratigraphy of the Canadian prairies; in Quarternary Stratigraphy of Canada – A Canadian Contribution to IGCP Project 24, ed. R.J. Fulton; Geological Survey of Canada, Paper 84-10, p. 58-68.

Gabrielse, H.
1967: Geology, Watson Lake, Yukon Territory; Geological Survey of Canada, Map 19-1966.

1968: Geology of Jennings River map-area; Geological Survey of Canada, Paper 68-55.

Harington, C.R., Tipper, H.W., and Mott, R.J.
1974: Mammoth from Babine Lake, British Columbia; Canadian Journal of Earth Sciences, v. 11, p. 285-303.

Hughes, O.L., Rampton, V.N., and Rutter, N.W.
1972: Quaternary geology and geomorphology, southern and central Yukon (Northern Canada); International Geological Congress, Field Excursion A11, Guidebook.

Hughes, O.L., Harington, C.R., Janssens, J.A., Matthews, J.V. Jr., Morlan, R.E., Rutter, N.W., and Schweger, C.E.
1981: Upper Pleistocene stratigraphy, paleoecology, and archaeology of the northern interior, eastern Beringia I. Bonnet Plume Basin; Arctic, v. 34, no. 4, p. 329-365.

Klassen, R.W.
1978: A unique stratigraphic record of late-Tertiary-Quaternary events in southeastern Yukon; Canadian Journal of Earth Sciences, v. 15, p. 1884-1886.

1983: Surficial geology, Coal River (west-half) Yukon Territory; Geological Survey of Canada, Map 13-1982, scale 1:250 000.

Klassen, R.W. and Morison, S.R.
1982: Surficial geology, Watson Lake Yukon Territory; Geological Survey of Canada, Map 21-1981, scale 1:250 000.
1983: Surficial geology, Wolf Lake Yukon Territory; Geological Survey of Canada, Map 14-1982, scale 1:250 000.
– Surficial geology, Laberge, Yukon Territory; Geological Survey of Canada, Map 8-1985, 1:250 000 scale. (in press)

Klassen, R.W., Morison, S.R., and Duk-Rodkin, A.
– Surficial geology, Carmacks (east half), Yukon Territory; Geological Survey of Canada, Map 9-1985, scale 1:250 000. (in press)

Lichti-Federovich, S.
1973: Palynology of six sections of late-Quaternary sediments from the Old Crow River, Yukon Territory; Canadian Journal of Botany, v. 51, p. 553-564.
1974: Palynology of two sections of late Quaternary sediments from the Porcupine River, Yukon Territory; Geological Survey of Canada, Paper 74-23, 6 p.

Lichti-Federovich, S. and Ritchie, J.C.
1968: Recent pollen assemblages from the western interior of Canada; Revue of Palaeobotany and Palynology, v. 7, p. 297-344.

Lord, C.S.
1944: Geological reconnaissance along the Alaska Highway between Watson Lake and the Teslin River, Yukon and British Columbia; Geological Survey of Canada, Paper 44-25.

Lowdon, J.A. and Blake, W. Jr.
1973: Geological Survey of Canada radiocarbon dates XIII; Geological Survey of Canada, Paper 73-7.
1981: Geological Survey of Canada radiocarbon dates XXI; Geological Survey of Canada, Paper 81-7.

McConnell, R.G.
1905: Report on the Klondike gold fields; Geological Survey of Canada, Annual Report (New Series) XIV, 1901, Part B.

Mott, R.J.
1969: Palynological studies in central Saskatchewan. Contemporary pollen spectra from surface samples; Geological Survey of Canada, Paper 69-32, 13 p.
1973: Palynological studies in central Saskatchewan. Pollen stratigraphy from lake sediment sequences; Geological Survey of Canada, Paper 72-49, 18 p.

Prest, V.K., Grant, D.R., and Rampton, V.N.
1967: Glacial map of Canada; Geological Survey of Canada, Map 1253A.

Rampton, V.
1971: Late Quaternary vegetational and climatic history of the Snag-Klutlan area, southwestern Yukon Territory, Canada; Geological Society of America Bulletin, v. 82, p. 959-978.

Ritchie, J.C.
1974: Modern pollen assemblages near the arctic tree line, Mackenzie Delta region, Northwest Territories; Canadian Journal of Botany, v. 52, p. 381-396.

Ritchie, J.C. and Lichti-Federovich, S.
1967: Pollen dispersal phenomena in arctic-subarctic Canada; Revue of Palaebotany and Palynology, v. 3, p. 255-266.

Tempelman-Kluit, D.
1980: Evolution of physiography and drainage in southern Yukon; Canadian Journal of Earth Sciences, v. 17, no. 9, p. 1189-1203.

Terasmae, J.
1967: Recent pollen deposition in the northeastern District of Mackenzie (Northwest Territories, Canada); Palaegeography, Palaeoclimatology, Palaeoecology, v. 3, p. 17-27.