QUATERNARY GEOLOGY IN THE SOUTHERN OGILVIE RANGES, YUKON TERRITORY

And

An Investigation of Morphological, Periglacial, Pedological and Botanical Criteria for Possible Use in the Chronology of Morainal Sequences.

by

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ABSTRACT

Five periods of ice advance in the North Klondike-upper Blackstone basins of the Ogilvie Mountains are recognized by the downvalley sequence of progressively older moraines. The youngest occurred during the last millennium and is represented by glacierets and fresh moraines. The other advances are of the Pleistocene Epoch; from youngest to oldest they are: Age I (valley glacier stage), Age II (transection glacier), Age IIA (transection glacier with piedmont) and Age III (mountain ice cap). Evidence for Age III is limited to the north slope of the ranges. Age IIA was recognized only on the north slope and may represent a slightly older pulse of the Age II. This chronosequence is tentatively correlated with those elsewhere in the northern Cordillera.

Within the region an array of surficial elements indicates that a continuous and discontinuous mosaic of processes have operated interdependently during the Quaternary. A product of these processes is mapped under one of eight facies - attention being directed to the varieties of features associated with the glacial and periglacial cycles. Of the latter, active, inactive and degradational forms exist. Strong correlations between the distribution of some types of surficial features and the underlying bedrock geology are recognized.

No changes in morphology, permafrost distribution, pebble weathering, pedogenesis and floral succession could be related to the ages of the Pleistocene moraines. The influence of permafrost on all ages of moraines, the variability in their environment of deposition, and an edaphic and climatic discontinuity produce greater differences than does the age factor. In the northern half of the study area, permafrost and associated phenomena were observed to greatly retard chemical alteration; on the other hand, they permit the development of only a vegetational and pedological "polyclimax", rather than a single mesic climax, in a time span of less than 11,000-15,000 years.

Frontispiece:

Chapman Lake Moraine of Age II (midground) and Blackstone valley from "Pilot Peak". "Kit Range", Taiga Valley and Central Ogilvie Ranges are in respectively the left, central and right background. Chapman Lake (left) has been developed by thermokarst cave-in activity and with resultant coalescense of many smaller basins. Note the swell and swale type of relief on the moraine and compare to Plate XXII.

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QUATERNARY GEOLOGY IN THE SOUTHERN OGILVIE RANGES, YUKON TERRITORY

And

An Investigation of Morphological, Periglacial, Pedological and Botanical Criteria for Possible Use in the Chronology of Morainal Sequences.

Foreword

This research provided the opportunity of studying the sequence and extent of multiple glaciation and the subsequent changes in landscape on both the north and south slope of a subarctic mountain range located in the Cordillera. The area of study encloses about 3,500 km^2. Because of the magnitude the reader of this thesis, or parts thereof, must have a geographical awareness from the outset. After grasping the broad regional physiographic relationships (Figs. 1, 2 and 5) it is desirable to memorize the geographic positions of major valleys and principal moraines (incl. their abbrev. names and relative ages) as given on Figure 4. In order to facilitate rapid geographical positioning of an event or feature under discussion a number of "ranges" within the map-area have been defined (pp. 6-7, c.f. Figs. 3 and 13).

INTRODUCTION

BACKGROUND, PURPOSE, SCOPE AND ORGANIZATION

Reconnaissance studies in glacial geology in the northern Cordillera at the turn of the century are summarized by Capp's (1932) publication on the glaciation of Alaska. Bostock (1936) was the first to detect evidence of multiple glaciation in Yukon Territory, and Péwé et al. (1953) made the first attempts to correlate multiple morainal sequences, mainly in Alaska. Other Quaternary investigations are summarized in Taber's (1943) monumental work. Since 1953 many detailed glacial and periglacial studies have been carried out in Alaska. However, in the Yukon Territory progress in Quaternary research before 1959 had been slow and sporadic; since then, several surveys have been undertaken by the Geological Survey of Canada. One such project, "Operation Ogilvie", involved mapping a two- to three-fold sequence of Pleistocene moraines as well as other Quaternary features within the Ogilvie and Wernecke Mountains.

In the Ogilvie project, moraines of the "youngest" (Late Wisconsin) and "intermediate" glaciations were noted, respectively, at North Fork Pass and nearby Chapman Lake 80 to 120 km northeast of Dawson (Fig. 1 and Spot Nos. 6 and 8 on Fig. 2). Dr. O. L. Hughes examined both of these morainal areas in an attempt to establish reliable characteristics that would permit correlations with moraines elsewhere. Morphological and spatial criteria were established and applied to the moraines mapped by Mr. P. Vernon elsewhere in the Ogilvie Mountains (Vernon and Hughes, 1966).

Additional detailed studies were undertaken by the writer in the North Fork Pass and Chapman Lake areas in 1964. These studies were to be used in "establishing the moraines as type localities for local nomenclature for the recognized glaciations" within the Ogilvie Mountains (pers. comm., Dr. O. L. Hughes), and to work out criteria for correlation - namely: permafrost, topography, pedology and successional vegetation.

The field season was to begin on May 26, 1964 but was delayed due to the lateness of winter in the northern Cordillera and to subsequent washouts on the access road - the Dempster Highway. With this turn of events the original project appeared to be doomed, for repairs to the road were not scheduled to be completed until the late summer. Hence, in June, 1964 detailed mapping of the lower North Klondike River region was undertaken as an alternative project. The plan was to carry the mapping northward along the Dempster Highway as it was gradually repaired. Unexpectedly, the road was quickly opened to as far

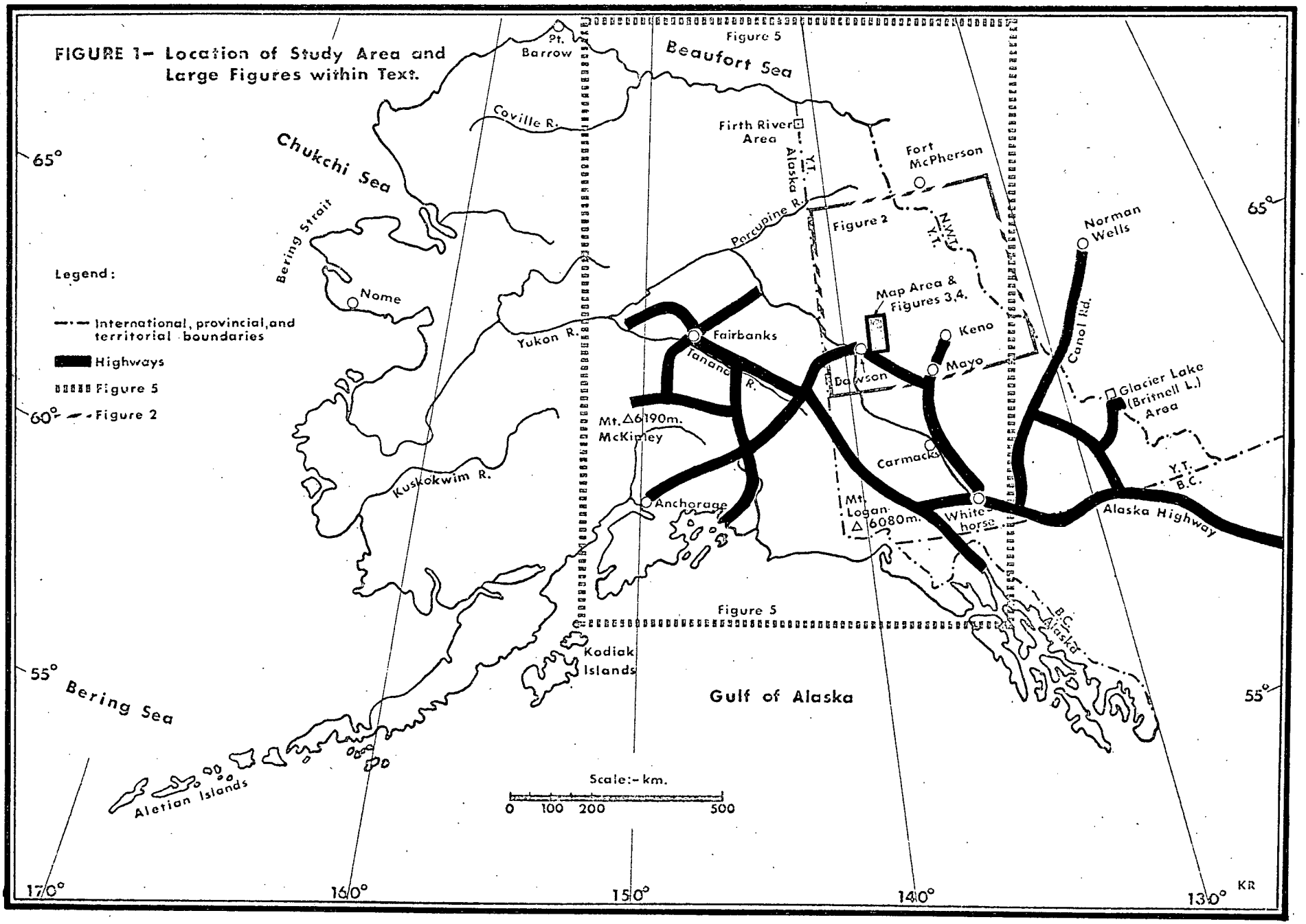
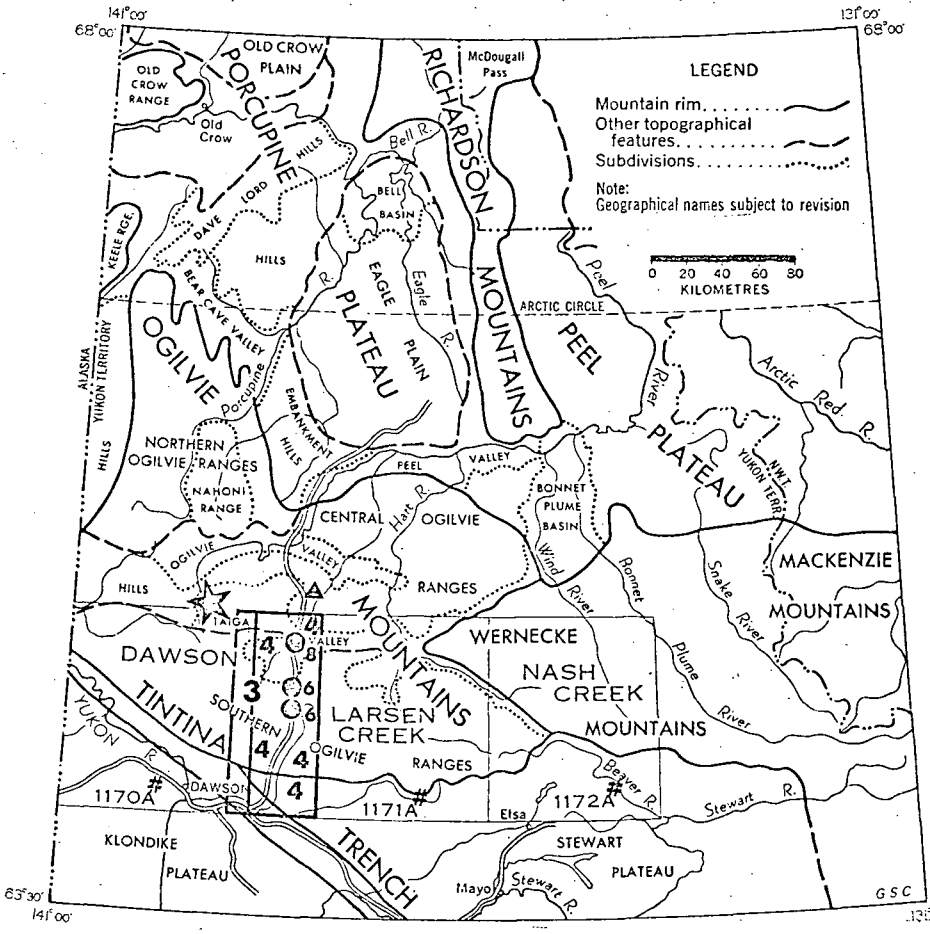


FIGURE 1- Location of Study Area and Large Figures within Text.
Legend:
International, provincial, and territorial boundaries
Highways
Figure 5
Figure 2
Pt. Barrow
Beaufort Sea
Figure 5
Coville R.
Chukchi Sea
Firth River Area
Alaska
Y.T.
Fort McPherson
Porcupine R.
Figure 2
N.W.T.
Y.T.
Norman Wells
65°
Bering Strait
Nome
Map Area & Figures 3,4.
Keno
Canol Rd.
Yukon R.
Fairbanks
Tanana R.
Dawson
Mayo
Glacier Lake (Britnell L.) Area
Mt. Δ6190m. McKinley
Carmacks
Y.T.
B.C.
Kuskokwim R.
Anchorage
Mt. Logan Δ6080m.
White-horse
Alaska Highway
B.C.
Alaska
Figure 5
Kodiak Islands
Gulf of Alaska
55°
Bering Sea
Aletian Islands
Scale:- km.
0 100 200 500
170°
160°
150°
140°
130°
60°
KR

FIGURE 2—Physiography of the Central Yukon Territory.



adapted from Bostock (1961); Vernon & Hughes (1966).

#	These numbers refer to map references in Vernon & Hughes (1966).
★	Region of triple moraine sequence depicted by Plate III in Vernon & Hughes (1966, p.8)
▲	Suspected lateral moraines of Age III in this region
3	Area enveloped by Figure 3 of this report
4	Area enveloped by Figure 4 and 1:50,000 Quaternary geology map accompanying this report
⊙6	Location of 1:37,500 scale Figures 6A, 6B and 7 of this report
⊙8	Location of 1:37,500 scale Figure 8 of this report

north as North Fork Pass by the end of the third week of June, so that the "young" moraines became accessible for the original planned study. Gambling that road repairs northward would continue at the same excellent rate, the writer curtailed the lower North Klondike work and moved to the pass for concentrated study. Fortunately, the Socony-Mobil Oil Company winter camp was north of the remaining washouts and arrangements were made with its maintenance man for periodical transportation to the "intermediate" aged moraine at Chapman Lake. Near the end of July the road repairs were completed and the remainder of the wet summer (until Sept. 5) was devoted primarily to detailed investigations on the moraine about Chapman Lake. On an intermittent basis during the summer, the lower North Klondike surficial work was gradually extended along the Dempster Highway to as far north as the Chapman Lake region.

During the course of the summer the emphasis of the project changed somewhat. The detailed permafrost study was dropped owing to the unexpected presence of a shallow permafrost table on some of the "youngest" Pleistocene moraines and the apparent absence of a shallow table on portions of the "oldest" moraine. Analyses of pebble weathering were substituted, and it was decided that the road side surficial survey should be plotted on a 1:50,000 scale map. Thus, detailed investigations on the moraines were reduced from the original intention and mapping received greater attention than anticipated as outlined by Hughes (1965). Time allotments to the various phases of the project in the 80 day field season amounted to: surficial geology - 30%, botany - 25%, instrumented land survey - 20%, pedology - 15%, and logistics - 10%.

The Geological Survey of Canada supported the field work and carried out many of the laboratory analyses. Much of the remaining analysis and office work lacked an adequate operating fund. The Geological Survey of Canada, Arctic Institute of North America, Yukon Territorial Government and a commercial air photo interpretation firm were sympathetic but were unable to provide financial support. Initial laboratory and plotting tasks were conducted during winter session course work of 1964-65. From May, 1965 till September, 1965 the botanical phase of the project was examined while the writer was employed on a half time basis for an oceanographic project. After a 13 month interlude to regain financial composure, the writer in November, 1966 received a modest U.B.C. Graduate Student Fellowship with summer extension, to continue the studies until the close of the summer of 1967. All told the laboratory and office work amounted to 17-18 months. Even so, the scope of the original plan had to be curtailed: the final pedo-

logical analysis was left in the hands of Mr. H. Hortie of the Dominion Soil Survey and the arithmetical analyses of the morainal profile survey were cancelled.

BEDROCK GEOLOGY, TOPOGRAPHY AND DRAINAGE

Introduction

The Ogilvie Mountains lie within the Northern Plateau and Mountain Area of the Interior System of the Canadian Cordillera (Bostock, 1948 and 1961). The study area transects the Southern Ogilvie Ranges and Taiga Valley portions of the Ogilvie Mountains (Fig. 2). It includes small portions of the Central Ogilvie Ranges to the north and the Tintina Valley, Klondike Plateau and Stewart Plateau units of the Yukon Plateau to the south.

Geological investigations in these regions have been surprisingly numerous. Most older investigations have been summarized by Green and Roddick (1962). The first extensive survey was undertaken by the Yukon Consolidated Gold Company in 1958 (Crawford, 1959), and in 1961 "Operation Ogilvie" by the Geological Survey of Canada included the mapping of the regions shown in Figure 2 (Green and Roddick, 1962). Detailed studies include Hyndman's (1959) analysis of a skarn zone on the north margin of the Tombstone Stock, Lambert's (1966) study on the petrogenesis of the adjacent Mt. Brenner Stock and Tempelman-Kluit's (1966) analysis of the structure and petrography of the Tombstone and adjacent North Klondike regions (Fig. 3). The last excellent effort, coupled with Green and Roddick's survey, are the sources of the geological map (Fig. 3) and the table of rock units (Table I) used for provenance and other studies in this report.

Klondike Plateau

The plateau is underlain by the highly metamorphosed Nasina and Klondike series of gneisses and schists (Units A and C on Fig. 3) with numerous intrusions of intermediate and ultrabasic bodies. The region consists of an anastomosing series of rounded, heavily-forested ridges and domes displaying classic youthful stage of drainage development. Narrow V-shaped valleys have created a relief of 900 metres. Monadnocks are reported on the plateau by Bostock (1948), but the domes in question do not as yet satisfy the criterion of Strahler's (1952) hypsometric integral equation. Glaciation within the region has not been recognized. The Klondike Plateau is the location of the

TABLE I LEGEND FOR BEDROCK GEOLOGY SKETCH MAP (FIGURE 3)[1]

Geologic Age	Green and Roddick Unit	Templeman-Kluit Unit	Colour Code	PREDOMINANT ROCK TYPES WITHIN UNIT*
PLEIST-REC.	XXV	-		UNCONSOLIDATED GLACIAL AND ALLUVIAL DEPOSITS.
TERTIARY	XXIV	-		ANDESITE; BASALT; SANDSTONE; CONGLOMERATE; AND MINOR SHALE.
U.CRET.-TERT.	XXIIA	-		POORLY CONSOLIDATED BROWN, ARKOSIC AND MICA SANDSTONE; CONGLOMERATE; LIGNITE; SHALE.
M.CRET.	XXIB	18		MONZONITE (± QUARTZ AND PORPHYRITIC); SYENITE; DIORITE; AND MINOR PYROXENITE, PHONOLITE, TRACHYTE, LATITE AND GRANITE.
M.CRET.?	-	17		PORPHYRITIC HORNBLENDE DIORITE DYKES.
LATE.L.CRET.	XX	16		THOLEITIC DIABASE (DOLERITE); GABBRO.
L.CRET.	XIXB	15		LIME-CEMENTED BROWN QUARTZ SILTSTONE; GREY SHALE.
L.CRET.	XIXA	14		PALE GREEN, BRIGHT RED, PHYLLITIC AND CHERTY SLATES.
L.CRET.	XVII	13		SUBMATURE, MASSIVE, BLUE TO GREY ORTHOQUARTZITE; BLACK AND PHYLLITIC SLATE; MINOR BROWNISH SILTSTONE .
	XVII	....	....	LIME CEMENTED QUARTZ SANDSTONE MEMBER OF UNIT 13.
M-U.JURAS.	XIV	12		BLACK GRAPHITIC SLATE AND PHYLLITIC SLATE; AND MINOR BROWN SILTSTONE.
M-U.JURAS.	XIV	11		BLACK GRAPHITIC SLATE AND PHYLLITIC SLATE; FELDSPATHIC SUBGREYWACKE.
TRIASSIC	XIV	10		FETID SHALY LIMESTONES.
TRIASSIC	XIV	9		DARK GREY SILTSTONE; FETID SHALY LIMESTONES.
CARB.-M.PERM.	XV	8		DARK GREY LIMESTONES; CHERT CONGLOMERATE; CHERT; AND MINOR SHALE.
M.DEV.-CARB.	XIII	-		BLACK ARGILLACEOUS SHALE, SLATE AND PLATY LIMESTONE; CHERT; CHERT PEBBLE CONGLOMERATE; QUARTZITE.
L.ORD.-U.SIL.	IX	6, 7		BLACK, GREEN, GREY CHERT, ARGILLITE, SHALE; MINOR BLACK LIMESTONE AND CHERT.
?-U.SIL.	VIII	-		GREY WEATHERING DOLOMITE AND LIMESTONE.
? ?-ORD?	IV	5		DARK BROWN TO GREEN TO LIGHT GREY BASALT (± CARBONATE IN VESSICLES); BRECCIA; TUFF; AGGLOMERATE; MINOR CHERT, SHALE, SILTSTONE AND LIMESTONE.
PC-??	III	4		MAROON AND GREEN SHALE; SLATE; MINOR LIMESTONE, BLACK CHERT; AND QUARTZ PEBBLE CONGL.
PC-??	III	3		FELDSPATHIC, LIMY, SUBMATURE ORTHOQUARTZITE; MINOR SILTSTONE AND SHALE.
PC-??	III	2		DARK GREY LIMESTONE-SILICIFIED AND DOLOMITIZED.
PC	III	1		BUFF BROWN TO RUSTY WEATHERING GRITS; FELDSPATHIC SUB GREYWACKE CONGLOMERATE; GREEN SLATE.
PC	II UNDIFF.	-		ORANGE PLATY DOLOMITE; DARK SLATES; MINOR PHYLLITE AND QUARTZITE.
	IIC	-		MASSIVE CHERTY, QUARTZOSE AND GREY DOLOMITE.
	IID	-		ORANGE WEATHERING DOLOMITE; BLACK SHALE; MAROON QUARTZITE; GREENSTONE.
	IIE	-		DARK GREY, THINLY-LAMINATED, DOLOMITE; MINOR CHERT.
PC	I	-		DARK WEATHERING SLATE AND ARGILLITE.

OTHER SYMBOLS: GEOLOGICAL BOUNDARY; RIVERS AND LARGE CREEKS, LAKE; MAIN HIGHWAYS; AERIAL COVERAGE OF TEMPELMAN-KLUIT'S (1966) MAPPING; AERIAL COVERAGE BY LAMBERT (1966).

[1] SKETCH MAP IS A COMPILATION OF GREEN AND RODDICK'S (1962) DAWSON SHEET, TEMPLEMAN-KLUIT'S (1966) TOMBSTONE SHEET, AND LAMBERT'S (1966) MT. BRENNER SHEET.

* MOST DOMINANT ROCK TYPE IS LISTED FIRST IN ANY ONE UNIT.

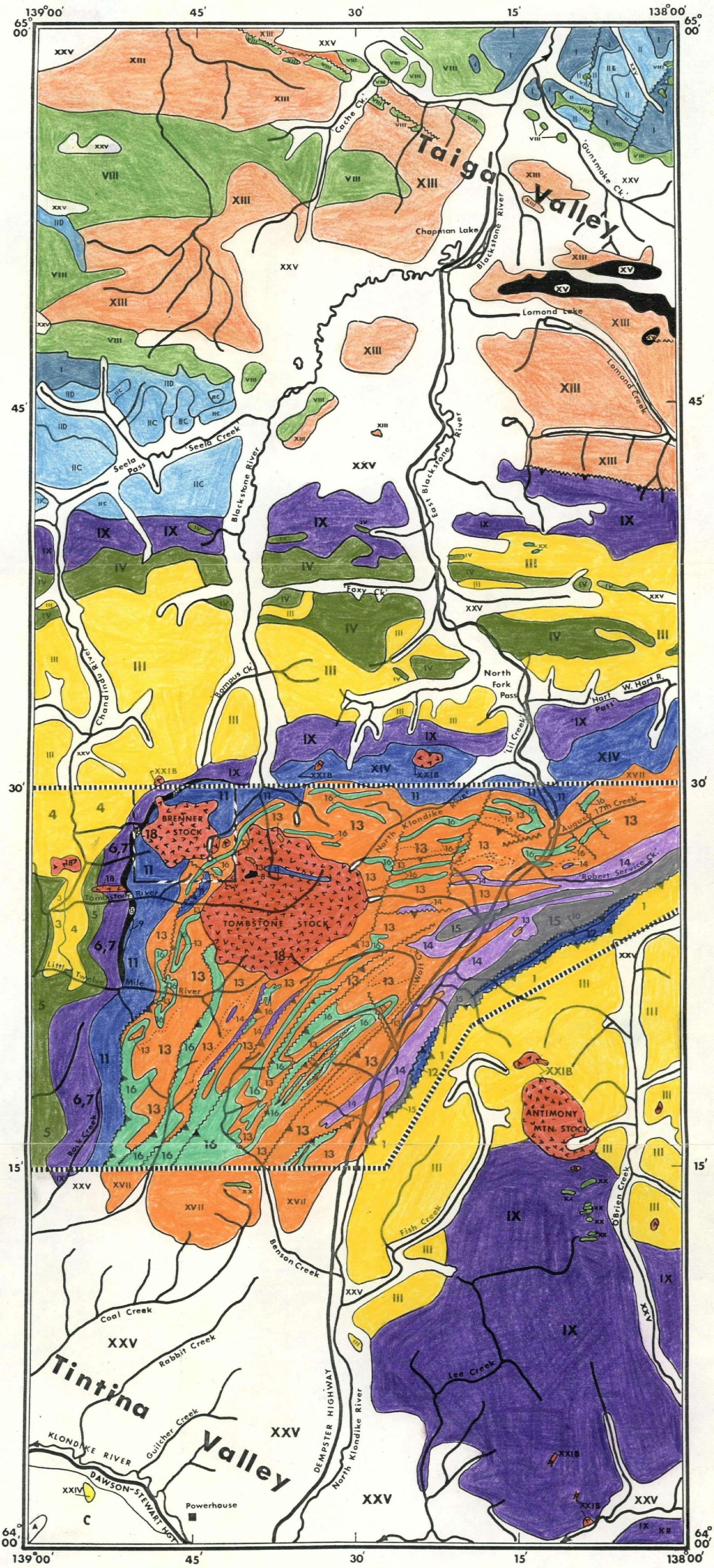


FIGURE 3

Sketch Map of the Bedrock Geology in the Upper Blackstone, O'Brien, Chandindu and North Klondike Drainage Basins of the Southern Ogilvie Ranges, Yukon Territory.

Scale - 1:253,440

Kilometres

6 0 6 12 18

1898 gold rush. To-day profitable placer mining is carried on by enterprising and well-equipped small operators. The local mining record, geology and geomorphic history have been examined and summarized by McConnell (1905), Tyrrell (1917) and Bostock (1948, 1957).

Tintina Valley

The valley represents a transcurrent fault zone 1000 km long and 15 to 20 km wide that is partially filled by Upper Eocene continental clastic and plant bearing sediments (Units XXIIA and XXIV - Table I). Dextral movement was computed to be 300 kilometres by Tempelman-Kluit (1966); he also suggests evidence for a vertical component of a few thousand metres within the fault system. The North Klondike River transects the northwest-trending structural alignment of the valley and has created a local relief of about 300 metres. Drainage within the trench is locally deranged - a condition brought about by the deposition of unconsolidated materials and by the slumpage of Tertiary sediments. Portions of the Tintina Valley have been glaciated during four distinct episodes (Bostock, 1966), but locally only one ice advance is readily conspicuous. The physiography, geology and glacial geology of the valley have been summarized by Blusson (1959) and Bostock (1948).

Stewart Plateau

This surface is a portion of the Yukon Plateau which according to Bostock (1961) might transect the map-area↓. In the study area the feature tends to be a transitional zone between Tintina Valley and the Southern Ogilvie Ranges; hence, the boundaries are rather arbitrary. To the east of the lower North Klondike valley the feature is underlain by south dipping lower Paleozoic fine grained clastics. However, most of the plateau is lithologically similar to the Klondike Plateau. The feature is drained by the (South) Klondike River within the map-area. Since there is a transitional character to the feature locally, the relief varies from 300 m in a high bench or a table to 850 m or higher in a set of hills with fine texture topography. The latter figure is dependent on the arbitrary boundary between the plateau and the ranges to the north. Portions of the Stewart Plateau have been blanketed by ice from four

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↓ In his 1948 publication the Stewart Plateau lies to the east of the map-area. The writer prefers this earlier interpretation rather than the revision as shown on Figure 2.

distinct glacial episodes (Bostock, 1966). Locally ice just reached the surface during the next to the last advance and did not reach it at all during a subsequent ice advance. Bostock (1948) summarizes the variability of the complex physiographic unit.

Southern Ogilvie Ranges

The Southern Ogilvie Ranges rise as a distinct fault-line scarp to the northeast of the Tintina Valley (Plate IA). The ranges are underlain by a complexly folded and faulted Precambrian to Cretaceous succession of layered volcanics, clastic sediments and prominent dolerite sill that are locally intruded by a series of acidic stocks; the lithology changes to a series of carbonate sediments on the north margins (Fig. 3). The overall structural trends vary from north to northeast on the south slope to east-west on the north slope of the ranges.

The youthful to early mature drainage within the ranges varries from a dendritic to an angulate variety of the rectangular pattern, but is modified to a radial pattern in the vicinity of the plutonic stocks. Principal streams draining the south slope are the Chandindu to the west, the North Klondike in the central region and the O'Brien to the east (Fig. 3). All are subparallel to the structural grain and all are part of the Yukon River system. The "main" and East Blackstone Rivers drain most of the north slope by transecting the structural trends. On the east and west margins of the map area the north slope is drained respectively by the Lomond Creek tributary of the West Hart and the unnamed south tributary of the Ogilvie rivers - the former however, is parallel to the structural trend. All rivers on the north side are a part of the Mackenzie drainage system. The North Klondike, East Blackstone, "upper main" Blackstone and "main" Blackstone (below the junction of the former two) have fairly uniform gradients averaging 8.5, 6.0, 4.2 and 6.9 metres per kilometre.

Summits are generally rugged and are connected by long branching ridges displaying either sharp arêtes or rounded crests. According to Cockfield (1920) the accordance of summits and ridges, at about 2050 m (above mean sea level = m.s.l.) in the central region dipping to about 1700 m (m.s.l.) at the margin of the ranges, is not a result of planation. The average and maximum relief are respectively about 900 and 1800 metres. The highest peak, "Mt. Frank Ray", reaches 2360 m (m.s.l.).

The Southern Ogilvies are a collection of several topographically and geologically distinct ranges; in order to generate any sort of discussion on

the glaciations within the region, the writer, like Tempelman-Kluit (1966), has found the need to define the following subdivisions as shown in Figures 13, 14 or 15.

"Tombstone Range" - Tempelman-Kluit (1966) uses this term to include all the terrain enclosed by Tintina Valley, North Klondike River, Chandindu River and Tombstone River in this range. This designation is cumbersome; it associates two topographically distinct areas, and disrupts the original prospector's terminology of the "Tombstone country" (Plate IB). Hence the writer has applied the name to the northern portion only of the above region. Thus the range is an east-west belt consisting of the southern portion of the rugged Tombstone Stock, and the smooth crested areas of the Northeastern structural division and northern portion of the Little Twelve Mile structural division (Tempelman-Kluit, 1966). South of the Little Twelve Mile River - "Wolf Creek" boundary (Fig. 3) the region is referred to as the "North Klondike Range" (Plate IIA); it is composed of a series of imbricate thrust sheets of quartzite (Unit XVII) and gabbroic sill termed the Wolf Creek Thrust, the Spotted Fawn Thrust and southern portion of the Little Twelve Mile structural subdivisions by Tempelman-Kluit (1966). The area is characterized by a series of west facing escarpments.

"Snowy Range" and "Prospector Range" - Tempelman-Kluit (1966) has proposed that these two groups be lumped together as the "Robert Service Range", but they are rather distinct entities. The "Snowy Range" is underlain by acidic stocks and the North Fork Thrust plates of Precambrian sediments whereas the "Prospector Range" is made up of the Northeastern division of younger sediments. The "Snowy Range" is bounded by its pronounced escarpment above the North Klondike River (Plate IIB) and "Robert Service Creek" - other boundaries include the Stewart Plateau and O'Brien Creek. The "Prospector Range" is defined as the area enclosed by "Robert Service Creek", North Klondike River, "Lil Creek" and the tributaries and upper reaches of both the West Hart and O'Brien systems (Plate IIIA).

"O'Brien Range" - This massif is enclosed by O'Brien Creek, Hamilton Creek, and the (South) Klondike River. The geology is similar to that of "Snowy Range".

"Cloudy Range" - This is an appropriately named structural division in Tempelman-Kluit's (1966) analysis. The region lies north of the Tombstone-upper North Klondike River through valley and includes all terrain encompassed by the Mt. Brenner Stock, northern one half of the Tombstone Stock and the region, including "Mt. Frank Ray", of the east-west trending sediments with

minor intrusives to the south of the upper East Blackstone River (Plate IIIB).

"Seela Range" - This range lies between the Upper Blackstone River, its "Bompus Creek" tributary, and the upper Chandindu River (Plate IVA). Its boundary to the north is Seela Pass, and to the south it is the rugged Mt. Brenner Stock. The region is composed of south dipping Paleozoic and older sediments.

"Rangifer Range" - Geologically similar to the "Seela Range", this region is encompassed by the main and East Blackstone River valleys (Plate IVA).

"Agglomerate Range" - This region (Plate IVB) is an east-west trending thrust plate of Precambrian-Lower Paleozoic sediments that overlie Upper Paleozoic Sediments just south of Lomond Creek. Hence, the boundaries are the East Blackstone River, North Fork Pass, "Hart Pass", and West Hart River with its Lomond and "Lateral Creek" tributaries.

"Patrol Range" - This vaguely defined feature is made up of the open to complex folds of the Tindir Group of sediments (Units I and II). It is enclosed by the region north of Seela Pass, east of the narrow through valley connection of the Chandindu-Monster Creek-Ogilvie River (south fork), and west and south of Taiga Valley (Plate VA).

"Kit Range" - This low white crested set of hills protrudes eastward into Taiga Valley in the region east of Kit Lake and northwest of Chapman Lake. The range is the crest of an anticline of Lower Paleozoic carbonates.

"Nehru Range" - This massif marks the south boundary of Taiga Valley to the east of Chapman Lake. It is bounded by the Lomond Creek, West Hart River, Michelle Creek, and the "Gunsmoke Creek" and "Pilot Creek" tributaries of the Blackstone River. The range represents a synclinal-anticlinal pair in Upper Paleozoic limestones (Plate VB).

Taiga Valley

This valley (Plate VIA) is an irregular east-west trending feature located on a belt of easily eroded shales of Upper Paleozoic age. The feature is transected by the Blackstone River. Locally, to the west of the river, the "Cache Creek" tributary is of a decidedly rectangular drainage pattern whereas the "Gunsmoke" tributary to the east is of a dendritic system. The valley is 220 km long and is quite irregular in shape; at one locality it broadens into the Blackstone Valley as an enclave 30 km wide (Fig. 2). The valley exhibits an undulatory relief that is locally as high as 450 m. At

Plate IA

Southern Ogilvie Ranges (background), Stewart Plateau and Tintina Valley (foreground) from Dawson-Stewart Highway.

Plate IB

"Tombstone Range" and upper North Klondike valley from the Dempster Highway. Tombstone Mtn. is on right background. Note the river icing in left midground.

Plate IIA

Glaciated midreaches of the North Klondike valley with "North Klondike Range" on the left and "Snowy Range" on the right.

Plate IIB

Glaciated "August 17th Creek" (foreground), "Prospector Range" (midground), "Snowy Range" (right central background) and "O'Brien Range" (left background) from "Mt. Robert Henderson".

Plate IIIA

"Prospector Range" (background) with "Mt. Robert Henderson" (left central skyline) from "Agglomerate Range" near North Fork Pass. Note the solifluction lobes on slopes in midground.

Plate IIIB

Glaciated "Rangifer Valley", "Alces Lake" (central foreground), and "Cloudy Range" from "Dall Sheep Mountain". Note faceted spurs on left wall of the main valley. East Blackstone River meanders from left to right and out of the picture.

Plate IVA

"Blackstone Mtn." of the "Rangifer Range" (left skyline), "Seela Range" (right skyline), and East Blackstone valley (foreground) from "Pilot Pk". Note "Henry Creek" fan (f), lake-pocked Age II lateral moraine (lm) and upper limit of Age II glaciation (arrow).

Plate IVB

"Agglomerate Range" and "Hart Pass" region from "Access Ridge" of "Prospector Range".

Plate VA

"Patrol Range", "Fitzgerald Ridge" (midground) and meanders of the "main" Blackstone valley to the west from "Pilot Peak". Note pingo (solid arrow) and thermokarst lake shores (dashed arrow) in valley.

Plate VB

"Nehru Range" from the Chapman Lake Moraine. "Pilot Peak" is on the right.

Plate VIA

Central Ogilvie Ranges, Taiga Valley and "Nehru Range" (right) to the northeast from "Pilot Peak". Note solifluction lobes in foreground.

Plate VIB

Central Ogilvie Ranges transected by the Blackstone valley. Note Chapman Lake Moraine (left), once glacier diverted stream channel (centre), and modified faceted spurs in Blackstone valley, and "Panorama Ridge" site of the oldest known erratics.

least two older glaciations extended from the ranges into this valley during the Pleistocene; the Chapman Lake area lies here.

Central Ogilvie Ranges

The central ranges consist of a concentrically folded sequence of Precambrian and Lower Paleozoic sequence of carbonates and fine grained clastics (Tindir Group, and younger). The ranges are transected by the slightly U-shaped Blackstone River valley, and are easily distinguished by their smooth, white and rounded ridge-tops (Plate VIB). The relief varies from 600 to 700 m and the summit elevations average 1600 m. This region has been involved in at least three glacial episodes though in each case it was less intense than those within the Southern Ogilvie Ranges.

REGIONAL CLIMATE

Weather records are not available from the study area. The nearest complete record has been taken at Dawson (el. 323.8 m m.s.l.). Its' climatic averages are shown in Table II. Parameters of significant interest are the (-) 4.8°C mean annual temperature, the exceedingly cold winter months, and the relatively high summer precipitation. The temperature record for Mayo (el. 415.0 m m.s.l; 185 km to the ESE) is about 1.5°C warmer than Dawson (on a mean annual basis) according to Kendrew and Kerr (1955). The climate approximates "Dfc" in the Köppen system (Strahler, 1965), but it does not conform precisely because of the dryness of the four winter months. The climate is termed "Continental" by Péwé (1965b) and is designated a "highly continental boreal climate" on Troll's (1965) more precise map.

The southern portion of the map-area is similar to Dawson. Northward, however, precipitation increases to a maximum near North Fork Pass - where summers are much cloudier and somewhat cooler than at Dawson; during the summer of 1964 there were 66 consecutive days of precipitation, and snow fell occasionally in every month. Three-day storms were interrupted by days with only brief late afternoon showers. Winter temperatures are probably warmer than at Dawson. However, due to the summer coolness the pass area may be more appropriately rated as "ET" in the Köppen system (Appendix IVC). The Blackstone drainage basin is probably cooler in the winter than that in North Klondike Valley and at North Fork Pass, but since it is on the open and distant north slope of the ranges it appears to have less cloud cover, less precipitation and slightly warmer summer temperatures. The climate north of

TABLE II Summary of climatic data for the city of Dawson, Y.T.[1]

MONTH	TEMPERATURE (°C.)			PRECIPITATION (mm.)		
	Mean Max.	Mean Min.	Mean	Rain	Snow[2]	Total
January	-23.6	-31.4	-27.6	0	20.6	20.6
February	-19.2	-28.4	-23.9	0	14.0	14.0
March	- 7.7	-21.6	-14.6	0.3	12.9	13.2
April	+ 5.7	- 8.6	- 1.3	2.3	5.1	7.4
May	+15.0	+ 1.1	+ 8.1	24.1	0.5	24.6
June	+21.2	+ 6.5	+13.8	32.5	0	32.5
July	+23.5	+ 8.6	+15.5	50.6	0	50.6
August	+18.8	+ 6.2	+12.6	49.3	0	49.3
September	+11.6	+ 1.1	+ 6.3	28.9	2.1	31.0
October	+ 0.4	- 6.7	- 3.1	7.6	20.1	27.7
November	-13.3	-18.7	-17.2	0.1	26.6	26.7
December	-21.7	-28.4	-25.0	0.5	23.6	24.1
			TOTALS	196.2	125.5	321.7
Annual	+ 0.8	-10.1	- 4.8			

Highest Recorded Temp. = +37.2

Lowest Recorded Temp. = -58.3

January Mean Wind Chill Factor = 1210 kg. cal./sq.m./hr.*

Mean Annual Degree (°C) Days of Freezing (Péwé, 1965b) = ca.3000

1 Data taken from averages posted on public notice board in the Dept. of Transport office at Dawson. The data represents the period of 1901 to 1963.

2 Snowfall would be 10 times the water equivalent figures given in this column.

* Figure is from Thomas (1961). Some of the temperature data is also given in his publication.

the pass may be approximated more accurately by Troll's (1965) designated "subarctic tundra climate". Despite the study area's being three degrees of latitude south of the accepted position of the Nordenskiold Line, the temperature regime north of the pass might be very similar to that which defines the line (Hare, 1951).

The study area lies within the zone of discontinuous permafrost (Péwé, 1955b and 1966; Brown, 1960 and 1967; and Legget et al, 1961). Tyrrell (1917) and Brown (1967) report permafrost thicknesses as great as 60 m in the valley bottoms near Dawson to the southwest, but today's placer operators are more inclined to quote figures of 20 to 30 m. On the other hand, McTaggart (1960) reports as much as 130 m in the Mayo-Elsa region to the east (Fig. 2). However, nearly all of these figures are from well shaded valley bottoms; in open regions or on the south facing slopes of Tintina Valley and the Southern Ogilvie Ranges permafrost may be absent (Vernon and Hughes, 1966). Péwé (1957) indicates the absence of permafrost in the vicinity of large streams and rivers in the climatically-similar Fairbanks region.

Within the study area permafrost as detected by a soil-ice table at shallow depths was observed in the North Klondike valley only at moss-insulated localities. North of the North Fork Pass permafrost could be found in valley bottoms at depths of less than 1 m on surfaces other than steep south-facing slopes, gravel hummocks, active flood plains and crests of hills or ridges. In some of these less favourable environments permafrost is shown to be present at greater depths by severe slump and collapse features on the floors of borrow pits. Such features are not found in borrow pits to the south of the pass; hence, permafrost in the soil-ice condition may be totally absent in many places within this region. Slightly more elevated valley floors and local physiographic peculiarities may account for the colder temperature regime responsible for the nearly ubiquitous presence of permafrost northward from North Fork Pass.

GLACIAL GEOLOGY

Previous Quaternary Work in the Ogilvie Mountains

McConnell (1905) in 1901 recognized Pleistocene glaciation in the Ogilvies while mapping the Flat Creek Beds, an outwash, located a few kilometres south of the present study area. Shortly afterwards Camsell (1906), in what is probably the first hint in the Yukon Territory of multiple glaciation, noted a succession of moraines in the Braine Creek valley of the

FIGURE 4 – Location of Moraines, Sample Sites, Sections, Detailed Map Figures, and Aerial Photo Plates.

Scale — 1:253,440

LEGEND

CENOZOIC

PLEISTOCENE AND RECENT

3 *FLUVIATILE DEPOSITS: silt, sand, and gravel*
- **3a**, *silt, sand, and gravel of terraces*
- **3b**, *silt, sand, and gravel of modern flood plains*
- **3c**, *silt, sand, and gravel of alluvial fans*
- **3d**, *silt, clay of fluvial or glaciolacustine orgin, with thermokarst depressions*

2 *GLACIO-FLUVIAL DEPOSITS: sand, gravel, minor silt*
- **2a**, *terrace and pitted-terrace, kame terrace and outwash delta deposits (see also pit and delta symbols)*
- **2b**, *hummocky or ridged deposits*
- **2c**, *esker complex deposits*

1 *GLACIAL DEPOSITS: till, minor sand, and gravel*
- **1a**, *terminal and recessional moraine deposits*
- **1b**, *ground moraine*
- **1c**, *dead ice deposits (with hummocky or knob-and-kettle form)*

Geological boundary (approximate, gradational)
Glacial striae
Drumlin or drumlinoid ridge
Direction of ice flow – last glaciation
– intermediate glaciation
Cirques-containing active ice in last glaciation
-containing active ice in intermediate or older glaciation, but not in last glaciation
End or terminal moraines – last glaciation (I)
– intermediate glaciation (II or IIA)
– age uncertain (IIA or III)
Limit of glaciation (inferred but not marked by end moraine) – last glaciation
– intermediate glaciation
Lateral moraines (locally including minor kame terraces)
Eskers and prominent ridges in esker complexes
Debris-covered glaciers
Rock glaciers (tongue-shaped, spatulate, lobate)
Erratic
Lateral and sub-lateral meltwater channels (arrow shows direction of flow)
Major meltwater discharge channels. (arrow shows direction of flow)
Incised channels of modern streams
Erosional scarp
Land or rock slide
Pingo
Patterned ground
Pits or kettles
Delta
Palsa
Sampling station, borehole station 140 +, 300 ⊗

Geology by P. Vernon and O. L. Hughes, 1961

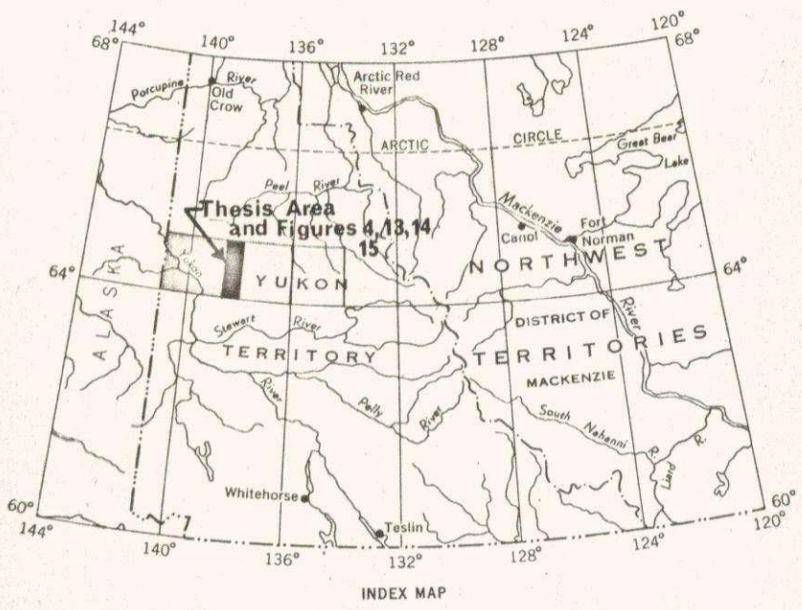
To accompany G. S. C. Bulletin 136 by Peter Vernon and O. L. Hughes

Geological cartography by the Geological Survey of Canada, 1964

Road, all weather
Other roads
Cart track
Trail
Power transmission line
Horizontal control point
International boundary
Stream ice and intermittent stream
Marsh
Contours (interval 500 feet) 2500

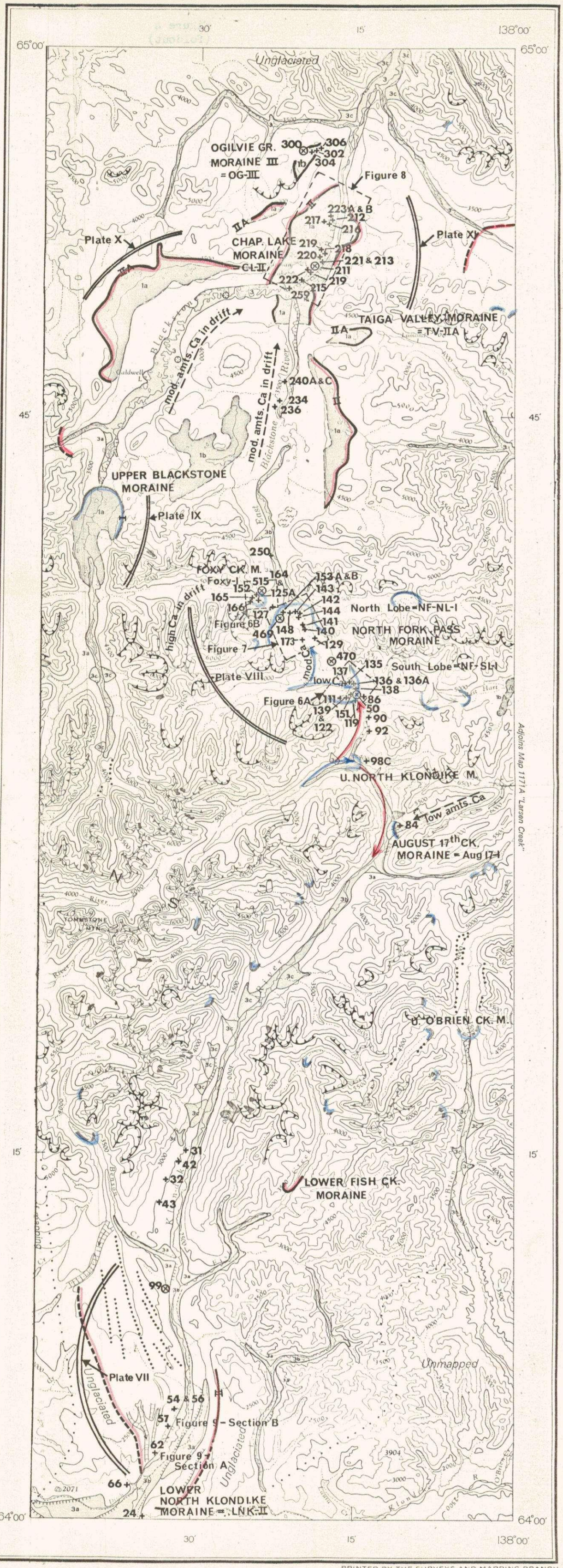
Base-map compiled and drawn by the Surveys and Mapping Branch, 1958

Mean magnetic declination, 33° 23′ East decreasing 3.8′ annually. Readings vary from 31° 46′ in the S W corner to 35° 00′ in the N E corner of the map-area



INDEX MAP

116B and 116C (East half)



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Wernecke Mountains (in Map 1172A area of Fig. 2). Cockfield (1919) recognized "intense glaciation" within the Little Twelve Mile-Tombstone region of the study area (Fig. 3). Bostock (1948) correctly deduced the reduced extent of Pleistocene glaciation towards the westward end, as compared to the east, in the Southern Ogilvie Ranges. During the preparation of the Glacial Map of Canada (1958) air photo mosaics were used by Bostock to outline the limits of the more extensive valley glaciation within the region. Crawford (1959) added to this with his field observations in preparing a respectable 1:500,000 scale glacial map of the Dawson sheet (Map 1170A area of Fig. 2) and the southwest quarter of the Larsen sheet (Map 1171A). The work is slightly marred by the apparent miscorrelation of some younger glaciation features in the Blackstone and Fish valleys to the older morainal termini located farther downstream. Green and Roddick (1962), Lambert (1966) and Tempelman-Kluit (1966) have noted various morainal and corrasional features of these two periods of glaciation.

Vernon and Hughes (1966) were the first to map the multiple glaciation sequence in the Southern Ogilvie Range and neighbouring Wernecke Mountains. As in Alaska (Karlstrom, 1960) each subsequent glaciation was found to be less extensive than its predecessor; in each episode, however, ice was found to be more extensive towards the east. In the "eastern region" a three-fold chronosequence of moraines was observed and evidence of a fourth ice advance was deduced from the elevated position of erratic localities. In the "western region" a "youngest" and "intermediate" glaciation were recognized from morainal sequences and erratics provided evidence of an "oldest" glaciation. The maps of their report also indicate the position of glacial corrasional, glacio-fluvial, fluvial, erosional, and permafrost features. Figure 4, this study area, is a sample of their mapping. In their report, the outlining of the glacial history is kept to a minimum in favour of examining various geomorphic criteria that help to distinguish the two younger glaciations. A special discussion on the ubiquitous rock glaciers is also included.

Related Quaternary Investigations

In the Yukon studies of multiple glaciation outside the Ogilvie Mountains are also in their infancy (Fig. 5). Bostock (1966) has mapped in reconnaissance fashion a four- to six-fold succession of glaciation limits on the Yukon Plateau and has formally named four of the sequences. Muller (1967), Bostock (1952) and Krinsley (1965) have mapped and outlined the various morainal and erratic limits in the Shakwak Valley-Wellesley Basin area of the southwestern Yukon. Rampton (1967) is remapping much of this area in conjunction with

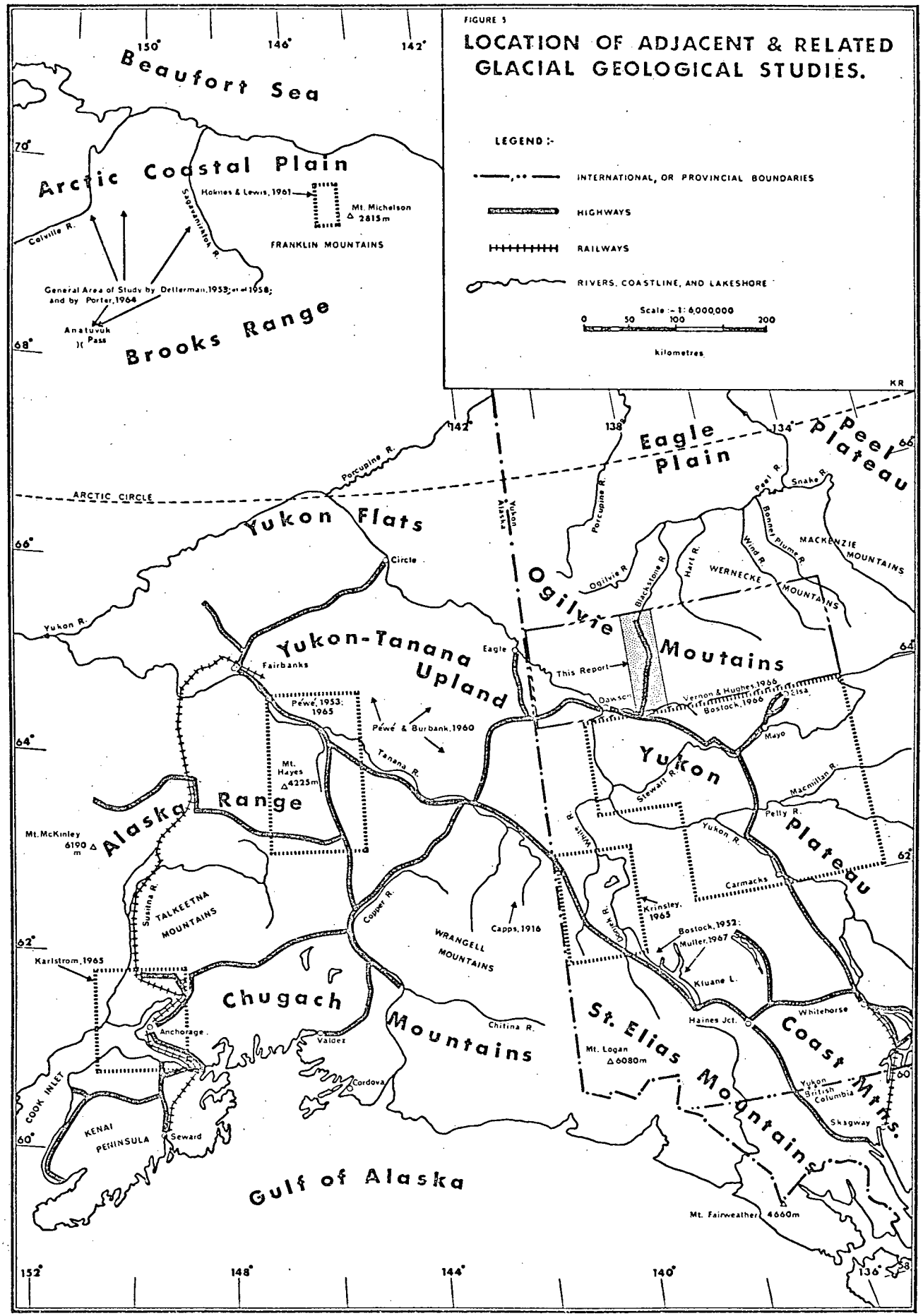
FIGURE 5
LOCATION OF ADJACENT & RELATED GLACIAL GEOLOGICAL STUDIES.
LEGEND :-
INTERNATIONAL, OR PROVINCIAL BOUNDARIES
HIGHWAYS
RAILWAYS
RIVERS, COASTLINE, AND LAKESHORE
Scale :- 1: 6,000,000
0 50 100 200
kilometres
KR
Beaufort Sea
Arctic Coastal Plain
Holmes & Lewis, 1961
Mt. Michelson 2815m
FRANKLIN MOUNTAINS
Colville R.
Sagavanirktok R.
General Area of Study by Detterman, 1953; et al 1958; and by Porter, 1964
Anatuvuk Pass
Brooks Range
Eagle Plain
Peel Plateau
Porcupine R.
ARCTIC CIRCLE
Yukon Flats
Circle
Yukon Alaska
Ogilvie Moutains
Ogilvie R.
Blackstone R.
Hart R.
Wind R.
Bonnet Plume R.
Peel R.
Snake R.
MACKENZIE MOUNTAINS
WERNECKE MOUNTAINS
Yukon R.
Yukon-Tanana Upland
Eagle
Fairbanks
This Report
Dawson
Vernon & Hughes, 1966
Bostock, 1966
Elsa
Mayo
Péwé, 1953; 1965
Péwé & Burbank, 1960
Tanana R.
Mt. Hayes 4225m
Yukon Plateau
Stewart R.
Macmillan R.
Pelly R.
Yukon R.
Alaska Range
Mt. McKinley 6190 m
White R.
Carmacks
Susitna R.
TALKEETNA MOUNTAINS
Copper R.
Capps, 1916
WRANGELL MOUNTAINS
Donjek R.
Krinsley, 1965
Bostock, 1952; Muller, 1967
Kluane L.
Karlstrom, 1965
Chugach Mountains
Chitina R.
St. Elias Mountains
Haines Jct.
Whitehorse
Coast Mtns.
Anchorage
Valdez
Mt. Logan 6080m
Cordova
Yukon British Columbia
Skagway
COOK INLET
KENAI PENINSULA
Seward
Gulf of Alaska
Mt. Fairweather 4660m
150° 146° 142° 138° 134° 70° 68° 66° 64° 62° 60° 152° 148° 144° 140° 136°

detailed studies on two Neoglacial and three Pleistocene morainal sequences. Mapping by Wheeler (1961) did not reveal multiple glaciation in the Whitehorse area. To the north of the study area Hughes (1963) mapped the glacial sequence and other surficial features in the Northern Ogilvie Mountains and adjacent Porcupine and Peel plateaux, but the results have not yet been published in full. According to Dr. R. B. Campbell (pers. comm.) several officers of the Geological Survey of Canada have completed a composite glacial map of the Yukon based on the above publications as well as additional photo interpretation. It is to be published eventually on a 1:500,000 scale.

In neighbouring Alaska a multitude of investigations have been accomplished on nearly all phases of Quaternary geology. Most recent Yukon investigations have been related to Wahrhaftig's (1958) work in the Riley Creek area of the north central Alaska Range. This work has since been updated and modified by Péwé et al.(1965) and Péwé (1965); both of these publications will be used for comparison purposes in this report. The investigation of multiple glaciation in the Eastern Brooks Range by Holmes and Lewis (1961) and the Yukon-Tanana Upland by Péwé and Burbank (1960) are also of direct concern here. Less pertinent publications are the chronology of Karlstrom (1965) in the Cook Inlet region and of Porter (1964) in the Central Brooks Range. Numerous other Quaternary research references are adequately reviewed by Péwé et al.(1965), Péwé (1965) and Bird (1967).

GEOGRAPHIC NOMENCLATURE

Unfortunately, the study area suffers from a scarcity of officially accepted place names despite the abundant local nomenclature that has developed since the turn of the century. Less than two dozen place names are quoted in the "Northwest Territories and Yukon" Gazetteer of Canada (1958). Bostock (1961) and Vernon and Hughes (1966) have since added a few more officially approved names. All additional names - taken from unpublished maps of Tempelman-Kluit (1966), Lambert (1966) and the Yukon Consolidated Gold Company (no dates); local residents and outfitters; signboards; or evolved by the writer[2] - are regarded (with two exceptions below) as unofficial and have

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[2] The series of names used for the lakes in the lower North Klondike valley originated from the Yukon Consolidated Gold Company's files. They are also known collectively as "Mischenko Lakes". Road sign creek names have been used despite some conflict with older local names; the latter appear in brakets on the accompanying map. Nomenclature coined by the writer and collaborators has been chosen with the following objectives: to recall the events and heroes of the Klondike Gold Rush, to honour the local explorers and developers of the Ogilvies, to commemorate the pioneers of periglacial research, and to describe unusual characteristics of the topographic element in question. During 1964 an outstanding world leader, Prime Minister Jawaharlal Nehru, died suddenly; the isolated "Nehru Range" has been named in his honour.

been designated, according to government policy (Fraser, 1964; pp. 125-6) by enclosing quotation marks.

Though missing from the Gazetteer the established name, Antimony Mountain, has been returned to the locally recognized position of its summit. Fish Creek, sometimes misplaced as well, is used as shown on the National Topographic Series (Dawson, 116 B & C). Spotted Fawn Gulch, a locality appearing quite often in publications, is also regarded as an official name in this report.

Names of several moraines, some serving as types, have been applied formally to this report without the use of quotations. However names of glaciations, glacial advances or glacial stages are used tentatively, in quotation, until their regional significance is more clearly established.

LOCAL ACCESS HISTORY

The Ogilvie Mountains were first visited for scientific purposes by William Ogilvie in 1888. His traverse through the ranges, however, was confined to their western margins, near the present international border. The Blackstone region of the study area is accessible by way of the Chandindu Valley and Seela Pass approach (Fig. 3). Indians of the Kutchin and Han subtribes used it as a travel route, but whites did not enter it until after the Gold Rush at the turn of the century. At this time, prospectors, trappers, missionaries and Northwest Mounted Police ascended the valley in order to enter the Peel River Valley by either the Blackstone or West Hart Rivers. Their destination was usually Fort McPherson.

Some prospecting into valleys alongside this Chandindu Valley route resulted in the staking of lead-silver claims in 1902 in the Spotted Fawn Gulch portion of the upper reaches of the Little Twelve Mile River (McConnell, 1906). By 1909 a power line, flume, and road were constructed up to a powerhouse located at the mouth of this tributary of the Chandindu. During this construction prospecting had reached the axis of the Southern Ogilvie Ranges, with copper claims staked near the North Fork Pass area. In the early 1910's the gold fields demanded additional electrical power. A civil engineer, Mr. V. Mischenko, laid out a power scheme for the lower North Klondike valley and had plans drawn up and power line right-a-ways slashed out by about 1916. However, the project died soon after. The geologist, Cockfield (1920), made the first topographic map of the lower and mid reaches of the North Klondike valley while en route to inspect a series of claims at Spotted Fawn Gulch. During these years the Fish Creek tributary of the North Klondike was also explored and by

1922 several visits had been made to stibnite showings near the summit of Antimony Mountain. Soon after, logging operations were begun in the middle reaches of the North Klondike valley. During the years to follow, prospecting and trapping continued in the Southern Ogilvie Ranges; the most persistent individual was the respected Mr. Frank Ray.

A modified version of the North Klondike power scheme was started during the 1930's. Waters of the main fork and north forks were captured by using an intake and long ditch system, and were carried to a powerhouse on the "main" Klondike River. The 10,000 KW plant was operational by 1935 and is at present the only source of power for the dwindling population of the Dawson district. The only permanent inhabitants of the map-area are those connected with the operation of this system.

During the 1940's float plane trips to Chapman Lake began, for trading with Indians at their summer tent camp ("Calico City"). In the early 1950's a short-lived winter road began at Eagle, Alaska, ascended the Tatonduk River valley to the west, and eventually reached the northwest corner of the map-area by way of "Cache Creek" before continuing northward to the DEWLINE radar installations. During the mid 1950's the Peel Plateau Explorations Co. (and subsequent exploration companies) used tractor trains on an elaborate winter tote road located on the floors of the North Klondike and East Blackstone valleys. Portions of this road lying north of the map-area were still being used by an oil company in 1964.

The federal government surveyed the tote road route during the summer of 1958 and in the following year began construction of the Dempster Highway. The aim was to extend the road into the Fort McPherson region of the Mackenzie District some 600 to 700 km to the north. To date only 140 km of road have been constructed to usable standards and all of this lies within the region covered by this report - Figure 2 is misleading in this respect.

Within the study area the highway has been a boon to mineral exploration. Two to three hunting out-fitters have now established themselves in the region on a perennial basis. In addition the road has suitably served the needs of this project. Away from the road and south of North Fork Pass, valley-bottom travel on foot or horse is easy, using extensive game trails. Travel on brush-laden slopes or old burns is more awkward, but not impenetrable. To the north of the pass valley-bottom travel is very slow because tussock tundra abounds and creates an unstable footing to even the experienced hiker. Horses are decidedly advantageous for long traverses in this area. On the other hand, high-level foot travel north of the Pass is rather easy going. Some areas to

the west of the highway can be approached most easily by float plane, but other than Lomond Lake, good landing lakes are scarce to the east of the highway.

FLORA AND FAUNA

Vegetation within the region consists of a Boreal type of spruce (Picea sp.) forest in the south and a sedge tundra in the north. Timberline varies between 1050 and 1200 m (m.s.l.) south of North Fork Pass, and north of the pass forests are not encountered until the southern margin of the Central Ogilvie Ranges is reached; here a Northern Woodland type of spruce forest occurs at elevations generally below the 950 m contour. Timberlines are accurately marked on the National Topographic Series of maps.

Big game is plentiful throughout most of the region save possibly the Tintina Valley portion. During the course of the summer grizzly bears (Ursus arctos horribilis) and black bears (Euarctos americanus) were observed by visitors to the North Klondike and tributary valleys. Dall sheet (Ovis dalli dalli) were often sighted in bands of 10 to 30 on rocky slopes throughout the entire region. Moose (Alces americana) are ubiquitous along the valley bottoms and are especially numerous in the East Blackstone valley. Magnificent chestnut-brown Osborn (woodland) caribou (Rangifer arcticus osborni) were spotted either alone or in bands of up to five on the less rugged ridge crests and slopes of the upper East Blackstone and mid-upper North Klondike drainage systems. Barren-ground caribou (Rangifer tarandus groenlandicus) visit the Blackstone drainage as part of their annual migration route. During the summer of 1964 a few forerunners of the main band appeared in early July; by the 20th of the month they had increased to about 30. On July 25th the main herd appeared just north of the North Fork Pass region - over 250 head in each of two bands. In the days following only scattered groups of 5 to 6 were observed and by the end of August all caribou had disappeared.

Smaller game sightings in the region include the following: a marmot (Marmota caligata) colony of about 20 at North Fork Pass, ubiquitous ground squirrels (Citellus parryi?) and snowshoe hares (Lepus americanus), a few chipmunks (Eutamias minimus) and foxes (Vulpes fulva?) in the North Klondike drainage, pika (Ochotona collaris) colonies on most talus slopes, rarely observed wolverine (Gulo luscus) and lynx (Lynx canadensis) near the upper North Klondike highway crossing, a single beaver (Castor canadensis) and coyote (Canis latrans) in the lower reaches of the North Klondike valley, unidentified lemmings throughout the region, and a pack of rather bold wolves

(Canis lupus) just southeast of Chapman Lake. Surveys by the Canadian Wildlife Service of the mammal population in the region are in progress.

Of fishes, the number of species appear to be few. Most angling activity is confined to the East Blackstone River where sporty arctic grayling (Thymallus arcticus) abound, 30 to 60 cm long. A few specimens were collected for the Institute of Fisheries of the University of British Columbia. Char (Salvelinus sp.) are frequently caught in this drainage as well.

Birds, particularly the smaller species, were not so carefully observed. Ravens and ptarmigans were ubiquitous throughout the region. Unidentified gulls, loons, hawks, ducks and shore birds were occasionally seen at North Fork Pass and Chapman Lake. Long-tailed jaegars, gyrfalcons, bald eagles, arctic terns, snow geese and perhaps golden eagles were occasionally seen just north of the pass throughout most of the summer.

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In field work in the Yukon the help and services of many local residents are required; these were unfailingly given by all citizens whether native or adventive. The writer appreciates their hospitality and helpfulness. In this regard a few of the outstanding contributions were by the families of Messrs. A. Nordling, G. Walmsley, A. Innes-Taylor, and D. Belmore. Mr. J. Langevan of the Dominion Forest Service kindly loaned a house trailer for one half of the field season. Mr. Al Close, foreman of the Dempster Division of the Yukon Territorial Government road maintenance crew, willingly provided transportation, working space and other services throughout the field season. Mr. C. Henderson stored equipment and samples and provided temporary accomodation as the occasion arose. Employees of the Yukon Consolidated Gold Company cheerfully supplied information. The Socony-Mobil Oil Company generously allowed use of their camp facilities for one half of the summer - special thanks goes to their winter camp maintenance man, Mr. Steve Cramer.

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Special thanks are extended to Dr. T. Péwé whom helped clear up many material problems. Dr. W. H. Mathews of the Department of Geology at the University of British Columbia supervised the project; contributions by the technical staff of the department, especially Messrs. E. Montgomery and J. Donnan, and by fellow graduate students, particularly Dr. B. N. Church, are gratefully received. Dr. J. R. Mackay of the Department of Geology gave useful criticism and preliminary advice; his fellow staff members and graduate students helped with many minor but important items. The department's map librarian, Mr. J. Schonfeld, kindly allowed several weeks of unobstructed use of their elaborate vertical reflecting projector. Dr. G. Rouse of the Department of Botany of the University of British Columbia organized all aid needed in the initial botanical analysis - special gratitude is expressed to him and his colleagues.

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My thanks go to Dean W. Gage for making available the various forms of financial assistance, whether grants or loans, that permitted the writer to even consider graduate work. Lastly, without the hours of analytical help, advice and encouragement by Dr. Robert Brooke at Simon Fraser University over the past few years this project probably would not have been completed. The writer is grateful to all of the above, as well as others, for their understanding and patience during the protracted process of completing this interdisciplinary study.

PART ONE: SURFICIAL GEOLOGY

METHODS

Field Survey

Field work for mapping the surficial geology was begun during the period of road washouts and continued on resupply days to and from Dawson and during intervals too wet for detailed studies described in Part Two of this thesis. The greater number of some 200 borrow pits, 50 stream cuts and 50 other artificial exposures in the North Klondike and East Blackstone valleys were visited. Sediment sequences were sampled and described in the standard manner as outlined in Appendices IB and IC.

Samples of till and of the pebbles and cobbles in representative tills of each age were collected at localities plotted on Figure 4. The former varied from 0.7 to 2.5 kilograms (dry). They were flaked randomly off cleaned and undisturbed exposures below the B, BC or CB layer of the overlying solum - where this existed. From 100 to 200 cobbles or pebbles were taken from the B horizon of the soil profile or, if soil was not present, as close to the upper surface of the till as possible. If plutonic clasts were present, an additional 25 to 50 cobble to pebble-sized pieces of these were gathered and stored separately. At any till or gravel exposure special attention was given to the maximum depth of visible oxidation and to the maximum depth of $CaCO_3$ leaching. Munsell (1954) soil colour charts were sometimes used to determine the maximum depth of oxidation, while carbonate was checked by the effervescence test.

Mapping was carried out on some 1:60,000 and 1:25,000 scale aerial photographs. These were viewed stereoscopically at the time of investigation in order to insure correct location and to delineate the extent of the deposit under scrutiny. The viewing also revealed adjacent forms to be investigated and selected traverses were subsequently run to check their texture, fabric and morphology. Pits were dug on the surface of some features if natural exposures were not present, though in terrain underlain by a high permafrost or pereletok table this was usually unrewarding. The upper limit of obvious glaciation on the walls of the North Klondike valley was established by selected traverses up slope to the limit of erratic blocks or "semi-bench-like" forms, where elevation was recorded by adjusted aneroid reading, and was plotted stereoscopically on the aerial photographs.

Steep slopes on the west-facing escarpment of the North Klondike River valley were mapped only by reconnaissance viewing with binoculars from good vantage points along the opposite valley slopes. Alpine slopes in the North Fork Pass region were similarly explored. However, the emphasis of the surficial survey was on features of the valley bottom or lower slope; the brief alpine survey was conducted for purposes of checking for the possibility of old elevated glaciation features. As the alpine zone was soon found to exhibit extensive mass-wasting, and no glacial features were discovered, this investigation was discontinued; hence the large unmapped alpine tracts on the accompanying 1:50,000 Quaternary map. Thus the surficial geological field work was confined to a belt varying from 2 to 10 km in width by 110 km long through the North Klondike valley, North Fork Pass, East Blackstone valley, and Chapman Lake region of the map area.

During the course of the summer three holes were drilled into permanently-frozen peat bogs by the field assistants and Dr. O. L. Hughes in order to obtain material for radio-carbon dating. A gasoline motor powered SIPRE-type ice-coring drill was used for this task; its method of operation is given by Hughes and Terasmae (1963). The latter author carried out a pollen profile analysis on the core from the Chapman Lake borehole site. The highlights of the profile are given in Appendix ID.

Laboratory analysis

Pebble counts were made of 50 to 200 specimens from each sample. All pebbles were first washed, and on a gross basis, checked for striations and roundness (Compton, 1962). All identifications are based on hand lens comparisons with either a partial set of rocks which had been studied in thin section from the "Mt. Brenner" area (Fig. 3) kindly prepared and loaned to the writer by Mr. M. Lambert or to almost a complete set of petrographic descriptions of the lithology of the "Prospector", "Snowy", "North Klondike", "Tombstone" and "Cloudy" ranges prepared by Tempelman-Kluit (1966) for a PhD dissertation. After identification the striations and roundness were examined a second time though on a clast basis; the results were checked against the initial gross determinations. If the two determinations did not agree the entire sample was re-examined quite carefully.

Grain size analysis of 21 samples of till and 2 samples of unidentified diamicton were carried out by the sedimentological laboratory of the Geological Survey of Canada in Ottawa. They were dried, sieved and pipetted into Wentworth size classes according to standard techniques given in Folk

(1965). All results, whether sieve or pipette, were given at whole phi intervals, but upon advice from Dr. A. Sinclair (Department of Geology, U.B.C.) they have been replotted at the next highest $\frac{1}{2}$ phi interval in order to present a truer average grain size at any given point on the cumulative-frequency curve (Figures A and B - Appendix IIA).

Map Production

The various landform deposits plotted on aerial photographs in the field were carefully re-examined by viewing its surface under a non-magnifying, Model MS-1, "Q-O-S Corp.", stereoscope. Geologic features established in the field work were re-outlined directly on the glossy photographs; these served as a basis for the recognition of nearby features not examined in the field and they too were inked onto the photograph. This process was continued from photograph to photograph until all valley bottom terrain in the map area had been outlined. Some 66 photographs at the 1:25,000 scale and 94 at tne 1:60,000 scale were examined; not all of these were examined while in the field. In addition the Blackstone River region north of the map area was studied by viewing 16 additional photographs and two uncontrolled, 1:125,000 scale, air photo mosaics; this was undertaken to determine the extent of the "oldest" glaciation. All photograph interpretation was aided by using field notes, botanical indicators as shown by Raup and Denny (1951) or Sigafoos and Hopkins (1952), and Ray's (1960) handbook on the interpretation of photographs. The marked photographs were then checked against the mapping of Vernon and Hughes (1966), and the field photography of Crawford (1959), Tempelman-Kluit (1966), and the writer. Direct discussions with Dr. D. Tempelman-Kluit helped to solve problems in the headwater regions of the North Klondike and Tombstone River areas.

Map-units of surficial deposits were selected from those given by Vernon and Hughes (1966), Bostock (1966) and Péwé (1965), with minor feature additions from Fulton (1962, 1963), Flint (1957), Mannerfelt (1945), Thornbury (1954) and Bird (1967). Units have been grouped by facies and parameters characterizing each are summarized in Appendix IA. Some of the less conspicuous erosional features such as glacial striae and meltwater channels were also mapped. However, the gross forms, particularly escarpments and cirques, have been adequately mapped with their ages indicated by Vernon and Hughes (1966). Accordingly, these are not replotted on the map accompanying this report.

The geological boundaries outlined on the aerial photographs were then transferred to a preliminary 1:50,000 manuscript map based topographically on the published contour map sheets of the Surveys and Mapping Branch of the Department of Mines and Technical Surveys. For this task a Saltzman Model 1414A vertical reflecting projector was used. For the southern half of the map area 1:50,000 scale topographic maps are available; hence, plotted geologic boundaries should be within 100 m of their true location. Only an 1:250,000 scale map (enlarged 5x) was available for the northern half; therefore, in areas away from known lakes and streams boundaries can be as much as 250 m off their true position.

In this project nearly all plotted geologic boundaries are to be considered gradational. Sub-arctic mass-wasting processes commonly eliminate the sharpness of boundaries; in other cases the original boundaries were not distinct for the sedimentation occurred as a gradational facies change. Some geologic boundaries cannot be differentiated by the photographs at all, but are known to be present in the area from either scattered textural observations or from sequential event inference. Such boundaries are indicated by a dashed line. Some geologic elements are superimposed as thin veneers on older and more extensive deposits; these also are generally marked by broken lines along with the appropriate veneer symbol on the map, for their boundaries are usually difficult to discern on the photographs. Where a feature needs to be subdivided (e.g. sub-features of a landslide), the boundary is marked by a dotted line.

Upon completion of the compilation the entire manuscript map was checked then traced with water-soluble ink onto a "mylar" or translucent plastic vellum. The enclosed Quaternary map represents five months of photo interpretation and manuscript drafting.

Mapping Reliability

For convenience the Quaternary map is reproduced here on a 1:50,000 scale. As portions of the North Fork Pass and Chapman Lake terrain were originally mapped by extensive ground observation on a 1:25,000 scale, some detail here had to be omitted. However, all detail has been included on the 1:37,500 reproductions of these areas in Figures 6, 7 and 8. Other areas along the Dempster Highway were mapped on a 1:60,000 scale while in the field; occasionally there are gaps in the field work and consequently the accuracy suffers. In valleys away from the highway the map is based solely on 1:60,000 scale aerial photo interpretation.

Because of these differences in the scale of mapping many periglacial features are incompletely represented. For example, terrain with ice-wedge polygon patterns cannot be distinguished satisfactorily on the 1:60,000 scale aerial photos. Hence, the map lacks this feature in most major valleys except those traversed by the Dempster Highway. Features not seen on any of the photographs (e.g., felsenmeere and upland patterned ground features) are recorded only where observed in the field. Production of a realistic or truly representative map at the 1:50,000 scale would require ground traverses in valley regions spaced at 500 m intervals and visits to every cirque basin and rounded ridge crest.

GENERAL RESULTS

Types of Surficial Deposits

Generally, the author's survey confirms the distribution of deposits indicated by Vernon and Hughes (1966) in their Map 1170A (Fig. 4 of this report). However, the present mapping extends farther up valley slopes, and subdivides many of their units. The greatest changes are in the terminal zones of former ice advances. The moraines commonly reveal a complex depositional sequence and are subdivided accordingly. Deposits of these zones include till, hummocky gravels, outwash gravels, bogs, colluvium, loess and other features of local importance. Other innovations in the mapping include the plotting of solifluction deposits and loess - both of which are ubiquitous on older deposits as irregular sheets. Surficial deposits occupy more than 50% of the land surface within the study area.

Apart from the solifluction deposits and loess sheets, the predominant deposit at the surface is a complex of ground moraine sediments. The portions consisting of till are of an average 10YR 3.7/2.0 moist Munsell (1954) colour (Table III). Pebbles within the tills are generally subangular; although roundness increases in the downstream direction from the head of the main trunk valleys involved in each glacial episode (Table IV). Lithologic analyses of the till's pebbles show that source areas are both local and distant. The distant source areas lie close to and on the axis of the Southern Ogilvie Ranges (Table V, Fig. 3). For example, in the till samples from the northern part of the map-area the Unit XVII-12 quartzites and the plutonic stock rocks can be derived only from the "Cloudy Range". The carbonate-enriched volcanic clasts in the tills just south of the North Fork Pass are derived from the nearby "Agglomerate" and "Rangifer" ranges.

TABLE III Munsell colour of tills occurring on the North Klondike - Upper Blackstone valley floor.

FIELD STN. NO.	MOIST COLOUR	TYPE OF EXPOSURE	DEPTH BELOW SURFACE	MORAINE ⩛ AND AGE**	MORAINAL CHARACTERISTICS: AVERAGE COLOUR	HUE LIMITS	VALUE LIMITS	CHROMA LIMITS
24	5Y5/4	artifical cut	1.5-9 m.	Tintina Valley-III? *	only one sample	-	-	-
31	10YR4/3	road cut	4.6 m.	Lower North Klondike-II				
32	10YR4½/3	borrow pit	30-150 cm.	Lower North Klondike-II				
43	2.5Y4/2	borrow pit	shallow	Lower North Klondike-II				
	2.5Y4/2	borrow pit	shallow	Lower North Klondike-II				
54	10YR3½/3½	borrow pit	shallow	Lower North Klondike-II				
56	7.5YR5½/4½	borrow pit	shallow	Lower North Klondike-II				
57	7.5YR5½/6	borrow pit	60 cm. - 2.4 m.	Lower North Klondike-II	10.8YR 4.2/2.8	7.5YR-5Y	3.5-5.5	2-6
62	2.5Y4½/3	borrow pit	shallow	Lower North Klondike-II				
66	2.5Y3½/2	borrow pit	shallow	Lower North Klondike-II				
86	10YR4/2	borrow pit	shallow	Lower North Klondike-II				
90	5Y4/2	borrow pit	shallow	Lower North Klondike-II				
92	10YR4/2	borrow pit	shallow	Lower North Klondike-II				
2nd sample	10YR3½/2½	borrow pit	very shallow	Lower North Klondike-II				
98C	2.5Y4/2	borrow pit	very shallow	Lower North Klondike-II				
84	10YR2½/1	soil pit	10 cm.	Aug.17th Ck.-I				
2nd sample	10YR3/1	soil pit	55 cm.	Aug.17th Ck.-I				
mottles	2.5Y6/0 to 5B6½/1	soil pit	50-75 cm.	Foxy Ck.-I				
165 matrix	2.5Y4½/2 to 5YR5/6				10YR3.8/1.7	5YR-2.5Y	2.5-6	0-6
135	10YR3½/2	soil pit	20 cm.	)	(for all I's)			
138	10YR3/3	soil pit	27 cm.	North Fork - south)	10YR3.2/2.3			
151	10YR3½/2	soil pit	15 cm.	lobe-I)				
129	10YR3/1	borrow pit	60-120 cm.	)				
148	10YR2½/1½	soil pit	30 cm.	North Fork - north)				
153A	10YR3/3	river cut	1 m.	lobe-I)	10YR3.0/2.2			
153B	10YR3½/2	river cut	1.2-2.1 m.	)				
127	10YR4/2	soil pit	50 cm.	Chapman Lake-II)				
215	2.5Y3½/2	river cut	1 m.	Chapman Lake-II)				
221	10YR3/1	soil pit	20-95 cm.	Chapman Lake-II)				
223	5Y3½/1	soil pit	10-30 cm.	Chapman Lake-II)				
234	10YR3½/1	river cut	1 m.	Chapman Lake-II)	9.75 3.25/1.05	7.5YR-5Y	2.5-4	0-2
236	5YR3½/1	river cut	7 m.	Chapman Lake-II)				
237	5YR3½/1	borrow pit	near surface	Chapman Lake-II)				
240A	7.5YR2½/0	river cut	3.0-4.6 m.	Chapman Lake-II)				
250	10YR3/1½	river cut	shallow	Chapman Lake-II)				
259	2.5Y2½/0	borrow pit	shallow	Chapman Lake-II)				
240C	10YR2½/1	river cut	30 m.	Taiga Valley-IIA	only one sample	-	-	-
304	10YR3/1½	soil pit	50-70 cm.	Ogilvie Gr.-III	only one sample	-	-	-

⩛ Arranged more or less according to increasing latitude; for location refer to Figure 4 or to Quaternary Map.

* This sample could be a mixture of till and Tertiary sediments.

** In relative terms only: I = youngest Pleistocene Moraine, II = Intermediate in Age, IIA = Older, and III = Oldest.

TABLE IV Gross angularity of the pebble clasts in selected samples of till in the North Klondike - upper Blackstone regions.

FIELD STN. NO.	MORAINE AND RELATIVE AGE **[1]	% ROUNDNESS OR ANGULARITY*** (COMPTON, 1962; PAGE 215)					% STRIAE	STN F.
		WR	R	SR	SA	A		
24	Tintina Valley - III(?)	0.5	4.9	12.9	35.4	45.7	29.5	203
31	Lower North Klondike - II	0	5.5	31.5	52.5	10.5	29.5	200
32	ditto (LNK)	0	0.5	10.0	75.5	14.5	20.0	150
56*	ditto	0	0	0	50.0	50.0	10.0	25
57*	ditto	0	7.0	29.0	56.0	8.0	23.0	100
86*	ditto	0	1.0	3.0	85.0	11.0	14.0	100
98C	ditto	0	0	10.0	80.5	9.0	25.5	200
84*	August 17th Creek - I	0	0	2.0	95.0	3.0	32.0	100
138	North Fork Pass - South Lobe - I	0	0	1.0	71.0	28.0	16.0	100
151	ditto (NF-SL)	0	0.5	3.0	65.0	31.5	20.5	200
148	North Fork Pass - North Lobe - I	0	0.5	8.0	77.5	14.0	28.0	200
153A*	ditto (NF-NL)	0	0	15.0	82.0	3.0	19.0	100
153B*	ditto	0	3.0	7.0	83.0	7.0	15.0	100
165*	Foxy Creek - I	0	2.0	5.0	85.0	8.0	18.0	100
127	Chapman Lake (CL)	0	0.7	6.6	66.6	25.1	28.0	150
250	ditto	0	0	12.0	72.0	16.0	20.0	50
240A	ditto	0	1.5	14.5	76.5	7.5	34.3	200
220	ditto	0	2.0	21.0	68.5	8.5	16.0	200
223	ditto	0.5	1.5	22.5	67.0	8.5	17.5	200
240C[2]	Taiga Valley (?) - IIA (TV)	0	1.5	17.5	78.5	2.5	38.0	200
304	Ogilvie (OG) - III	0	2.0	15.0	62.0	21.0	20.0	200

*** WR = well rounded, R = rounded, SR = subrounded, SA = subangular, A = angular

** Refer to Figure 4 for explanation of location and age relationships.

* Uncracked specimens were not examined.

[1] Abbreviations as shown in brackets, are often used in this report.

[2] Correlation to the Age IIA ice advance is by stratigraphic assumption only.

TABLE V Provenance of pebbles in % frequency in selected samples of till from the North Klondike-upper Blackstone Region

STN. NO.	MORAINE AND AGE	SUSPECTED GEOLOGIC BEDROCK UNIT SOURCE OF ORIGIN - TABLE I , FIGURE 3									
		II,VIII	III-I, (3)	IV-5	XVII-13	XIX,XIV,IX**	XX-16	XXIB-17-18	CONT.AUR.	XXIIA	UNKNOWNS ⩛
24	TINT.V.-III(?)	0	51	2	30	0	0	0	2	7	8
31	L.N.KLONDIKE-II	0	28	1(?)	43	4	17	3	1(?)	3	1(?)
32	DITTO	0	24	0	44	2	12	1	0	6	11
56 *	DITTO	0	8	4(?)	0	20	24	0	32(?)	0	12
57	DITTO	0	14	0	47	29	0	0	1	0	9
86	DITTO	0	35	12	19	21	0	6	6	0	1
98C	DITTO	0	34	9	14	32	0	9	0	0	2
84	AUG.17TH CK.-I	0	8	0	76	4	11	0	0	0	1
138	NF-SL-I	0	36	0	25	32	0	5	1	0	1
151	NF-SL-I	0	33	4	16	25	1	20	0	0	1
148	NF-NL-I	0	26	10	23	38	0	2	0	0	1
153A	NF-NL-I	0	23	12	20	35	1	5	0	0	4
153B	NF-NL-I	0	20	5	19	51	0	4	1	0	0
165	FOXY CK-I	0	8	82	3	5	0	2	0	0	0
118***	CHAPMAN L.-II	0	CA. 8	CA. 50	CA. 8	CA. 32	CA.2	0	0	0	0
127	DITTO	0	16	69	5	6	0	1	0	0	3
250*	DITTO	0	16	20	12	44	0	TRACE	0	0	8
240A	DITTO	2	11	21	35	4	5	4	3	0	16
220	DITTO	0	19	9	32	8	5	5	0	0	22
223	DITTO	0	18	4	30	16	3	8	0	0	21
240C	TAIGA V.-IIA	0	8	28	25	11	1	2	0	0	25
304	OGILVIE-III	2	29	13	33	9	3	4	0	0	7

* ANALYSIS OF STATIONS 56 AND 250 IS BASED ON 25 PEBBLES; ALL OTHER STATIONS ARE BASED ON 100 PEBBLE IDENTIFICATIONS.

** THE PELITE, SILTSTONE AND CHERT CLASTS OF UNITS III, IV AND XVII ARE INCLUDED IN THIS CATEGORY.

*** PEBBLES AT THIS STATION ARE FROM GRAVELS OF A CREVASSE DEPOSIT - NOT A TILL.

⩛ THIS CATEGORY INCLUDES DYKE ROCKS, QUARTZ VEIN, PELITES AND METAMORPHIC ROCKS FROM SOUTH OF NORTH FORK PASS; THE CATEGORY INCLUDES MOST PELITES, CARBONATE SANDSTONES AND LIMESTONES OF UNITS II, III, 6, IX, XIII, XV, XVII AND XIX IN SAMPLES FROM THE TAIGA VALLEY REGION.

Deglacial deposits occur in regions occupied by former ice fronts, either as extensive outwash bodies or as areas of hummocky micro-topography. Kame-like features are common in the lower North Klondike valley but are scarce in other regions. Eskers and glacial lake deposits are uncommon in the map-area.

Fluviatile gravel deposits occur as continuous broad ribbons on valley floors and are fed by alluvial fans on the lower valley slopes.

Loess is found on most valley bottom regions away from zones of recent fluviatile action. However, much of it has been slightly reworked by mass-wasting processes and to the north of North Fork Pass the deposits are bound by perennial ground ice.

Miscellaneous deposits include those associated with permafrost and mass-wasting. Bogs are extensive in the northern third of the map-area in valley bottoms where permafrost is present. Solifluction debris, talus deposits and colluvium are found on most slopes throughout the region and commonly occur together as a mixed deposit. Lobed solifluction accumulations are especially abundant on the mountain slopes in the northern half of the map region. Rock glaciers, felsenmeere, glacierets and landslide deposits are limited to the headwaters or upper reaches of the Tombstone, Blackstone, O'Brien and North Klondike drainage regions.

Time Sequence of Glacial Episodes

Vernon and Hughes (1966) described three Pleistocene glaciations in the map-area (Fig. 4). Only minor alterations to their mapping and evaluation of the sequence of ice advances are necessary. These include the following:

1) relocation of some ice fronts in their "youngest glaciations" ("blue limit") and the addition of some previously unrecognized glaciated valleys to this sequence;
2) re-evaluation of some of their proposed "red limit" or "intermediate glaciation" limits in the northern or Chapman Lake region of the map-area;
3) plotting of "older glaciation" features; and
4) recognition of the "Little Ice Age" as a mappable glacial event and the re-evaluation of the existing bodies of ice associated with this event.

The "youngest Pleistocene ice advance" or "last glaciation" reaching the "blue limit" is referred to as the "Age I ice advance", or "Age I glacial stade", in this report. This involved development of valley glaciers extending upward to a limit generally marked by grooves, benches, channels and faceted spurs some 150-250 m above the valley floor.

In addition to the ice fronts shown by Vernon and Hughes (1966) (Fig. 4) the writer has detected evidence of valley glacier limits of the same relative age at the following localities: the headwaters of "Wildhorse Creek"[1] and an adjacent but unnamed west-facing valley in the northern "Rangifer Range"; the tributary valley west of "Wonkle Mountain" and the headwaters of "Peasoup Creek" in the "North Klondike Range"; the mid reaches of "Chisolm", "Antimony" and "Labby Creeks" in the "Snowy Range"; and the "Marmot Creek" basin between "Storm" and "Dall Sheep" mountains in the "Agglomerate Range". Close to the last-named, an ice terminus existed at the mouth of the "Elf Lake" valley; the adjacent cirque valley to the east is correctly marked with a bulbous ice front on Map 1170A but the two cirque valleys east of this again also show a weak morainal development at their combined mouths. Moraines were also found at the mouths of isolated cirques (e.g. "Edge Mountain") on the upper North Klondike valley (Plate XIIC).

At least two ice front termini are misplotted on Map 1170A. The surveys conducted on the August 17th Creek moraine (= Aug.17-I) in the "Prospector Range" showed that the end of this moraine is at the mouth of the creek rather than 4 km upstream where their "blue limit" is located. A similar error was found at the "Junior Creek" exit to the main Blackstone valley.

Though usually marked by Vernon and Hughes (1966) in their survey (Map 1170A) Age I recessional moraine features have been omitted by them for the area covered by Figure 4. Such features can be found in the upper Blackstone River, "Foxy Creek", "August 17th Creek", Little Twelve Mile River, and other unnamed valleys; they are plotted on the accompanying 1:50,000 scale map.

The "intermediate Pleistocene ice advance" to the "red limit" of Vernon and Hughes (1966), was more extensive than the Age I advance. Glaciers were interconnected from one master valley to the next (transection or through glacier; Ahlmann, 1933; or Davis and Mathews, 1944). In the North Klondike valley the upper ice limits of this advance could be traced at elevations of 350 to 450 m above the present-day valley floor from as far south as the exit into the Tintina Valley to as far north as the "big bend" in the valley just south of North Fork Pass. Former surface gradient of the ice in that portion of the valley was approximately 11 m/km, whereas the gradient at the snout was probably double this figure. Ice to the north of the big bend at this time

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[1] Since names in quotes are local names, they do not occur on the Figure 4 map; they may be found on the 1:50,000 Quaternary map.

had passed through both North Fork and "Hart" passes as a sheet 180 m thick with a surface sloping to the north at about 10.5 m/km. Throughout the East Blackstone valley ice appears to have been 100 to 250 m thick with a gradient of about 9.6 m/km. In the Chapman Lake terminal zone the ice surface gradient was about 17 m/km. The gradients in all cases are approximate and are inferred from the elevations of lateral moraines, "semi-benches" (or Schliffgrenze) and erratics.

The "intermediate" ice advance is difficult to interpret at the north end of the map-area because of a two-tiered sequence of morainal features that is not everywhere present. The lower set of features includes the Chapman Lake Moraine (Fig. 4, Plate XI) and is here designated as Age II (or CL-II). The upper set of morainal features is designated Age IIA and includes the following features: the "black limit" (Vernon and Hughes, 1966; Fig. 4) glaciated lobe of "uncertain age" near Lomond Lake (Plates XI and XIIB) a belt of previously unrecognized morainal terrain to the east of Chapman Lake near the "Gunsmoke Creek" region (near "Boot" and Pistol" lakes on the 1:50,000 scale map), the upper "red limit" to the northwest of Chapman Lake on Figure 4 (Plate XI), the billowy set of moraines on the "Fitzgerald Ridge" crest (west of Chapman Lake -- Plate X) and the upper set of moraines to the south of "Geodesy Dome". The Age IIA ice advance is referred to as the Taiga Valley Moraine (or TV-IIA) in this report.

Altimetry reveals that the Lomond Lake digitation of the Age IIA ice advance was at least 75 m higher than the subsequent Age II advance in the East Blackstone valley (Plate XI). The TV-IIA morainal terminus deposits are not preserved in the Blackstone valley and may never have been deposited at all.

Problems arise from this Age II versus Age IIA distinction. The first concerns the inferred "red limit" on Map 1170A (Fig. 4) in the "Gunsmoke Creek" valley; it was vaguely discerned on the aerial photographs at the position suggested by Vernon and Hughes, but whether it should be Age II or IIA is not known for gelifluction activity in this region could easily mask a moraine deposited by a short valley glacier that had occupied such a wide trough (Taiga Valley). The second problem is the span of time between the two advances; that is, whether the two record separate glaciations, or whether the CL-II ice front is only a recessional advance of an overall "Age IIA glaciation". There is little evidence to suggest a long time interval between the two; although, as will be shown, the criteria for establishing longevity is difficult to find or prove in the permafrost country on the north slope of the Southern Ogilvie Ranges. The two-stage sequence of moraines cannot be traced far upstream from

the confluence of the Blackstone valleys nor can a multiple advance be readily distinguished at the "red limit" (designated Age II) in similar-positioned lower North Klondike or Fish Creek valleys of the south slope of the ranges. Hence, either the map-area has witnessed two glaciations of roughly the same proportions in areal extent or the Age II moraine is a younger recessional advance of a slightly older Age IIA main phase glaciation. Limited stratigraphic exposures do not aid in solving the problem.

The inferred "red limit" by Vernon and Hughes on the lower slopes and floor of "Seela Creek" valley also presents a problem, regardless of the glacial sequence farther downstream. The ice front as shown in Figure 4 implies ice push from the main Blackstone valley into the tributary valley. Considering ice volumes and potential ice producing cirques in the "Patrol Range" to the west this is unlikely. Furthermore the aerial photographs suggest valley glacier ice flow from the Seela Pass and the headwaters of "Seela Creek" into the main Blackstone valley during these times.

The "oldest glaciation" (here designated as the Ogilvie Ground Moraine - Age III or OG-III) was known previously from just outside the area of present study by evidence of erratics only. According to Vernon and Hughes (1966) ice of this age in the Blackstone portion of Taiga Valley probably did not extend into the Central Ogilvie Ranges. However, morainal topography north of the map-area (Fig. 2), somewhat faceted ridge spurs in the ranges (Plate VIB), and known minimal ice thicknesses in Taiga Valley imply the existence of an ice sheet extending in dwindling proportions into the Central Ogilvie Ranges. The upper limits and lateral extent of this glaciation could not be established in this survey. No evidence could be found on the south slope of the ranges to indicate the former presence of this glacial episode.

"Oldest" glaciation may be a misnomer, for surrounding surveys (Bostock, 1966; Vernon and Hughes, 1966) indicate the possibility of a much older glaciation, but this could be a problem in correlation.

Recent glacial advance in the "Tombstone" and "Cloudy" ranges is assigned a late postglacial age (since 600 A.D.) by Vernon and Hughes (1966). In this report it is referred to as the "Little Ice Age" (Neoglacial of Hughes, 1967) and is given a "Re" designation. The survey revealed downstream end moraines detached from the present glacier ice termini and fresh moraines in other recently ice-abandoned cirques -- Crawford (1959) illustrates both with colour photographs. These pictures coupled with aerial photograph observations, reveal that many of the so-called "debris-covered glaciers" of Vernon and Hughes (1966) are actually glacierets of relatively clean ice surfaces. Some debris is always present but as a rule is not too extensive.

TABLE VI Radiocarbon date results from the North Klondike-Upper Blackstone map area and surrounding regions.

STN. NO. [4]	G.S.C. NO.	DEPTH (cm.) BELOW SURFACE	MANNER COLLECTED	LOCALITY [1] - DRAINAGE	MATERIAL	PF?	HORIZON MARKER [2]	REFERENCE [3]	MEAN DATE(B.P.)
99	294	175-185	SIPRE drill	Near "Glacier Ck." - North Klondike	silty peat	yes	Top of colluv. loess	G.S.C.-RC-V	5,190
99	343	60-70 (?)	SIPRE drill	ditto - same hole	fibrous peat	yes	Above volcanic ash	pers.comm.	1,240
211	296	385-395	SIPRE drill	Chapman Lake Moraine - Blackstone	organic silt	yes	Above till-in loess(?)	G.S.C.-RC-V	13,870
211	310	155-170	SIPRE drill	ditto - same hole	fen peat	yes	Above higher loess	G.S.C.-RC-V	9,620
211	311	245-255	SIPRE drill	ditto - same hole	silty peat	yes	Below higher loess	G.S.C.-RC-V	10,900
300	295	345-350	SIPRE drill	Above Chapman Lake Moraine terminus in "Cache Ck." - Blackstone	organic silt	yes	Above till-in loess(?)	G.S.C.-RC-V	6,650
300	409*	265-270	SIPRE drill	ditto - same hole	silty peat	yes	Above till-in loess(?)	pers.comm.	5,290
The following were collected in 1961 or in 1965 from the map area by Dr. O.L. Hughes for this project:									
173	411*	305	Hand	Upstream from north lobe of North Fork Pass Moraine - East Blackstone	organic silt	yes	Above glacio-lacustrine; below loess; in gravel	pers.comm.	5,070
-	469*	130	SIPRE drill	On north lobe of North Fork Pass	peat	yes	Above till	pers.comm.	3,180
-	416*	145		ditto - near above hole	peat	yes			
-	470*	490	SIPRE drill	Northeast side of "Alces Lake" between north and south lobes of Nork Fork Pass	silt with twigs	?	Above till-in colluvium	pers.comm.	11,250
-	471*	210	SIPRE drill	Moraine - East Blackstone		?	Above till-in colluvium	pers.comm.	7,050
-	50		Ship's Auger	On south lobe of North Fork Pass Moraine	gyttja	no	Above till-in paludal	G.S.C.-RC-I	7,510
-	415*	160-165	SIPRE drill	Bogs** @ small pond on terminus of Foxy	peat	yes	Above till	pers.comm.	6,840
-	515*	380-400	SIPRE drill	Creek Moraine - East Blackstone	organic silt	yes	Above till	pers.comm.	13,740
The following were collected during "Operation Ogilvie" "Operation Porcupine" and "Operation Mayo" and pertain to this project:									
-	67	200	?	Northwest end of Hart Lake - Hart (in Age I Moraine = "North Fork Pass Moraine)	marl & organic organic residue	yes	Above peat	G.S.C.-RC-II	12,900 12,120
-	97	200	Hand	Jct. Peel and Bonnet Plume Rivers	wood	no	Above glacio-lacustrine	G.S.C.-RC-II	8,700
-	128	234-235	SIPRE drill	"Gill Lake" - N.Ogilvie Ra.-Ogilvie R. (in Age II Moraine?)	silty gyttja	yes	Bog in terminal moraine	G.S.C.-RC-III	12,550
-	181	2000	Hand	Snake River - Locality beyond Late Wisconsinan glaciated terrain of Laurentide and Montane ice sheets	wood in organic silt	no(?)	Above boulder gravel; below thick gravel	G.S.C.-RC-II	31,000
-	192	Basal	?	Headwaters of Miner River-N.Ogilvie Ra.	peat	?	Impounded by Age I mor.	G.S.C.-RC-IV	6,670
-	331	1830	Hand	2.7 km. S.of Mayo on Stewart River	wood	no	Directly beneath till of McConnell Moraine (?)	Bostock (1966)	46,580
-	365	220-230	SIPRE drill	Twin Buttes, Talbot Plateau-Stewart R.	organic silt	yes	Bog lies beyond limit of late Wisconsinan mor. but inside limit of McConnell Moraine	G.S.C.-RC-V Bostock (1966)	10,840

* Dates will be published in the Geological Survey of Canada's (G.S.C.) "Radiocarbon"-VI paper.

** Drill holes in different positions but on the same bog

[1] Localities may be found on Figure 4, the accompanying Quaternary map, Vernon and Hughes (1966), and in the "Radiocarbon" series.

[2] The age of the organic material fixes a maximum or minimum date to the marker horizon.

[3] Personal communications were by Dr. O. Hughes to the writer in April of 1967.

[4] Station numbers are those of the writer's field designations and are located on Figure 4 and on the 1:50,000 Quaternary map.

Rock glaciers of post Hypsithermal interval were mapped by Vernon and Hughes (1966) on a form basis in the area; apparently only the larger and more obvious are considered, for the observations from this survey reveal about three times the number indicated on their Map 1170A. Many are still active and, where possible, these have been distinguished from obviously dormant rock glaciers on the accompanying 1:50,000 Quaternary map.

Radiocarbon Dating

Table VI records the radiocarbon dates. On the whole the dates are excellent as far as the Age I ice advance(s) are concerned, but are disappointing for the dating of older morainal sequences. The Age I ice advance occurred at least 13,740 years before present; paradoxically, material from the bottoms of two of three bogs located on older morainal surfaces yielded younger ages while the other was only 130 years older. Dating of intermediate samples in the bog cores provided two interesting sidelights. A period of extensive silt deposition occurred about 10,000 years B.P. (Borehole Station No. 211), and a thin volcanic ash layer in the core of Borehole Station No. 99 was deposited just prior to 1230 years B.P. In addition, material gathered from Field Station No. 173 provided radiometric evidence of loess deposition less than 5000 years ago.

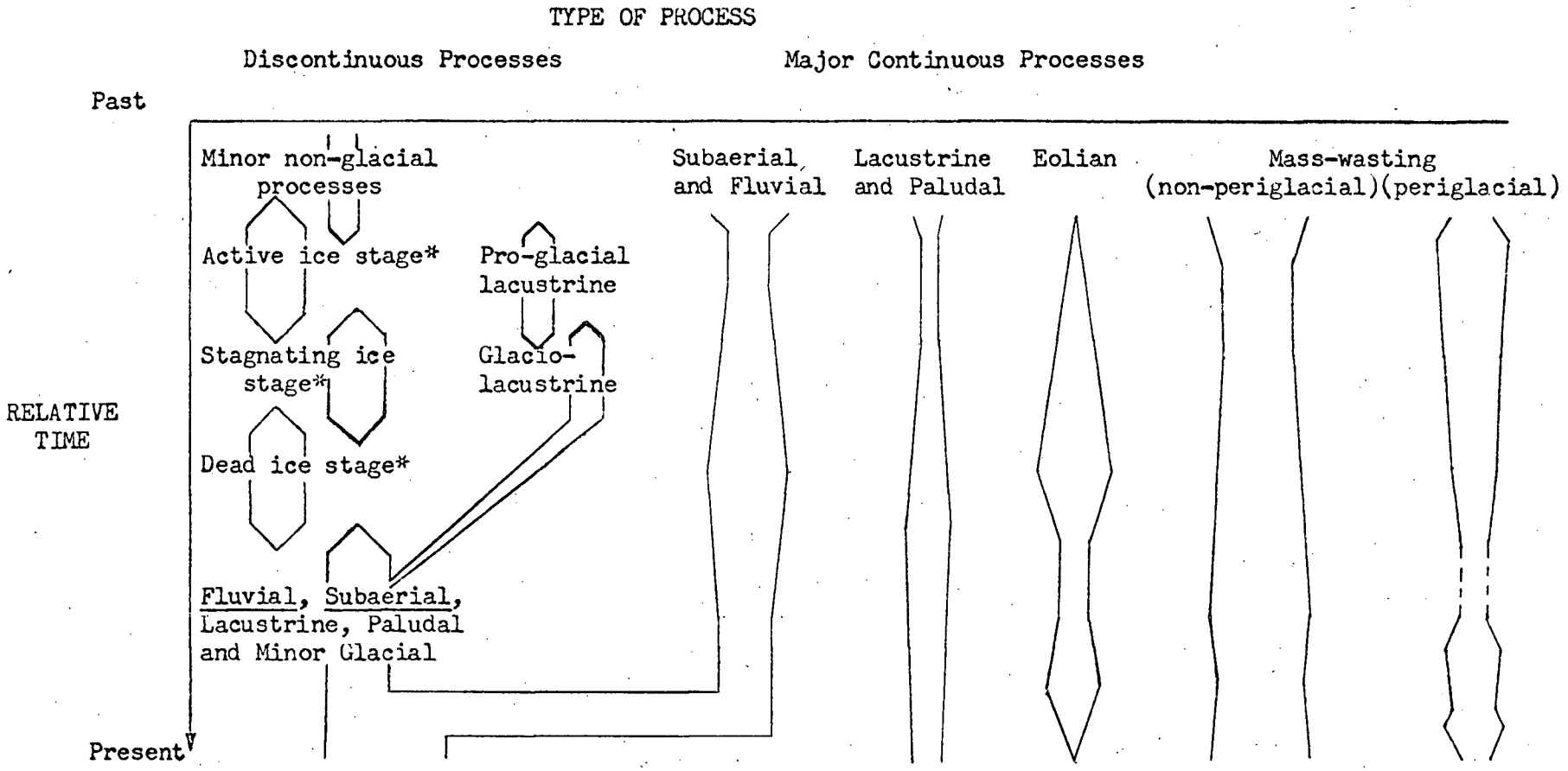
DESCRIPTION AND DISCUSSION OF THE MAP UNITS

Introductory Remarks

Earlier work (Péwé et al., 1965) has established that glacial, periglacial, fluvial, (arid), and eolian geomorphic cycles were and are in operation in the northern Cordillera. These various erosional events have acted both interdependently and in successive stages to produce a complex but sequential series of landforms. Since the glacial cycle has been multiple and of varying extent throughout the northern Cordillera, landscapes are commonly of a compound multicyclic origin. A multitude of previous investigations in especially nearby Alaska has established that landforms are created or modified by glacial, glaciofluvial, fluvio-glacial, glacio-lacustrine, fluvial, mass-wasting, eolian, paludal, colluvial, lacustrine, vegetation successional and pedological processes.

Some of these processes are continuous while others are spasmodic (Table VII). Glacial, deglacial (s.lat.), and eolian processes occur intermittently whereas fluvial, mass-wasting, paludal, colluvial and perhaps organic processes are continuous; that is, continuous in time but not necessarily at the same elevation or geographic position, because the intermittently occurring glacial

TABLE VII Time distribution of geomorphic processes; their relative dynamic interplay in the Southern Ogilvie Ranges of the Yukon Territory.



Notes - The chart considers only one glacial stade and interstadial couplet. Recessional advances are not considered for sake of simplicity.

* These are the sequence of events at one locality on a glacier; upstream and downstream from this locality the active and dead ice stages can respectively be expected.

or other climatically controlled processes may displace their areas of activity. For others it may mean concentrated activity - in either event the processes are operationally adapted to the new climatic and geologic restrictions.

Events or processes directly concerned with glaciation occur in a more or less orderly sequence at any one locality, but not all processes have necessarily occurred or are required to occur at that locality. In a typical mountain glaciation cycle the onset of ice advance creates discharge rivers with broad expanses of gravel flats (= Flint's (1957) "valley trains"). In summer winds may carry the finer particles from the non-vegetated "flats" to areas of deposition tens of kilometres downwind (Péwé, 1951). With a warmer or dryer climate the glacial advance episode gives way to deglacial processes. In this new event ice may still be the main depositional agent during initial ice melting. At any one locality, however, ice becomes less important as a depositional agent as climatic amelioration continues. Glacio-fluvial deposition will give way to an erosional process carried out predominately by the action of running water derived from the wasting ice - called a fluvio-glacial process in this report. In turn a lacustrine deposition may take over if discharge channels are dammed or are exceeded by an increased melt discharge from the nearby ice surfaces. Meanwhile the eolian cycle may have been in action throughout the entire glacial-deglacial cycle and will continue until vegetation reinvades its source area. Often the winds continue to carry loess long after the valley bottom is entirely reinvaded by fluvial, subaerial, colluvial, and paludal processes. As valley slopes are usually exposed initially in a deglaciation cycle, mass-wasting (s.lat.) processes usually precede the non-glacial process in the valley bottoms. Table VII briefly summarizes the interactions and dynamics of principal processes in a typical glaciated locale within the northern Cordillera. The table indicates the need for a careful systematic approach to the organization of morphostratigraphic units (Richmond 1962a) in any mapping project. The writer has chosen to do this by the facies method as adapted by Fulton (1963) for use in studies of deglaciation.

Sedimentary Facies

Concept, Usefulness and Limitation

Given a gradational and sequential change in depositional processes on one hand, with a few isolated depositional events interpenetrating them, the problem of genetic and even non-genetic classification of surficial deposits becomes a complex task. Once the geomorphic form, structure and texture of the sediments

are evaluated, a depositional environment is identified. In other words, an inferred facies is established from the dominant process or processes occurring in that environment at time of deposition. That is, a facies is at once a reflection of: a single process or combination of simultaneous processes, an environment for these processes, and a composition which distinguishes a stratigraphic unit derived from these processes from other units. Where two or more processes are involved the investigator is faced with the problem of determining:

1) the dominant contributing process;
2) the lateral and vertical variation in the relative amounts of these processes; and
3) the possibility of a complete facies change as sharp, but hidden, onlaps in what appears to be a morphologically distinct unit.

In the present study it was noted in the field work that facies changes were generally gradational; or what was once a distinct facies boundary on the surface has since been modified by a secondary or subsequent mass-wasting process (usually gelifluction) so that a pseudo- or secondarily produced gradational boundary is formed. Hence, environmentally controlled processes can yield distinct, gradational, interfingered and mixed superposed geologic boundaries. Despite these pitfalls the observable features of the surficial deposits in the map-area strongly suggest that the processes of the four erosional cycles listed above are also good facies indicators. Where overlap, secondary mixing or simultaneous deposition has occurred in the processes a "mixed facies" has been evolved to represent any of the following situations:

1) simultaneous deposition at one site by two or more of the complex mass-wasting and colluvial processes, or
2) mixing of glacial, deglacial, eolian, or other facies with debris created by mass-wasting and colluvial processes, or
3) reworking of glacial, deglacial, eolian or other facies or combinations thereof by subsequent gelifluction action.

A facies may be regarded in part as a time-rock unit, as Fulton (1963) suggests, in the manner depicted by Table VIII. The table is simplified by avoiding the complication of continually deposited facies; they are difficult to delineate for they are complicated by their merger with fluvial processes of the deglacial cycle as shown in Table VII.

The usefulness of the system can be shown by the use of the glacial "drift" terminology. According to Flint (1957) all deposits associated with a glaciation are called "drift". In the early stages of study of the effects of former glaciations drift was subdivided into non-stratified (till) and stratified varieties. Such a division is useful as long as there is no implication of a

TABLE VIII Relationship of time-rock units to sedimentary facies in a glacial cycle*

TIME-ROCK	FACIES**	RELATIVE IMPORTANCE OF DEPOSITIONAL AGENTS	COMMENTS
GLACIAL	GLACIAL (1)	ICE » WATER, ICE	DEPOSITION DURING ACTIVE ICE ADVANCE.
GLACIAL-DEGLACIAL	"GLACIO-FLUVIAL" (2)	ICE ≥ WATER	DEPOSITION DURING ACTIVE ICE PHASE BUT WITH STAGNATING MARGINS; FIRST ONSET OF CLIMATIC AMELIORATION; TRANSITION FROM ICE ADVANCE TO ICE EQUILIBRIUM TO EARLY WASTAGE STAGES.
DEGLACIAL	"FLUVIO-GLACIAL" GLACIO-LACUSTRINE (3)	WATER » ICE	DEPOSITION DURING FINAL WASTAGE STAGES IN DEAD ICE CONDITIONS.
	FLUVIAL, SUBAERIAL (4)	WATER, WATER > GRAVITY	DEPOSITION RELATED TO GLACIATION BUT TAKES PLACE BEYOND LIMITS OF DEAD OR STAGNATING ICE.
NON-GLACIAL	FLUVIAL, PALUDAL SUBAERIAL, (7) AERIAL ***	WATER, WATER + VEGETATION WATER > GRAVITY GRAVITY > WATER, GRAVITY	DEPOSITION AFTER TOTAL DISAPPEARANCE OF THE REGIONAL GLACIAL EPISODE.

* THAT IS, A CYCLE TYPICAL OF THE INLAND SUBPOLAR GLACIATIONS OF YUKON OR ALASKA.

** NUMBERS IN BRACKETS BEHIND EACH FACIES REFER TO DESIGNATED MAP UNITS OF THIS REPORT.

*** THE AERIAL FACIES IS ACTIVE THROUGHOUT ALL TIME-ROCK UNITS BUT IS MOST PREVALENT OR IN EVIDENCE IN THE MORE RECENT EVENTS.

for the distinction between "Glacio-fluvial" and "Fluvio-glacial" refer to pp. 27 and 54.

PLEISTOCENE TO RECENT

1 — Glacial Facies (Active Ice) – Undifferentiated. Till ± indurated, gravel, and minor sand.
- 1A. Terminal (Frontal, End) Moraine Deposits. } at maximal extent of glaciation.
- 1B. Lateral Moraine Deposits.
- 1C. Ground or Bed Moraine Deposits.
- 1D. Drumlinoid Moraine Deposits.
- 1E. Proglacial Outwash Deposits.

2 — Glacio-fluvial Facies (Stagnating Ice) – Undifferentiated. Gravel, sand, silt, and minor till.
- 2A. Proximal Outwash Deposits ± pitted.
- 2B. Lateral Meltwater Channels and Associated Deposits.* large; small; one wall.
- 2C. Overflow Channel and Associated Deposits.* Drains away from the ice. large; small.
- 2D. Rill Deposits – not associated with obvious channels.
- 2E. Kame Deposits. Frontal aprons and marginal terraces at the maximal extent of glaciation.
- 2F. Hummocky or Ablation Moraine Deposits.
- 2G. Recessional Moraine and Kame Complex Deposits.

* Unless otherwise indicated.

3 — Fluvio-glacial and Glacio-lacustrine Facies (Dead Ice) – Undifferentiated.
- 3A. Eskers and Eskeroid Complexes. Gravel, sand, and silt. >>>>>>
- 3B. Crevasse Deposits. Gravel, sand, and minor silt.
- 3C. Kettled Terrace Deposits. Gravel, sand, and minor silt.
- 3D. Lacustrine Deposits – glacial lake origin. Silt, minor sand and clay.
- 3E. Distal Outwash 'Fan' Deposits – not pitted. Gravel, sand and minor silt.
- 3F. Overflow and Subglacial Channels, and Associated Deposits. large; small.

4 — Fluvial and Sub-aerial Facies – Early Post-glacial.
- 4A. Terrace Deposits – not kettled. Gravel, sand and minor silt.
- 4E. Fan and Bajada Deposits – usually with frontal escarpment. Gravel, sand and silt.

5 — Eolian Facies – Glacial and Post-glacial.
Loess Sheets. Thick blankets >1m.; or thin veneer on any of Units 1-8 as indicated by overlay. Usually the deposit has been reworked by solifluction processes. However, flow lines are not over conspicuous on aerial photos. Thicknesses are given in a few locations. eg. +45cm.

6 — Periglacial Facies – Glacial and Post-glacial.

6A — Lobed Solifluction Deposits – Undifferentiated. Thick mappable entity; or thin veneer of < 1m. on any of Units 1-8 as indicated by overlay. (st) = soil terraces; (lt) = lobate terraces; (sb) = soil lobes; (tm) = tundra mudflows. refer to Sigafoos & Hopkins, 1952. Highway Res. Bd. Spec. Rept. No. 2.

6B (b) — Patterned Ground Deposits. Stone stripes, nets, and circles on valley walls and elevated benches; as beaded stream courses (b); and as ice wedge polygons superimposed on lowland silts that blanket any of Units 1-8.

6C — Rock Glaciers – (AC) Active; (DC) Dormant. Angular blocks and interstitial ice. Spatulate, lobate, and tongue types indicated by geologic boundaries – refer to Vernon & Hughes, 1966. Bull. Geol. Surv. Canada. No. 136.

6D (p) — Peat Bog Deposits – associated with permafrost; palsa type also indicated.

6E — Pingos. Ice and silt.

6F — Felsenmeere. Nonsorted angular blocks. Only those encountered in field surveys are indicated.

7 — Fluvial, Aerial, and Sub-aerial Facies – Undifferentiated. Mainly Late Post-glacial.
- 7A. Fan and Bajada Deposits – usually without frontal escarpment. Gravel, sand, and silt.
- 7B. Fan-head Trench Deposits. Gravel.
- 7C. Alluvial and Talus Cone Deposits. Angular blocks, gravel, sand, and silt.
- 7D. Flood Plain, Meander Belt, and Braided Stream Deposits. Gravel, sand, and minor silt.

7E — Talus and Protalus Deposits. Blocks, grit, and minor silt. As a distinct entity; as a thin or sporadic veneer.
- 7F. Paludal Deposits – not associated with active permafrost. Silt, 'muck,' and minor sand.

7H — Landslide, Slump, and Fragmental Flow Deposits – in bedrock or surficial deposits. Teeth indicate zone of accumulation. Early to Late Post-glacial.
- 7i. Low Terrace Deposits. Gravel, sand, and minor silt.

8 — Mixed Facies
Slope and sheetwash, mass wasting debris, thin veneers of non-lobed solifluction deposits. Occurs as >1m. thick blankets; or as a veneer superimposed on/or sporadically scattered with any of Units 1-9.

9 — Unclassified Deposits
Usually mantled by Units 6A, 7E or 8.

GL — Debris Covered Glaciers and Glacierets – Late Post-glacial. Ice, and interstial blocks and grit.

TERTIARY AND OLDER

R **R+9** — Bedrock – > 25% outcrop exposure; or interspersed with Unit 9.

MISCELLANEOUS SYMBOLS:

Re, I, II, IIA, III – Glaciation and Glacial Stade Indicators – Re = 'Little Ice Age'; I = Late Wisconsin; II = Recessional Pulse of Early Wisconsin?; IIA = Climax Stade of Early Wisconsin?; III = Illinoian?. Symbols are used as prefixes to Units 1, 2, 3, and 4 where practical. With decrease in age the lesser the extent of ice coverage.

– Limits of observed maximal extent of glaciation. Relative age as indicated above.

– Trend of down-valley ice-flow. Drumlinoid Feature; Glacial Strale and Groove.

1405 – Glacial Erractic Locality – elev. m. msl.; Castellated Outcrop.

Th – Collapse Pits; Thermokarst Activity. In segregated or Tabar ice.

+No. 88, ⊗No. 99, +1230 – Geologic Field Station; Borehole Station; Spot Elevation in m. msl.

△2249, △2060, ○439 – Triangulation Station; Bench Mark; Approximate Summit Elevation. – m. msl.

– Gradational Geologic; Assumed or Inset Geologic; Non-geologic Boundaries.

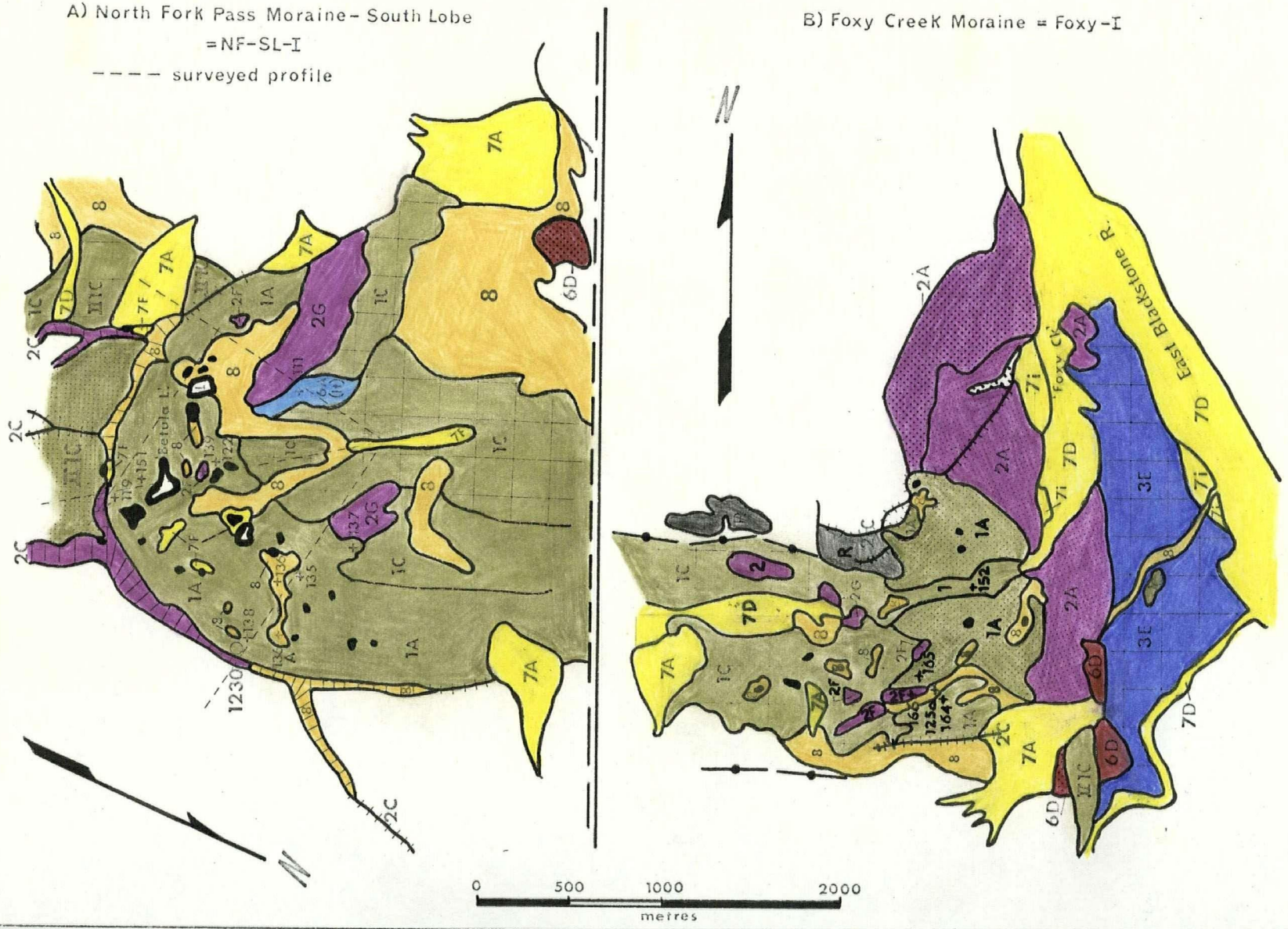
– Highway; Winter or Secondary Roads; Water Power Ditch System.

1500 – Contour Lines. 150 metre intervals below 1500 metres; 300 metre intervals above 1500 metres.

– Lakes; Large Rivers and Streams with Braided Flood Plain.

YCGC – Buildings; Borrow Pits; Yukon Consolidated Gold Company.

FIGURE 6 Surficial Geology of Morainal Termini



PLEISTOCENE TO RECENT

1 — Glacial Facies (Active Ice) - Undifferentiated. Till ± indurated, gravel, and minor sand.
- 1A. Terminal (Frontal, End) Moraine Deposits. } at maximal extent of glaciation.
- 1B. Lateral Moraine Deposits.
- 1C. Ground or Bed Moraine Deposits.
- 1D. Drumlinoid Moraine Deposits.
- 1E. Proglacial Outwash Deposits.

2 — Glacio-fluvial Facies (Stagnating Ice) - Undifferentiated. Gravel, sand, silt, and minor till.
- 2A. Proximal Outwash Deposits ± pitted.
- 2B. Lateral Meltwater Channels and Associated Deposits.* large; small; one wall.
- 2C. Overflow Channel and Associated Deposits.* Drains away from the ice. large; small.
- 2D. Rill Deposits - not associated with obvious channels.
- 2E. Kame Deposits. Frontal aprons and marginal terraces at the maximal extent of glaciation.
- 2F. Hummocky or Ablation Moraine Deposits.
- 2G. Recessional Moraine and Kame Complex Deposits.

* Unless otherwise indicated.

3 — Fluvio-glacial and Glacio-lacustrine Facies (Dead Ice) - Undifferentiated.
- 3A. Eskers and Eskeroid Complexes. Gravel, sand, and silt.
- 3B. Crevasse Deposits. Gravel, sand, and minor silt.
- 3C. Kettled Terrace Deposits. Gravel, sand, and minor silt.
- 3D. Lacustrine Deposits - glacial lake origin. Silt, minor sand and clay.
- 3E. Distal Outwash 'Fan' Deposits - not pitted. Gravel, sand and minor silt.
- 3F. Overflow and Subglacial Channels, and Associated Deposits. large; small.

4 — Fluvial and Sub-aerial Facies - Early Post-glacial.
- 4A. Terrace Deposits - not kettled. Gravel, sand and minor silt.
- 4E. Fan and Bajada Deposits - usually with frontal escarpment. Gravel, sand and silt.

5 — Eolian Facies - Glacial and Post-glacial.
Loess Sheets. Thick blankets >1m.; or thin veneer on any of Units 1-8 as indicated by overlay. Usually the deposit has been reworked by solifluction processes. However, flow lines are not over conspicuous on aerial photos. Thicknesses are given in a few locations. eg. +43cm.

6 — Periglacial Facies - Glacial and Post-glacial.

6A — Lobed Solifluction Deposits - Undifferentiated. Thick mappable entity; or thin veneer of < 1m. on any of Units 1-8 as indicated by overlay. (st) = soil terraces; (lt) = lobate terraces; (sb) = soil lobes; (tm) = tundra mudflows. refer to Sigafoos & Hopkins, 1952. Highway Res. Bd. Spec. Rept. No. 2.

6B (b) — Patterned Ground Deposits. Stone stripes, nets, and circles on valley walls and elevated benches; as beaded stream courses (b); and as ice wedge polygons superimposed on lowland silts that blanket any of Units 1-8.

6C — Rock Glaciers - (AC) Active; (DC) Dormant. Angular blocks and interstitial ice. Spatulate, lobate, and tongue types indicated by geologic boundaries - refer to Vernon & Hughes, 1966. Bull. Geol. Surv. Canada. No. 136.

6D (p) — Peat Bog Deposits - associated with permafrost; palsa type also indicated.

6E — Pingos. Ice and silt.

6F — Felsenmeere. Nonsorted angular blocks. Only those encountered in field surveys are indicated.

7 — Fluvial, Aerial, and Sub-aerial Facies - Undifferentiated. Mainly Late Post-glacial.
- 7A. Fan and Bajada Deposits - usually without frontal escarpment. Gravel, sand, and silt.
- 7B. Fan-head Trench Deposits. Gravel.
- 7C. Alluvial and Talus Cone Deposits. Angular blocks, gravel, sand, and silt.
- 7D. Flood Plain, Meader Belt, and Braided Stream Deposits. Gravel, sand, and minor silt.

7E — Talus and Protalus Deposits. Blocks, grit, and minor silt. As a distinct entity; as a thin or sporadic veneer.
- 7F. Paludal Deposits - not associated with active permafrost. Silt, 'muck,' and minor sand.

7H — Landslide, Slump, and Fragmental Flow Deposits - in bedrock or surficial deposits. Teeth indicate zone of accumulation. Early to Late Post-glacial.
- 7i. Low Terrace Deposits. Gravel, sand, and minor silt.

8 — Mixed Facies
Slope and sheetwash, mass wasting debris, thin veneers of non-lobed solifluction deposits. Occurs as >1m. thick blankets; or as a veneer superimposed on/or sporadically scattered with any of Units 1-9.

9 — Unclassified Deposits
Usually mantled by Units 6A, 7E or 8.

GL — Debris Covered Glaciers and Glacierets - Late Post-glacial. Ice, and interstial blocks and grit.

TERTIARY AND OLDER

R, R+9 — Bedrock — > 25% outcrop exposure; or interspersed with Unit 9.

MISCELLANEOUS SYMBOLS:

Re, I, II, IIA, III — Glaciation and Glacial Stade Indicators - Re = 'Little Ice Age'; I = Late Wisconsin; II = Recessional Pulse of Early Wisconsin?; IIA = Climax Stade of Early Wisconsin?; III = Illinoian?. Symbols are used as prefixes to Units 1, 2, 3, and 4 where practical. With decrease in age the lesser the extent of ice coverage.

I — Limits of observed maximal extent of glaciation. Relative age as indicated above.

, — Trend of down-valley ice-flow. Drumlinoid Feature; Glacial Strais and Groove.

□1405 , — Glacial Erractic Locality - elev. m. msl.; Castellated Outcrop.

, Th — Collapse Pits; Thermokarst Activity. In segregated or Tabor ice.

+No. 86, ⊗No. 99, +1230 — Geologic Field Station; Borehole Station; Spot Elevation in m. msl.

▲2249, △2060, ○439 — Triangulation Station; Bench Mark; Approximate Summit Elevation. - m. msl.

, , ... — Gradational Geologic; Assumed or Inset Geologic; Non-geologic Boundaries.

, , — Highway; Winter or Secondary Roads; Water Power Ditch System.

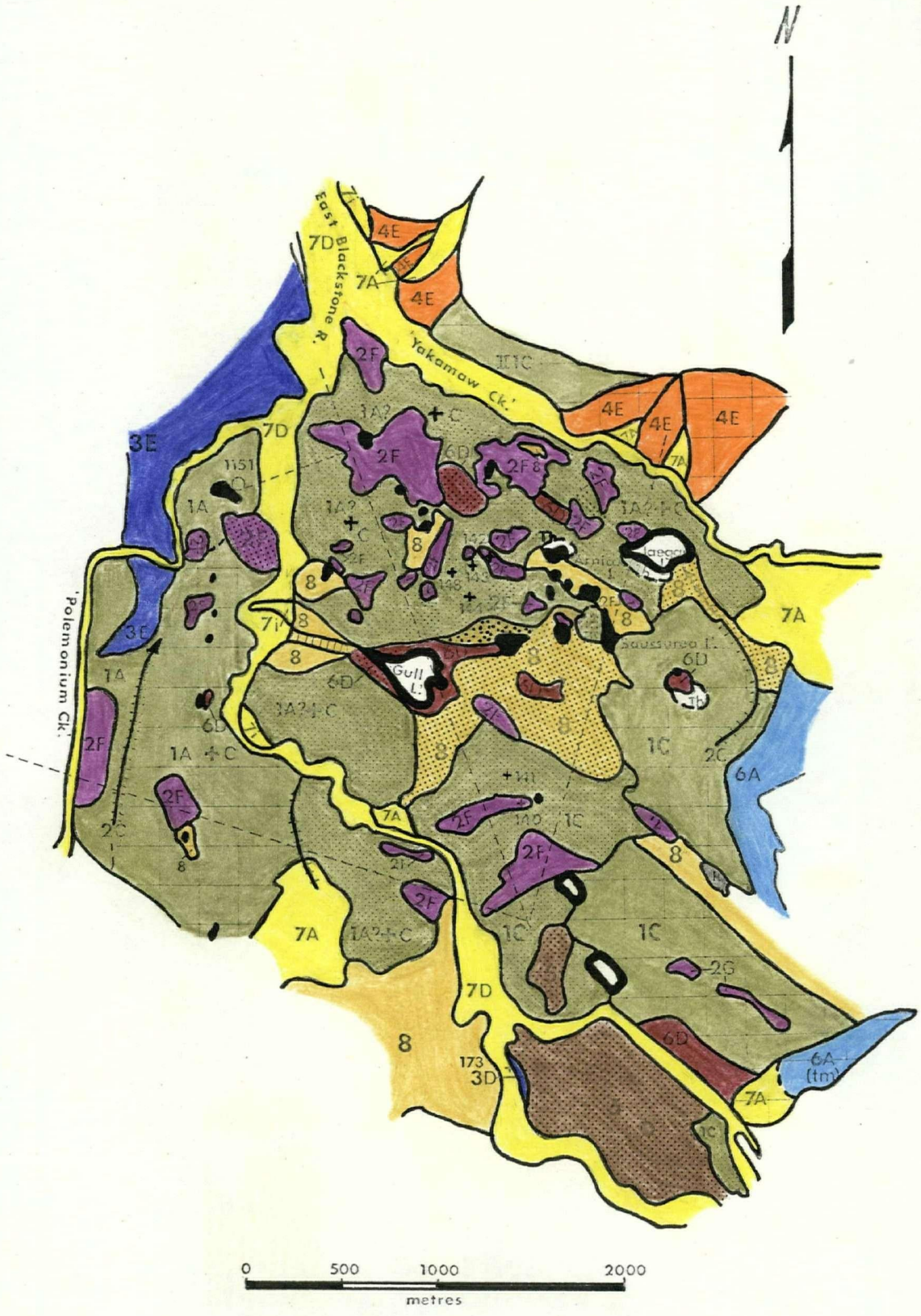
1500 — Contour Lines. 150 metre intervals below 1500 metres; 300 metre intervals above 1500 metres.

, — Lakes; Large Rivers and Streams with Braided Flood Plain.

■ , ● , YCGC — Buildings; Borrow Pits; Yukon Consolidated Gold Company.

Figure 7 Surficial Geology of the North Lobe of the North Fork Pass Moraine = NF-NL-I

---- surveyed profile



PLEISTOCENE TO RECENT

1 Glacial Facies (Active Ice) - Undifferentiated. Till ± indurated, gravel, and minor sand.

1A. Terminal (Frontal, End) Moraine Deposits. } at maximal extent of glaciation.
1B. Lateral Moraine Deposits.
1C. Ground or Bed Moraine Deposits.
1D. Drumlinoid Moraine Deposits.
1E. Proglacial Outwash Deposits.

2 Glacio-fluvial Facies (Stagnating Ice) - Undifferentiated. Gravel, sand, silt, and minor till.

2A. Proximal Outwash Deposits ± pitted.
2B. Lateral Meltwater Channels and Associated Deposits.* large; small; one wall.
2C. Overflow Channel and Associated Deposits.* Drains away from the ice. large; small.
2D. Rill Deposits - not associated with obvious channels.
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* Unless otherwise indicated.

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3A. Eskers and Eskeroid Complexes. Gravel, sand, and silt. >>>>>>
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3D. Lacustrine Deposits - glacial lake origin. Silt, minor sand and clay.
3E. Distal Outwash 'Fan' Deposits - not pitted. Gravel, sand and minor silt.
3F. Overflow and Subglacial Channels, and Associated Deposits. large; small.

4 Fluvial and Sub-aerial Facies - Early Post-glacial.

4A. Terrace Deposits - not kettled. Gravel, sand and minor silt.
4E. Fan and Bajada Deposits - usually with frontal escarpment. Gravel, sand and silt.

5 Eolian Facies - Glacial and Post-glacial.

Loess Sheets. Thick blankets >1m.; or thin veneer on any of Units 1-8 as indicated by overlay. Usually the deposit has been reworked by solifluction processes. However, flow lines are not over conspicuous on aerial photos. Thicknesses are given in a few locations. eg. +45cm.

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6C – Rock Glaciers - (AC) Active; (DC) Dormant. Angular blocks and interstitial ice. Spatulate, lobate, and tongue types indicated by geologic boundaries - refer to Vernon & Hughes, 1966. Bull. Geol. Surv. Canada. No. 136.

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7B. Fan-head Trench Deposits. Gravel.
7C. Alluvial and Talus Cone Deposits. Angular blocks, gravel, sand, and silt.
7D. Flood Plain, Meander Belt, and Braided Stream Deposits. Gravel, sand, and minor silt.

7E – Talus and Protalus Deposits. Blocks, grit, and minor silt. As a distinct entity; as a thin or sporadic veneer.

7F. Paludal Deposits - not associated with active permafrost. Silt, 'muck,' and minor sand.

7H – Landslide, Slump, and Fragmental Flow Deposits - in bedrock or surficial deposits. Teeth indicate zone of accumulation. Early to Late Post-glacial.

7i. Low Terrace Deposits. Gravel, sand, and minor silt.

8 Mixed Facies

Slope and sheetwash, mass wasting debris, thin veneers of non-lobed solifluction deposits. Occurs as >1m. thick blankets; or as a veneer superimposed on/or sporadically scattered with any of Units 1-9.

9 Unclassified Deposits

Usually mantled by Units 6A, 7E or 8.

GL Debris Covered Glaciers and Glacierets - Late Post-glacial. Ice, and interstial blocks and grit.

TERTIARY AND OLDER

R R+9 Bedrock – > 25% outcrop exposure; or interspersed with Unit 9.

MISCELLANEOUS SYMBOLS:

Re, I, II, IIA, III - Glaciation and Glacial Stade Indicators - Re = 'Little Ice Age'; I = Late Wisconsin; II = Recessional Pulse of Early Wisconsin?; IIA = Climax Stade of Early Wisconsin?; III = Illinoian?. Symbols are used as prefixes to Units 1, 2, 3, and 4 where practical. With decrease in age the lesser the extent of ice coverage.

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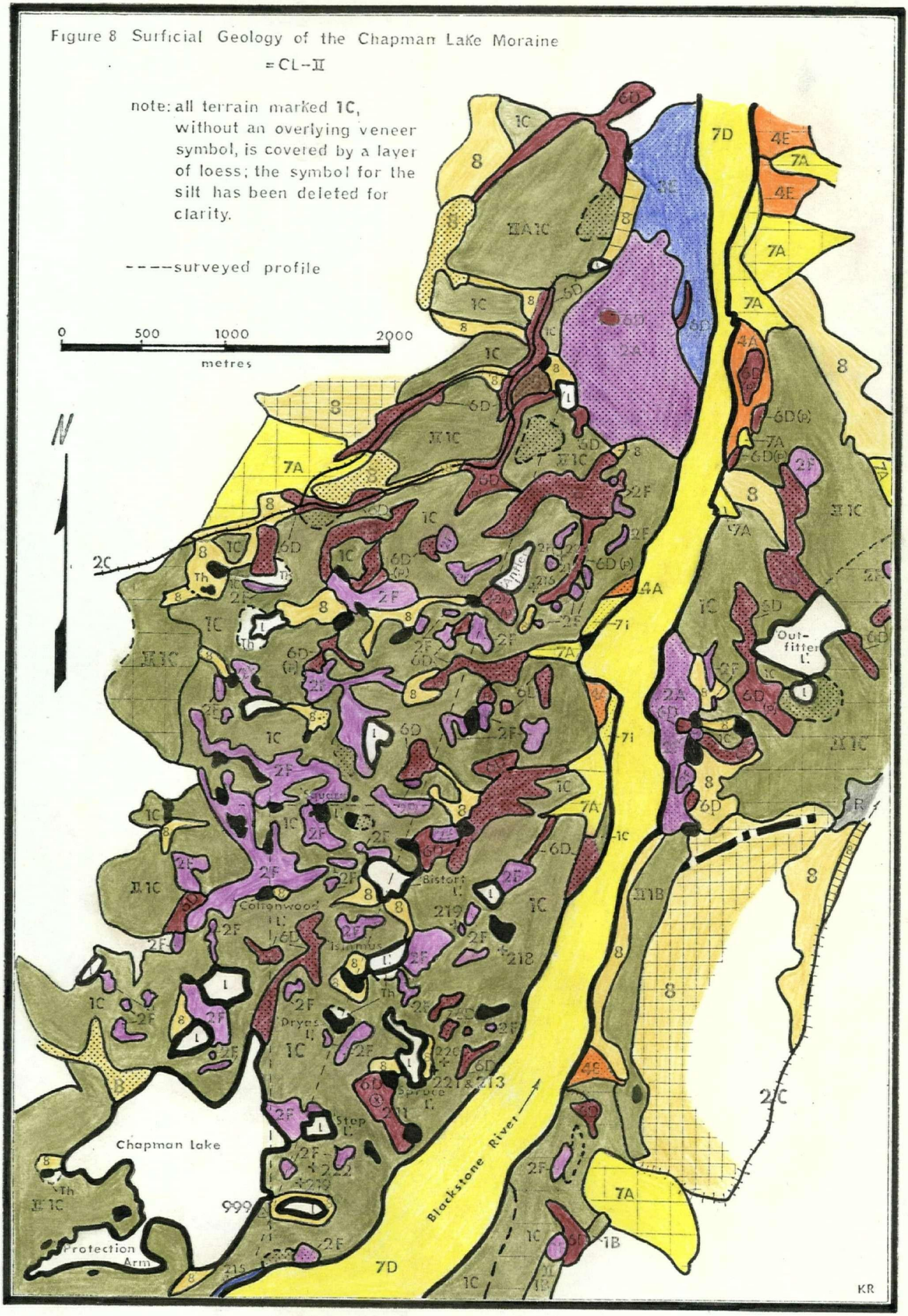
- Lakes; Large Rivers and Streams with Braided Flood Plain.

YCGC - Buildings; Borrow Pits; Yukon Consolidated Gold Company.

Figure 8 Surficial Geology of the Chapman Lake Moraine

=CL-II



time difference between the two. Stratified deposits can grade into non-stratified deposits during synchronous deposition in the active or stagnating zones of glacier termini (Boulton, 1967). However, the agents responsible for their deposition are quite different, and over a period of time during deglaciation water will increase at the expense of ice as a depositional agent. Hence, over a period of time a gradual change of processes has led to a difference in the character of the "drift" being deposited. Or, on a time rock-facies basis a glacial process has given way to a glacio-fluvial process.

Facies Application to Study Area

Since one of the aims of this study is to attempt to establish the sequence of glacial-deglacial events, the various map units are grouped according to the facies outline in Table VIII. In addition the mixed (8), periglacial (6) and eolian facies (5) are considered, but not within the sequential framework of Units 1, 2, 3, 4 and 7. Subdivisions within each of the facies are again a genetic reflection of variations in morphometry, structure and texture. The fluctuations in the depositional processes create distinct elements within the sequence of time and environment depicted by the facies. The subdivision of the facies is based upon the classification of glacial-deglacial features in the works of Mannerfelt (1945), Flint (1957) and Fulton (1963). Fulton used a facies framework for an area of moderate relief that had been subjected to glaciation of the ice-cap style. To adapt his concepts to a valley glaciation in an area of low to strong relief some minor modifications were needed, hence Mannerfelt's units were fitted into Fulton's primary facies classification. The fitting was largely dependent upon the depositional characteristics given by Flint. This may appear at first awkward, but Mannerfelt's classification is based upon position of the unit or element relative to the glacier, rather than on the time sequence of the depositional or erosional agents; hence, some of his groupings had to be dismembered, for the elements within them are not deposited simultaneously.

The classification of non-glacial deposits in the area of study in this report is based on a compilation of fluvial, eolian and mass-wasting processes discussed by Flint (1957) and Thornbury (1954). The works of Troll (1944) and Bird (1967) were used in the gross appraisal of the periglacial facies.

The numbers associated with the description of the units and sub-units to be discussed immediately refer to the map enclosed in the pocket of the back cover of this report and to Figures 6-8. Since the map records five periods

or episodes of glacial deposition, map Units (facies) 1, 2, 3 and 4 are discussed where possible according to the glacial chronological sequence given in the previous section labelled "General Results".

Map Unit 1 - Glacial Facies (Active Ice Environment)

This unit includes all deposits associated with the advance of an ice lobe to its maximal or equilibrium state. The deposits are mostly poorly sorted and poorly stratified tills, but minor lenses or sheets of poorly- to well-stratified gravels, sands and silts have been recognized at the terminal regions of the former glacier. Topographic expression of this unit is highly variable.

The distribution of the glacial facies is intermittent regardless of which of the five glacial episodes is being considered. No stratigraphic sequence has been found in the area that depicts any more than two glacial episodes at any one exposure. The most extensive and best preserved examples of this facies pertain to the Age I and Age II glacial episodes (Fig. 4). Deposits of the Age I glacial facies are widespread at valley glacier terminus positions, but are only intermittently present in "upstream" regions. Morainal "drift" associated with the Age II ice advance is exposed on low broad ridge crests and in lowlands 20 to 25 km upstream from their former glacier termini. In the upper reaches or source areas, the Age II deposits have since been superposed or removed by the succeeding Age I ice advance. On steeper valley walls "drift" of either advance has either never been deposited or has since been retransported by colluvial and solifluction processes. The ice advances prior to the Age II are represented by "drift" exposed only on the uplands of the northernmost portion of the map-area. Morainal "drift" associated with the recent withdrawal of cirque glaciers (Age Re) is displayed as sharp crested features.

Five sub-units of the glacial facies have been recognized in this study. They are similar to those defined and described in Flint's (1957) textbook, and a summary of their form, texture and fabric is given in Appendix IA. Their distribution and significance will be discussed in the following pages.

Sub-unit 1A - Terminal Moraine Deposits

Definition and Terminology

Within the map-area some former valley glaciers have deposited simple and distinct terminal moraines whereas others have left indistinct morainal features or a complex accumulation of deglacial-glacial deposits belonging to map Units 1, 2 and 3. In order to avoid confusion the variety of deposits demarcating

the maximal extent of a valley glacier advance will be called a morainal terminus, without any restrictions on the nature of the enclosing deposits. A terminal moraine in this report is a moderately ridge-like form, comprised predominately of a pronounced thickening of till, oriented transversely to the valley axis, deposited at the maximal downvalley extent during a particular glacial episode. This usage is similar to Chamberlin's (1883) definition of a terminal moraine; however, other interpretations exist.[1] Some morainal termini have been given formal names in this report (e.g. Chapman Lake Moraine - see Fig. 4); the name refers to all of the subunits of deposits which make up the morainal terminus. However, since some moraines are comprised of mainly the terminal moraine component all morainal termini studied in the map-area are discussed and compared to some extent in the Unit 1A sub-facies as well as in Part 2A of this report.

Terminal Moraine Descriptions

Terminal moraines of a recent (Age Re) ice advance are found in the "Tombstone" and "Cloudy" ranges; they lie in east-, west- and northward-facing cirques at elevations more than 1230 m above mean sea level. The moraines are of sharp crested arcuate ridges and are easily visible on 1:60,000 scale aerial photographs. Their basal widths are from 50 to 100 m and the lengths of the crests are 300 to 1000 m. Moraines similar in age, size and form are illustrated by Holmes and Lewis (1961, p. 861) from the Franklin Mountains of the Eastern Brooks Range (Fig. 5).

Age I terminal moraines of small valley glaciers are numerous in the central portion of the map-area. Generally terminal moraines show an arcuate plan with a low subdued profile (e.g. the August 17th Creek Moraine = Aug. 17-I), though

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[1] According to Flint (1957) Chamberlin's usage is undesirable; rather he refers to an "end moraine" as a ridge-like accumulation of "drift" built along any portion of the margin of a glacier, and a terminal moraine is that portion of the "end moraine" built along the downstream or terminal margin of a glacier lobe, whereas a lateral moraine is the end moraine built along the lateral margin of the glacier. Mannerfelt (1945) groups lateral and end moraines as separate entities; "terminal" and "recessional moraines" would be subdivisions of the "end moraine" association in his scheme. Both Mannerfelt's and Flint's subdivisions have drawbacks in the northern Cordillera, for lateral moraines can be tens of kilometres away from a morainal terminus and, hence, can hardly be visualized as the downvalley "end" of a former glacier terminus. Recessional moraines generally depict a glacial-deglacial environmental interface and are not commonly associated with the maximal extent of the glacial episode. Their definitions allow variations in the agent, time, and environment of deposition whereas this report adheres to a narrower set of conditions. For this reason the use of the term "end moraine" will be avoided.

the moraine at "Hart Pass" must be regarded as a glaring exception. Most moraines lie at elevations between 900 and 1200 m at the mouths of narrow valleys in the zone of Unit III grits or Unit XVII quartzites (Table I). Hence, the semi-indurated till has a sandy and porous texture with subangular pebble components showing little signs of weathering. Secondary accumulations of loess and ablation moraine deposits are scarce on these moraines and permafrost, if present, is not near the surface.

The North Fork Pass Moraine (Age I) is a hammerheaded feature in plan with morainal development at the north (NF-NL-I) and south (NF-SL-I) lobes (Plate VIII). The topographic position of the south lobe is rather atypical, for it is on the flat divide of North Fork Pass. Ice flowed southward uphill to reach the pass, from the trunk glacier which reached the East Blackstone-North Klondike through valley 1.5 km north of the pass, due to the deflection created by a barrier ("Dall Sheep Mountain") that stood before the path of ice flow. On the other hand, the ice of the north lobe flowed (with little interference from the surrounding terrain) on a low downvalley gradient towards the common junction of "Foxy Creek", "Yakamaw Creek", and the East Blackstone River. Thus the moraines that developed at each lobe were a product of similar depositional environments.

The NF-SL-I moraine has a corrugated appearance. Three to four distinct crests lie 50 to 100 m apart on it; the crests are sub-parallel to one another, and are separated by troughs 5-10 m deep. The corrugate moraine rises approximately 40 m above the surrounding terrain on an [illegible]pt profile at its outermost periphery. The NF-NL-I moraine, on the other hand, consists of two broadly-convex transverse ridges some 1300 m apart and of 30 m depression between the crests. It rises 35 m above the surrounding flood plain but lacks the distinctive corrugated appearance of the smaller south-lobe counterpart (Plates VIII and XXI).

The crests of both lobes of the moraine are made up of a fresh, semi- to well-indurated, non-sorted, and non-stratified till. The dominant sediment mode is a fine to medium pebble component; pebble shapes are predominately subangular (Table IV). However, mechanical analysis of the till (Table IX and Appendix IIA) reveals approximately 7% more clay-size components in the NF-NL-I tills. This clay-rich condition is no doubt a reflection of the erosion susceptible bedrock zone that lay in the path of the advance of ice that ulitmately stopped at the NF-NL-I lobe. The south-facing slopes above the glacier (in "Rangifer Valley") in the vicinity of "Mt. Andersson" consist of a suite of an easily-disintegrated, highly-altered volcanics and associated fine-grained, sedimentary rocks (Unit IV - Table I). Pebble counts from the till

TABLE IX Relative percentages of sediment component groups in selected tills.

FIELD SAMPLE NO.↓	MORAINE AND RELATIVE AGE	% TEXTURAL COMPONENTS				DOM. MODE
		GRAVEL	SAND*	SILT	CLAY	
24	Tintina Valley** - III(?)	42.9	40.1	11.4	5.6	med. peb.
57	Lower N. Klondike - II	32.9	42.8	15.4	8.1	c. sand
56	Lower N. Klondike - II	40.5	28.0	22.3	9.2	m. peb.
32	Lower N. Klondike - II	Incomplete analysis				?
31	Lower N. Klondike - II	44.1	33.0	15.6	7.3	m. peb.
86	Lower N. Klondike - II	31.7	33.2	20.1	15.0	m. peb.
98C	Lower N. Klondike - II	27.1	33.1	23.8	16.0	f. sand
84	August 17th Ck. - I	38.4	35.3	21.1	5.2	m. peb.
165	Foxy Ck. - I	21.6	32.4	24.0	22.0	v.f. peb.
138	North Fork-South Lobe- I	40.0	27.9	22.0	10.1	m. peb.
151	North Fork-South Lobe- I	36.1	32.1	17.9	13.9	m. peb.
148	North Fork-North Lobe- I	25.5	26.2	26.5	21.8	m. peb.
153A	North Fork-North Lobe- I	35.7	31.0	20.5	12.8	f. peb.
153B	North Fork-North Lobe- I	31.4	31.9	20.5	16.2	f. peb.
127	Chapman Lake - II	29.6	22.5	33.8	14.1	c. silt
215	Chapman Lake - II	52.9	24.1	19.4	3.6	f. peb.
220	Chapman Lake - II	34.8	35.9	20.8	8.5	c. peb.
223	Chapman Lake - II	56.2	28.4	10.5	4.9	m. peb.
240A	Chapman Lake - II	41.7	31.8	19.2	7.3	f. peb.
250	Chapman Lake - II	25.4	32.4	29.0	13.2	f. peb.
240C	Taiga Valley (?) - IIA	34.5	27.4	19.8	18.3	f. peb.
304	Ogilvie - III	33.2	28.1	27.3	11.4	l. peb.

↓ - Refer to Figure 4 for location of stations.

* - Sand includes all grain sizes between 2.0 mm.and .060 mm; granule size group is included in the gravel portion of the analysis.

** - Regarded as a tilloid until further study.

(Table V) yielded a higher than normal percentage of such rock types. Tills are probably more than 25 m thick on both lobes. Porosity of the till is variable; some test pits drained moderately rapidly on either lobe. A few ponds on the NF-SL-I drained during the course of the summer whereas this did not occur on the till portions of the NF-NL-I terminus.

Secondary accumulations on the NF-SL-I terminus appear to be confined to a trace of hummocky gravel and to colluvial-paludal deposits in gullies and closed depressions. Loess was not found on the NF-SL-I. Soil pit studies on the NF-NL-I revealed a congeliturbated gleyed silt on the low-gradient till slopes; an eolian origin is most probable (see Appendix III; soil pit site Nos. 141 and 144). Hummocky gravels are extensive on the north lobe - particularly near the northern margin. The distribution of permafrost is not the same on the two moraines. Permafrost features on the north lobe include the shallow active layer above an interstitial ice-bound sediment, the ice-wedge polygon patterns in swales, the thermokarst activity on pond shores, and the hummocky bog surfaces (palsen features), whereas none of these features were detected on the south lobe.

Analogs of the north lobe are rarely illustrated in the literature, although the Tschwsahmon III Moraine in the White River district is a possible geomorphic equivalent (illustrated by Krinsley, 1965, p. 303). The south lobe resembles the corrugated profile of the McConnell terminal moraine as located at its type locality on the Stewart Plateau (illustrated by Bostock, 1966). Vernon and Hughes (1966) illustrate similar "hammerheaded" moraines of identical age relationships (their "blue limit") in the headwaters of the Ogilvie-Tatonduc River systems (their Map 1170A - see Fig. 2) northwest of this area, in the headwaters of Michelle Creek between the Central Ogilvie Ranges and "Nehru Range" to the northeast (Map 1171A); and in the Police Creek-Middle Hart River area of the easternmost Southern Ogilvie Ranges (Map 1172A).

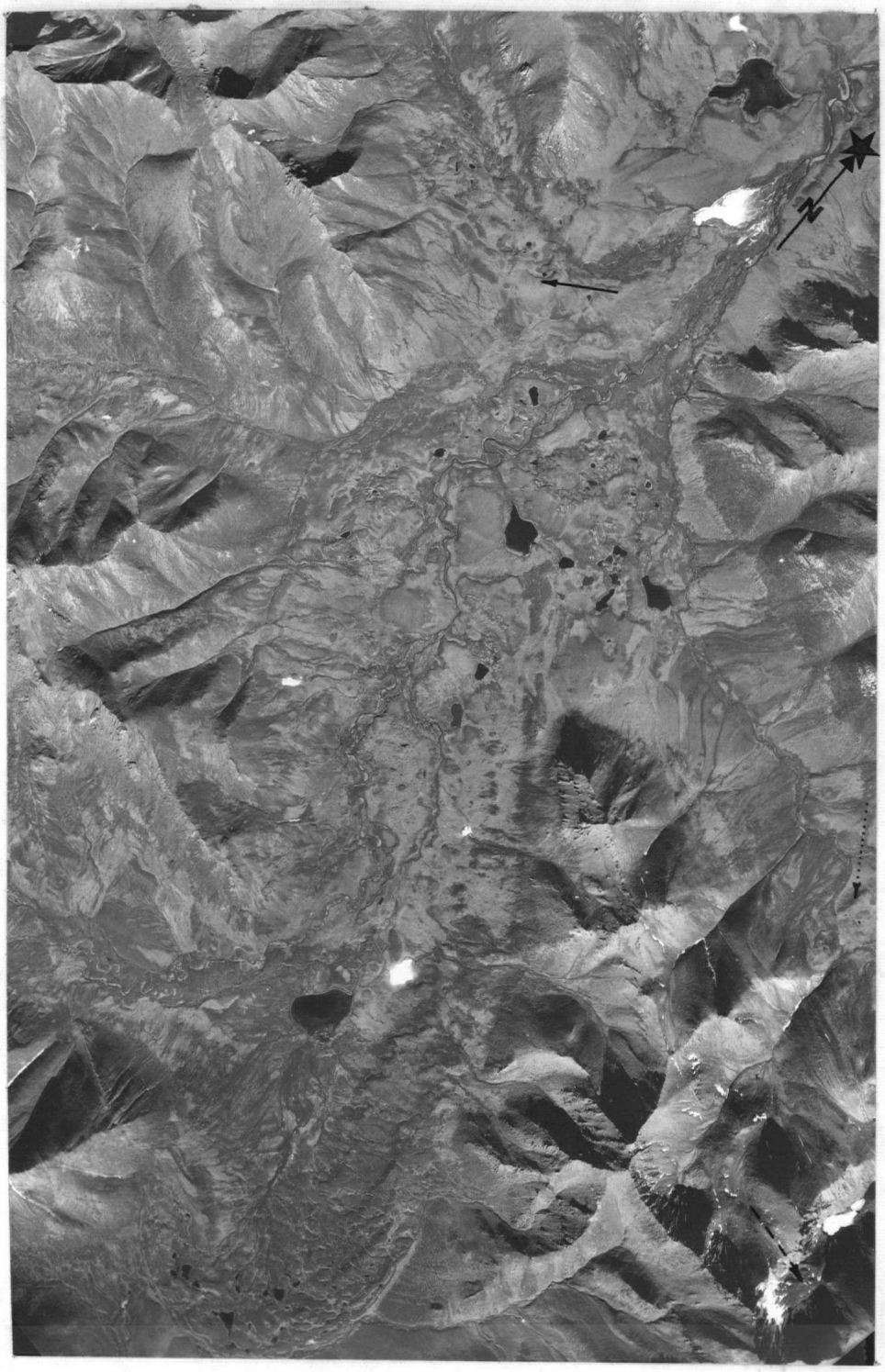
Foxy Creek Moraine (Foxy-I) lies near the larger NF-NL-I terminus (Plate VIII). The moraine rises 60 m above the surrounding valley floors in subdued profile; its two to three arcuate crests are roughly 250 m apart. Possibly it rests upon an older (Age II) recessional moraine. Till in the moraine is rich in clay-sized particles, and the pebble components are derived almost entirely from the carbonate-enriched volcanic unit (Table V and Fig. 3). As permafrost is present at least intermittently near the morainal surface, drainage on the surface of the moraine is poor. Secondary accumulations on the till include gravel hummocks, loess and colluvial-paludal deposits. The moraine is comparable to an unnamed "blue limit" moraine on the upper reaches

Plate VII Lower North Klondike Moraine (Age II) region

(RCAF 13135-5; 1 cm = 600 m)

Snout of former Lower North Klondike Glacier was just out of the lower left hand corner of picture and upper limit of ice is marked by the arrow to the east. Note the meltwater discharge channels (m) esker (e), arcuate recessional moraine (r), ridge of drumlinoid till (d), kettled river terrace at "Mischenko Lakes" (t) and kames (k). The finger-like ridges between the kames are probably gradational features in the kame-esker series.

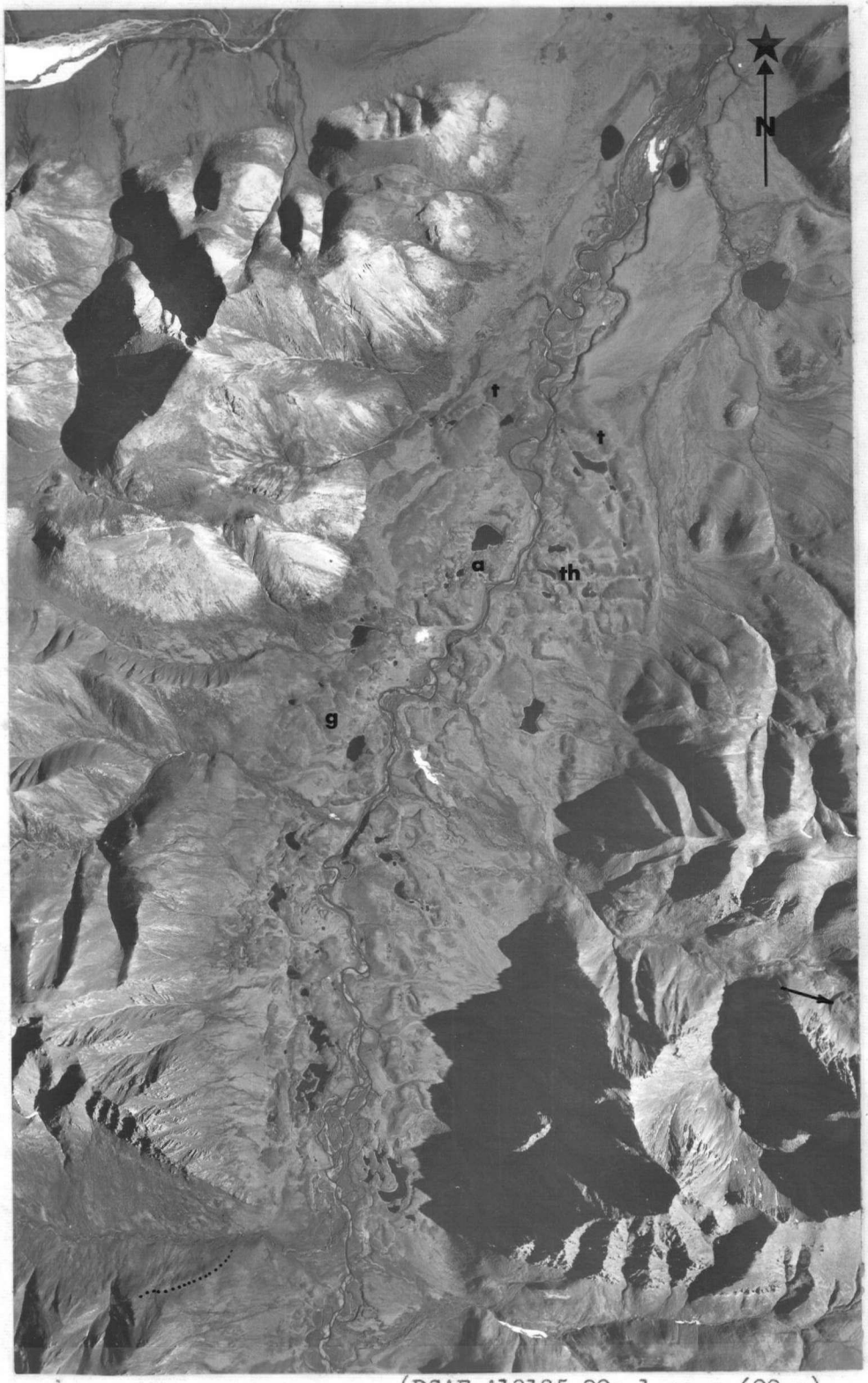
Plate VIII The hammerhead-shaped North Fork Pass Moraine (Age I)



(RCAF 13135-130; 1 cm = 600 m)

Note the corrugated appearance of the south lobe (lower left) as compared to the hummocky swell and swale relief of the north lobe (upper centre). Glacier responsible for the moraine flowed out of the valley coming into the picture from the lower left. Note also: Foxy Creek Moraine (solid arrow), rock glacier of probable complex origin (dashed arrow), and crevasse deposits in "Yakamaw" valley (dotted arrow). East Blackstone River flows from lower left to upper right in the picture.

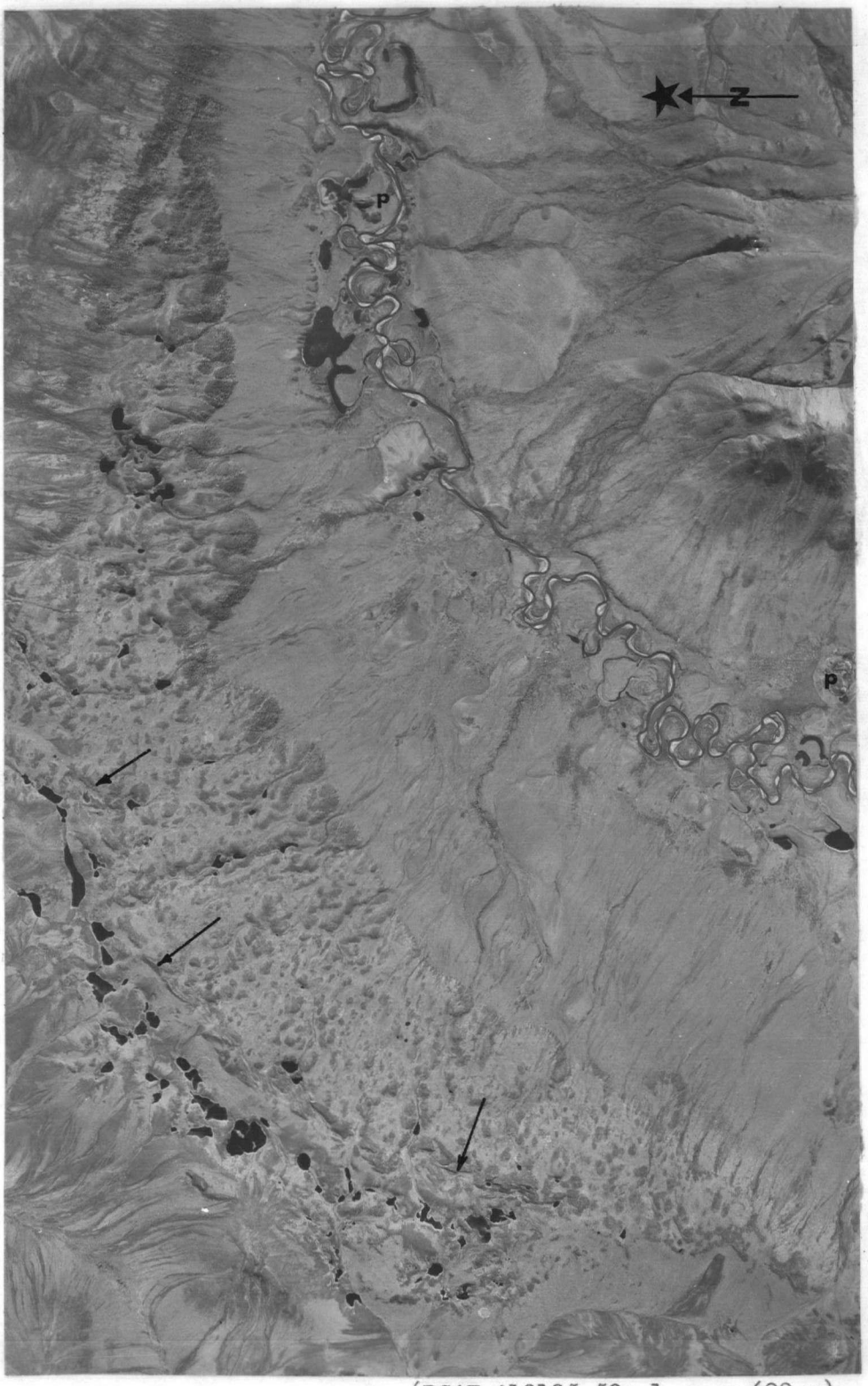
Plate IX Upper Blackstone Moraine (Age I)



(RCAF A13135-20; 1 cm = 600 m)

Note arcuate terminal moraine (t), ablation moraine (a), thermokarst activity (th), icing on "Seela Creek" (upper left), ground moraine (g), active sharp crested terminus of rock glacier (arrow), subdued arcuate moraine of Age I glaciated "Junior Creek" valley (dotted outine in lower left) and incised valley of non-Age I glaciated "Arrow Creek" to the lower right. "Main" Blackstone River flows to the north.

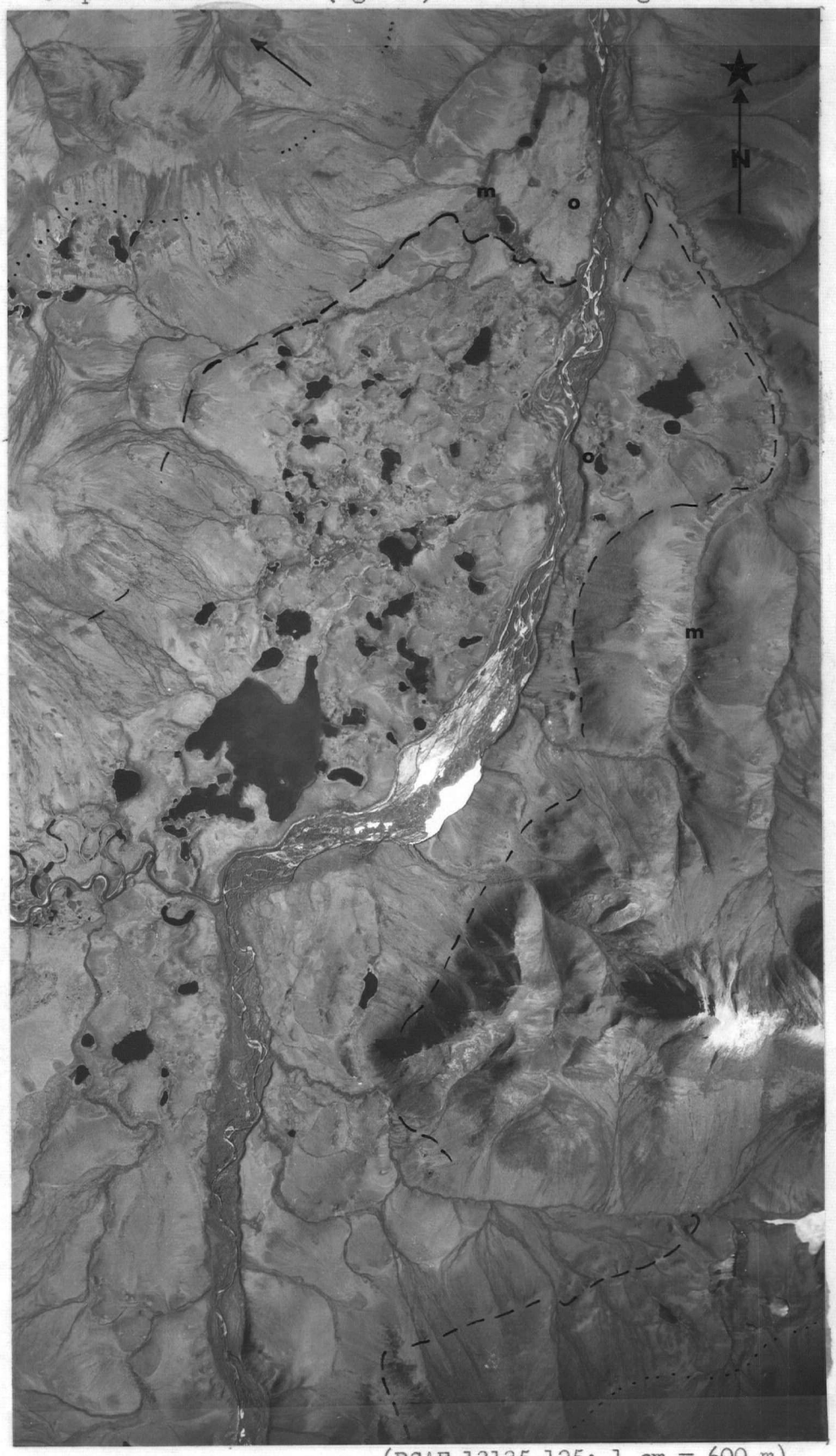
Plate X Lateral moraine complex on "Fitzgerald Ridge".



(RCAF A13135-53; 1 cm = 600 m)

Ice flowed from right to top centre. Upper limit of Age II ice is marked by solid arrows whereas billowy moraines of Age IIA lie in lake-pocked zone to its left. Note pingos (p), thermokarst and cave-in activity on lakes in the incised flood plain of the "main" Blackstone valley and on the billowy moraine.

Plate XI Chapman Lake Moraine (Age II) and surrounding features



(RCAF 13135-125; 1 cm = 600 m)

Age IIA Taiga Valley Moraine (dotted outline) lies above and beyond Age II Chapman Lake Moraine (dashed outline). Age III Ogilvie Ground Moraine indicated by arrow. Note also: meltwater discharge channel (m) and outwash (o).

of the West Hart River (illustrated by Vernon and Hughes, 1966, p. 10), and to terminus "A" of a multiple morainal sequence in the Central Alaska region as shown by Ray (1960, p. 104).

The Upper Blackstone Moraine (Age I) has a single crested narrow terminal moraine in front of a 10-kilometre stretch of deglacial deposits (Plate IX).

Terminal moraines located at the mouths of isolated cirques (Age I and II) are vaguely displayed within the map region. The northeast-facing cirque on the slopes of the "North Twin-Edge" mountain region (Plate XIIC) a peripherally located terminal moraine. The till of the moraine is very poorly sorted and lacks induration; pebble and cobble components are numerous and are very angular. The arcuate ridge of the moraine has been buried by subsequent outwash; no doubt this type of burial is the reason for the apparent absence of moraines at many other cirques.

Morainal termini of Age II do not display distinct terminal morainal ridges within the map-area. At the Lower North Klondike Moraine (LNK-II) the loess covered terminus zone consists of a thin ground moraine sheet (Sub-unit 1C) overlain by a complex of glacio-fluvial (Unit 2) deposits. The Chapman Lake Moraine (CL-II) is more of a borderline case, for it is similar in form to the NF-NL-I moraine. In this instance the loess covered ground moraine displays an irregular swell and swale topography with patterned ground, palsa bog and other periglacial features, and is mantled by intermittent patches of ablation gravel.

The Taiga Valley Moraine (TV-IIA) is similar to the CL-II except that the problem is one of distinguishing between a lateral, terminal and ground moraine in the region between "Gunsmoke Creek" and the Blackstone River. The morainal terminus does not exist in the Blackstone valley but the ice front of the TV-IIA advance was located formerly in the vicinity of the junction of the "Cache Creek" valley tributary to the Blackstone valley.

The Ogilvie Ground Moraine (OG-III) is not represented by any sort of a terminal feature within the map-area.

Discussion

From the foregoing descriptions of moraines several items of importance have been brought forth: namely -

1) there is an acute difference in form between the two lobes of the North Fork Pass Moraine; why?
2) morainal termini are not always marked by a proximal terminal moraine as defined in the introduction, for several processes contribute to the construction of a morainal terminus; and

3) some of the former valley glaciers in the map-area lacked a morainal terminus of any sort.

The simplest (from a depositional viewpoint) moraine in the map-area is the NF-SL-I. The corrugate feature is made up of mainly a terminal moraine subfacies; it could have originated according to the "push moraine" hypothesis as described in Flint (1957). Push moraines are constructed by bulldozing action of the expanding margin of the glacier on the marginal "drift"; however the NF-SL-I feature may be too large to be accounted for by this type of activity. Flint (1957) suggested that the ridge being pushed cannot be higher than 8 m, whereas the south lobe ridges rise at least twice this high on the outer periphery. Dimensionally the south lobe conforms to Flint's description of a "washboard moraine" - a feature yet to be satisfactorily explained by the literature. The low-profiled swells of the north lobe of the North Fork Pass Moraine are a contrast to the steep-sided profile of the arcuate crests of the south lobe.

According to Flint (1957) steep outer faces and greater heights of profiles of terminal moraines imply one or more of the following:

1) steep ice gradients coupled with rapid ice flow and rapid corrasion during valley glaciation; or
2) great loads of coarse drift scoured and avalanched from valley walls in the upstream regions of the ice flow; or
3) the prolonged existence of an ice terminus that had moved slowly to the maximum terminal position; or
4) an ice terminus in a state of oscillatory movements during the climax period of the glacial episode.

These items are no doubt significant but points 1) and 2) cannot be used to account for differences in the profiles and the general makeup between the south and north lobes. Point 3) merits attention for it is not inconceivable that the south lobe of the glacier withdrew at a slower rate than the north lobe. Since the morainal terminus at the south lobe is corrugated, point 4) coupled with point 3) can perhaps be reconciled as contributing to the differences in profiles. That is, while minor recessional oscillations of ice occurred at the south lobe of the moraine the ice of the north lobe may have undergone a different response to the minor surges of ice (e.g. protracted withdrawal).

However, other possible factors accounting for the differences of morainal termini must be considered. For one, the two lobes of till are texturally different, and according to Flint (1957) clay-rich tills are related to low relief forms because the material is more susceptible to solifluction and soil creep - and these processes are certainly active on the north lobe. However, the Age I Upper North Klondike Moraine and probably the Upper O'Brien Creek

Moraine are texturally similar to the south lobe and both have low subdued profiles somewhat similar to that of the north lobe. A second consideration is that (according to Speight, 1940) "a low-gradient, low-velocity glacier inhibits the buildup of a single debris ridge, but rather favours the deposition of an ablation moraine sheet". This may have contributed to the difference between the two lobes, for the ice was on a steep reverse ground gradient at the south lobe and the surface of the ice itself was probably sloping towards the north lobe. Hence, little meltwater was available to erode the terminal moraine at this locality; rather, the water flowed to the north carrying supraglacial ablation moraine with it. On this view the abrupt profile of the south lobe is a consequence of the reverse basal (to the ice) slope condition. The profile has not been modified by deposition of ablation moraine or outwash. Thirdly, the abrupt profile of the NF-SL-I has been preserved because loess was not deposited on the lobe; whereas loess of possibly two periods of deposition blankets the north lobe. The south lobe is relatively isolated from the influence of katabatic winds of the North Klondike and East Blackstone valleys; hence, loess deposition generally missed the North Fork Pass area.

The Age II morainal termini examined by the writer are developed in much the same ways as the NF-NL-I. Ground moraine at the CL-II and LNK-II termini does not progressively thicken in the downstream direction; hence the evolution of a proximal ridge of terminal moraine probably never took place at these locales. Rather the complexity of processes taking place at their termini were probably relatively similar in kind, extent and volume of the various types of depositions occurring at the NF-NL-I moraine. Supraglacial and englacial debris were concentrated in their terminal zones and after deglaciation, the deposition of loess had further modified their primary and early secondary accumulations. Since deposition of loess the CL-II and the NF-NL-I moraines have been further modified by thermokarst activity (refer to map Unit 6 discussion).

The absence of terminal moraines and morainal termini in a few other valleys within the map-area is not unusual. The absence of terminal moraines has been a subject of extensive discussion and controversy in the literature. Since Flint's (1942) lectures on deglaciation it has been generally accepted that the absence of a terminal moraine does not always signify "stagnating" ice conditions; other environmental conditions or implications are possible. In addition to Speight's (1940) argument, presented above, Flint mentioned that the lack of a terminal moraine could also be a reflection of low debris load in the ice, or a retreat of ice without pause from a short-lived, maximum ice front position. Capp's (1916) explanation for an absence of a moraine in the

White River district of Alaska (Fig. 5) put heavy emphasis on the narrowness of valley wall geometry and a high meltwater discharge from the glacier; thus fluvial elimination of any debris carried by the ice had taken place. Speight (1940) has also suggested fluvial elimination was well as the possibility of burial of a morainal terminus by fluvial deposition. Within the map-area many of the smaller valley glaciers of Age I could build only subdued moraines because surrounding fluvial activity and environmental geometry would not permit much morainal buildup during the probable short period of ice existence at maximum position. In the case of the Upper North Klondike Moraine region the ice surface in the terminus zone was inundated by debris brought in from unglaciated tributary valleys such as the "Lil Creek" canyon area. The terminus of the glacier downwasted with little withdrawal and less morainal buildup.

The comparison of morainal termini for purposes of age distinctions and correlations must be approached cautiously. Only those moraines built under similar environments of primary deposition can be compared; even then the type of secondary modifications of these moraines must also be similar for it is the relative degree of change of these modifications that are used for the comparison of morainal form versus time. Some such comparisons have been attempted in Part 2A of this thesis.

Sub-unit 1B - Lateral Moraines

General Characteristics

The distinction between a lateral and a terminal moraine has been discussed. Lateral moraines, as defined for this study area, are commonly ice-deposited debris occurring along the uppermost lateral margins of a glacier. Moraines more or less parallel to a lateral moraine, at successively lower elevations on a valley wall are here called recessional moraines following Holmes and Moss (1955), and are classified under map Unit 2.

Lateral moraine deposits are typically composed of unsorted, unstratified, loose to indurated till, but in the mapping of this report minor pockets of stratified materials associated with the glacio-fluvial facies are also included. Surface form of undisturbed lateral moraines should show a "reverse slope" or tilt to the valley wall as suggested by Holmes and Lewis (1961) and the long axis gradient of the morainal crest can be expected to be irregular. Since steep slopes border many lateral moraines in the map-area, mass-wasting and colluvial processes have obliterated or modified many of them. Hence many lateral moraines are not recognized; some features classified as mixed deposits (Unit 8) are no doubt lateral moraines. In a few instances lateral moraines may never have

been deposited, for Speight (1940) claims that a protected area is required for their successful deposition and preservation.

Lateral Moraine Distribution

Recent (Age Re) lateral moraines of the "Tombstone" and "Cloudy" ranges are sharp crested features; they occur either as isolated ridges, or in places as an extension of the terminal moraine near the mouth of a cirque. The largest one measures 1.5 km in length by less than 100 m in width and borders a glacieret north of "Prune Mountain". Moraines similar in form and age are illustrated by Holmes and Lewis (1961, p. 861) in their Eastern Brooks Range study.

Age I lateral moraines are not common in the map-area. The west wall at the NF-NL-I displays a lateral moraine 1.3 km long that slopes on an even 3° profile toward the former ice terminus (Plate XIIIA). However, the "Rangifer Valley" source area is devoid of any upstream continuation of this feature. In the upper North Klondike valley a lateral moraine ridge complex occurs at the junction of two valleys near "Mt. Frank Ray" in the "Tombstone Pass" region. According to Dr. D. Tempelman-Kluit (pers. comm.) the ridge consists of loose, coarse gravel. No doubt the feature represents a medial moraine developed in either the juxtaposed or, less likely, the inset position (Sharp, 1948) by an ice tributary (originating from the east-facing cirque of "Mt. Frank Ray") as it discharged into the main North Klondike valley glacier.

Other lateral moraines are found at "Pack Saddle Pass", in the "Wolf Creek" valley, near the snout of the August 17th Creek Moraine, upstream from the Upper O'Brien Creek Moraine, northeast and west of the Antimony Mountain massif, and in the upper reaches of the "main" Blackstone valley. Nearly all are subdued in appearance and none are any longer than 1.5 km; those indicated by Vernon and Hughes (1966) in the upper Blackstone valley are too small to plot as distinct entities on the 1:50,000 scale map. The lateral moraines of the upper Blackstone valley plotted by Crawford (1959) are what the writer considers to be glacio-fluvial features below the upper limit of the Age I ice margin. Only one lateral moraine is known to be associated with an Age I (?) cirque floor: a subdued ridge of loose "till" was located in lateral position on the slopes of a basin drained by "Marmot Creek" in the North Fork Pass region. No doubt other isolated cirques have lateral moraines but the moraines cannot be discerned on aerial photographs.

Lateral moraines of Age II, are distinct in many portions of the northern map-area (Plate X). They are almost totally absent near the main axis of the Southern Ogilvie Ranges. In the Tintina Valley or southern region of the

map-area subdued lateral morainal features were detected on photographs of the Guilcher-Rabbit Creek area, and vaguely and sporadically on the eastern limits of the lower North Klondike ice lobe. In the latter area some of the features may be frontal kames. Farther upstream lateral moraines are also vaguely displayed on the slopes of the "Signal Hill" and "Vantage Ridge" regions of the "North Klondike Range". Similar features could not be recognized in the "Snowy" and "O'Brien" ranges.

The lateral moraines of the northern regions exhibit billowy, undulatory, and partially subdued forms on the broad ridges flanking both Blackstone valleys. On "Fitzgerald Ridge" the moraine is a ridge 6 km long, sharp crested, narrow and intermittently continuous (Plate X). In the region known as "The Highlands" (between the "Nehru" and "Agglomerate" ranges) the moraine is lake-pocked and subdued, 1 to 1.5 km wide and with a continuous length of 11 km which blends with the ground moraine on adjoining slopes to the west. Farther north the moraine narrows for "Erratic Ridge" was an obstacle to ice flow; beyond that it can be traced, intermittently and rather vaguely, into the "Pilot Creek" basin (Plates XI and XIIB) and thence into the main Blackstone valley as a subdued feature 100 to 150 m wide. On the lower slopes northwest of "Pilot Peak" this moraine expands and gradually changes into the ground moraine of the Chapman Lake terminus zone near "Outfitter Lake" (Plate XI). The opposing moraine on "Fitzgerald Ridge" cannot be traced to the Chapman Lake terminus zone so easily.

A similar billowy lateral moraine, called the Denali-I (or Donnelly), is described from the McLaren River-Tangle Lakes region of the Central Alaska Range (Péwé, 1965). The Snag and the older Donjek lateral moraines of the Kluane Plateau-Wellesley Basin area of the southwest Yukon also show comparable forms according to the illustrations by Krinsley (1965). Closer to the map-area, the Age II lateral moraine on "Fitzgerald Ridge" is similar in form to a morainal ridge marked as "last glaciation" by Vernon and Hughes (1966, p. 8) on a photograph showing a <u>triple</u> morainal sequence at the headwaters of the Ogilvie River. The sequence lies just northwest of the map-area and is shown on Figure 2. An air photo mosaic of this region suggests that the moraine is more likely to be of "intermediate" or Age II glaciation. That is, the outer morainal loop on their photograph is possibly Age IIA. The unmentioned inner loop is likely to be Age I, or possibly a recessional phase of the Age II ice advance.

<u>Lateral moraines of Age IIA</u> have been listed in a previous section of this report entitled General Results. Most of them exhibit a billowy form in plan

view. On "Fitzgerald Ridge" the lateral moraine is a lake-pocked feature similar in appearance to the Age II lateral moraine described above for "The Highlands" region (Plate X). South of "Geodesy Dome" the billowy moraines of each major valley have coalesced to yield a complex hummocky ground moraine and lateral moraine array. No traces of the east lateral moraine of the East Blackstone valley were found in the "Highlands" area, for ice overrode the ridge to flow into the headwater canyons of the tributaries of the Lomond Creek drainage basin. However, north of "Erratic Ridge" the lateral moraine re-appears; the feature descends at a 7° gradient (Plate XIIA and B) towards the "Pilot Creek"-Lomond Lake divide in the usual billowy and lake-pocked form. The lakes are characterized by steep shores developed by thermokarst and cave-in activity (Plates X and XIIA). North of the "Pilot Peak" area the moraine is again found near "Gunsmoke River" but at this point the geography suggests that this should be considered as one lobe of a bifurcate terminus zone. Hence, it has been mapped tentatively as a ground and terminal moraine, but its form is not too different from that of the lateral moraines just described.

The Age IIA lateral moraines are similar in form to those illustrated in the following reports: the outermost morainal loop of Vernon and Hughes' (1966, p.8) triple morainal sequence; the lateral portion of the moraine (designated "A") from unidentified terrain in Central Alaska (Ray, 1960, p.104), and the Snag and older Donjek moraines in the Kluane Plateau-Wellesley Basin region of the Yukon (Krinsley, 1965, pp. 389 and 391).

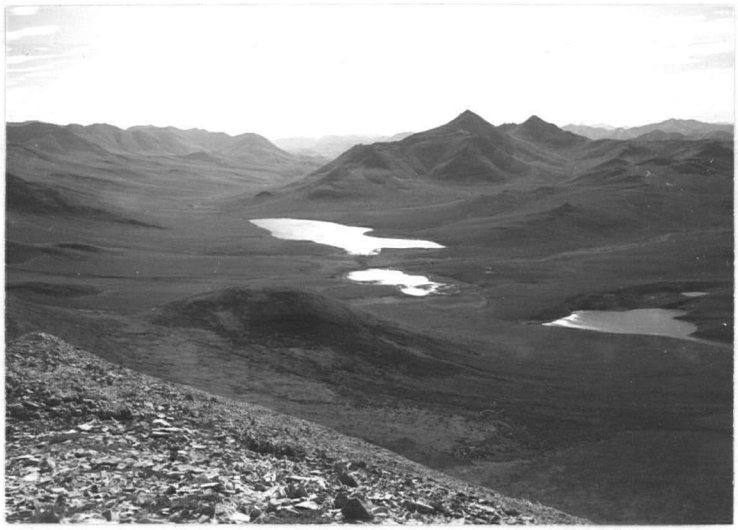
Lateral moraines of the Age III glaciation have not been detected in the map-area. However, the 1:60,000 scale aerial photographs and a photomosaic yield hints of their presence on gentle Blackstone valley slopes some 15 km north of the map-area (Fig. 2).

Sub-unit 1C - Ground Moraine (Bed Moraine or Lodgement Till) Deposits

Introductory Notes

Definition. According to Flint (1957, p. 131) "ground moraine has always connoted the concept of accumulation beneath the glacier"; he defines ground moraine "as moraine having low relief devoid of transverse linear elements". His definition and concept is used in this report though ground moraine occurs in all degrees of modification, and its texture grades into that of other deposits throughout valley bottoms and lower valley walls. Hence it is often difficult to specify the exact mode of origin of a particular deposit. The degree of preservation, gradation or modification not only depends on age, but

Plate XIIA



Lomond Lake and valley (centre) and Age IIA Taiga Valley Moraine (right) showing thermokarst cave-in activity. Photo from "Pilot Peak".

Plate XIIB

Two-fold sequence of moraines in "Erratic Ridge - Pilot Creek" basin area. Dashed line is upper limit of Age II ice; dotted line marks upper limit of Age IIA ice.

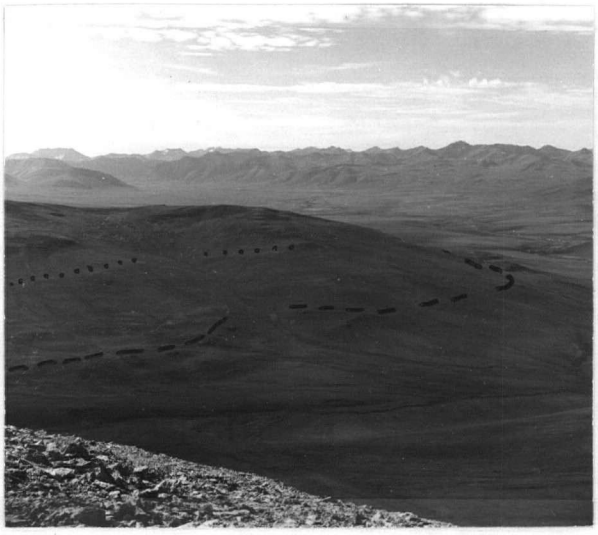


Plate XIIC

Isolated cirque (lower right foreground) from "Discovery Ridge". "Monolith Mtn." (left skyline) is a portion of the Tombstone Stock. "Mt. Frank Ray" (ca. 2360 m), the highest peak in the Southern Ogilvie Ranges, lies to the right.

is also influenced by topography, permafrost, vegetation, the presence or absence of surficial veneers of loess, drainage, and other factors.

Mapping Procedure. Map Sub-unit 1C is best designated as a complex "drift" made up of till of generally subglacial depositional origin and minor covers of colluvium (Unit 8), small patches of thin loess (Unit 5), reworked paludal silt (Unit 7F), pockets of deglacial deposits (Units 2 and 3), volcanic ash, and a variety of debris derived from a complex of mass-wasting processes (Units 6 and 7). When the surficial cover is greater than 20 cm but less than a metre in thickness it is so indicated on the accompanying map by the appropriate unit veneer symbols. Superficial veneer more than 1 m thick is mapped as a separate entity; ground moraine may or may not occur beneath it. With extensive 1:12,500 scale field mapping the complexes intermingled in the ground moraine could be subdivided and reclassified.

Mode of Occurrence. Surface expression of the ground moraine sub-unit varies from a continuous smooth swells and swales through irregular hummocks of low relief to a modified flute terrain. The last is found, for example, on the Age II glaciated west walls of the North Klondike valley. In tributary valleys and on the mid slopes of valley walls the ground moraine occurs as patchy sheets.

General. Ground moraine was extensively examined in the field on Age I and II valley floors and walls; was briefly sampled from a broad Age III ridge crest; but was not examined on "Little Ice Age" cirque floors (Age Re), IIA surfaces, on cirque floors of Ages I and II. Texturally the drift is much the same irrespective of age relationships (Table IX; Appendix IIA). Colours of the till (Table III) and angularity of the pebble components (Table IV) are also much the same throughout the area but the variation in lithology of the pebbles (Table V) is diverse. North of the North Fork Pass area the ground moraine is slightly more modified by permafrost and its association of periglacial features. For convenience textural qualities, thicknesses, distribution and modifications of the ground moraine will be discussed under five regional headings: Lower North Klondike and North Fork Pass Tills of Age II, North Fork Pass Moraine Tills, East Blackstone Valley Tills, Age III Till North of Chapman Lake, and Controversial Diamiction.

Lower North Klondike and North Fork Pass Tills of Age II

Ground moraine is extensive in the mid and lower reaches of the North Klondike valley floor. Throughout this region it is mantled by thin layers of loess and mass-wasting debris. The till is an unsorted, fresh, loose to well indurated deposit that occurs as intermittent thin sheets varying in thickness from a few centimetres to at least 3 m. Mechanical analysis of the till shows

the texture to vary from muddy gravel to muddy sandy gravel. The gravel-sized components are subangular to subrounded in shape (Table IV); subrounded boulders slightly greater than one metre in long axis diameter are found in a few of the borrow pit exposures. Exposures of till become increasingly rare in successively upstream portions of the North Klondike valley. On the lower east slopes of "Dipslope Mountain" near the highway an exposure of till is 5 to 6 m thick and is very sandy and bouldery in texture.

Just south of North Fork Pass the ground moraine is less than a metre thick and is invariably mantled by either a thin layer of solifluction debris or isolated patches of rill deposits (Sub-unit 2D). The matrix of the till is generally less muddy than the till samples of the lower North Klondike region. Monzonite boulders up to 1 m in long axis diameter are not infrequent, and at Field Stn. No. 92 a lag boulder sequence (non-bevelled tops) lies in the basal portion of the till.

North Fork Pass Moraine Lodgement Till (Age I)

Till in this moraine, like the terminus of Lower North Klondike Moraine, exhibits a subdued rolling relief. Some morainal surfaces are blanketed by a 30 cm thick layer of frost-susceptible loess. The tills are unsorted, lightly weathered, and are rich in clay-sized particles. Gravel components, including monzonites 2 m in diameter, are predominately subangular in shape (Table IV). This till may be more than 7 m thick at some localities.

East Blackstone River Tills (Age II-IIA)

In this region tills are mantled by reworked loess and are encased in permafrost. Thicknesses vary from a very scant 30 cm to as much as 25 m or more; the compactness is variable - the less indurated being in the terminus zone of the Chapman Lake Moraine. The gravel-sized components of the till are usually of subangular shapes (Table IV), exhibit only light weathering or alteration, and are of pebble to boulder sizes. The matrix varies from silty to sandy (Table IX); clay-size components increase in the upstream direction. At Field Stn. No. 240 (Plate XIIIB), just north of the Socony-Mobil base camp, the upper 25 m of till in a river cut exposure are separated from a nearly equivalent thickness of clay-rich basal till by a 1 to 2 m thick sequence of varved silts. This lowermost till may be a remnant of the Age IIA ice advance.

Age III Till North of Chapman Lake

This ground moraine occurs on a rounded ridge crest between "Panorama Ridge" and "Chapman Hills". Solifluction is intense in the upper portion of the till on sloping localities but an undisturbed till with a muddy gravel texture occurs beneath a 50 cm layer of gleyed but unfrozen silt on the flatter regions. Due to extensive mass-wasting on slopes the extent of the ground moraine cannot be directly determined, but may eventually be approximated by a compilation of ridge top localities.

Controversial Diamiction (Rel. Age -III?)

On a corner of the Yukon Consolidated Gold Company's ditch system some 2 km south of the North Klondike River intake an artificial exposure (Field Stn. No. 24) reveals an olive-yellow section of unsorted, well indurated, muddy sandy gravel rich in slightly to moderately stained quartzites and other minor clasts (Table V). Black streaks of graphitic schists and carbonaceous material suggest crude structural planes dipping approximately 10 to 15 degrees toward the north. The exposure had been mapped by Dr. H. S. Bostock as Eocene clastic sediments (Dr. O. L. Hughes, pers. comm.) and the interpretation of the planar features was that of "slickensided shear planes that resemble low angle shear planes in the White Channel Gravels[2] at Paradise Hill on the left limit of Hunter Creek above the mouth of Last Chance Creek" some 20 km west-southwest of the controversial exposure (Dr. O. L. Hughes, pers. comm.). However, neither Dr. O. L. Hughes nor the writer preclude the possibility of a glacial till of early Pleistocene age for the following reasons:

1) The structural planes could be interpreted as thrust planes in till created by downvalley ice flow against an uphill barrier or impediment[3], or could represent former thrust planes in the basal ice (as shown in Flint, 1957, p. 73).

2) Striations, some parallel and others randomly oriented, occur on 26% of clasts making up the diamiction; in addition a few pebbles exhibited the typical faceted flatiron and pentagonal forms of glacial pebbles illustrated in Flint (1957).

3) The pebble and cobble components are sound for the most part, they are not nearly as weathered as those in a borrow pit exposure of gravel at nearby Field Stn. No. 57 (Plate XIVA & B) - there all clasts, especially

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[2] Assumed by Bostock (1966) to be pre-Pleistocene or pre-oldest recognized glaciation, but is not the forementioned Eocene clastic sediments.

[3] Dr. W. H. Mathews (pers. comm.) doubts the need of an impediment in the development of thrust planes.

gabbros, crumble upon touch. Admittedly a different set of moisture and permeability conditions occur at the two localities and the lack of severe weathering does not eliminate Tertiary age possibilities. Also, in this connection Bostock (1966) reports an exposure of Klaza (= Age III?) till containing diorite boulders that "crumble on touch" at a locality some 75 km to the southeast of the map-area. However, just southeast of the map-area (in Tintina Valley) the writer spent a few days measuring sections and examining exposures of Klaza till, all pebbles in the till were quite sound.

4) The diversity of rock types, including Tertiary lignite, suggest an older Pleistocene age. However, gabbros and monzonites are typical rock types in glacial deposits derived from the Southern Ogilvie Ranges; despite extensive searching they could not be found in the controversial exposure. Hence, there is still some case for the late Tertiary hypothesis.

Possibly the exposure marks the disturbance in situ of Tertiary fanglomerates by the thrusting action of an overlying pre-Age II glacier. This hypothesis could account for the two types of striations, the lack of granitic clasts, and the presence of structural planes. The section warrants more study.

Sub-unit 1D - Drumlinoid Morainal Deposits

Streamlined molded forms created during the active movement of valley glaciers are intermittently displayed in the southern two thirds of the map-area. One extreme end member of this type of landform series is a drumlin of till and/or bedrock, while the other is a fluted surface in the ground moraine or grooves in bedrock (Flint, 1957). All gradations between the drumlin and the fluted surface types exist on portions of valley floors and slopes. They occur in both the bedrock and in the drift, and one grades into the other. The bedrock forms will be described in the subsection dealing with glacial corrasional features.

The drumlinoid features that occur along valley walls have streamlined, semi-bench-like appearance (= a portion of the Schliffgrenze)[4]; their upper occurrences were often used to establish the maximum upper level of a glacial episode. The drift portion of this form varies from a very indurated sandy matrixed till to a very poorly-sorted "loose" gravel.

Drumlins proper, valley bottom forms, occur in the region once covered by the "Lower North Klondike Glacier" (Age II) between Rabbit Creek and the Dempster Highway; they are superimposed on north-trending swell and swale topography. In aerial photographs some of them appear to be 800 m long and

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[4] In contrast to non-streamlined "semi-bench-like" kame terraces to be described.

200-400 m wide. Those near to the highway consist of a very indurated till and seem to be directionally controlled by the trend of an underlying bedrock structure. Some are nearly identical in form to Armstrong and Tipper's (1948) description of groove-sided drumlins.

Fluted surfaces are best displayed on the floor portions of the headwater regions of many of the tributary valleys; hence, most are of Age I.

The origin of streamlined glacial features varies according to their form. The typical drumlin types are found on nearly flat terrain just south of and above Benson Creek. The uphill basal gradient required of the Benson valley tributary glacier as it flows into the main trunk glacier occupying the North Klondike valley is an ideal environment for development of a drumlin field, according to Armstrong and Tipper (1948). Grooving on the drumlin side is no doubt due to subglacial boulder drag (as suggested in Flint, 1957). Fluted and grooved surfaces on the valley walls and in the headwater regions are parallel to ice flow trends; their exaggerated development is associated with parallel structures in the bedrock - especially in "Wolf" and "Grizzly" valleys. Some may have developed by subglacial boulder drag, and some may have been formed by the molding of till in subglacial tunnels while others may have been produced by a combination of both processes (as suggested by Flint, 1957).

Small areas of streamlined molded forms are common in the generally amorphous ground moraine. These have not been subdivided as mappable entities though occasionally their trend is marked by the drumlin symbol. The line between drumlinoid drift and the general ground moraine is a gradational boundary as far as this map-area is concerned. Some glacial geologists (e.g. Holmes, 1947) would argue a drumlin origin for the previously discussed billowy-surfaced moraines (Plate X); that is, each "pillow" of the moraine is sub-parallel to the former flow of ice. However, the writer suspects that in this region, the ovoid shape of the "pillows" is a secondary product of colluvial, eolian and mass-wasting processes. Nonetheless, streamlined forms are sparse in the northern third of the map-area, and an originally streamlined shape may have become accentuated by these subsequent processes.

Sub-unit 1E - Proglacial (Advance) Outwash Deposits

Introduction

According to Flint (1957) outwash is stratified drift that is "stream built beyond the glacier itself". Proglacial outwash is normally identified by features associated with a contemporaneous ice front of no specific age

relationships (Dr. W.H. Mathews, pers. comm.); in this report the term implies stratified deposition at an ice front up to the period of maximal ice advance. Hence, the subunit is considered (perhaps incorrectly) as a time-rock boundary or time-geoclimatic unit in this report. Therefore, outwash lying beneath the till (= Flint's advance outwash) is of the glacial facies, whereas stratified deposits of apron or fan-like form deposited beyond the ice during ice stagnation and subsequent dead ice phases of deglaciation (= Flint's recessional outwash) are included in map Units 2 and 3. Using this restricted definition of proglacial outwash, possible mappable exposures of this material are limited, for exposures are few, and where till is absent there is no method of distinguishing the younger deglacial outwash from that of the proglacial outwash. The separation of outwash in the 3 facies delimiting the glacial-deglacial cycle was found to be troublesome in this map-area; the presence of outwash in a map-area in fact is a drawback to the use of the facies concept of sediment classification for areas covered by only valley glaciers. The significance of the total volumes of outwash deposition during a particular glacial episode are discussed as a whole under Sub-unit 3E.

Environment

Proglacial outwash is deposited in an aggradational fluvial environment created when channelled flow of drainage water on predominately the ablation surface of an advancing ice tongue[5] discharges out onto a wide valley floor of low gradient in front of the actively advancing ice terminus. Non-glacial "inwash" aids in the development of this environment as well. The section at Field Stn. No. 215 (located on Fig. 4; described in Appendix IB) is perhaps the one most indicative of the onslaught of a proglacial environment. The outwash deposit of Age II overlies an older lacustrine deposit; initially there is a gradual change from a lacustrine to a fluvial environment for sand and granules overlie the silts. After 3.7 m of such sediments a 0.3 to 1.1 m thick deposit of well rounded gravel of the proglacial environment arrives on the scene. This in turn grades into the overlying till. The gradient of deposition of the outwash at this locale was approximately level. However, advance outwash in the North Klondike valley was deposited on about a 0.9%

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[5] In this map-area the ice was probably of the polar type (= temp. below 0°C); hence, little water would move under the ice except at the outermost periphery of the glacier.

gradient; this is within Flint's (1957) suggested limits and is only 0.15% less than a similar gradient of outwash environment located in the Delta River area of Alaska (Péwé, 1965).

Distribution of Outwash

The extent of the proglacial outwash sub-unit remains incomplete because of scanty exposures. In the lower North Klondike region this distribution of fresh gravel beneath the Age II till suggests that a thin, more-or-less continuous deposit may have existed on the lateral portion of the valley while the main bulk of the gravel (now eroded out) was deposited in the axial portion of the valley. Upstream from "Peasoup Creek" proglacial outwash was not found in this region. In the Blackstone valley intermittent deposits of outwash beneath the till occur as far south (upstream) as the "Henry-Caribou Creek" region in the East Blackstone valley. Proglacial deposits of Age I are rarely observed in exposures; they were probably not deposited at the south lobe of the North Fork Pass Moraine, for gradients of both the valley floor and the ice surface were dipping to the north or reverse direction.

Other Features

In the map-area stratified gravels of proglacial deposition could be distinguished from older gravels of non-glacial association by a lack of good stratification in the former. In the case of the lower North Klondike valley, the proglacial gravels lack a well developed zone of oxidation. However, this criterion is not applicable north of the axis of the Southern Ogilvie Ranges for chemical weathering of older deposits was found to be much slower. At all exposures visited the outwash was more than a metre thick; textures vary from sand to sandy gravel to coarse gravels. The gravels beneath the till on the north lobe terminus of the North Fork Pass Moraine have pebbles with a high frequency of disc and blade shapes. At a few localities the disconformably distinct outwash is slightly indurated just beneath an overlying lodgement till.

Miscellaneous Glacial Features (no map unit number)

Glacial Erratics

Holmes and Lewis (1961), Detterman (1953), Péwé (1965), Karlstrom (1965) and Bostock (1952, 1966), to name a few, have relied heavily on the occurrence of erratics to establish the existence and sometimes the limits of older and oldest glaciations in various regions of the northern Cordillera (Fig. 5).

Vernon and Hughes (1966) consider that erratic localities signify the existence of one or two older glaciations (both unnamed) in the "eastern regions" of the Ogilvie and Wernecke mountains and of an "oldest glaciation" in Taiga Valley to the east and the Seela Pass to the west of our study area. In this investigation erratics of an age greater than Age II were found between Vernon and Hughes' localities on ridge tops in the Blackstone valley, but no erratics of similar age were discovered in the North Klondike valley.

The best erratic indicators are the conspicuous plutonic rocks (Table I, Unit XXIB) derived from the axially located Mt. Brenner Stock, Tombstone Stock, "Antimony Mountain Stock" and related apophyses (Fig. 3). Other rock types are not quite as useful though Vernon and Hughes (1966) used the Unit XVII quartzites to establish the western limits of Age II("red limit") ice in the lower North Klondike valley (Fig. 4). With careful appraisal, the writer could also rely on the Unit XX gabbro-dolerites, the Unit III grits, and the Unit IV altered volcanics as indicators.

Erratics were used (for the following:)

1) to help establish the upper limits of "Age II glaciation" in the North Klondike valley and to establish a slope gradient of the former ice surface;
2) to estimate the maximum upper level of Age II ice in the North Fork Pass area;
3) to confirm the glaciated appearance of the upper western shoulder of "Pilot Peak" (covered by Age III ice);
4) to add to the information concerning the extent of ice of the little-known "Age III glaciation".

Unfortunately the topography is too steep and too little of it was exposed during the "Age III glaciation" to establish its upper limits by erratic analysis in the North Klondike region. Krinsley (1965) also noted a scarcity of erratics of the Nisling and Donjek glaciations in the Wellesley Basin area of the Yukon Plateau, and like the writer attributes this to the fact that in high ice fields "nunataks, if present, would contribute little debris to the slowly moving ice". Tempelman-Kluit (pers. comm.) located an erratic at the 1950 m level on the north ridge of "Horn Mountain" (el. ca. 2160 m) in the "Cloudy Range". The find may be well above the Age II and IIA source ice levels in this region, but this cannot be confirmed from inspection of aerial photos.

The upper limit of known "Age II (or IIA) ice advance(s)" in the North Fork Pass area is not known precisely, for all erratic localities are on slopes subjected to solifluction or other mass-wasting processes. For example, the highest recorded locality, 1470 m, is on semi-stabilized talus. "Erratic Ridge" is a locality prolific in erratics, which are probably of both Age IIA

and Age III. This demonstrates the difficulty of relying wholly on erratic analysis for the delineation of old glaciations when two or more of them have termini beyond or "downstream" from the erratic locality. Also it is possible that the "Age III glaciation" is not the oldest in the area. "Age IV glaciation" is suggested, provided the inferred correlations of glacial episodes is correct, by modified drift and erratic localities elsewhere in Alaska (Péwé et al., 1965) and the Yukon (Vernon and Hughes, 1966; Bostock, 1966), but no definite evidence for it was found in this study area.

Corrasional Features

U-shaped valleys, and the related development of horns, arêtes, and hanging valleys have been described and discussed by previous investigations in this region.

Within the study area striae were seldom found on bedrock even in moss-protected situations, for the abundant quartzites and the erosion-susceptible fine-grained sedimentary clasts are notoriously poor media for their retention. Since the climate is ideal for frost riving processes, and the past tectonic history was conducive to the development of joints, the glacially-polished bedrock surfaces have been shattered enough to destroy striae in the cherts, slates, and carbonates. Some striae were found on quartzites in the "Mt. Cairnes" vicinity of the North Klondike valley; but none was found in the North Fork Pass area. No crescentic marks or chattermarks were located on the traversed areas. Hence glacial grooving, stoss and lee, crag and tail and drumlinoid forms are of much more practical use in determining the trend of glacial ice flow than are glacial striae in the study area. Grooves are found on valley walls and floors and drumlinoid bedrock features are found only on valley floors south of latitude 64°40'N. Both types are equally numerous on Age I and Age II glaciated surfaces.

The map in this report does not indicate all the grooves that are exposed in the area; only the most obvious ones in a "field" are plotted. As expected, their orientation indicates a flow of ice parallel to the general trend of the valley in which they lie. The sudden disappearance of grooves up a more or less uniform slope (geologically and topographically) was used as an indicator of maximum ice extent when corroborative evidence downstream or upstream from the interface is available. This type of indicator was very useful in "Foxy Creek" and in certain tributaries of the O'Brien Creek valleys; however, due to the unfavourable orientation of structural planes such features were much more difficult to discern in the "North Klondike Range".

"Drumlinoid bedrock forms" is used as an inclusive term for stoss and lee, crag and tail, and other streamlined ridge forms. Many of these occur in the areas of drumlinized drift. A very pronounced drumlinoid feature is developed in the monzonites of the Tombstone Stock at the headwater region of the Blackstone River. Many similar but less pronounced features are noticeable on aerial photographs, and these permit reliable conclusions concerning ice flow.

Faceted spurs below sharp ridges were found on the aerial photographs of most major valleys in the southern two-thirds of the map-area (Plate IIIB). Facets were useful in marking the upper limits of the Age I and II ice advances in the North Klondike and O'Brien valleys, for they are often at the same elevations as other glacial features elsewhere in the valley (e.g. "Wolf Creek" valley). Without this type of additional information it was not possible to assign ages conclusively to the facets, and for this reason many have not been used as glacier formline indicators on the accompanying 1:50,000 scaled map.

Faceted spurs associated with the older glaciations are difficult to confirm. For example, a set of distinct facets exists below sharp ridge crests and above an Age II moraine in Fish Creek valley but there is no other glacial evidence to relate this set to an "Age IIA or Age III glaciation". Due to the erosion susceptibility of the Unit IV altered volcanics and Unit IX fine-grained clastics (Table I) Age II, Age IIA and Age III faceted spurs could not be distinguished with any assurance in the East Blackstone valley. A study of such features farther to the north in the Central Ogilvie Ranges (Plate VIB) may lead to some information concerning the extent of older glaciations, if tied into other glacial features (erratics, till, etc.).

Cirque development is a preliminary phase and usually also a final stage of valley glaciation in an area of high relief (Flint, 1957). Since the extent, period of development, and internal geomorphic characteristics of cirques have been indicated by Vernon and Hughes (1966) as shown in part by Figure 4, they were not given specific attention in the field study. A few were visited during the course of routine surveys for other features.

The development of a cirque first by nivation, then by glacial corrasion, and again still later by nivation is reviewed by Flint (1957). Primarily, preferential accumulation and summer preservation of snow are the factors limiting these processes and, hence the distribution of cirques. According to Bird (1967) and Flint (1957) bedrock structure and type is only a minor consideration in cirque development, and the role of bedrock in the distribution of cirques has seldom been convincingly demonstrated. In the present study it was found that under the nearly uniform granitic rock conditions in the

TABLE X Elevations and orientations of cirques containing ice in the late glacial phase of the last Pleistocene ice advance.

AREA[1] Western Region	Eastern Region	AVERAGE ORIENTATION[1] AND ELEVATION[2] (m.m.s.l.) OF CIRQUE FLOORS[3] West	Northwest	North	Northeast	East	Southeast, South, and Southwest
	*Central Ogilvie Rge.	-	1520(1)	1450(1)	1520(1)	-	-
	*"Nehru Rge."	-	-	-	1450(2)	-	-
*"Rangifer Rge"		1680(1)	1680(3)	1600(2)	1520(1)	-	-
	*"Agglomerate Rge."	-	-	1560(2)	1520(1)	-	1650(3)
"Cloudy Rge."		1800(1)	1690(5)	1630(3)	1660(4)	1610(9)	1660(5)
	"Prospector Rge."	1520(1)	1460(1)	1520(1)	1680(1)	-	1570(1)
"Tombstone Rge."		1580(5)	1480(5)	1480(4)	1510(6)	1570(2)	1580(4)
	"O'Brien Rge."	1340(1)	-	1378(1)	-	-	-
	"Snowy Rge."	1490(6)	1450(3)	1440(6)	1450(3)	-	1510(3)
"North Klondike Rge."		1520(8)	1395(6)	1490(6)	1400(6)	1430(1)	1510(3)
VARIATION IN ELEVATION		1400 1340 -1800 -1520	1280 1420 -1830 -1570	1400 1300 -1740 -1600	1340 1370 -1700 -1680	1430 - -1680 -	1440 1490 -1710 -1680

[1] Those ranges west of the East Blackstone - North Klondike valley system are in the western region. The ranges are arranged on a north to south latitudinal basis.

[2] The elevations refer to the uppermost cirque floor if the area in question is in a pater noster series of basins.

[3] Those cirques occupied at present or previously by recent cirque glaciers are not included in this analysis.

* Elevations are much more approximate than those not asterisked; all elevations are taken fron contour maps; frequency of cirque floor occurrence given in brackets.

"Tombstone", "Cloudy" and Antimony Mountain of the "Snowy" ranges cirques are more abundant on northward facing slopes, as compared to other slope directions. The relative scarcity on southern exposures is a reflection of the contrast in insolation and in, as will be shown shortly, windward orientation to the late Pleistocene storm tracks. In these areas cirques are present, to come extent, on the southeast-facing slopes; but in the surrounding areas where sedimentary rocks have a pronounced southeasterly regional dip (the direction of the dip of the thrust sheets) cirques are rare on the southeast exposure but numerous on the west-facing escarpments (Table X). Hence, to some extent structure has exerted a control on the development of cirques (c.f. Fig. 4 with Fig. 3).

Vernon and Hughes (1966) have separated Age I cirques from older cirques on the following geomorphic criteria: the pattern of internal drainage, erosion of arêtes and the distribution of rock glaciers and tarns. Though these clues may apply to the southern Ogilvie region as a whole, local complications of varying lithology, recent glacier occupation and stage or type of development of cirque (incipient versus mature glacial) have lead to some inconsistent age assignments. Cirques are well preserved in the quartzites and monzonites not only because of the relative short time span since the Age I glacial episode but also because of the nature of the rock, which makes a good substrate for corrasion but is resistant to subsequent erosion. Rock glaciers, as it will be shown under map Unit 6 discussion, tend to develop in the quartzites, while lake basins are common to the monzonites (c.f. Fig. 4 to Fig. 3).

Cirques are spectacularly developed where they have been associated with valleys once harbouring extended Age I valley glaciers; coalesced cirques are classically displayed in the headwaters of "Wolf" and "Axeman" creeks. Paternoster series of basins and riegels are typical of many tributary valleys of the "Cloudy" and "Tombstone" ranges and are best developed in the "Twin Lakes", "Syenite Lakes", and "Azure Lake" regions. In these areas each of 3 to 4 basins in the steep-walled valley is separated from the next by a nearly vertical drop of 70 to 200 m and the basin of "Azure Lake" itself is a typical hanging valley above the Blackstone valley floor - the sudden drop between the two is at least 210 m. The development of successive cirque basins in a valley is given by Flint (1957) so well the description warrants direct quotation with respect to those in the study area - - -

> "At the heads of some valleys two to as many as five small cirques, separated from each other by short vertical distances, have been reported, only the highest one now containing a firn bank. Probably such flights of cirques, constituting a sort of stairway, formed successively from lowest to highest during the rise of the snowline following the last glacial maximum. We might deduce that, during sufficiently slow descent of the snowline at the beginning of a

> glacial age, cirques form in sequence from the top downward; the lowest firn bank becomes a glacier and rapidly enlarges its cirque, which engulfs one or more of the higher cirques, erasing the evidence of their former existence. With subsequent rise of the snowline, new cirques form at successively higher altitudes if slopes are not too steep ..... This theoretical sequence explains the common occurrence of only a single cirque at a valley head and also the local occurrence of more than one cirque."

The foregoing theory could be disrupted by a lithologic control of corrasional processes and to some extent this is the case in the spectacular examples. Resistant gabbro-dolerite sills (Unit XX; Table I) separate two successive basins in the "Azure Lake" and "Twin Lake" areas; and a change from monzonite rock to incompetent sediments occurs between the lowermost and middle basins of the "Syenite Lake" region.

The elevation of cirque floors has often been used to determine the past elevation of the orographic snowline in a region (Flint, 1957). Péwé and Burbank (1960) and Miller (1961) have successfully used this criterion in Alaska. The test has been attempted, despite the probable drawbacks of lithologic and structural control of development, on the Age I cirques. Nearly all cirques have fed a valley glacier, at least a short one, but only those with a flat floor are considered in the figures presented in Table X. This floor is interpreted as being developed during the cirque phase at the culmination of late glacial-deglacial stages of the last Pleistocene glaciation (as per Flint's theoretical sequence in a previous quotation), and this should override the objections that might be raised about the use of the non-isolated type of cirque[1].

The data suggest an orographic snowline at 1400 to 1670 m (m.s.l.) level with an inclination to the southeast. It averages about 120 m higher to the north of the main axis of the Southern Ogilvie Ranges; and, from sparser data are an average 50 m lower in the west compared with the east in the map-area; the latter figure will no doubt increase when cirques in the "O'Brien Range" are fully investigated. Paradoxically the southeast region of the "Snowy Range" is devoid of cirques. Tentative interpretation suggests, despite this anomaly, that heavier precipitation was brought by moisture-laden winds from the Gulf of Alaska via the eastern Yukon Plateau; for Hughes (1966) suggests a northwestward ice advance to account for the glacial deposits in the Stewart Plateau (Fig. 2). In turn, Vernon and Hughes (1966) define a transection

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[1] as opposed to an isolated type of cirque - see Plate XIIC.

glacier system of Age I relationships that gradually disappear as it approaches the Southern Ogilvie Ranges from the southeast (Fig. 2). Coincidentally, the extent of older glaciations once blanketing the Yukon Plateau are shown by Bostock (1966) to gradually dwindle to the west and northwest and Vernon and Hughes (1966) indicate a reduction in Age II ice cover towards the west and northwest portions of the Ogilvie Mountains.

The increase in the orographic snowline on the northward rain shadow of the range axis is in agreement with observations in the Central Alaska Range to the west, as outlined by Wahrhaftig and Cox (1959), Péwé (1965b) and Péwé et al. (1965). The Late Pleistocene snowline is roughly the same as that quoted (1420 m) for the Yukon-Tanana Upland by Péwé and Burbank (1960).

Some cirques glacierized during the "Little Ice Age" are lower in elevation than similarly-oriented surrounding Age I cirques that escaped this later event. However, the lower elevation is probably not due to the recent corrasion of the "Little Ice Age" ice, but rather to the more favourably shady environment that permitted the longer survival of Age I ice in these cirques. Since the gradual disappearance of this Age I ice, glaciers have redeveloped in these cirques during recent ("Little Ice Age") times.

Map Unit 2 - Glacio-fluvial Facies

Deglaciation or events directly associated with the deglacial cycle can occur as a progressive series of changes of the wasting of the ice lobe, and of the type of deposition around the ice lobe. Flint (1942, 1957) distinguished between thinning actively moving ice and detached ice masses and discusses a kame-esker series of deposition, but does not organize a picture of consecutive events and their related processes in deglaciation. Initial thinning of actively moving glacier ice is referred to by Fulton (1963) as the transitional or early stagnating phases of deglaciation and is characterized by supraglacial runoff controlled by the regional gradient of the ice surface. As downwasting on the less actively moving glacier continues meltwater runoff is diverted to a marginal drainage for the ice surface generally develops a pronounced convex-up transverse profile - this stage of deglaciation is referred to as the stagnating phase by Fulton. When wastage has reached the stage of inactive ice, detached ice masses, and thin concave-up hummocky-surfaced ice tongues meltwater runoff is by in large of subglacial and englacial drainage, and the stage of deglaciation is referred to by Fulton as the dead phase. Not all phases are necessarily represented by characteristic depositions during a deglacial cycle.

Map Unit 2 is concerned with deposition and erosion during the stagnating phase of the deglacial environment; the unit also includes possible deposition during the transitional phase, for in a region of valley glaciation the distinction of deposits or erosional forms associated with either phase of deglaciation was found to be generally inconclusive. That is, the map unit is concerned with those deposits associated with retreat of actively moving ice. Map Unit 3 deals with the products of those processes associated with the dead phase. The 1960 edition of the Glossary of Geology lists the terms glacio-fluvial and fluvio-glacial as synonyms. However, for the purpose of this report the writer has chosen the former term to refer to the facies or processes associated with erosion or sediment deposition of the stagnating ice phase - that is, ice and water are equally important transporting agents in the erosion or deposition of a particular element designated to map Unit 2. In turn fluvio-glacial will refer to facies or processes associated with the dead ice phase (i.e. map Unit 3).

The presence of the glacio-fluvial facies implies rapid wasting of a glacier. Initially ice is removed by rapid downwasting (Demorest, 1942); especially near the margins of the glacier. Near the glacier terminus the ice is reduced to a hummocky, debris-littered surface while upstream the transverse profile of the ice lobe is convex-up. Eventually ice can become detached from the downwasting ice lobe (hence, dead ice) and the upstream migration of the sequence of deglacial events takes place as described by Flint (1957, p. 163). The Unit 2 facies is a record of those deposits and landforms created in the vicinity of or at the margins of "stagnating" ice; they include pitted outwash laid down at and close to contemporaneous ice-contact faces, channels and channel or sheet (rill) deposits formed by ice diverted streams, kames, and hummocky ablation moraine deposits developed near the margin of the glacier during its maximal position of the glacial episode or of a prominent but subsequent recessional halt or slight re-advance. Though some extend beyond the extreme limits of the ice advance with which they are associated, most are believed to have formed during retreating stages - any pre- and proglacial forms (Unit 1) are likely to have been overridden and buried or else destroyed.

Some sub-units or deposits of the Unit 2 facies have been involved in a long record of circular controversy concerning the processes involved in their origin. Several variations of an ice-contact process are now recognized to have yielded the same deposit (Holmes, 1947; Flint, 1957), but concerning the relative contribution or importance of each variation there is far from

unanimous agreement. Fulton (1963) prefers to dodge the subdivision of the glacio-fluvial facies or of these deposits because of the controversial genetic origins ascribed to them, and refers to all morphological entities of this facies as "morainal gravels". Flint (1957), in broad terminology, prefers the term "ice contact drift", for the sediment comprises a mixture of and gradations between non-stratified and stratified fabrics. I have attempted to subdivide the facies on a genetic basis according to their characteristics as listed in Appendix IA.

Sub-unit 2A - Proximal or Pitted Outwash Deposits

In the discussion of map Sub-unit 1E (proglacial outwash) the difficulty of recognizing fool-proof criteria for the assignment of outwash to the various phases of the glacial-deglacial cycle was mentioned. The Sub-unit 2A outwash is recognized by its proximal position to an ice front (at maximal recessional position) as delimited by a terminal moraine or marginal ice-contact feature and by the presence of kettle pits on the surface of the outwash. However, kettle pits are often masked into obscurity by a subsequent deposition of alluvium or loess; pits can be created by thermokarst activity (refer to map Unit 6) on, originally, non-pitted outwash surfaces; and proximal outwash can be deposited without enclosing ice blocks that would otherwise be capable of producing pits.

Distinguishing proximal outwash from distal non-pitted outwash (Sub-unit 3E) in the terms of the facies concept can be arbitrary for the latter may be the contemporaneously deposited downstream continuation of the former (e.g. at the CL-II terminus). The distinction is more difficult where the former maximum ice position is obscure. Other difficulties arise when a proximal or distal outwash has been subsequently truncated in a narrow valley by a fluvial cycle. A non-reworked outwash terrace (2A or 3E) is difficult to distinguish from a kettled terrace (3C) or a non-kettled terrace (4A or 7i). Terraces on opposite walls of narrow valleys at similar elevations are indicative of a dissected outwash apron or valley train (Flint, 1957, p. 140); if terraces alternate at different elevations , the form could be an outwash modified by subsequent fluvial terracing. Unfortunately the criteria is not suitable for terraces are generally exposed on one wall only (e.g. Fish and Benson creek regions). Outwashes of Age I deposited in the North Klondike, Blackstone, O'Brien and Fish valley bottoms as fans emanating from the mouths of tributary valleys constitute a final problem. Ice fronts were located at the narrow

exits of such valleys; in such an unusual environment the deposition of outwash proximally to the ice was virtually impossible - rather debris was carried until deposited on "broad", low-gradient floors of the master valleys located downstream. Into what facies or unit is the resultant outwash fan classified? The writer concluded that the fans were continually deposited until near the close of the dead ice phase at upstream (tributary) locales; hence, the final top surface of deposition is a Unit 3 surface.

For the above reasons proximal outwash is not a commonly recognized feature in the map-area. Outwash of the Unit 2 facies has been identified at the outer terminal periphery of the Foxy Creek Moraine (Foxy-I) and Chapman Lake Moraine (CL-II). At the former locality an exposure of outwash 500 m in length is about 8 m high; the deposit has an exposed 6-7 m thickness and contains boulders up to 1 m in long axis diameter at the latter locale. In the North Fork Pass region proximal outwash has been eroded away by fluvial activities at the NF-NL-I terminus, and because of the unusual topographic condition mentioned under Sub-unit 1A it was never deposited at the NF-SL-I lobe. Proximal outwash has not been identified at the former margins of the "Age IIA ice advance", though such may be represented by the planar surfaces on the northward-facing slopes of the "Fitzgerald Ridge" and 'Gunsmoke Creek" regions; extensive gelifluction in these regions creates uncertain identification. Proximal outwash has not been recognized at the thresholds of cirques, nor at the snouts of present day glacierets, nor in association with the "Age III glaciation".

Sub-units 2B and 2C - Meltwater Channels and Associated Channel Deposits

The classification, usefulness and significance of the various types of meltwater channels are given in the works of Mannerfelt (1945), Sissons (1961), Wheeler (1961) and Fulton (1963). Lateral (marginal, extramarginal and serpentine) channels are grouped under Sub-unit 2B, whereas overflow (and proglacial of Flint, 1957) channels are classified under Sub-unit 2C. Subglacial channels (chutes, etc.) are more common to the dead ice phase (accord. to Fulton, 1963) and hence, are classified under map Unit 3. Not all channels in the map-area could be so classified because correlative and supporting evidence from surrounding surficial deposits was not available. Channel deposits are a lag or veneer of small inset benches, patchy sheets, bars, "boulder trains" that occur in most meltwater channels but are, in many cases, covered by a thick (greater than 1 m) colluvium, alluvium, paludal deposits,

loess or other deposit (as indicated on the Quaternary map). A few channel deposits, up to 3-4 m thick are found along the North Klondike valley where the Dempster Highway has been built across the channels.

During the late Pleistocene Epoch most of the present day creeks and rivers were overflow channels (Sub-unit 2C) - only the underfit or dried up water courses are marked on the accompanying 1:50,000 scale map. For example, the North Klondike, Lee, O'Brien, Blackstone and Tombstone drainages were obviously major meltwater discharge channels (so marked on Crawford's (1959) map) as they were fed directly by large trunk glaciers; whereas Rabbit Creek, Guilcher Creek, Coal Creek, "Lateral Creek", and upper Lomond Creek, though devoid of ice cover, carried meltwater from off nearby Age II ice surfaces. Hence, the latter type are marked on the 1:50,000 scale map; channels of this type vary from 25 to 500 m in width. The larger are the smooth concave-walled valleys of Rabbit and Coal creeks that had drained the western limits of the lower North Klondike trunk glacier during Age II. Misfit streams are numerous in the peripheral areas adjacent to the CL-II and TV-IIA moraines. Several drainage channels lie north of "Fitzgerald Ridge", of which most are associated with the "Age IIA ice advance". Lomond Creek, "Gunsmoke Creek" and tributaries of the "Cache Creek" valleys were overflow channels during the "Age II and IIA ice advances", but they exhibit misfit characteristics only in their upper reaches.

Overflow channels, of the glaringly misfit type, are not associated with the "Age I ice advance". At North Fork Pass the south lobe of the moraine is entirely rimmed by a channel of only 50 m maximum width by 1-3 m in depth; the channel is floored with a few monzonite lag boulders up to 1-2 m in diameter. Overflow channels at the Aug. 17-I and Foxy-I morainal termini have been cut through bedrock barriers and are similar to Ray's (1935) descriptions of gorges at the Spencer Glacier terminus in the Kenai Peninsula of Alaska.

Lateral channels (Sub-unit 2B) occur along valley walls and carry supraglacial meltwater off the convex ice surface during the stagnating phase. The most commonly recognized are the two-walled forms, for the one wall type stands a greater possibility of obliteration due to solifluction activity. The best examples of the former are located near the junction of "Lil Creek" with the North Klondike valley. Serpentines (Mannerfelt, 1945) have been observed only on the slopes south of "Morrison Creek" in the lower North Klondike region. Lateral channels occurring at the upper maximal ice limit of a glacial episode are rare in the map-area. The best examples of such are

found in the "Bompas Creek" region of the "Seela Range" and along the eastern digitation of the lower North Klondike valley where the Age II ice pushed its way into the Lee Creek drainage basin. Marginal drainage appears to be best developed below the upper limits of ice because the convex-up profile of the stagnating glacier is needed to concentrate surface runoff water along margins in order to provide sufficient force, capacity and competence for the development of channels. Most lateral channels are found in bedrock whereas overflow channels are not uncommon in till or gravel (e.g. "Linta Creek" region).

Sub-unit 2D - Rill Deposits

Rill deposits, using Fulton's (1962) description as opposed to colluvial deposits (Unit 8), are found in the lower North Klondike borrow-pit road cut exposures. They occur as patchy sheets of semi-stratified veneers of gravel, sand and silt overlying the ground moraine (Fig. 9A) that are in turn, at some localities, overlain by eolian silt (Plate XIVA). The gravel component of these deposits is subangular to subrounded in shape; discs, blades, or rollers that are characteristic of extensive stream transport are rare. The deposits are associated with nearby meltwater channels and are thought to have originated by sheet wash of the ground moraine by water derived from nearby stagnating ice surfaces. Such an explanation is not agreeable to some Quaternary geologists (e.g. Bird, 1967), but is the one used by Fulton (1962, 1963) in his area of study. The writer favours this mode of origin for the deposits are associated with nearby meltwater channels and the creation of such would be difficult after deglaciation but prior to the deposition of a distinct loess.

Recognition of rill deposits to the north of the lower North Klondike valley is difficult for the veneer is prone to being mixed with colluvial and eolian debris by solifluction or other mass-wasting processes on slopes. Such modifications are especially prevalent in the Taiga Valley region.

Sub-unit 2E, 2F and 2G - "Ice-Contact Deposits" or "Morainal Gravels"

Ice-contact stratified deposits are the most difficult elements to classify in a survey of glaciated terrain. According to Flint (1957), kame terraces, kames, kettles, collapse masses, and eskers constitute a gradational series within this group. The first two subdivisions are undoubtedly the most

troublesome and have a long backlog of clashes in the literature; the last mentioned is considered under map Unit 3 in this report; collapse masses are referred to as hummocky ablation moraine of Unit 2; and kettles are not noted as a stratigraphic unit, but rather as a characteristic of several sub-units in Units 2 and 3. Ice contact deposits associated with a suspected prolonged halt or minor ice readvance during a gradual period of deglaciation are referred to as a recessional complex in this report. The complex may be made up of stratified and non-stratified drift and very detailed mapping would be required to classify the elements within them.

Kames (and Kame Terraces)(Sub-unit 2E)

Within the map-area a variety of isolated mounds, terraces, steep aprons, ridges and bench-like features meet the broad diversity of kame descriptions in the literature as summarized by Flint (1957). However those that are crevasse fillings are not included in Unit 2, for it is the writer's opinion that such can only be deposited in final form during the dead ice phase; therefore the reader, if interested in this argument should refer to map Unit 3. The various types of kames in the map-area that are formed during the stagnating phase are described in the following paragraphs.

Isolated mounds of gravelly "drift" (kames proper?) occurring on flat terrain are not common in the study area. The best example is located on the east side of "Linta Creek" in the Lower North Klondike Moraine (Plate VII). This symmetrical-sided feature is almost 50 m high and has a basal length of 500 m. It is oriented roughly parallel to the trend of the Age II ice flow. Although the form is suggestive of a "perforation deposit" (Cook, 1945), the orientation of the feature and the rounded cobble component suggest supra-glacial transport of materials into a frontal channel on or slightly behind a stagnating ice margin. Kames of the isolated variety located on lowermost valley sides (Flint, 1957; Fig. 8-7B) are not nearly as obvious as the foregoing flat terrain type for various slopes processes tend to mask their identity. Those mapped on the lower east-facing slopes of "Signal Hill" (lower North Klondike valley) displayed 2-3 m deep kettles, yet they were entirely hidden by spruce forest in the aerial photographs. The isolated type of kame grades into hummocky ablation moraine in the map-area, and the distinction between the two must be left up to the arbitrary discretion of the investigator.

Kame terraces (or kame complexes), occurring on higher positions of the valley walls than the previous type, were recognized in most valleys

previously subjected to Age I, Age II, and Age IIA ice advances. The largest kame terraces are 1-2 km long and 300 m wide. In "Wolf Creek" valley, "main" Blackstone valley, O'Brien Creek valley and Taiga Valley such kames occur at the upper limit of glaciation as distinct benches. In the North Klondike valley the features have only a vaguely discernible bench-like form; as such they should perhaps be termed as a "valley-wall bench" a non-genetic term used by Fulton (pers. comm.).

Frontal kames (Mannerfelt, 1945) are conspicuous on the lateral portions of the CL-II moraine in the vicinity of "The Lioness" and on the leading edge of the terminal moraine at the headwaters of "Lil Creek" ("Hart Pass"). Frontal kames might be classified or regarded as the steeper portions of a proximal outwash apron. They are incomplete fan-like features that mark the transitional zone between a terminal moraine of the glacial facies and a proximal outwash of the glacio-fluvial facies. At the Aug. 17-I terminus a favourable stream-cut exposure shows the transition from the loose till of the moraine, to very bouldery gravel, to the cobble gravel of the outwash fan.

The most mystifying deposits of all are found in the lower North Klondike terminus region. Four ridges of gravel 1.0 to 2.5 km long and 250-350 m wide rise some 50 m above the surrounding ground moraine and associated rill deposits (Plate VII). The gravel is poorly sorted and with subangular to sub-rounded pebble components. No closed depressions or cuspate upper margins are apparent on their surfaces. They vaguely resemble eskers, but lack the typical sinuosity and stratification. They may represent Flint's (1957) transitional phase from a kame to an esker, or they may be a variation of Armstrong and Tipper's (1948) compound eskers. The latter are assumed to be developed partly on ice, partly in crevasses, and partly in subglacial tunnels. However, the North Klondike features lack the typical subparallel ridges depicted by the plotted cross sections of their McKinnon Esker. Since the ridges of the North Klondike locale have characteristics common to both esker complexes and kames the features are marked as an unqualified Unit 2 on the Quaternary map accompanying this report.

In summary, it appears that the diversity of kame-like features in the map-area demands the broad usage of the term "kame" if it is to be used at all. Kame deposits initiated controversy from the day that Professor Geikie first coined the term to describe the isolated, symmetrical and steep-sided gravel hillocks in Scotland. The isolated form noted on Plate VII is a perfect replica of his description. Cook (1945) prefers to limit the

terminology to this type of feature. Holmes (1947) suggested that the wider meaning of the term be retained to provide a name for all isolated or grouped sag and swell features of ice contact origin. Cook would term the group varieties as "kame complexes" while Flint (1957) and Mannerfelt (1945) would designate them as kame terraces if associated with marginal stagnation of ice. Since some of the terraced and frontal varieties do not occur in groups, Holmes' general usage of the term is perhaps more appropriate to the variety of forms in the map-area.

Hummocky Ablation Deposits (Sub-unit 2F)

Ablation moraine deposits are an important unit of sediment to consider when making detailed studies of morainal termini for they were found to be irregularly concentrated on them both horizontally and vertically. Such deposits are most widespread on the Chapman Lake Moraine (CL-II) and are nearly as abundant on the O'Brien Creek (Age I), Upper Blackstone (Age I), NF-NL-I, and Upper North Klondike moraines. On the other hand such deposits are rare occurrences on the TV-IIA, NF-SL-I, Aug. 17-I and other smaller moraines of Age I relationships; they are more frequent but are of only minor consequence on the Foxy-I and LNK-II moraines. The distribution of ablation deposits on the various moraines receiving detailed study are shown on identical scaled maps (Figs. 6-8). Scattered deposits, perhaps slightly more subdued, of identical origin and stratigraphic relationships can be discerned on the OG-III moraine. Obviously the low hummocky and irregular sheet-ridge characteristic of these deposits will have a pronounced influence on the final topographic form a morainal terminus will take and because of the gravelly texture of the sediment the subsequent modifications (chemical, periglacial, pedological and botanical) taken by this type of deposit will be different than the modifications brought about on other sedimentary components of a morainal terminus.

The environmental complications (from a depositional viewpoint) of the irregular distribution of hummocky ablation deposits has been discussed under map Unit 1A. The relationship of this irregular distribution to the form of the moraine is discussed in Part 2A of this thesis. Unlike surrounding lower ground, ablation moraine hummocks are free of a masking eolian silt mantle. Due to this fortuitous circumstance the ablation moraine hummocks were also used to illustrate the relationship of the rate of soil genesis and botanical succession to the various ages of moraines (Parts 2C and 2D).

Since the sediment varies from loose or porous till to well-sorted but poorly stratified gravel, ablation deposits represent the transition from ground moraine to kames (as previously mentioned) or eskers. Hence the sub-unit can represent or is a result of the processes associated with the glacial, transitional, stagnating or dead ice phases. Past studies of this deposit have suggested a variety of environment interpretations. All investigators will agree that much of the materials in such deposits are from supraglacial and englacial sources on the glacier. Mackay (1960) briefly reviews the literature on hummocky deposits in his discussion of a detached ice block origin of a set of regular spaced ridges in the Stopover Lake area of the Northwest Territories. Flint (1942, 1957) associates the deposition of such debris with severe stagnation, ice detachment and eskers while Ogilvie (1904), Speight (1940), Sharp (1949) and Boulton (1967) point to the copiuos quantities of deposition of supraglacial drift about thin but active ice termini. Hence, the sub-unit cannot be regarded as a typical member of any time-rock unit in this report; rather, the assignment of it to the glaci-fluvial (Unit 2) facies must be interpreted merely as indicating its average or more prevalent position between two extremes of evolution and deposition.

Flint (1957) distinguished between collapse masses and ablation till by the amount of stratification and thickness of the resultant drift. The inference is that the former are thick deposits on thin underlying ice while the latter is a thin deposit on the surface of thick ice. Such a relationship is questionable as Ogilvie (1904) and Sharp (1949) have demonstrated that the amount of debris on the ice surface depends partly on the rate of supply, method of supply and position of supply to the glacier. Hence, Flint's distinction between the two is not used in this report, though this does not imply that thin hummocky ablation deposits, as found on some moraines in the map-area, are not associated with severe stagnation. Rather the writer cannot see the justification for a collapse masses unit.

The hummocky deposits located away from a morainal terminus on "Fitzgerald Ridge" is worthy of special mention. Their position on the upper slopes is unusual for in this zone a glacier is usually subjected to ice marginal runoff and the associated elimination of supraglacial debris. Yet, the deposition of such an extensive deposit implies that the Age II ice surface failed to develop a sufficiently convex-up profile during deglaciation of the trunk glacier in this region.

Recessional Moraine and Associated Kame Complexes (Sub-unit 2G)

Arcuate features resembling morainal ridges that occur upstream from the known maximal positions of glacier ice of a particular episode are termed recessional moraines in this report. The features where examined were made up of loose till and gravel but the textures probably cover the complete spectrum of indurated till to stratified local pockets of sand and silts. North of North Fork Pass such features are blanketed by loess or solifluction deposits thus providing a very subdued appearance. A complete arcuate or festooned loop, convex downvalley, is the ideal form of a recessional moraine. However, in the map-area such a condition is not exhibited for subsequent fluvial erosion has eliminated much of the axial portions while a variety of degradational processes on slopes has masked the apical portion of such drift. Hence, arcuate recessionals are projected from the intermittent occurrences of frontal kames (or kame moraines), valley-sided ridges, critically situated patches of ablation moraine, swells in the ground moraine and the position of certain meltwater channels. In this manner of recognition one to four sets of recessionals (some vaguely defined) were discerned for both withdrawal periods of Age I and Age II ice advance. In all instances the recessionals are much more subdued and incomplete than the Late Pleistocene recessionals, such as illustrated by Holmes and Moss (1955), or as mapped by Vernon and Hughes (1966) to the east of the map-area, or as mapped by Krinsley (1965) in Shakwak Valley.

Of Age I recessionals, one to three sets were found in about one half of the valleys involved in the period of ice advance - thus corroborating Vernon and Hughes (1966) mapping to the east and west of the study area. With the exception of the Upper North Klondike Moraine all occur upvalley from pronounced and well defined morainal termini depicting the maximum extent of valley ice during the Age I episode. The most pronounced recessionals occur at the North Fork Pass Moraine[1] (Fig. 6A and Plate XIIIA) and Upper Blackstone Moraine whereas the most weakly developed recessionals were discovered as minute valley-sided ridges upstream from the Aug.17-I terminus. In the latter location the features could not be detected on the 1:60,000 scale aerial photographs. Positions of the three sets of recessionals, where present, are not comparably situated from one valley to the next. However, this does not imply that the halts in ice retreat were not synchronous though this may have been in the case of the latest Age I recessional halts - one set of recessionals are found near the mouths of a few cirques.

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[1] This recessional developed before 11,250 years B.P. (Table VI).

Plate XIIIA

Lateral moraine (solid arrow) and recessional moraine (dashed arrow) on "Mt. Andersson". Moraines slope to the north lobe of the North Fork Pass Moraine. That's right, they are barren ground caribou in the midground.

Plate XIIIB

Varved silts of segregated ice (above man) at Field Stn. No. 240. Till beneath the silts (No. 240C) is assumed to be Age IIA whereas till (No. 240A, not visible) above silt is of Age II.

Recessional moraines (Age II) associated with the lower North Klondike ice lobe exhibit very subdued ridges some 1 to 2.5 km long between "Linta" and Guilcher creeks. These are tentatively considered to be kames associated with a weak ice readvance; axial portions of the recessional were either never deposited due to runoff problems at the stagnating glacier snout or else were deposited initially but have since been dissected by the subsequently developed North Klondike River. The recessional moraine is locally exposed in the "Tom O'Hara Lake" region but is mostly concealed on the eastern side of the valley by extensive solifluction on the valley wall. A slightly younger recessional lies 40 km to the north on the valley floor between the "Chisolm" and "Grizzly" creek tributaries. Since extensive lateral meltwater channels are associated with this feature, a prolonged halt in ice retreat is suspected to have occurred in the late stages of the Age II deglaciation.

On the north slope of the Southern Ogilvie Ranges recessional features of Age II are vaguely displayed upstream from the Chapman Lake Moraine in both the East and "main" Blackstone valleys. It is not known whether these features were developed contemporaneously with the first of the recessionals described for the lower North Klondike valley. Recessional features are also suggested at the mouths of some East Blackstone tributaries in localities still farther upstream. For example, the mouth of "Wildhorse Creek" is marked by a subdued recessional feature that marks the remnant and prolonged position of a valley ice lobe (deglacial phase of Age II) that once fed the trunk glacier of the East Blackstone system. This tributary valley is sufficiently narrow and so oriented (east) as to escape the longer periods of insolation during the day; hence, its ice would not downwaste nearly as rapidly as the East Blackstone valley ice stream. Similarly the writer suspected a similar recessional at the mouth of "Foxy Creek" just to the south, but in this case an "Age I ice advance" has since overridden the feature, thus probably giving the younger terminal moraine an anomalous height above the valley floor (60 m).

Recessional moraines and associated kame complexes associated with the "Age III glaciation" and the "Age IIA ice advance" have not been recognized to date unless the Chapman Lake Moraine of Age II is considered as a recessional of the Age IIA. This possibility is explored in subsequent sections of this thesis, for Vernon and Hughes (1966) show two sets of "red limit" moraines (Age II-IIA) in the eastern ranges region of their mapping (Map 1172A - refer to Fig. 2).

With the exception of the "Monolith Mtn." locale, recessional moraines are not present at the snouts of the receding glacierets that now occupy favourably-oriented cirques of the "Tombstone" and "Cloudy Ranges".

Map Unit 3 - Fluvio-glacial Facies

Surficial units included in this map unit are those associated with the dead ice phase of deglaciation, as discussed under map Unit 2. Features developing about, under and within the downwasting ice include subglacial chutes, channels (Sub-unit 3F) and associated rill (lag) deposits, crevasse deposits, (Sub-unit 3B) and eskers (Sub-unit 3A), whereas those occurring in the downstream direction as a consequence of a dead ice front are the retreatal type of distal outwash (Sub-unit 3E), and the kettled stream terraces (Sub-unit 3C). As mentioned in map Unit 2 some outwash fans are also included in this Unit 3 facies, but the facies distinction is far from satisfactory with a few deposits of this type. The characteristics of each of these sub-units is given in Appendix IA. Hummocky ablation moraine ascribed to Sub-unit 2F but developing in the manner proposed by Mackay (1960) would be a member of Unit 3. However, in the map-area these deposits generally do not show evidence of a detached ice-block origin that Mackay noted in his study (exc. - refer to Plate IX).

The separation of the stagnating from the dead ice phase will be a continual source of trouble in regional glacial studies for the change over from one to the other is a gradational sequence and is reflected by gradational changes in depositional environment. The distinction will be necessarily complicated as the investigator moves from areas of high relief to areas of moderate or low relief environment for the character of an ice lobe is influenced by its topographic setting. Flint (1942, 1957) does not distinguish between the two phases; he claims that the prime indicator deposit, an esker, can be built and preserved during the phase of feeble ice movement (= late stagnating ice phase). Crevasse deposits and glacio-lacustrine deposition (Sub-unit 3D) can be an expression of a similar regimen. However, eskers and crevasse deposits are placed by the writer in Unit 3 here because their main or final development generally takes place after ice movement has ceased - otherwise their form would usually be destroyed.

Within the study area dead ice features are predominant in terminal zones. This, no doubt, reflects the lack of subglacial drainage in a polar type of ice, indicates a lack of detached ice masses during deglaciation of valley and trunk glaciers in the region, and points toward a topographic control on their development. Where valleys are narrow or at least confined the deposits are narrow ribbons or benches of outwash material that have escaped being torn away by subsequent fluvial action; on the other hand, at the expansive lower North Klondike region Unit 3 debris has been deposited irregularly over a broad zone of ice wastage.

Sub-unit 3A - Eskers and Eskeroid Complexes

As previously mentioned, eskers are one end member of the series of deposits that begins with kames. The various hypotheses concerning esker development are discussed by Flint (1957). They are not too common in the study area.

"Fitzgerald Ridge" eskers are intimately associated with ablation moraine deposits and are oriented at right angles to the former ice flow direction. They illustrate three important features:

1) the transition from hummocky deposits (perhaps of collapse origin at this locale) to eskers is gradual;
2) the ice must have been "dead" in this region in order to facilitate esker development parallel to the fall-line (normal to the contour) of the valley wall; and
3) hummocky ablation till was deposited at the onset of the dead ice phase but may have been initiated during the active or transitional, and stagnating ice phases on higher portions of the slope.

In the lower North Klondike region, aside from the giant "kame-esker" gradations discussed previously (Sub-unit 2E), the areas of prolific esker development are about "Morrison Creek". All eskers occur as subdued ridges; one is 100 m wide and stretches for 7 km parallel to the direction of the ice flow. Near the former terminus of the "Age II ice advance" in the North Klondike valley a subdued eskeroid form lies on the east side of the valley at right angles to the ice flow - a feature supporting the hypothesis of "dead" ice conditions during subglacial esker development. Eskers generally occur with subglacial channels (Sub-unit 3F) and associated rill deposits on the slopes of "Signal Hill". The eskers may have been developed first in englacial tunnels that eventually "dropped" to subglacial position by subsequent erosion and deposition.

During deglaciation of the Age I ice lobe in the upper North Klondike valley a remarkable series of eskers and eskeroid complexes developed on the lower portions of the valley slopes. Many are associated with subglacial channels and are oriented at oblique angles to the downvalley axis of ice flow. The NF-NL-I moraine also exhibits eskers with a similar environment of deposition. Other than at "Hammer Creek" in the "Cloudy Range", eskers could not be identified in other Age I glaciated terrain.

Sub-unit 3B - Crevasse Filling Deposits

Crevasse deposits are considered as a specialized type of kame by Flint (1957) and characteristics used to distinguish them from eskers are given by

Tipper (1963). Crevasse deposits undergo initial development during the late stagnating and early dead ice phases. Their preservation however, because of orientations oblique or transverse to local ice flow, demands a final evolution during the dead ice phase. That is, the final straight ridge cannot be maintained during ice movement; yet, the feature cannot be deposited too late in the dead ice phase for a crevasse pattern is soon obscured by ablation, chuting and slumping as described by Mackay (1960).

Only one set of crevasse deposits could be identified in the map-area. The deposits lie on Age II glaciated terrain of the "Yakamaw" valley in the "Agglomerate Range" (Plate VIII). This is near one of the many accumulation zones of the once vast East Blackstone-North Klondike transection glacier; hence the deposits were developed during the last phase of the Age II deglaciation. The form of the deposits in plan view is a subtle but distinctive pair of offset or en echelon straight ridges oriented transversely to the trend of the valley. The ridge tops are a scant 3 to 4 m above the surrounding terrain and their combined length is about 700 m.

The deposit consists of a 2:1 ratio of subangular to angular locally derived volcanic pebbles of which 25% exhibit faint randomly-oriented striae. Hence, transport distances involved in the deposition are short and at least some material was derived from till. The mechanical analysis of a sample taken from this deposit reveals a very low mud component (6.3%) and a higher than normal percentage of gravel (48.0%) (Appendix IIA). These values would be extreme for most tills in the map-area (Table IX) and are unrealistic for the North Fork Pass region regardless of age of ice advance being considered. Since hummocky ablation deposits are absent in the area the crevasses were probably filled by lateral rather than supraglacial gravel "inwash" from the lower slopes of "Yakamaw" valley - also, not too much supraglacial debris would be expected in the mid ice-stream position of the accumulation zone.

No doubt crevasse deposits of marginal, longitudinal and possibly radial relationships to former ice margins occur in the map-area as well. Many small deposits on valley floors marked as Sub-units 2 undifferentiated, 2E and 2F should no doubt be Sub-unit 3B but cannot be so placed because of a lack of telltale form or pattern.

Sub-unit 3C - Kettled Terrace Deposits

The origin of the various types of kettles and their position in the kame-esker series is discussed by Flint (1957). Kettles signify "detached ice masses" and they can be associated with any of the glacial, glacio-fluvial

and fluvio-glacial facies as delineated by the enclosing material, textures and landform peculiarities. Kettled terraces, however, imply the last remnants of "dead" ice, for the general planar form cannot develop in areas of extensive ice block burial.

The distinction between kettled outwash aprons and kettled terraces is a matter of texture and proximity to the former ice front. Pitted outwash aprons of poorly sorted gravel commonly straddle the entire valley near the ice while kettled terraces of well sorted material are confined to narrow belts located alongside the valley walls downstream.

Kettled terraces exist in the upper reaches of the "main" Blackstone valley but are scarce or absent elsewhere in the map-area.

The "Mischenko Lakes" (or "Big, "Tom O'Hara" and "Thana" lakes) appear to be kettles on a zone of flat terrace in the lower North Klondike valley. However this kettle inference is uncertain for Dr. O.L. Hughes (pers. comm.) suggests that the features were a result of uneven alluvial-fluvial filling of the North Klondike valley either after the Age II deglaciation or during the development of retreatal outwash at the time of Age II deglaciation. That is, a lack of complete lateral aggradation on the valley floor is suggested in either case. Péwé (1965) has used this hypothesis - "Aggradation by the Tanana River - - - - - has apparently dammed several of the valleys of the Yukon-Tanana upland during late Pleistocene time. This damming has resulted in the formation of several lakes .....". However, in the North Klondike valley this explanation seems unapplicable because:

1) "Mischenko Lakes" are not located in tributary reentrant valleys; hence, in a topographic sense nothing is dammed by aggradation;
2) "Tom O'Hara Lake" borders on what appears to be a glacio-fluvial recessional feature; hence the adjacent kettle terrace (fluvio-glacial facies) is a natural time-rock sequence of events; and
3) the location of the lakes is not unusual if the shade factor produced by a favourably oriented 180-metre high mesa-like ridge to the east-southeast is taken into consideration.

With regard to items two and three, ice blocks would be preferentially preserved against total melt for a longer period of time and a re-working of glacio-fluvial deposits would account for the overall planar form.

Sub-unit 3D - Glacio-lacustrine Deposits

There are subtle distinctions in terminology between lakes dammed by active, by stagnating and by dead ice. The first are termed proglacial lacustrine, the stagnating-ice dammed are defined as collapse lacustrine

(Fulton, 1963), and the latter are simply lacustrine. The term glacio-lacustrine is ambiguous with respect to the time-rock classification, but it is necessary when all three types of lake develop successively in the same standing body of water.

Lakes in the study area are placed in the Unit 3 facies because collapse structures were not found in the varved[1] silt deposits - though admittedly this is a weak criterion when based on so few exposures where segregated ice conditions may exist. Glacial lakes were no doubt common during "Age II, IIA, and III glaciations", but the evidence for these is not likely to be preserved because of the susceptibility of the deposits to permafrost and the removal of any established strandlines by solifluction and subsequent glaciations. In the study area varved silts were recognized upstream from the NF-NL-I arc at Field Stn. No. 173 (Fig. 7), at Field Stn. 240 on the East Blackstone River, and beneath the till of the CL-II terminus at Stn. 215 (Fig. 8). Another region where varved silt may have been deposited lies beneath a bog, 6 km^2 in areal extent, just east of the confluence of "Ptarmigan Creek" with the East Blackstone River. Similar deposits were not found in the lower North Klondike valley though there are several ideal ice dam localities. Dr. O. L. Hughes (pers. comm.) reports varved silts lying beneath the Flat Creek Beds[2] (McConnell, 1905) just east of the study area in the (South) Klondike valley. Proglacial lakes and ice margin lakes of the early stagnating phase were probably prevalent during all of the Pleistocene glaciations; however, they were most likely small ephemeral bodies and the deposits they produced would be included in the kame complexes (Sub-unit 2E and 2G).

The varved silts section upstream from the NF-NL-I represented a lake of at least 2 km^2 in areal extent of which "Alces Lake" may represent the surviving remnant. The section of silts (Stn. 173) is 8 m thick in the ice segregated condition[3]. Due to the segregation the number of varves could not be counted. The silts are overlain disconformably by fluvial gravel and organic rich silt (= loess). The base of the former was dated at 5070 years B.P. (Table VI). Ice wedges (Plate XVIA) transect both the varved and organic silts.

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1. Assuming annual deposition for each dark-light couplet.
2. Flat Creek Beds are assigned to the Nansen Drift (Age IV?) by Bostock (1966).
3. In view of Mackay's (1966) research on segregated ice the true thickness could be less than half this figure.

Ice-segregated varved silts (Plate XIIIB) at Field Stn. 240 (just north of the Socony-Mobil Oil Company base camp) probably represents a short lived shallow pond perhaps developed at the time of Taiga Valley (Age IIA) ice retreat. The 2 m thick unit (true thickness closer to 50 cm ?) overlies Age IIA (?) till and is in turn overlain by till assumed to be a portion of CL-II ice advance[4]. Drag structures were not observed in the silt.

Varved silts in non-segregated condition measure 17 m in thickness in a 19 to 20 m high exposure overlooking the Blackstone River near Chapman Lake (Stn. 215). As this is the best developed lacustrine silt locality known in the study area the section is described in detail in Appendix IB. A total estimate of the number of varves in the section is not possible because of recent slumping at the base of the exposure, and variations in varve sizes (1.6-7.5 cm). However, in one 2.4 m thick sequence 150 varves were counted. The characteristics of the varves are similar to the general descriptions of varves given by Flint (1957). Occasionally the light coloured or coarser grained unit shows minor fluctuations in grain sizes; colder weather in periods of summer runoff or variations in current patterns within the lake may be explanations for this variability. Bedding planes in the sediment show slight undulations; these may be cambers due to differential compaction or a condition brought about by the fluctuation in the overlying CL-II ice snout. Another hypothesis, though least likely, is that the wavy condition may have been brought about by the withdrawal of segregated ice as the section was gradually exposed. The area of silt deposition depicted by this section was probably the size of the present day Chapman Lake. The lake is not a remnant of the standing body of water responsible for the deposition of the silts in the section however; though Chapman Lake is dependent upon these silts for its growth by thermokarst activity (refer to map Unit 6).

Sub-unit 3E - Distal Outwash Fans, Valley Trains and Retreatal Outwash Deposits

Concept

As previously mentioned outwash is a continuous depositional product throughout the cycle of glaciation. Downstream from the glacier snout proximal (Sub-unit 2A) and proglacial or advance (Sub-unit 1E) outwash grade

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[4] The correlation of the stratigraphic sequence of tills to the two tiered sequence of moraines located downvalley cannot be proven.

into a non-pitted distal outwash and as deglaciation continues the distal outwash zone (Sub-unit 3E) advances upstream to deposit what is termed a "retreatal" outwash. The assignment of distal or non-pitted outwash of fan or apron-like form to the dead ice facies may be questioned as it is the problem of possible continuous deposition during all phases of the glacial-deglacial cycle. Of retreatal deposits of ribbon form, the distinction between fluvial terraces and deglacial outwash is also difficult, for according to Flint (1957) small detached ice masses trapped in typical aggradational outwash conditions will not melt out to leave kettle depressions. The designation between the two ribbon-form types of deposits has been arbitrarily applied in Vernon and Hughes' (1966) mapping.

Types of Fluvio-glacial Outwash

Non-pitted outwash fans appear as two types within the map-area. One type is represented by an apron that is maybe the downstream continuation of a pitted outwash located in proximal position to the glacier snout. The distinction between the proximal and distal is arbitrary. The other type of distal outwash occurs as a distinct fan downstream from a former ice front. Only a narrow intervening channel, rather than proximal outwash, connects the fan to the former position of the ice terminus. The first type represents glacial discharge into a broad master valley (e.g. CL-II terminus) whereas the other type is developed where the glacier snout has terminated at a very confined portion of a valley (e.g. Age I glaciers in tributaries of the North Klondike valley).

Outwash as a long narrow body (ribbon type) of deposit is known as a "valley train" (Flint, 1957) whether downstream, alongside or upstream from the former ice front. "Retreatal outwash" is applied to that part of a valley train that occurs upstream from the former limit of glaciation while at maximal extent. According to Flint (1957), as the outwash retreats upvalley the valley train of the downstream position can be dissected or breached from the "unloaded" meltwater discharge upstream. This process took place in Benson Creek, Fish Creek and upper Blackstone valleys.

Very small outwash deposits associated with cirques are included in the Unit 3 facies, for it is assumed here that in order to yield any significant waterlaid debris there must be a long period of optimum melt conditions. No pitted depressions were found on these surfaces. The outwash is proximal in position with regard to the glacier snouts under these conditions (e.g. valleys west of "Mt. Walker" in the "Snowy Range" or the recent cirque glaciers of the "Tombstone Range".)

Stratigraphic Significance of Outwash

Outwash terraces in ideal conditions of preservation have been useful in establishing sequences of multiple valley glaciations. For example Holmes and Moss (1955) could extend downstream and upstream the slopes of several ages of outwash terraces and thus differentiate between the four Pleistocene events recognized in the Wind River Mountains of Wyoming. Such ideal multiple sequences of terraces are not present in this study area. At best the Age II retreatal outwash in Benson and Fish Creeks can be traced upstream until it intersects with the Age I terminal moraine or proximal outwash. Presumably the meltwater discharge from the Age I ice advance is partially responsible for cutting a valley below the older outwash levels.

Distribution and Regimenal Significance of Outwash

Outwash, regardless of facies type, was extensively developed during all late Pleistocene glacial episodes. According to Flint (1957) the volume of outwash is related to the duration of the glacier terminus and to the rate of drift delivery to the terminal zone of the glacier. Both factors are regulated by climate, and Flint (1957, p. 141) points out that "on the northeastern (landward) side of the coastal mountains of Alaska, end moraines are bulkier than those on the seaward side of the same mountains where precipitation is more abundant". His explanation is that the greater volumes of meltwater on the wetter side washes away the terminal drift (existing and potential) into outwash deposits. The Ogilvie Mountains of an inland geographic position, do not display such startling differences between the morainal or outwash deposition on the opposite sides of its southern ranges. The greater outwash volume (Age II) on the south slope is partly a result of a local topographic influence, the larger trunk glaciers to the south (because of larger source area), as well as a probable moisture cline.

General Characteristics

Textural and structural fabrics of the outwash are much the same throughout the study area and are given in Appendix IA. The following is based upon numerous artificial and natural exposure investigations in the North Klondike and East Blackstone valleys of the map-area. Distal escarpments and bisecting exposures of 2 to 8 m in height are found for Age I and Age II outwash deposits. However, in the proximal portions the thicknesses are as much as 25 m for some of the larger Age I aprons. With the exception of the upper North Klondike

region, outwash is covered invariably by a blanket of loess 30 to 120 cm thick.

Small blocks of till were found in the exposures lying at the transition of proximal pitted to distal non-pitted outwash for the CL-II terminus but were not observed in more distal exposures. However, in the same outwash sequence boulders 1 m long were found sporadically from the former maximal position of the ice terminus to 5 km downstream. Such a distance downstream could be accounted for by jökulklaup activity (pers. comm., Dr. W. H. Mathews) or by transport on slabs of ice developed seasonally in the manner suggested by Flint (1957).

Most outwashes in the study area are bounded by escarpments. Those not breached by retreatal outwash processes have been subsequently bissected by ravines, fan-head trenches or even temporary base level flood plains in accordance with the general degradation fluvial processes occurring in the Ogilvie Mountains at present. Outwash associated with present-day cirque glaciers of the "Tombstone Range" is the only exception.

Outwash associated with the LNK-II ice advance is not easily classified according to the facies system. Mass-wasting and eolian processes have filled in possible areas of kettled depressions in the outwash (Unit 2), and the exact outermost limits of the ice lobe are not accurately known. Hence most of the outwash has been tentatively assigned to the dead ice facies (Unit 3).

Sub-unit 3F - Subglacial and Overflow Channels and Associated Rill Deposits

According to Fulton (1963) subglacial drainage begins during the stagnating phase of a glacier but it is not typical or prevalent until the succeeding dead ice phase is reached. Mannerfelt's (1945) classification divides subglacial drainage into chutes (trenches running downslope on a valley wall) and channels (trenches running parallel to the longitudinal axis of a valley floor). Overflow channels where associated with detached ice masses or deglacial lake drainage would also be grouped with the fluvio-glacial facies.

Textural and fabric characteristics of the rill deposits in this sub-unit are the same as those given for Sub-unit 2D. Rill deposits not associated with subglacial channels or eskers have been grouped into the glacio-fluvial facies (2D) for it is difficult to estimate their time-rock position without other corroborative evidence. On the valley walls of the North Klondike River, in both the upper and lower reaches, subglacially derived chutes and associated rill deposits are generally associated with eskers; this condition

has developed during the Age II as well as the Age I deglaciations. The majority of these chutes are a few metres deep by 500-1000 m long.

The association of meltwater channels with eskers requires caution. For example, the meltwater channel occupied by "Morrison Creek" in the lower North Klondike valley "uplands" is located beside eskers, but downstream the same channel breaches them. Hence, a subglacial environment for the channel is questionable - the feature may be an overflow channel from an upstream position of the stagnating ice lobe.

Subglacial channels no doubt existed on many more portions of valley slopes than those indicated on the map, but these trenches have since been obliterated by mass-wasting processes.

Map Unit 4 - Fluvial and Subaerial Facies

This unit considers two slightly different environments of deposition - fluvial and subaerial. The two may or may not occur with the glacial-deglacial cycle, as shown by Table VII. The fluvial environment involves the glacial and non-glacial cycle whereas the subaerial environment of Unit 4 involves only the intermittent deposition in and by shallow water transport in the non-glaciated portions of the terrain. The subaerial environment directly associated with deglaciation is covered by map Sub-unit 3E as previously discussed.

The duration of the continuous existence of the fluvial processes is difficult to establish in the study area. In the southeast portion of the "Snowy Range" fluvial and subaerial processes may have been in continuous operation since before the onset of the "Age III glaciation". In larger valleys elsewhere in the map-area these processes have been in continuous operation since the end of the "Age II ice advance". In smaller valleys, or in the upward reaches of the larger valleys, the fluvial cycle began in early postglacial times following the "Age I ice advance". Because of the time span these facies have been split into two time-rock groups. Those occurring prior to the time between the Hypsithermal interval and the Late Postglacial period (following the "Age I ice advance") are included in map Unit 4, while those occurring since that time (ca. 3000 years B.P. - Heusser, 1960) are assigned to the modern day "facies complex" of events - Unit 7. The distinction between the two units is based on the following:

1) Deposits of Unit 4 are bounded by river-ward or frontal escarpments; the escarpment indicates a significant difference in elevation between the feature and the surrounding flood plain. That is, the fluvial and subaerial processes have been degrading the valleys to a new base level since the Hypsithermal interval.

2) As noted by Péwé (1965) in the Tanana valley (Fig. 5) deposits of Unit 4 are invariably covered by a veneer of colluvium, eolian silt, bog, or mixed deposits more than 20 cm thick, whereas those of Unit 7 are usually not so blanketed in the map-area.

Depositional and other characteristics of fluvial and subaerial deposits are given in Appendix IA; the problem of separating them from some fluvio-glacial features is discussed under map Unit 3.

The study of fluvial deposits has received much attention in Alaska (e.g. Péwé, 1965) and in the Klondike Gold Fields to the south of the map-area (e.g. McConnell, 1905). Péwé has been able to correlate terraces to periods of glaciation. Although this study is oriented toward a similar goal, river terraces could not be similarly used in this area.

Sub-unit 4A - River Terrace Deposits

The distribution of old (and younger) terraces is sparse. Topography is partly responsible for their absence, for narrow valleys in the map-area have not been conducive to terrace development following a deglaciation - especially where stream gradients are more than 1%. Also, where narrow terraces may have developed following the Age II glaciation many have since been obscured by mass-wasting debris. However, even in broad valleys such deposits are scarce. Apparently rivers have not finished a rapid downcutting phase in the erosion cycle. Terracing conditions will not develop until there is first a period of extensive lateral planation and secondly a following period of downcutting by the master streams in the area (without the interference of a nearby ice advance).

The "younger" terraces of Unit 4 are found at the Foxy-I, NF-NL-I and Upper O'Brien Creek morainal termini. The East Blackstone River has resorted and planed portions of the Foxy-I pitted outwash, and portions of the lake silts upstream from portions of the NF-NL-I moraine. The NF-NL-I locality is not marked on the map as it was viewed in stratigraphic section only; however the base of the fluvial sediments (dated at 5070 years B.P. - Table VI) lie on the varved silts some 2-3 m above present day river levels.

At the Upper O'Brien Creek Moraine the creek has cut into a portion of and resorted the sediments of the ground moraine, hummocky ablation till, pitted proximal and distal outwashes. These terraces cannot be confused with outwash terraces for the two are at different levels in adjacent positions; admittedly, one could argue that the lower is a retreatal outwash terrace, but if we become highly technical the "retreatal application" could apply for almost all terraces in a glaciated mountainous terrain.

FIGURE 9A Approximate Stratigraphic Relationships at Field Stn. No. 66

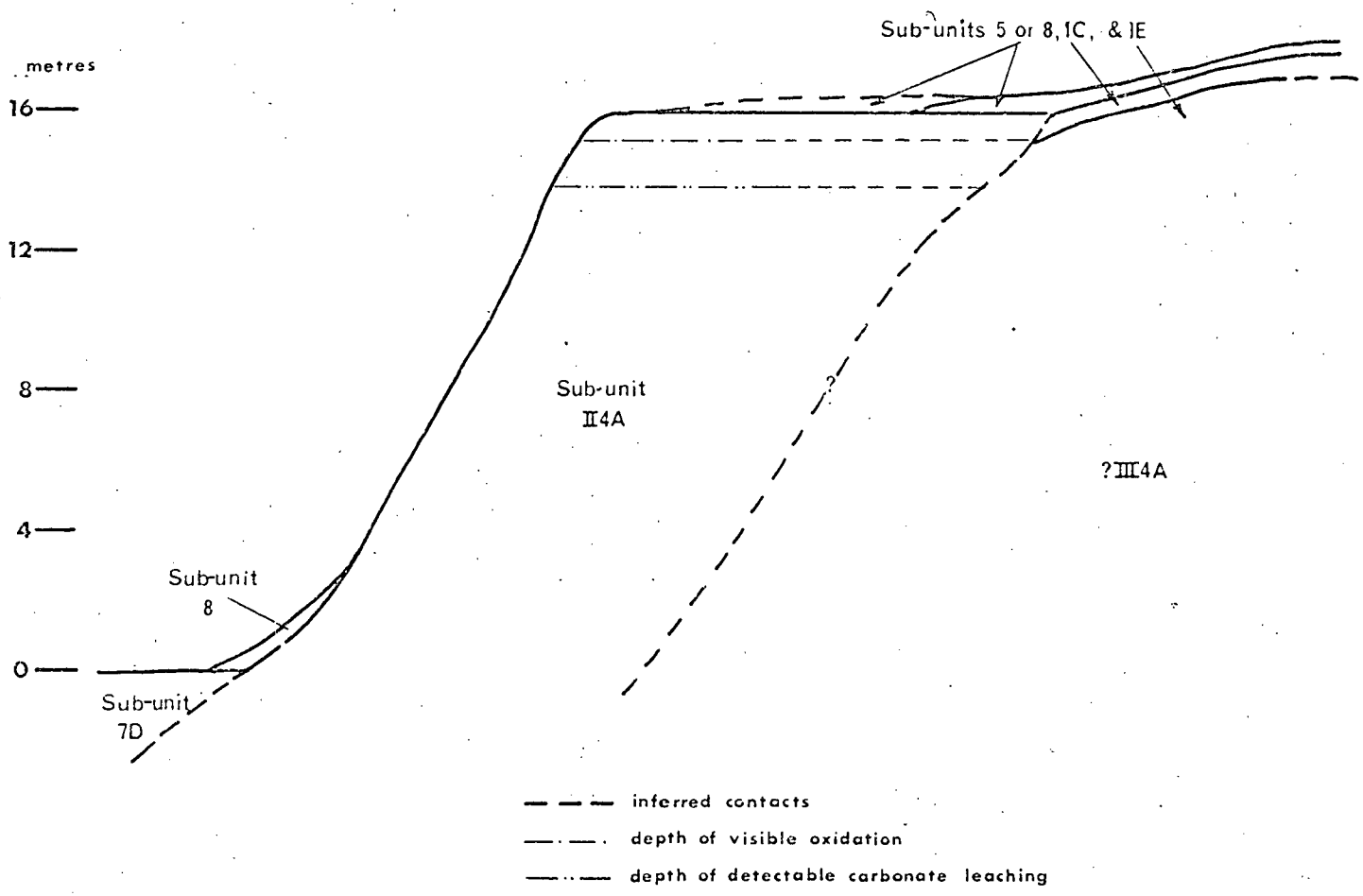

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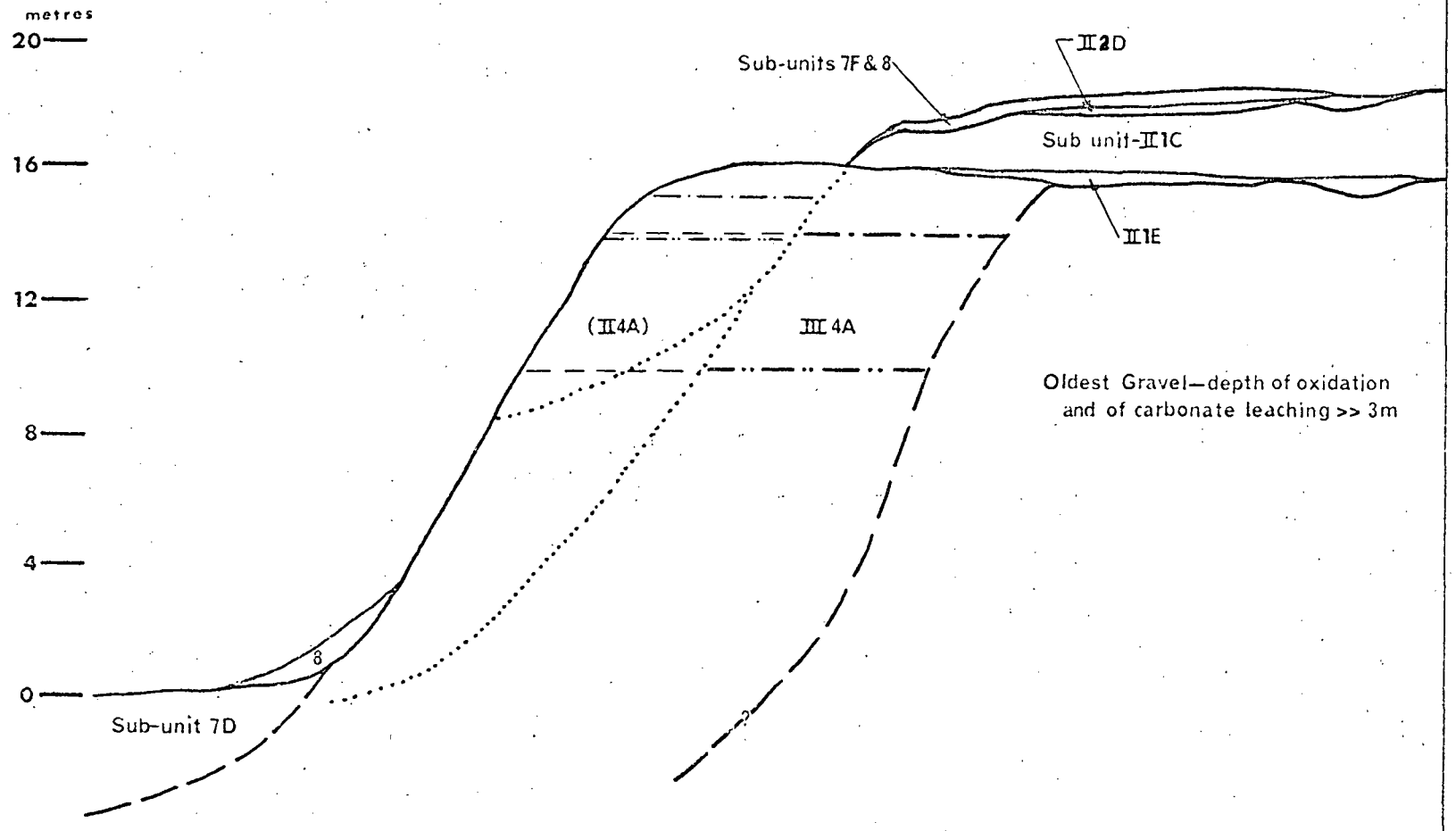
FIGURE 9B Idealized Composite Section about Field Stns. 54 & 57



In the lower North Klondike valley three or four ages of terrace development are found, although only two occur as distinct land forms and one of these is of the modern Unit 7 group. The others occur in stratigraphic section only. The Age II terraces just above the valley flood plain in the vicinity of the Fish and Benson Creek tributaries and are probably developed from the resorting of deglacial deposits. A terrace at the Yukon Consolidated Gold Company's (YCGC) intake farther downstream is 16 m above flood plain level (Fig. 9 - Sec. A). Plutonic clasts in the gravel are tough, fresh, and lack obvious cloudiness in the feldspar component; hence little weathering has taken place since deposition. The gravel in the terrace was probably derived from till of Age II and from an underlying "Age III" gravel. The older terraces in the lower North Klondike valley lie for the most part beneath an Age II ground moraine and are distinguished from the above younger terrace by a two-fold increase in depth of the zone of oxidation and of carbonate leaching (Fig. 9 - Sec. B). Considering the stratigraphic position of this gravel (below an impervious till) the difference in leaching and oxidation depths is quite significant - the older gravels must be considerably older than the Age II deposits and for the time being will be assigned to an hypothetical Age III. Remnants of this Age III gravel are found in escarpment sections intermittently along a 12 km stretch of the valley. The elevation of exposure appears to be similar on both sides of the valley - the areal extent of this gravel before the Age II glaciation may have been as much as 18 km^2. The feature might have been even more extensive - perhaps continuous with a flat feature since overridden by Age II distal outwash located at the junction of Lee Creek to the (South) Klondike valley.

Four kilometres upvalley from the YCGC intake on the North Klondike a very old gravel is exposed unconformably (Plate XIVA) beneath an Age II till (Fig. 9, Sec. B). The gravel is composed of thoroughly rotten rock clasts (Plate XIVB) that disintegrate on the slightest touch. Thick $CaCO_3$ crusts occur on all gravel-size components throughout its 3 m of vertical exposure in the pit (Stn. 57). Bostock (1966, p. 2) describes a similarly weathered gravel some 250 km southeast of the study area and assigns an oldest glaciation age (Nansen drift) to it. However, apparently not all gravels of the Nansen drift are so much altered, though his younger Klaza drift also shows the rotten characteristic at a few locales. The extremely weathered condition of the gravels at the lower North Klondike locality suggests a fluvial deposition contemporaneous with the Nansen drift or with an interglacial period before or after it.

Plate XIVA

Borrow pit at Field Stn. No. 57. Reworked loess is underlain by a 5-10 cm thick layer of rill deposits that in turn lie on Age II till at dotted line. Till with quite solid clasts overlies unconformably (dashed line) an old, very-weathered and poorly sorted gravel.

Plate XIVB

Comparison of gabbro clasts from the above exposure. The relatively fresh specimen on the left (from the till) is stained as a surficial rind; oxidation penetrated this cobble only on a fracture plane. The completely oxidized and altered specimen on the right (from the underlying gravel) crumbles upon touch.

Sub-unit 4E - Fan and Bajada Deposits (Inactive Types)

Fans are by far the more prevalent member of the Unit 4 facies in the map-area. Their age varies from Age II to very recent but, as discussed earlier, this facies deals only with those showing abrupt frontal scarps and which therefore are older than Late Postglacial (of Age I). Textures within a fan deposit are unpredictable (Appendix IC). Within the area of study textures varying from till-like diamiction to well sorted and bedded gravels and sands were observed. Thicknesses of fan deposits are not known. However, escarpments of 8-9 m in the mid reaches of the North Klondike valley, 3 m in the East Blackstone valley, and 10 m in the main Blackstone valley ("Cache Creek" area) were measured.

It seems likely that most fans of Sub-unit 4E ended their development more or less simultaneously in the late glacial to late deglacial period of the Age I episode. At this time valleys were choked with proglacial and early deglacially derived debris. Fans graded into the "valley train" at this time as "inwash". However, the fans began to develop terminal escarpment as the retreatal outwash stage accompanied the stagnating ice front upstream. This time relationship is based on the similarity of the distal outwash fans (3E) to the fans not derived by deglaciation and is fortified by the uniting of the "Ying Yang Creek" outwash fan with a neighbouring fan of non-glacial origin in the North Klondike valley. This synchroneity in deposition between the two types of fan does not always occur; for at the "Junior Creek" exit to the upper "main" Blackstone valley a morpho-stratigraphic sequence of distal outwash fans (3E), old fluviatile fan (4E), and modern day fan (7A) is exhibited. Péwé (1965) also shows the latter age relationships from his Ruby Creek-Yardang Flint Station fan studies in the Delta River valley of the Alaska Range (Fig. 5). The fan is 18-30 m high at the terminal scarp and began its entrenchment only 6000 years ago due to "perhaps the downcutting of the Delta River or more likely because of the shift of the Delta River to the east side of the valley, nipping the fan ....." that is, lateral planation without vertical downcutting is a possible mode of escarpment development.

Two fans in the East Blackstone valley are worthy of special attention. The "Henry Creek" fan (Plate IVA) is the largest single fan in the study area. It measures 2.3 km in downslope length by 1.5 km width. Much of its debris originates from Age II-IIA morainal deposits on the slopes of "Geodesy Dome". The stratigraphy of the upper layers (Appendix IC) shows that the feature once supported a podzol soil before subsequent burial by the combined action of processes belonging to the eolian and periglacial cycle. However, the latter

event did not stop surface drainage completely, for another partially eluviated soil type has developed on the surface of that portion of the fan lying adjacent to the stream. However, farther away from the stream, drainage was less effective; the warming influence of a body of flowing water is absent and features associated with permafrost are developed in the overlying frost-susceptible silts. Hence, in the permafrost zone intrazonal rather than zonal soils exist on the surface of the fan. The "Ptarmigan-Caribou Creek" fan (a bajada) is just south of the above described fan and possesses many of the above described textural and pedological features.

Péwé (1965) has found it rewarding to study large old fans archeologically and radiometrically. Some of those in the lower North Klondike valley may yield this type of data once they are more fully exposed by artificial means. Hence construction activities in this area should be visited periodically in order to obtain additional clues to the Quaternary history of the region.

Map Unit 5 - Eolian Facies

Introduction

Silt of wind-blown origin blankets most lowland regions inside and adjacent to the study area. Within the central Yukon Tyrrell (1917) and Campbell (1952) have examined "muck"[1] deposits in the Klondike Gold Fields just southwest of the study area; though not strictly loess deposits they probably contain wind-derived material as well as local humic and paludal material, and they would be classified by Péwé (1965) as a "retransported silt". There are no published accounts on loess of the central Yukon; however, there is an extensive literature concerning the loess deposits of nearby Alaska, as summarized by Péwé et al. (1965). These neighbouring studies have revealed that loess is a complex deposit despite its simple appearance in exposures. It can cover a broad time spectrum in the Quaternary Period and the material can therefore be an important stratigraphic marker-horizon.

Silt deposits in Alaska exhibit convoluted, massive and even bedding structures; they contain size fractions varying from sand to clay dimensions; they show organic components; they may or may not be associated with permafrost; and they lie on valley bottoms, on valley slopes and on ridge tops. Hence, their origin has been controversial. Tuck (1940) and Black (1951) ascribed an eolian origin and attribute the "muck" portions to a reworking of the material by solifluction. Taber (1943, 1953) steadfastly claimed that the veneer was

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[1] "Muck" is an ill-defined term; Tuck (1940) describes it as a humic rich silt usually associated with permafrost in valley bottoms.

derived in situ by frost-riven distintegration of the underlying bedrock or older surficial deposit, and that during warmer periods the material was re-transported from slopes to valley bottoms.

Péwé (1951), however, observed modern dust storms in the Delta and upper Tanana valleys and found that the windblown material had grain size frequency distributions similar to classical loess deposits elsewhere. In his 1955 and 1965 publications he discounted Taber's hypothesis for the origin of such silts about the Fairbanks area on stratigraphic, textural, mineralogic and other grounds, and noted the association of loess with sand dunes and ventifacts on the north slopes of the central Alaska Range. Hence, Péwé et al. (1965) accounted for the silts as products derived from the wind sorting action of outwash and other deglacial deposits.

The age of the eolian deposits is diverse. Péwé (1953b, 1965) recognizes Illinoian loess on the hilltops about Fairbanks, Wisconsin loess throughout the Tanana valley, and recent deposits about the extensive gravel flats near the mountain fronts. The deposition of the postglacial loess occupies a time span from 8000 (8500?) years B.P. to about 2000 years B.P. in the Fairbanks-Delta region. The rate of deposition has continually decreased in postglacial times until it is now of only a brief seasonal phenomena in the Tanana River area; and silt carrying winds are non-existent in most vegetated regions located away from the seasonally flooded valley floors.

Loess Deposits of the Map-area -- Distribution

No doubt loess in the study area has the same age distribution and complexity as described in Alaska, but due to lack of significant exposures in critical regions the older loess has not been found. Loess is found both as a distinct and as a mixed facies on most deposits in the map-area, and has locally been in more or less continuous deposition since at least 13,840 years B.P. (Table VI and Figure 10). Loess occurs as distinct massive blankets on flat terrain (e.g. CL-II outwash apron), as a congeliturbated deposit on low gradient slopes (e.g. NF-NL-I Moraine), and as a mixed deposit (Unit 8) with colluvium or mass-wasting debris (e.g. most slopes on valley walls).

Silt veneers are widespread but of variable thicknesses in the lower North Klondike valley. In most areas the veneer is at least a 5 to 10 cm thick horizon in the soil profile and generally it has been reworked by normal pedological processes. In some exposures (e.g. Field Stn. No. 54) silts have buried brunizolic soil profiles developed on an Age II till. Subsequent soil development on the veneer is limited to a regosolic or gleysolic profile in the

lower North Klondike region. In a few locales the loess thickness increases to 60 cm, but in each site examined, congeliturbation appears to have disrupted any original massiveness the deposit may have once had. A few stones from the underlying unconsolidated deposits are invariably incorporated into the silt and air holes have developed in the resultant mixture.

In the middle reaches of the North Klondike valley silt as a wind-carried product could not usually be detected in exposures. Most of the terrain in this region is of a valley-wall slope or fan surface. However, at the elevated escarpment of the "Chisolm Creek" fan 60-90 cm of colluviated eolian silt is a distinct stratigraphic cap. Near the snout of the Age I Upper North Klondike Moraine 30 cm of colluviated silt overlies a solifluction mantle developed in situ from underlying bedrock. Eolian silt and sand are present as patches on the surface of the "moraine" itself. Farther to the north "Lil Creek" valley (south of the North Fork Pass) appears to be blanketed by thin layers of loess but in many localities the deposit has since been reworked by colluvial and gelifluction activity. The moraine on the crest of the pass (NF-SL-I) is apparently devoid of eolian silt (as previously explained).

In the East Blackstone valley the complexity of the loess layers increases. On valley slopes the deposits are probably reworked into the solifluction deposits; the first deposit of recognizable loess on valley floors occurs near "Alces Lake". Exposures on the east side of the river (Field Stn. 173; Fig. 7) reveal at least a 60 cm thick layer of massive brown silt above a 5000 year old fluvial gravel and older varved silt. Inward from the exposure the loess is probably thicker, as the presence of ice wedges might suggest. The deposit overlaps the morainal zone to the north but it is not known whether the convoluted and gleyed silt mantling the moraine (e.g. Field Stn. Nos. 141 and 144) is the same stratigraphic unit. On the gravelly portions of the crest of the Foxy Creek Moraine, just to the west, a 10 cm thick eolian sand was found to have buried a well developed Brown Wooded soil (e.g. Field Stn. No. 166). The eolian silt at Stn. No. 173 may be a correlative to this deposit.

Downstream from the vicinity of the Age I moraines in the East Blackstone valley silts average 50 cm in thickness, show a consistent lack of bedding, and are usually covered by organic soils except where noted in the description of Sub-unit 4E fan surfaces.

On the Chapman Lake Moraine loess covers all features, save the hummocky ablation till features, in a massive to convoluted layer varying from 5 to more than 120 cm thick. Soils developed on the silts are typically gleysolic, organic and regosolic types, as permafrost is usually present. Greater thick-

nesses of silts occur on the north end of the Chapman Lake Moraine and on the outwash north of the moraine; at the latter area brunizolic soil profiles, occasionally gleyed, are developed on the loess surface while buried soil profiles occur in the deposit. Valley slopes about the moraine are undergoing constant gelifluction probably at the expense of previous loess deposition. The crest of the flatter-topped ridges in the region appear to be capped by 50 cm of silt if the soil pit analysis at Field Stn. No. 304 is representative (Appendix III).

Chronologic Relationships of Loess in the Map-area

In the North Klondike valley two periods of loess deposition are indicated by the following:

1) the presence of an eolian cover on the Age I Upper North Klondike Moraine.
2) the discovery of ventifacts by Dr. O. L. Hughes (pers. comm.) on the deglacial debris of the Age II Lower North Klondike Moraine.

However, the maximum extent of the younger loess (and sand) in the downvalley direction could not be determined by the writer though the material does blanket distal outwash fans in the mid reaches of the valley (e.g. Chisolm Creek fan). There is no radiometric evidence available to pin point the period of this younger deposition though it must be younger than that of the Age I (= 13,740 years minimum) moraines. Near the mouth of Benson Creek Borehole Stn. No. 99 suggests that deposition ceased prior to 5190 years B.P. (Table VI). If loess has been deposited since this time the later event was at a slow rate and the evidence has been masked by simultaneous deposition (i.e. intermixed) with Unit 6 and Unit 7 features. The Age II deposition of loess in the lower North Klondike valley is more nebulous, for there are a lack of more than one buried soil profile in the sections of loess examined. The ventifact evidence is inconclusive for Péwé (1965) has shown both Late Wisconsin and older wind faceted stones in the Delta River area of Alaska. However, the younger are within 15 km distance from the Wisconsin ice fronts at that locality; those of the lower North Klondike are 30 km from the Age I glacier fronts. Hence the development of ventifacts during the Age II deglacial cycle appears as an attractive hypothesis. It is complicated, however, by the possibility of ventifacts being developed by snow blasting during the Age I ice advance (Dr. W. H. Mathews, pers. comm.).

Stratigraphic relationships appear to be demonstratably more complex in the Blackstone drainage basin; successions of buried soil profiles are the rule rather than the exception (e.g. Field Stn. 215; Appendix IB). From

borehole logs, selective radiocarbon dating(Table VI) from samples within these logs and from critical stratigraphic exposures the following sequence of deposition is revealed.

Silt lying above dated fluviatile sediments at Field Stn. 173 (Fig. 7) must be younger than 5070 years B.P., and utilizing information from nearly silt free drill holes[2] on the moraine itself (G.S.C. 416 and 469 - Table VI) the deposit may be younger than 3100 years B.P.[3] Since buried soil profiles occur on the nearby Foxy Creek Moraine the period of youthful deposition appears to be widespread in the region. This silt deposition is here referred to as the "Rangifer Loess". The data, however, does not signify that this loess is not older than 5070 years for the fluvial sediments may have been deposited simultaneously with the earlier phases of loess development. Borehole data might suggest this loess to have started 6650 years B.P. (Stn. No. 300 - Table VI), but as is the case at the lower North Klondike locale the origin of the silt at the bottom of the hole is debatable. Péwé (1965) records the start of eolian deposition at 6000-7000 years B.P. on fan surfaces located within the Alaska Range. This may be an illogical correlation in view of the evidence in the next two paragraphs.

Between 6650 (or less) and 9600 years B.P. loess activity may have been in a period of quiescence compared to what preceded and what has been described after this interval. According to the borehole log for Station No. 211 (Dyck et al. 1966, pp. 20-21; and Appendix ID) a remarkable burst of eolian deposition occurred in a peat bog on the CL-II Moraine (Figs. 4, 8 and 10) between the interval of slightly more than 10,900 to slightly more than 9200 years B.P. The rate of deposition was about 15-20 cm per 1000 years (only a quarter of the rate recorded in some Alaskan localities). Presumably the influx of silt is associated with vast expanses of outwash gravel exposed during the deglaciation of the Age I episode in the upstream portions of the Blackstone River(s). As noted earlier this loess outburst is referred to as the "Blackstone Loess". Between 10,900 and 13,870 years B.P. the drill log records a lull in eolian activity.

Utilizing the stratigraphic data at Field Stn. 215 (Appendix IB), the above borehole figures, and the data concerning the "Rangifer Loess" period,

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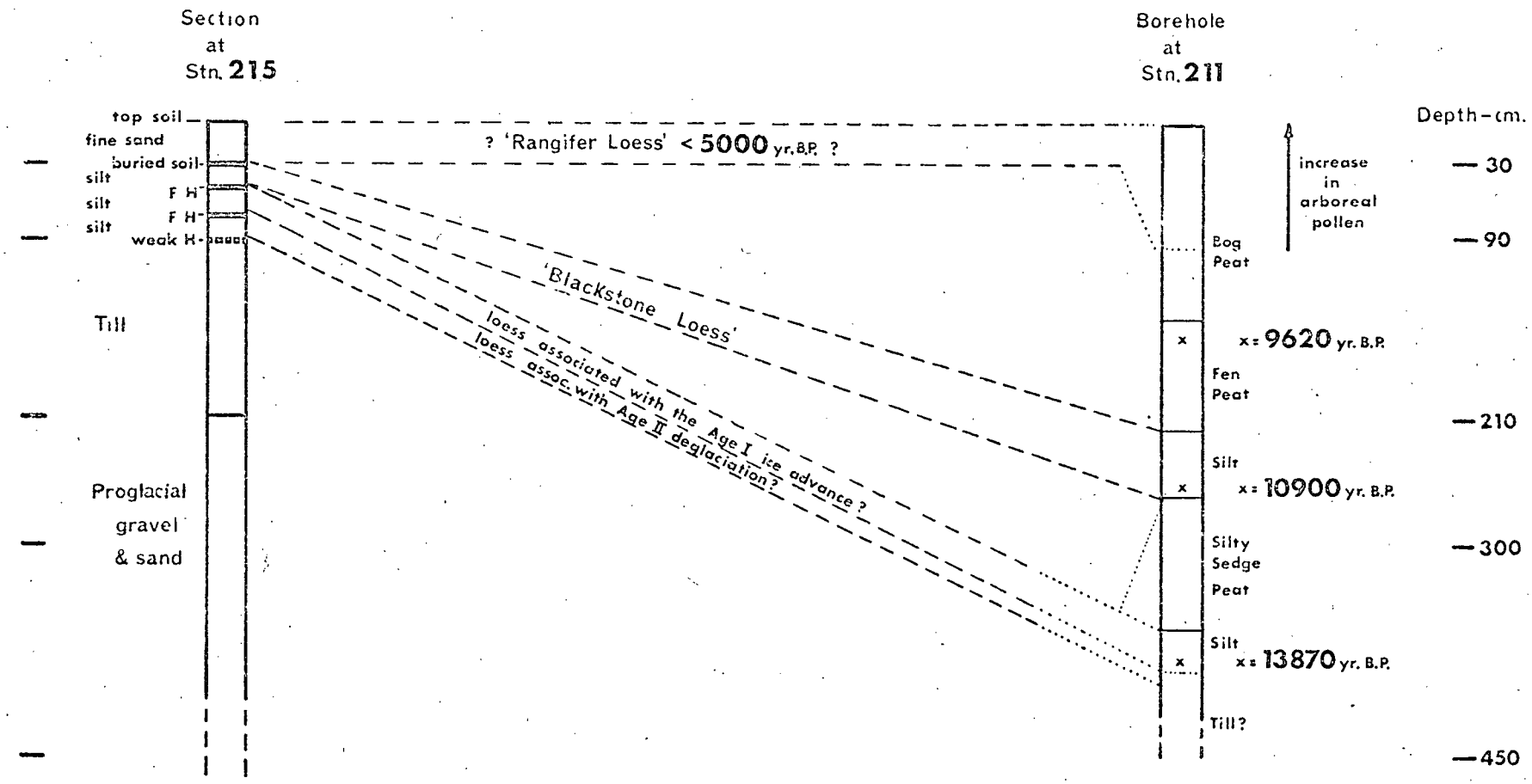
[2] That is, till (?) rather than silt was encountered at the bottom of these holes but loess may be mixed with peat layers above the bottom of the hole.

[3] Péwé (1965) indicates loess deposition to as recent as 2000 years B.P. on the Ruby Fan in the nearby Alaska Range.

FIGURE 10 Proposed Loess Stratigraphy on the Chapman Lake Moraine



the stratigraphic relationships at the Chapman Lake Moraine are suggested in Fig. 10. The correlation assumes that the "Rangifer" (perhaps the slightly older extension?) has reached this far north from the North Fork Pass area but has been dispersed in the partially unexamined upper portion of the drill log for Borehole Stn. No. 211. If this is not so then loess sheets associated with recessional phases of the CL-II ice advance must be recorded in the complex soil profile at Stn. 215. It should be pointed out that other profiles are not so revealing; generally only one developed profile is buried at other localities (e.g. Stn. 234; Appendix IC). The analysis as it now stands must be regarded as tentative, but illustrates the potential of loess stratigraphic time marker horizons in the region. The assessment would become much less conjectural if ventifacts could be found on the tops of the outwash exposures to the north of the moraine.

Volcanic Ash

One specialized form of eolian deposition is included with Unit 5. A 1-2 mm thick bed of white volcanic ash from the "non-humified" peat horizons was detected in the borehole at Stn. No. 99 about 70 cm below the bog surface. The ash is at least 1240 years old (Table VI) - much younger than 5190 years. Since the former figure is derived from peat immediately above the ash it is reasonable to suppose that this is an extension of the Upper Yukon and Tanana basin ash found by Capps (1915 and 1916), mapped by Bostock (1952) and dated by Fernald (1962) at 1520 to 1750 years B.P. The ash was distributed as a bilobed or two-directional fan (north and east). According to studies by Stuiver et al. (1964), the double fans represent two periods of eruption about 200 years apart. Their studies on the eastern dacitic lobe (feldspar = andesine) indicate an age of 1425 years B.P. - or younger than the northward andesitic (feldspar = labradorite) portion of 1635 years B.P. Our date, strangely, approximates the eastern lobe figure despite the proximity to the northern lobe. Unfortunately the ash layer is too thin to be found on other surfaces or localities in the map-area and hence is not a useful chronologic tool as used by, for example, Fernald (1962) and Rampton (1967).

Map Unit 6 - Periglacial Facies

Introduction

According to the AGI Glossary (1960) periglacial "refers to areas, conditions, processes, and deposits adjacent to the margin of a glacier". However, the term is used in much broader and narrower concepts as reviewed

by Bird (1967, pp. 157-159). The map-area for the most part today lies within a periglacial morphogenetic region (Thornbury, 1954, p. 64), and all of the area was within it at various glacial intervals during the Pleistocene Epoch. This type of region is characterized by mass-wasting processes which govern the shaping of today's landscape. The boreal forest aspect of the south third of the study area contrasts with the subarctic conditions to the north. However, the climatic characteristics of the boreal morphogenetic region as compared to the periglacial morphogenetic region overlap. The differences in the two regions can be readily observed by comparing Plate VII (south) to Plates X and XI (north). Both regions are in a youthful to mature transition stage of the periglacial cycle of erosion (Peltier's concept in Thornbury, 1954).

Mass-wasting processes of the periglacial environment are summarized by Thornbury (1945, p. 84). Creep, solifluction and debris avalanching all occur within the study area and can operate in combination to produce many of the periglacial features (e.g. solifluction lobes). These processes also work with processes characteristic of other facies; hence, a deposit may represent the transition between the periglacial and a glacial, or subaerial, or gravity, or eolian, or other facies. For example, some rock glaciers are a combination of deglacial-glacial and creep or avalanching processes; "solifluction fans" represent the intergradational product of solifluction plus subaerial depositional processes; eolian silt deposition and solifluction are often synchronous processes and can account for vast areas of mixed deposits (map Unit 8); and so on.

Compared to the territory of Alaska to the west or the Mackenzie Delta and the shield areas to the east, investigation of periglacial features in the Yukon Territory has been limited. Radforth (1966), Bird (1967), Péwé et al. (1965), and Cook (1959 and 1961) have summarized most recent research in these neighbouring regions. Previous periglacial observations close to the map-area include: discussions of ground ice, rock glaciers and frozen "muck" of the Klondike gold fields by Tyrrell (1904, 1910, 1917); Cairnes' (1912) research on solifluction in the western regions of the Ogilvie Mountains; permafrost problems in the Keno-Elsa area by Wernecke (1932); permafrost soil investigations in the northern Yukon by Mackay et al. (1961) and Drew and Shanks (1965); study of patterned ground phenomena in the Icefield Ranges by Sharp (1942); notes on several periglacial forms or features about Whitehorse and Keno respectively by Wheeler (1961) and McTaggart (1960); and mapping of gross features in the Ogilvie and Wernecke Mountains by Vernon and

Hughes (1966). The last work is the basis of the study of various features within this report. Much of the present mapping work is an expansion or revision of their effort as shown in Figure 4.

Periglacial Features in the Map-area

Features associated with the periglacial cycle vary from hidden to recently exposed ground ice phenomena, to non-descript landscape veneers to gross features that are spectacularly obvious to even the casual passer-by. If the features have a diagnostic form and are large enough they are outlined on the accompanying Quaternary map or on Figures 4, 6, 7 and 8. Other features are briefly mentioned near the end of the discussion.

Ground ice features common on permafrost terrain have been classified by Mackay (1966). In his soil ice category, Taber (or segregated) ice and pore ice are common in the north half of the map-area. Pore ice is readily found in most eolian silt deposits (map Unit 5), whereas Taber ice was found in varved silts (Sub-unit 3D) at two localities (Plate XIIIB). Mackay's intrusive ice category is represented by two pingos (Sub-unit 6E) on the Blackstone River flood plain. Ice wedges (Sub-unit 6B) are representative of Mackay's veined ice category, and numerous river icing localities (Plate IB) fit into the extrusive ice division; the few debris-covered glaciers and snowbanks buried by talus activity comprise the buried ice grouping.

Lobed solifluction deposits (Sub-unit 6A) are conspicuous on much of the sloping landscape whereas patterned ground (Sub-unit 6B) phenomena of the upland variety are common but not easily detected on aerial photographs. Rock glaciers (Sub-unit 6C) and felsenmeere (Sub-unit 6F) are common to the portions of the map-area underlain by competent bedrock. Most features (6A, 6B in part, 6C and 6F) are not totally dependent upon the presence of perennially frozen substrata for their development or accumulation (Flint, 1957).

Other periglacial features in the area are dependent upon the local degradation of permafrost for their existence. Thermokarst cave-in features and collapse pits are members of this group and are common in the valleys north of North Fork Pass.

Duration of the Periglacial Cycle

This is a problem not easily resolved for the pollen profile of a peat bog (Appendix ID) does not reveal decisive evidence of periods of climatic amelioration since the "Age I glaciation". During each glaciation those lands

not inundated by ice, according to theory, should have been subjected to intense periglacial activity. What happened between glaciations is problematical. According to Flint (1957), the zone of discontinuous permafrost decreased in areal extent during an interglacial or interstadial period. The extent of reduction of the periglacial cycle is not accurately known in the northern Cordillera. If the most recent postglacial period is any criterion, local reduction of periglacial activity during older glacial intervals was only slight. Weathering investigations discussed in Part 2 of this thesis bear this out. However, in the lower reaches of the North Klondike valley these remarks will have to be modified, for well oxidized gravels above and below Age II till would suggest periods of climatic amelioration. Tyrrell's (1917) theory of the development of "muck" in tributary valleys of the Klondike system advocated warm interglacial periods. Péwé's (1957, 1965) evidence of fossil ice wedges and stained loess indicates an interruption of the periglacial cycle during the Sangamon Interglacial in the nearby Tanana River region (Fig. 5).

During the "Age I glaciation" the periglacial condition was probably more intense than today, for inactive rock glaciers occur at abnormally low elevations in the lowermost west-facing slopes of the "Snowy Range" (Table XI).

Since the conclusion of the "Age I glaciation" three intervals of decreased periglacial activity are suspected from the following evidence:

1) 0.3 to 3.0 metres of down-melting of ice wedges in the Tanana Valley of Alaska (Péwé, 1965); the melting began during the interval 6300 to 8000 years B.P.[1] and terminated about 3500-4000 years B.P.; the pollen profile (Appendix ID) suggest a vague decrease in cold climate species during this interval.

2) the onset of development of rock glaciers about 3000 years B.P. as recorded by Wahrhaftig and Cox (1959) in the central Alaska Range and the subsequent waning of these features about 2000 years ago;

3) the redevelopment and resurgence of rock glaciers subsequent to 1400 years B.P.; the advance of cirque, valley and piedmont glaciers in Alaska (Péwé et al., 1965) in the last few centuries; and the subsequent warmer climatic conditions in the 1600's, 1800's (Péwé, 1965), and the early 1930's and 1940's in the Dawson and Fairbanks regions (Thomas, 1961).

Sub-unit 6A - Lobed Solifluction Deposits

At this point it is probably beneficial to refine the terminology - according to Washburn (1965) solifluction should be designated gelifluction when frozen ground is present. The net effect of this gelifluction on the

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[1] Radforth (1966) suggests that this period of warming may have begun 10,000 years ago.

Plate XVA

Lobate terraces (intergrade varieties) on north slope of "Dall Sheep Mtn." Large lobe on lower left was examined as shown in Figure 11.

Plate XVB

The snout of the above mentioned solifluction lobe. Field assistant indicates the scale.

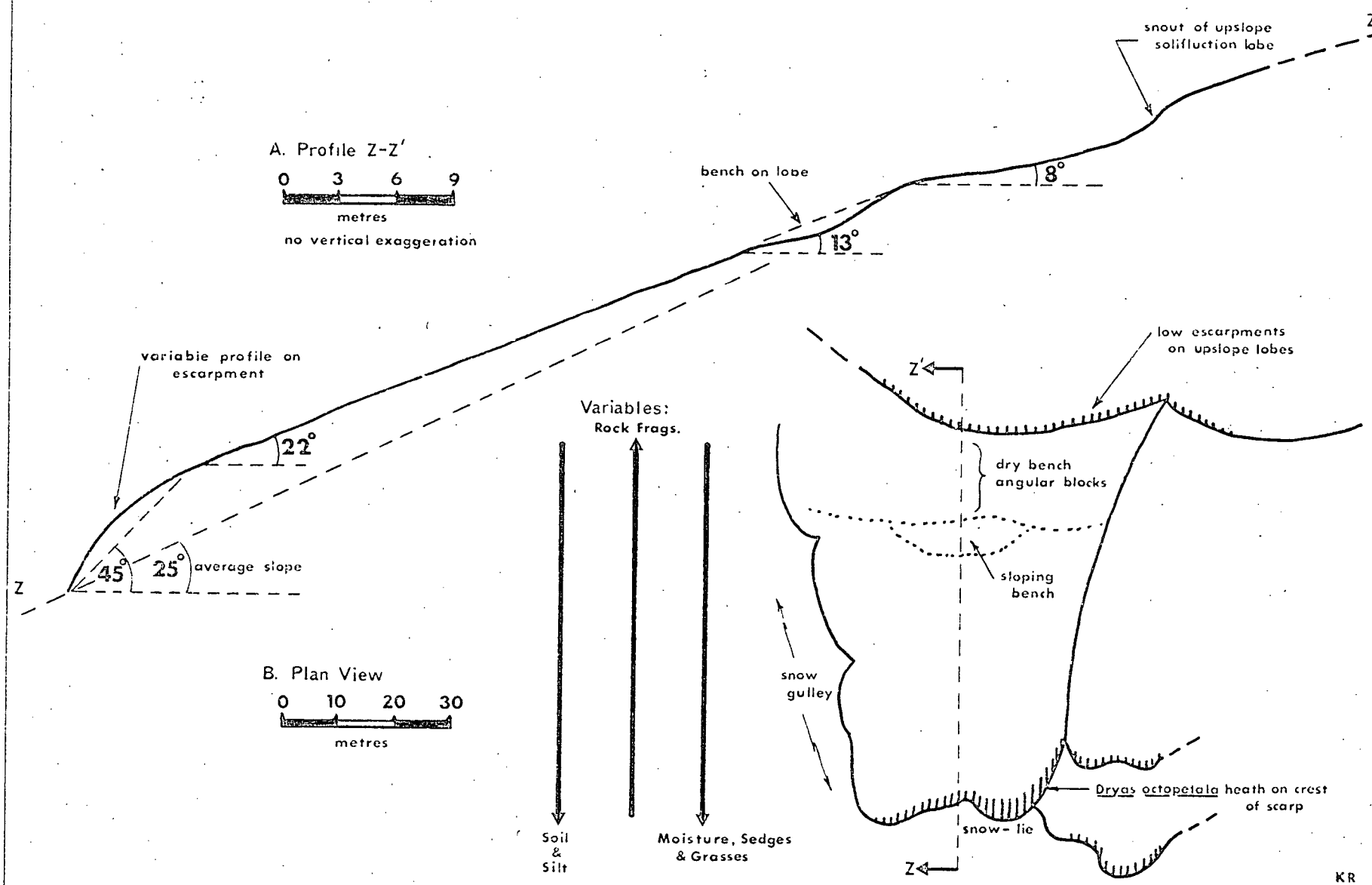
landscape is a streamlining, or festooned appearance. Sub-unit 6A deals only with the lobed derivatives of gelifluction. Other forms are generally mixed or masked with colluvial, frost-rived, eolian and other secondarily-derived debris on most surfaces and are therefore mapped as a mixed deposit as discussed under map Unit 8.

Since much of the terrain in the map-area has a steep slope, lobed solifluction deposits are very common. The lobes are regarded as distinct geologic entities and are usually produced by a combination of gelifluction with some other process(es) as outlined by the pioneering classic of Sigafoos and Hopkins (1952). Lobed solifluction deposits are subdivided by them into several recognizable forms on the basis of morphometry, initial slope of development, the variations in the types of processes producing them, vegetation and water table characteristics. The following types are recognized: elongate benches of soil terraces (st), scalloped escarpments of lobate terraces (lt), tongue-like soil lobes (sb) and hummocky, fan-like tundra mudflows (tm). A variation of the last-mentioned form is Drew and Shanks' (1965) solifluction fan. Transition forms between each category are recognized, for a gradational series that changes from one form to another during downslope migration has been outlined by Sigafoos and Hopkins.

Soil terraces (st) up to 500 m long were observed on the southwestern flanks of the "Snowy Range" some 300 m above the North Klondike River. These features undoubtedly occur elsewhere in the "Snowy" and "North Klondike Ranges" but limitations with aerial photographs and in traversing have restricted their being mapped.

Lobate terraces (lt) and soil lobes (sb) together form one of the most extensive surficial deposits. Throughout the study area it is difficult to separate the two. Either both types intermingled on the same slope or the intergrade form would be present. On the northeast slopes of the ridge crest connecting "Angelcomb Peak" to "Dall Sheep Mountain" in the North Fork Pass area the intergrades were eventually mapped as lobate terraces (Plate XV) according to the following reasoning. The prominent lobe shown in Plate XVB was measured as indicated in Figure 11. The survey indicates that in slope and dimensions the feature is close to a soil lobe - the profile length is 1.6 times the width; this is slightly under the two-fold ratio suggested by Sigafoos and Hopkins (1952) but is closer to a soil lobe than the typical lobate terrace(width along the contour greater than profile length). However, the profile in Figure 11 reveals an absence of an upslope steep-sided depression equivalent in volume to the downslope lobe (a mandatory requirement

FIGURE 11 Pace and Compass Survey of a Solifluction Lobe (intergrade variety) on "Dall Sheep Mtn."



for a typical soil lobe). Hence, the features for the time being are classified as modified lobate terraces.

The distribution of lobate terraces or areas of lobate intergrades (marked as a non-suffixed 6A) is of interest. The features occur in scattered zones on the slope of the North Klondike valley, but appear to be quite rare in the terrain of the "North Klondike Range" underlain by quartzite and gabbros. Lobate terraces occur as scattered fields in the monzonite stock zones and increase in frequency in the northern portions of the "Snowy Range" and in the nearby "Prospector Range"; these areas are underlain by erosion-susceptible fine-grained clastics. Wherever either this rock type or platy limestones occur north of North Fork Pass there is a high density of lobate terraces. In the siliceous dolomites of the "Seela", "Patrol", and Central Ogilvie Ranges lobate terraces are not nearly so common. Hence, their distribution appears to be lithologically controlled where allochthonous deposits are thin.

Tundra mudflows (tm) are scattered sparsely on lower slopes throughout the southern two thirds of the map-area. It is difficult to distinguish between permafrost-controlled and non-permafrost-controlled mudflows. Where permafrost is suspected to be absent, or not in the surficial mantle, the features have been mapped under map Sub-unit 7H. Tundra mudflows are relatively small features according to the diagnosis of Sigafoos and Hopkins (1952). In the study area small flows were found only on midslopes in extensive areas of lobate terraces about the North Fork Pass region. Fresh scars were observed a few metres wide and 20 to 30 m in downslope length. On the lower portion of the slopes, especially "Dall Sheep" and "Angelcomb" mountains, these features measured 1.0 to 1.5 km in downslope length by 250 to 500 m in width. The larger type exhibited pronounced hummocky and frontal scarps and an upslope apex radiating from the mouth of large gullies. Though both are mudflows the form of the larger is decidedly fan-like as shown by the following section at the base of "Angelcomb Mountain":

- thin layer of colluvium on surface underlain by -
- 2 m of moderatley bedded silt and fine sand underlain by -
- a thin organic horizon underlain by -
- 3 m of interbedded silt, sand, and well-rounded fine gravel.

Some of the textural arrangement resembles a fan, but the hummocky form on the surface and buried organic layers suggest a solifluction type of intermittent deposition. The feature is apparently derived from two alternating processes and would represent a gradation between fans of the subaerial facies and tundra mudflows of the periglacial facies. Drew and Shanks (1965) have called similar

features in the Firth River area (Fig. 1) "solifluction fans"; this term may be appropriate in the North Fork Pass region also.

Similar large-scale solifluction lobe-like features are located on the lower North Klondike valley floor just opposite the "Morrison Creek exit". These features appear to have been created by coalescence of a series of mudflows from off the steep west-facing slopes overhead. Elsewhere, a tundra mudflow-like feature is found in the "Talus Lake" area of the upper Tombstone Valley. It is 1.2 km long by 300 m in width, along the contour, and is situated beneath an area of extensive lobate terrace development. In photographs taken by Crawford (1959) and Tempelman-Kluit (1966) the feature appears to be gravelly; hence it may not have been developed by the typical tundra mudflow process.

In summary, the lobed solifluction features described by Sigafoos and Hopkins (1952) can be found in the Ogilvie Mountains. Since their work was carried out farther to the west, and was the pioneering research in this field of study, it is not unexpected to find the variations described above. In some regions vast areas of very poorly developed solifluction lobes appear to be developed directly on residual soil developed from the underlying bedrock. Hence, in the "Nehru Range", for example, a lobed solifluction veneer symbol is employed as a separate entity from the previously mentioned mixed deposit veneer symbol (Unit 8). Within the study area the majority of lobed features appear to be active; this condition is not surprising for Péwé et al. (1965) mark the zone of their present development in Alaska in those areas above or beyond the forest limit, such as is the case in this study area. However, the development is considered by the writer to be marginal, as shown by the orientation of many of the lobed features. Where their development is in a healthy state the features should be concentrated on south-facing slopes and should be contributing to the development of asymmetrical valleys as found by Currey (1964). In this map-area the features are most pronounced on northerly-facing slopes and are least developed on the southerly-facing; valley asymmetry was not observed.

Sub-unit 6B - Patterned Ground

The sub-unit deals with two distinct patterned features. Those of the valley bottom are ground-ice features developed as foliated ice wedges in polygonal patterns. The other feature is the complex array of upland and valley slope features developed by frost sorting action on unconsolidated deposits; they are devoid of distinct ice masses and consist of various arrangements and sizes of stripes, circles, nets, etc.

Ice Wedge Polygons of the Valley Bottoms

The investigation of ice wedges are summarized by Péwé (1966a). Two surface forms of ice wedge polygon terrain are recognized: high-centre polygons, and low-centre or raised-edge polygons. The latter usually indicate the active grrowth of the foliated ice wedge itself, whereas the former mean inactivity or thawing conditions. However, Hussey and Michelson (1966) show that inactive forms can be low-centred under certain drainage conditions.

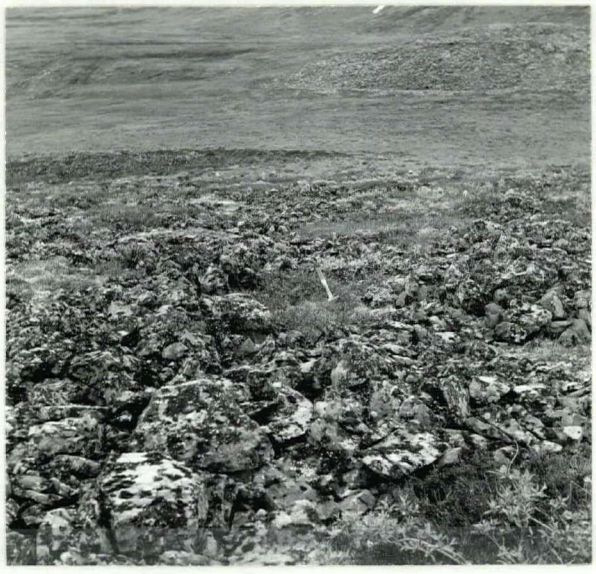
According to Péwé (1966a) active ice wedges are located within the zone of continuous permafrost or north of the southern limit of the mean annual -6° to -8°C isotherm; a minimum of at least 2800 Celsius degree-days of freezing per annum are required. Less than 140 cm of snow falls during the winter period. Snow, if packed by drifting, provides little insulation between the ground and the air. Summers are correspondingly cool and cloudy and the rainfall for the summer period is about 20 cm. Table II shows that the Dawson area does not quite have the temperature requirements to maintain active wedges, but suggests that the more elevated Blackstone and Taiga Valley regions may have the conditions necessary to promote their growth. However, the environmental conditions characteristic of the zone of inactive ice wedges overlap a few of the above values; though the zone is confined generally to the region of discontinuous permafrost.

In the study area ice wedge terrain is prevalent only north of the axis of the Southern Ogilvie Ranges. Polygons appear in the East Blackstone valley just north of the NF-SL-I surfaces (Plate XVIA). From this point northward all valley bottom areas away from active streams, all morainal depressions, most low-sloping benches, all inactive fan surfaces, and most crests of gentle swells support ice wedges. The distribution of ice wedge polygons on certain of the surficial landforms is interesting. The largest continuous expanse of polygons (2.5 km^2) is on the "Ptarmigan and Caribou Creek bajada" - the pattern show up as knife-like incisions on the aerial photographs. Eolian silts less than 1 m thick lie on this feature and no doubt the growth of polygons is restricted somewhat by this thin frost-susceptible layer. To the east of this region (opposite side of the East Blackstone River) the broader cracks in the polygons imply either older age of polygons or a thicker frost-susceptible growth medium. Polygons are confined to proximal portions of the CL-II outwash - the portion of the outwash covered by a thicker loess mantle. Ice wedges sometimes occur on older river terrace gravels (Sub-unit 4A) veneered by silt but are never found on young terraces (Sub-unit 7i) or young fans (7A).

Plate XVIA

Ice wedge polygons developed in loess and varved silts upstream from inner loop of the north lobe of the North Fork Pass Moraine.

Plate XVIB



Sorted stone circles developed in quartzites on the north-facing benches of "North Twin Mtn." These features lie above the former upper limit of the Age II ice at this locale.

Typically the polygons are 4- or 5-sided, 20 to 50 m in diameter, and are bounded by troughs 50 to 100 cm deep, filled with water. Secondary and tertiary development occurs inside some of the larger "master" polygons.

The distribution of high-centred and low-centred types is random - the two can occur in the same locality though usually not side by side. The low-centred variety was found on both the NF-NL-I and the CL-II moraines. Their raised edges are turfy and dry, and are about 1 m above the shallow ponded water within the polygon. The ratio of occurrence of raised lip to high-centred polygons is somewhere between 1:1 and 1:2 in the Blackstone drainage basin within the area covered by the 1:25,000 scale aerial photographs. The distribution probably indicates the precarious balance between the state of discontinuous to continuous permafrost that must exist in the area. Indicators of the marginal balance are also shown by flow-lines transecting polygon development in the region between the East Blackstone River and "Gyrfalcon Creek". In other portions of the same region "Gyrfalcon Creek" follows a beaded drainage (Sub-unit 6B-b) that bisects a zone of low-centred polygons. Polygons are not formed on surfaces adjacent to seasonal streams, yet are quite well developed on the same parent material a few tens of metres away (e.g. "Henry Creek" fan). This, too, is an indication of the delicate balance between their present development versus degradation.

Fossil wedges are an unusual feature. In Alaska, Péwé (1965) reports Illinoian to recent ages for these features. His theory of origin (1966a) includes ice wedge growth of the crack; later the ice melts out and material of bimodal grain size distribution slumps into the void. In studies at Taylor Dry Valley, Victoria Land (Péwé, 1959; Berg and Black, 1966), polygons under active development were located without the ice wedge; they are cracks derived by cold contraction and are filled seasonally with eolian silt and sand. The fossil wedges located about 10 km south east of the study area show sand filled fissures (Plate XVII) in oxidized gravels of probably post Klaza drift age (Bostock, 1966). Plate XVIIB indicates that the cracks are filled by silt and sand - not with gravel derived by slumpage. The silt is of the same character as the loess blanket capping the gravel to either side of the wedge; perhaps ice wedges were never present in these wedges either. The time of wedge formation was probably during the Reid or younger McConnell ice advances (Bostock, 1966).

Plate XVIIA

Plan view of fossil sand-wedge-filled polygons excavated at borrow pit on Dawson-Stewart Highway just southwest of map-area.

Plate XVIIB

Two sand wedges in transverse section and intervening sand wedge in longitudinal section at above locale. Material above field assistants left hand is a recent man-made accumulation.

Patterned Ground of the Uplands

The origin, classification and significance of the patterned ground features associated with "soil" resorting are summarized by Washburn (1956). Cook (1961) has reviewed their occurrences in Canada. These features, first reported in the map-area by Crawford (1959), are numerous in both as sorted and non-sorted patterns in the map-area. However, since they occur on uplands or upper slopes they have not received the attention they deserve, and they are not adequately represented on the accompanying 1:50,000 scale map.

Sorted stripes, nets and polygons are found on Age II glaciated surfaces of the North Klondike valley especially in the terrain underlain by quartzites. In the "Lil Creek" canyon area a non-sorted series of gravel steps arranged in imbricate fashion was found on the slopes near the highway. Each gravel step is a semicircular "pad" of 30 to 50 cm radius. Sorted stone circles were located on the edge of a felsenmeere above the "Age II glaciation" limits on the nearby "North Twin Peak" area (Plate XVIB). The circle was made up of a periphery of subangular boulders of locally-derived quartzite and gabbro about a central zone of gritty "fines" 60 to 100 cm in diameter. It cannot be proven whether these circles and polygons are undergoing active development at present; McTaggart (1960) considers those at Keno to be inactive remnants that had developed during a previous colder climatic interval.

Surprisingly, patterned features were not noticed on upland traverses north of North Fork Pass. Apparently altered volcanics, fine-grained clastics and carbonate rocks are not suitable for much more than the development of striped soil patterns.

Sub-unit 6C - Rock Glaciers (and "Debris Covered Glaciers", Glacierets)

Previous Research and Genesis

Rock glaciers are a spectacular feature of the northern Cordillera and are common in most ranges except those bordering the coastal margin. Capps (1910) carried out the first extensive study of rock glaciers in Alaska. His hypothesis concerning their development is that snow and water drifts into talus blocks; after gradual buildup of both components the feature eventually attains a weight of rock and ice (secondarily derived) necessary to promote downslope movement by creep and flowage. This has been substantiated by the extensive research in the Central Alaska Range by Wahrhaftig and Cox (1959), who considered and rejected most other suggested modes of origin. Rock glaciers also occur elsewhere in North America; they lie at least as far south

as the Sierra Nevada. The investigations by Ives (1940), and Outcalt and Benedict (1965) in the Colorado Rockies are pertinent to this discussion, for their ideas on the development of rock glaciers by also the downwasting of debris-ladened glaciers (primary ice) and by a combination of snow and rock avalanche buildup are applicable to some debatable features in the map-area. According to Flint (1957), rock glaciers derived from either secondary or primary ice are both possible, but the former are more common.

Research on rock glaciers in the Yukon Territory has been limited. Tyrrell (1910) claimed that a type of rock glacier occurred just behind the town of Dawson on the Moosehide "Scar", but the unusual spring-fed source of the rubbly talus has led to dispute as to whether this is really a rock glacier: Wahrhaftig and Cox (1959) are doubtful, but Bird (1967) is prepared to accept it within the realms of the rock glacier concept.

Vernon and Hughes (1966) mapped over 100 rock glaciers in the Southern Ogilvie Ranges and Wernecke Mountains according to two classification schemes. Firstly they distinguish between primary ice rock glaciers (their "debris-covered glaciers") and rock glaciers with incipient-developed ice. Secondly they subdivide the latter according to the lobate, tongue and spatulate classification proposed by Wahrhaftig and Cox. Vernon and Hughes wonder whether the glacier-cored type was overlooked by Wahrhaftig and Cox, for such characteristics as conical pits, tension crevasses, incised meander furrows and upstream spoon-shaped depressions are present in some rock glaciers in both study areas (the Alaska and Southern Ogilvie Ranges).

Types of "Glaciers" in Map-area

The two-fold classification of rock glaciers (s.lat.) suggested by Vernon and Hughes is not as simple as they imply; once more their Map 1170A (Fig. 4 in part) is very misleading. Aerial photographs suggest that in the "Cloudy" and "Tombstone" Ranges 5 of the 7 "debris-covered glaciers" on Figure 4 are glacierets containing relatively pure ice, on which ablation moraine is extensive near the snouts of one near "Mt. Frank Ray" and another in the headwaters of "Wolf Creek". Two of the seven marked in northward-facing cirques of their Figure 4 could not be found by Dr. D. Tempelman-Kluit (pers. comm.); two others marked as rock glaciers (secondary ice) were found by him at "Monolith Mtn." and "Yoke Mtn.", but debris is virtually absent on both according to photographs taken by Tempelman-Kluit (1966) and Crawford (1959). However, Crawford did observe at the "Yoke Mtn." locality that headwall debris is gathering on the upper margins of the ice surface and periodically it would

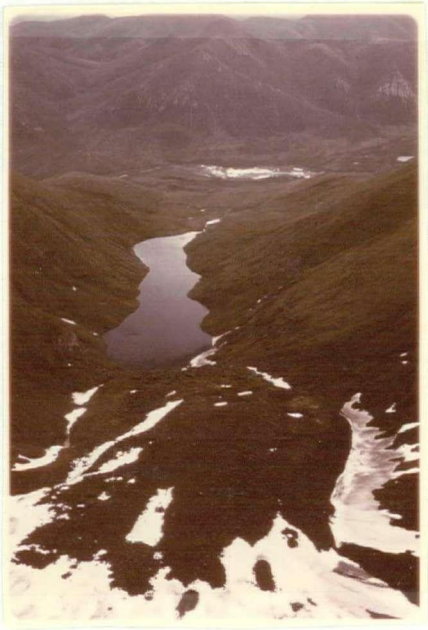
slide towards the concave medial portion of the glacier. In addition four other primary ice glaciers, not marked at all on Vernon and Hughes' Map 1170A (Fig. 4), are found in the "Tombstone Range" - the one in the head cirque of Spotted Fawn Gulch has extensive debris cover while the other three are relatively free of debris. Hence, only 2 or 3 glaciers in the "Tombstone" and "Cloudy" ranges deserve the "debris-covered" designation - incised meander furrows are found on those at the "Wolf Creek" and "Mt. Frank Ray" localities. Since confusion apparently exists, all of the above bodies derived from primary ice are lumped together on the accompanying Quaternary map as glacierets.

In the "Elf Lake" valley of the "Agglomerate Range" there is another debris-covered glacier" (Fig. 4), of complex origin. This feature may be cored by glacier ice, as suggested by a marginal meander furrow, headwall firn (Plate XVIIIA), and a series of slit-like furrows at the snout (Plate VIII). However, it appears to be generating secondary ice in situ as rock debris falls onto its surface. Furthermore, primary snow and ice is being carried down onto the surface by way of a conspicuous gully slashing the headwall. It has been designated as a rock glacier, for probably more than 50% of its volume is rock and much of the transporting medium is not likely to be primary glacier ice. Furthermore, the spoon shaped depression is only vaguely present, and collapse pits, crevasses and radial fissures do not appear to exist. Others of the 80-odd rock glaciers (presumed to be cored by secondary ice) in the map-area may well have a similar multiple origin.

At several localities within the study area the writer suspects that rock-fall onto pre-existing snowbanks has triggered the eventual growth of some rock glaciers. In some valley floor localities the avalanching source proposed by Outcalt and Benedict (1965) appears to be a plausible origin for some lobate types. In the "Mt. Chisolm" region a severe landslide may have been the predecessor of rock glacier development; subsequently, snow and water have percolated into the debris zone to produce a spatulate form of rock glacier that existed for a period of time.

Thus the 12 (or more?) glacier-ice-cored features and 85 secondary ice-cored features in the map-area represent all gradations between relatively uncontaminated glacierets, partial debris-covered glacierets, total debris-covered glaciers, and rock glaciers of several origins. Glacierets and rock glaciers are two end members of a gradational ice to rock series, just as ice-wedge polygons and sand-wedge polygons are in the McMurdo Sound region of Antarctica (Berg and Black, 1966). The basic variables governing the type of glacier to be produced are: the ratio of the rate of snow or firn accumulation to the rate of rock block delivery, the amount of and time of subsequent snow

Plate XVIIIA



Rock glacier of complex origin in "Elf Lake" valley of "Agglomerate Range". Rock glacier may be underlain in part by stagnant glacier ice but is currently being added to by a mixture of snow and rock derived by avalanching from cirque walls. Some secondary ice may be developing in situ as well.

Plate XVIIIB

Inactive lower portion of a reactivated rock glacier located in the isolated cirque shown in Plate XIIC. Rock glacier appears to be of the secondary ice-derived type.

or ice melt, and the geometry of the catchment "basin". Hence, rock glaciers provide a gradational boundary between the glacial and periglacial facies - both facies are climatically controlled by temperature; but variations in moisture requirement govern the final type produced. Furthermore there is a gradational boundary between landslides (aerial or gravity facies) and rock glaciers (periglacial facies), as shown by Thornbury (1954).

Characteristics of Rock Glaciers

Surface features on rock glaciers are adequately described by Wahrhaftig and Cox (1959), Outcalt and Benedict (1965) and Vernon and Hughes (1966). However, rock glaciers can be similar in size and shape to landslides of the rotation slump or fragmental rock flow varieties. Within the map-area some of the features of this type in tributaries of the North Klondike valley were particularly difficult to classify.

Within the map-area there exist the tongue, lobate and spatulate varieties of rock glaciers. The larger lobate type measure about 1500 m in contour width by 800 m in downslope length (e.g. cirques east of Antimony Mtn.); smaller forms with the same 1:2 length to width ratio are more common. The tongue-shaped glaciers are up to 1.5 km in downslope length by up to 1 km in accumulation zone width; the total relief between the source and terminus is as great as 500 m in the "Snowy Range". Spatulate glaciers are as large as the tongue shape; occasionally the terminus lobe fans out to as much as 2 km in lateral width in the "Snowy Range". The sequence of development of these forms is well described by Wahrhaftig and Cox (1959).

Active and inactive (dormant) rock glaciers have been recognized in most surveys of the northern Cordillera and both are present within the map-area (Plate XVIII). Active types can be positively identified by yearly measurement, but the active-inactive criteria listed by Wahrhaftig and Cox (1959) and by Vernon and Hughes (1966) are reliable to the point that only reactivated glaciers sometimes create problems with the determination. Unfortunately these criteria require field observation for in many cases, rock glaciers are often in shadow zones on aerial photographs. Within the map-area the writer was unable to assess the regime of 19 of 86 detected rock glaciers[2] for this reason. However, with the remainder, the observations indicate that the ratio of active (including 7% reactivated) to inactive is roughly 2:3 (Table XI).

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[2] With the exception of the "Elf" valley locale the primary ice type of rock glacier is not included in the ratios and percentages to follow.

Wahrhaftig and Cox (1959) estimate a 1:1 ratio of active to inactive types within the central Alaska Range; about 13% of their total of rock glaciers are reactivated forms. The similarity of these two ratios suggests similarity in environmental conditions. Within the map-area the writer noted that in a given locality dormant rock glaciers are at lower elevations than their active neighbours. Most of the spatulate rock glaciers are dormant in the area.

With respect to the budget of glacierets, their recent withdrawal from one or sometimes two sets of terminal moraines is obvious. One glacier has retreated as much as 1 km whereas others have completely disappeared recently.

Rock glaciers are decidedly sporadic in distribution. Whereas ice glaciers or glacierets are confined to one zone within the map-area, rock glaciers can be lacking despite the suitable elevation and orientation of the cirque in question. According to Wahrhaftig and Cox (1959) the reason for this is a lithologic control of their development. Platy and schistose rocks weather into sizes too small to yield the porosity needed for interstitial ice development. Figure 3 indicates that much of the northern half of the map-area lacks suitable resistant and blocky bedrock sources. The greatest number of rock glaciers occur in a zone of grits (Unit III) on the western escarpments of the "Snowy Range"; yet they are scarce on the range's southeastern dip slope. A second concentration of rock glacier proliferation is on the escarpment faces of the imbricate thrust sheets of blocky Keno Hill Quartzite (Unit XVII) and associated gabbroic sill (Unit XX) near the Tombstone Stock. On the other hand, rock glaciers are scarce in the terrain underlain by the erosion susceptible clasts of Units II, III in part, IV, VIII, XIII, XIV and XV; but the siliceous carbonates of Unit I are apparently suitable for development of rock glaciers. Hence, there appears to be a significant correlation between lithology and rock glacier within the map-area.

Elevations of Rock Glaciers and Glacierets

Crawford (1959) estimated that the firn line in the "Tombstone" and "Cloudy" ranges is 1975 m (m.s.l.). However, I estimate the firn line for the "Cloudy" range at about 1760 m (m.s.l.), whereas it is 200 m lower for the "Tombstone" owing to a much shadier environment about the glaciers. The exception is the east-facing glacieret on "Monolith Mountain"; here the firn line is at about 1850 m (m.s.l.). Table XI indicates that the termini of rock glaciers are about 300-700 m below the regional firn line. The firn line in the central Alaska Range is about 100-200 m higher than that of the map-area, but there too Wahrhaftig and Cox have seen rock glaciers as much as 700 m below

TABLE XI Elevations (m.) of rock glacier termini in the North Klondike - Upper Blackstone drainage basins.

GEOGRAPHIC AREA, (ARRANGED IN DESCENDING SOUTH TO NORTH ORDER.)		AVERAGE ELEVATION (m.)[1], ORIENTATION AND REGIME STATUS[2] OF ROCK GLACIERS. NORTH AC	NORTH DO	NORTH UN	EAST AC	EAST DO	EAST UN	WEST AC	WEST DO	WEST UN	SOUTH AC	SOUTH DO	SOUTH UN	TOTAL F. IN RANGE	BEDROCK GEOLOGY (TABLE I)
"Snowy Range"	- av.el.	1260*	1260	1380	-	-	-	1175**	1185	1160	-	1110	-		XXIB
(normal group)	- F.	5	3	2	0	0	0	6	8	4	0	3	0	31	III, XIX
(low group)	- av.el.	-	-	-	-	-	-	-	(760)	-	-	-	-		
	- F.	0	0	0	0	0	0	0	(3)	0	0	0	0	(3)	ditto
"North Klondike Range"	- av.el.	1490	-	1445	1445	1245	0	1520	-	-	-	-	-		XX
	- F.	3	0	2	2	2	0	1	0	0	0	0	0	10	XVII, XXIB
"Tombstone Range"	- av.el.	1345*	1460	1480	-	-	1050	-**	-	1280	-	1540	-		XVII, XXIB
	- F.	3	1	1	0	0	1	0	0	1	0	1	0	8	XX, XIX
"Cloudy Range"	- av.el.	1600*	-	1630	-**	1800	1565	-	-	1770	1490	1710	-		XVII, XXIB
	- F.	4	0	2	0	1	2	0	0	1	1	1	0	12	XIV, III, IX
"Prospector Range"	- av.el.	-	-	-	-	-	-	1050*	1275	-	-	1190	-		XVII, XX
	- F.	0	0	0	0	0	0	1	2	0	0	1	0	4	IX, XIX
"Seela Range"	- av.el.	-	-	-	-	-	-	-	-	-	1510	1550	-		ITC, IX, IV
	- F.	0	0	0	0	0	0	0	0	0	1	1	0	2	III
"Rangifer Range"	- av.el.	1400	1550	-	-	-	-	1700	-	1450	-	-	-		III, IV
	- F.	1	2	0	0	0	0	1	0	1	0	0	0	5	IX
"Agglomerate Range"	- av.el.	1550	1425	-	-	-	-	-	-	-	-	-	-		III, IV
	- F.	1	2	0	0	0	0	0	0	0	0	0	0	3	IX, XIII
Central Ogilvie Ranges	- av.el.	1200	-	-	-	-	975	-	1275	-	-	-	-		I, II
	- F.	2	0	0	0	0	2	0	1	0	0	0	0	5	VIII
Mean Elevations (m.)		1400	1400	1290	1445	1430	1220	1260	1210	1300	1500	1340	-		
Total Frequencies (F)		19	8	7	2	3	5	9	11	7	2	7	0	83	

[1] - Orientation refers to direction the snout of the glacier is facing; [2] - AC = active, DO = dormant, UN = regime not known;
* - indicates that reactivated rock glaciers are included, and lowermost elevation of the active portion is used;
** - indicates northwest or northeast facing rock glacier has been included in the north group.
[3] - Rock glacier are not found in the map portions of the "Kit", "Nehru", "Patrol" and "O'Brien" ranges.
[4] - Elevations for the "Seela Range","Rangifer Range", "Agglomerate Range" and Central Ogilvie Ranges are not as accurate as those to the south of these areas.

this line. This phenomenon is accounted for by the insulating effect of the debris on the rock glacier.

Table XI indicates that a majority of rock glaciers are in north-facing basins; the high number of west-facing as compared to east-facing ones is due to the structural control previously suggested. As expected, south-facing active rock glaciers are fewer and are also at higher elevations; south-facing glacierets do not exist. Generally, termini of active rock glaciers are at slightly higher elevations within the central portions of the map-area, and are lowest within the "Snowy Range". This is roughly in agreement with the cirque analysis of Table X. The slightly higher central region elevations may be due to a shortage of quantitative data and to the lack of 30 m contour-interval maps for the analysis of the north half of the map-area. Surprisingly, inactive rock glaciers were not too much lower (save three exceptional circumstances) than active forms and occasionally they were higher than the active ones in a given range. The same phenomena was noted by Wahrhaftig and Cox (1959), though rarely did the elevations of the inactive exceed the active.

The elevations of the active forms in the map-area are similar to those of the Windy Area of the east central Alaska Range. The west- and south-facing inactive glaciers of the map-area are in agreement with the elevations of inactive forms in the Windy region whereas inactive east- and north-facing ones are in close agreement with those of the west central (Wood River) area of the Alaskan Range (all as given by Wahrhaftig and Cox, 1959). Average values here, however, are about 200 m lower than the interpolated values[3] of the entire Southern Ogilvie Ranges and portions of the neighbouring Wernecke Mountains as given by Vernon and Hughes (1966).

Chronology of Rock Glaciers and Glacierets

Wahrhaftig and Cox (1959) claim that the active and inactive rock glaciers are related to two periods of post-Hypsithermal cooling - that is, since 3000 years B.P. (Heusser, 1960). The lower and the inactive rock glaciers are assumed by Wahrhaftig and Cox to have been initiated between 3000 and 2500 years B.P. In the interval of 2000 to 1500 years B.P. the climate warmed sufficiently to halt development, but between 1400 and 670 years B.P. the active glaciers and rock glaciers of today were born, according to Rampton's

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[3] Note that their figures quote an average headwall or accumulation zone elevation of 1800 m (m.s.l.). Our figures are compared to the terminus positions - assumed to be 100-200 m lower on the average.

(1967) and other published data. Some of the older inactive rock glacier forms were reactivated at this latter interval as well. Vernon and Hughes (1966) say that these age relationships also hold for those occurring in the Ogilvie Mountains. The writer concurs, for one active rock glacier is developed on a fresh slide zone that in turn exists on an Age I glaciated valley wall. According to Terasmae (in Dyck and Fyles, 1963) significant warming of the climate occurred in the Dawson area about 270 years B.P. and Péwé (1965) indicates pulsating withdrawal of glaciers in the central Alaska Range at 1870, 1830 and 1650 (?) A.D. It is not known whether rock glaciers have become dormant during the last few centuries.

Only a very few rock glaciers in the central Alaska Range can be related to an initial growth period during the Late Wisconsin Stade. Péwé (1965) points out one such possibility in the High Valley region. In the map-area the 750 m terminus elevations of three inactive rock glacier snouts in the "Snowy Range" is anomalously low when compared with others nearby. The features are covered by a scrub forest and are much more subdued than neighbouring inactive forms. These features lie on Age II glaciated slopes and are best explained as having developed during the time of the Age I ice advance (or Late Wisconsin Stade).

Sub-unit 6D - Peat Bogs Associated with Permafrost

Introduction - Bog Genesis

The Algonkian term "muskeg" refers to any natural area of accumulated peat, whether it be on slopes, domes, flats or depressional terrain (Heusser, 1960). Studies on subarctic peat bogs have been extensive in Scandinavia since the turn of the century. The work has been reviewed by Drury (1956) and subsequent North American investigations are summarized by Bird (1967).

To understand bog development one must adopt a geological viewpoint (Drury, 1956). In his area of study the following modes of development were realized:

1) Flatiron-shaped bodies of water in an old flood plain are colonized by the Spaghnum and related forms of water absorbing mosses. Eventually successional floral changes accompany the gradual elimination of free water taken up by the mosses; the area is then invaded by sedges, shrubs, etc.

2) Forest regions are invaded by forest mosses and moisture is thereby accumulated. Spaghnum mosses then invade and generate a swamp or marsh condition due to their ability to retain 300% moisture by weight. Bog conditions develop from the marsh eventually (paludification).

3) Permafrost or pereletok terrain is thawed or ruptured and bog producing conditions are established (depergelation).

The differences between numbers 1 and 2 are the initial moisture conditions. In the first a hydric condition is converted eventually to a mesic condition, according to standard ecological successional concepts, whereas the second illustrates the reverse trend. With the second the zone of permafrost may rise closer to the ground surface as the moss becomes a more effective insulating blanket. In the map-area bogs have been devloped by all three of the above methods.

Since bogs of the first type are not directly related to permafrost they are listed under map Sub-unit 7F (recent paludal deposits). Bogs evolved by method two occur throughout the map-area. They can be observed in their early development beneath the spruce forest, and in final development at Borehole Stn. No. 99 of the lower North Klondike valley. Intermediate stages occur under the scattered clumps of white spruce (Picea glauca) at the base of "Panorama Ridge" in Taiga Valley. Since the bogs developed by method two are usually in forest zones they are not easily recognized on aerial photographs. Hence, Sub-unit 6D represents primarily the mapping and investigation of bogs evolved by "depergelation" and those in the advanced stage of "paludification". Depergelation types are intimately associated with thermokarst and cave-in lake processes; such phenomenon are common at the NF-NL-I, CL-II and TV-IIA moraines. Neither type of bog is abundant at the NF-SL-I, Foxy-I or OG-III moraines.

Palsa and String Bog

Bogs of the tundra regions are classified not only by their mode of genesis but also are subdivided on the basis of form as compared to climatic zone. Troll (1944) and others (summarized by Bird, 1967) distinguish palsen or ice-cored hummocked types of the flat terrain in the zone of continuous permafrost from the string or strangmoor type of the slightly sloping terrain in the zone of sporadic permafrost and seasonal frost. Hare (1959) implies that palsa bogs have been invaded terrain once occupied by strangmoors in the Labrador Trough, though the increasing wetness created by the advance of continuous permafrost. Drury (1956) challenges the environmental requirements of the strangmoor type postulated by Troll (1944), and claims that he mistranslated the Scandinavian literature containing the original descriptions and processes of their formation. Strangmoors with festooned to arcuate peat ridges are found on flat terrain underlain by permafrost (discontinuous zone) in the Kuskokwim valley (Drury, 1956), Tanana valley (Péwé, 1965) and on flat

terrain in the continuous permafrost zone of the Firth River region (Drew and Shanks, 1965). Hence the latter two investigations would also refute Troll's claims, but Bird (1967) apparently would not.

The significance of hummocky surface bogs appears to involve not only mistranslation but also a problem of geographic unawareness. Zonation of the two types of bogs may occur in the Canadian Shield but obviously this is non-existent or overlapping in cordilleran regions. Within the map-area, for example, both types of bog are found on flat and slightly sloping habitats of the CL-II moraine. Some of these bogs appear to be gradational between the irregular hummocked and the regular ridged type. Drew and Shanks (1965) note that some strangmoors are broadly-ridged (Plate XXIIIA) and others are narrowly-ridged. The latter have accumulated calcium carbonate as a distinct layer in the ridged portion. Both narrow and broad ridges occur in the morainal areas of this region. The broad ridges are up to 1 m wide by 1 m above the bog whereas the more uniform narrow ridges are only 15 to 30 cm wide and 10 to 20 cm above the water. Because of this gradational development all bogs showing any sort of marked microrelief are noted by a (p) on the accompanying map; that is, the term palsa is not used in a strict sense on the Quaternary map and in Figures 7 and 8.

Bog Distribution and Studies

The largest bog of the map-area lies on the Age II glaciated portion of the East Blackstone valley just east of the "Ptarmigan Creek" tributary. It measures 3 km in length by 1 km in cross valley width, and is dissected by numerous ice wedges. The bog is probably shallow and its development was probably enhanced by the underlying, frost-susceptible fine-grained sediment (loess?). It is connected upvalley to a large (1.5 km^2), hummocked bog showing at least 25% open water. Large bogs are also noted in the main Blackstone valley at Caldwell Lake, at the junction to "Seela Creek", and upstream on the deglacial debris of the Age I Upper Blackstone Moraine.

Surprisingly, bogs are not very noticeable in the northwestern and northeastern corners of the map sheet and are scarce to the south of the main axis of the Southern Ogilvie Range. Despite the ideal basin-and-ridge topography on the NF-SL-I moraine hummocked bogs are not obvious. Hence, for the younger surface lack of permafrost and insufficient fine-grained soil do not appear to be conducive to bog development, whereas for the older region (Age III) bogs have either since disappeared through erosional sequence or there was a lack of initial irregular relief to promote their development.

Some bogs were cored for age dating purposes, as previously mentioned (Table VI). The drill log for the Chapman Lake hole (No. 211) is given in Appendix ID. According to the log it appears that the bog was developed by conversion of a marsh to a peat bog by a moss absorption process. The marsh may have been a lake that was shoaled by continual cave-in activity in the manner described by Bird (1967). If so, the bog may have first been developed by rupture (depergelation) and second, a gradual moss invasion. In addition to these studies, Field Stn. No. 217 was set up on a strangmoor and studied pedologically and botanically; the results are given in Appendices III and IVC.

Bog Growth Rates and Chronology

Table VI indicates that peat development has varied both vertically and regionally, from 1660 to 6000 years for a metre of accumulation. No doubt the accumulation time fluctuates with compaction, permafrost activity, type of vegetational succession, inwash etc. The same irregular rate is exhibited by data from surrounding regions. For example, the bog overlying the "White River ash" took only 660 years for a metre of accumulation (775 using Fernald's (1962) new date) in the Chisana district (Capps, 1916), whereas the same stratigraphic marker in the Kluane Lake area reveals that an overlying bog required 4200 years for one metre of development (Stuiver et al., 1964). At Borehole Stn. No. 99 peat above the same ash layer would need 1800 years for a metre of accumulation, whereas it was 3400 years for one metre of accumulation below the stratum. The older bogs give a slightly more consistent accumulation rate. For example, the Twin Buttes locale near Mayo (Dyck et al. 1966. G.S.C. No. 365) required an average 4900 years for a metre in a 10,840 year old bog and the "Gill Lake" bog (Dyck and Fyles, 1964. G.S.C. No. 128) northwest of the map-area required 5400 years for a metre of accumulation. Both of these rates are slightly longer accumulations than the average 3600 years for a metre of development in the 13,800 year old bogs on the CL-II and Foxy-I moraines.

Generally these growth rates are of the same order of magnitude as those of non-permafrost type bogs of coastal Alaska - 605 to 5200 years for a metre of accumulation (Heusser, 1960). However, these "rates" are slower than the averages of 1000 years per metre of development in Oregon and Washington (Heusser, 1960) and the 1430 years/m for British Columbia (interior locality by Nasmith et al. 1967; and Queen Charlotte by Heusser, 1960). Hence, bog development in the subarctic Cordillera is not only about half the "rate" of temperate regions but it also fails to show the steady growth rate suggested by Nasmith et al.

The most frustrating problem in northern Cordillera peat coring chronology is our failure to obtain dates older than Late Wisconsin for bogs developed on obviously much older moraines. The Age III moraine (Borehole Stn. No. 300) illustrates this situation; the 6650 years B.P. date is less than half the age of the Age I moraines. If the thermokarst cycle of Bird (1967) is correct there does not appear to be any chance of old or original bog being preserved on old morainal topography. This is illustrated by the nearly identical dates for the bogs on the Age I and Age II moraines. Vernon and Hughes (1966) point out that there are depressions on the North Fork Pass Moraine where organic accumulation has not yet begun. That is, the problem is not only one of thermokarst, but also at least 14,000 years may elapse before bog development starts, in some depressions. It would appear that if bog dating is to be used as a successful tool in moraine chronology there can be no substitute for high frequency sampling.

Sub-unit 6E - Pingos

Studies on North American pingos are reviewed by Bird (1967) and Péwé and Müller (1966). Investigations to date are beginning to reveal the widespread occurrence of pingos, especially in the unglaciated portions of the northern Cordillera. In Alaska, Holmes et al. (1962) and Péwé (1965) discussed the origin, morphometry, age and local distribution of pingos. These features are subdivided into open (hydrolaccolith) and closed types. The former are common in areas of high relief while the latter are more numerous on the flat coastal areas of Canada and Siberia. Both are developed according to the hydraulic press principle but variations in the initial permafrost environment determine the type to be developed. Müller (1959) describes in full the environmental requirements and the mode of emplacement of each type. Talik zones (at least temporary ones) are essential to the development of both types of pingos, and Müller concludes that they are confined to the southern limits of permafrost (latitude 65°-74°N; permafrost zone not specified). The pingos in the map-area and in the Fairbanks region lie within these limits; though as Holmes et al. (1962 and 1966) indicate the south limit of pingo development is in the zone of discontinuous permafrost.

Only two pingos are known in the map-area and neither was visited by the writer. Vernon and Hughes (1966) illustrate by low oblique aerial photography a collapsed pingo mass some 5.5 km northeast of Caldwell Lake in the main Blackstone valley (Plate X). A hemispherical mound about 20 m high by 40 m in diameter is located on one portion of its rim and a similarly elevated, convex

arcuate ridge 300 m long occupies another portion. The entire feature is 400-500 m in diameter and is surrounded by bog and shallow lake combination. Vernon and Hughes (1966) suggest that the arcuate ridge is a rim of a collapsed and much larger pingo or an ice heaved feature comparable in age to the "small pingo" upon a portion of it.

The second pingo is much more clearly defined and is located in the scalloped flood plain of the main "Blackstone valley some 9 km west of the Dempster Highway crossing (Plate X). It resembles a truncated cone, elliptical in transverse section, with a summit fissure that plunges to the north. The basal, long-axis diameter is 150 to 200 m, the corresponding short-axis diameter is half that, and the summit fissure is 50 to 75 m in length. The steep sided feature stands at least 20 m above the surrounding terrain (Plate VA). The dimensions of this feature are similar to the Alpha Pingo in the Fairbanks region of Alaska (Péwé, 1965).

The pingos in the map-area should be of the open type - especially the asymmetrical one located at the base of the fans on the steep slopes of the "Chapman Hills". However, the pingo near Caldwell Lake is not close to such a fan and is surrounded by lakes; it may be the collapsed remnant of a closed type pingo. However, the minor dome ("small pingo") within it indicates that the origin is complex - perhaps an open system pingo is represented by the rejuvenated form.

Pingo development postdates flood plain development. The flood plain is not youthful as attested by the escarpments and scalloped appearances. Péwé (1965) gives a 6000 to 8000 year age to the "Alpha-Beta" group of pingos in the Fairbanks region. Those of the map-area are probably younger for thermokarst developments in the lakes of the flood plain indicate an age possibly as much as a quarter of the above figure (refer to ensuing discussion on thermokarst). This would agree with the findings of Holmes *et al.* (1966), for they indicate from their work in the unglaciated regions of central Alaska "that the existence of pingos cannot be related to any single climatic period but rather it seems that they have formed throughout postglacial times --- " (from Péwé and Müller, 1966, p. 550).

Regardless of postglacial variations in chronology, pingos indicate the continuation of the periglacial cycle in the area and help to emphasize the delicate transition of discontinuous to continuous permafrost that must exist in the Blackstone valley.

Sub-unit 6F - Felsenmeere

Bird (1967) and Cook (1961) summarize the Canadian research on felsenmeere. The "equiplanation" studies of Cairnes (1912) in the western Ogilvies are about the only significant contribution from the Yukon Cordillera approaching felsenmeere studies. The significance of felsenmeere as an indicator of unglaciated terrain in the Canadian Shield is controversial. According to the latest information (Bird, 1967) the feature can survive the effects of glaciation. Because of such anomalous occurrences the writer can not establish the upper limit of the "Age III glaciation" by felsenmeere limits. Evaluation of erratic localities (above Age II ice limits) and projected possible profiles of this ice surface reveal that felsenmeere localities ("Signal Hill", "Discovery Ridge" and "North Twin Mtn.") of the North Klondike drainage would have most likely been buried by Age III ice. Furthermore, the examined localities reveal that angular blocks of quartzite (Unit XVII) comprise the bulk of these deposits. This would suggest active development of the felsenmeere today.

Environmental conditions conducive to felsenmeere development are listed by Bird (1967) as follows:

1) Lithology - fine-grained sedimentary rocks are not prone to felsenmeere development; spectacular forms are confined to granitic, high grade gneissic and quartzitic source areas.
2) Frost heaving temperature regime in the climate.
3) Adequate joint systems in the bedrock.

Felsenmeere development is confined to the "Snowy", "Tombstone", "North Klondike" and portions of adjacent ranges underlain by the Keno Hill Quartzites (Unit XVII) and grits (Unit III). North of these regions broad ridge crests are littered with an unsorted fine residuum between tor-like features which according to Bird (1967) represent the final stages of felsenmeere evolution (a variation of Cairnes equiplanation hypothesis). However, this stage is hypothetical, for rock types of the north slope region are those not conducive to initial felsenmeere development - that is, altered volcanics, platy carbonates and fine-grained fissile clastics.

Regardless of the degree of development of felsenmeere it appears that periglacial action of this type occurs at elevations as low as 1250 m (m.s.l.) within the map-area today.

Miscellaneous Periglacial Festures (no map unit numbers)

Within the map-area some thermokarst and tor features are indicated on the accompanying map while other minor features remain as unrecorded. The

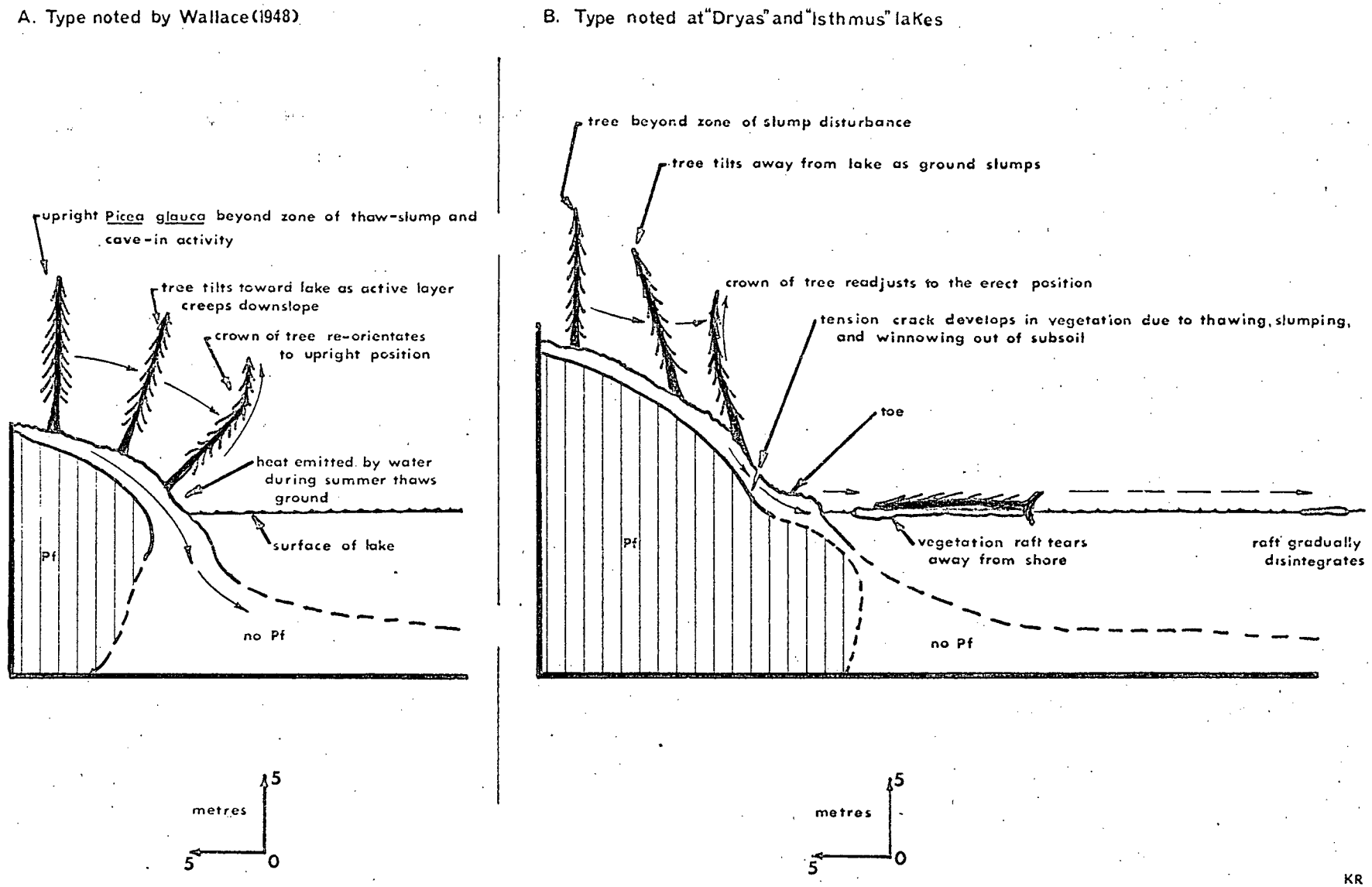
distribution of the former two is far more extensive than indicated but because of lack of significant or conclusive evidence the more controversial would-be designations are omitted. Thermokarst activity is an indicator of permafrost or pereletok distribution at the degradational stage and is an important process in the development of lakes and bogs within the northern one half of the map-area. Tor-like or "castellated outcrop" features have been used by Bostock (1966) and Muller (1967) to outine the extent of older Pleistocene glaciations on the Yukon Plateau (Fig. 5).

Thermokarst activity, collapse pit and thaw-lake development are ice degradational processes opposed to the present day development of ice wedge or other ground ice features. Bird (1967) gives an excellent resume on the topic; apparently, the definition of the process is vague. Whereas Péwé (1965) includes ice wedge thawing as a thermokarst phenomena, Mackay (1958a) limits the phenomena to the melting of ground ice sheets. The writer follows the latter course. According to Bird (1967) thermokarst activity is restricted to terrain of fine sediment textures near the southern margin of permafrost (zone not indicated).

Within the map-area three large elliptical pits are found associated with nearby flood plain activity at the mouth of "Foxy Creek" and near the pingo localities in the main Blackstone valley. Their long axis diameters are 100-250 m and the depths are less than 10 m. These pits are four times as large as those described by Bird (1967) and those about Chapman Lake (Plate XXA). The pits are connected to the flood plain by drainage ravines; hence the anomalous features may represent thaw-lake basins or thaw sinks, as described by Hopkins (1949), that drained catastrophically.

Cave-in thaw lakes are a widespread feature of the Blackstone drainage basin. While some may represent the thaw sink development the majority are the result of the cave-in process as outlined by Wallace (1948) and as shown by Figure 12. Wallace's observations in flood plain areas indicate a four-stage cycle of development which he designates as: youth, early maturity, late maturity and old age. The younger stages occur upstream from the older. In the flood plain just west of the Dempster Highway crossing of the "main" Blackstone River, the youthful stage is denoted by numerous small lakes in abandoned channels; the early mature stage is depicted by the coalesced lakes with scalloped margins; and the late mature stage (integration of drainage channels through basins and incipient levee formation) appears to be just beginning in the three largest basins centred about the asymmetrical pingo (Plate X). The climax old age stage (segmentation of lakes by natural levees) is not present in the area and according to Dr. J. R. Mackay (permafrost

FIGURE 12 ThermoKarst Indicators on the Chapman Lake Moraine



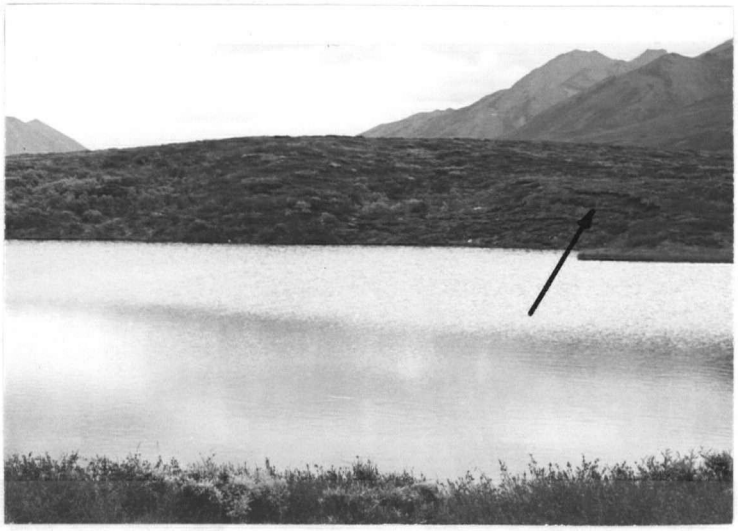
seminar, March 17/64) this is not always a final stage of development. Younger stages also occur upstream in both the East and "main" Blackstone River flood plains and adjacent regions (e.g. at "Two Moose Lake").

Thermokarst cave-in lake activity is developed in the swell and swale topography of the morainal areas of the Blackstone valley. The necessary irregularities in the "initial relief" are present to permit optimum depth of thaw activity and there are still sufficient "initial surface residuals" left to promote continuation of activity according to the "initial surface settlement" theory of Hussey and Michelson (1966). The most spectacular activity has and is taking place on the Chapman Lake Moraine and the cycle is certainly the most active geomorphic degradational process occurring on the Age II, Age IIA and NF-NL-I moraines. However, the phenomenon is not too common on the OG-III and Foxy-I moraines and is not known on NF-SL-I surface despite the abundance of ideal irregular relief.

The active cave-in phenomenon is shown by tension cracks developing in the mat of shore line vegetation at "Arnica" and "Saussurea" lakes (Fig. 7; Plate XIXA) on the NF-NL-I moraine and at "Isthmus Lakes" (Fig. 8) on the CL-II moraine. In the latter locality the mats were found just offshore (Plate XIXB). The slopes of nearby "Dryas Lake" also exhibit "drunken forest" indicators, but they are reversed in orientation (Fig. 12B) from the usual type of Wallace (1948) or Péwé (1966b). Since "relict initial relief" and "final relief" is high on the Chapman Lake Moraine the tree crowns tend to bend towards the region of the initial surface. The basin banks tend to rotationally slump or sluff perhaps because of the retardation in permafrost melt at depth as shown by Figure 12B. Eventually the accumulated mass at the toe of the slope on the shore edge is torn away and for a short period is seen on the lake surface. Winter ice cover and its following spring break-up gradually disintegrate the vegetation raft.

According to Bird (1967) the largest known single thaw lake is 1-2 km in diameter. The depth of water in a thaw lake basin, according to heat transfer theory (Hussey and Michelson, 1966) should not exceed 3 to 4 m, and shallow water is indicated by aerial photographs of such basins in the map-area (Plates X and XI). Since peripheral morainal zones are conspicuous by their depressional topography, basins coalescence is brought about by thermokarst activity. Plate XI shows that Chapman Lake, approximately 4 km^2 in extent, was at least 18 separate basins initially, and the present complex basin is about to engulf another 9 or 10 adjacent basins. The convergence of thermokarst activity at this lake is probably due to the presence of frost-susceptible varved silts that underlie the region (refer to discussion of

Plate XIXA

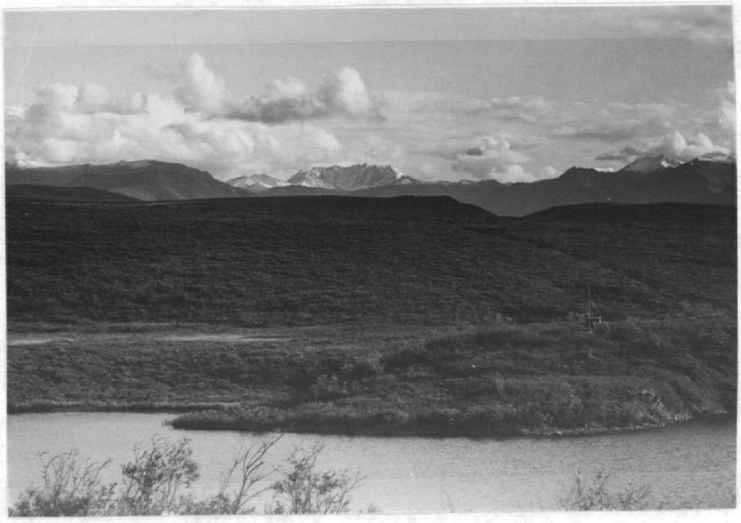


Tension cracks (arrow) caused by thermokarst activity on shore of "Arnica Lake" (located on the north lobe of the North Fork Pass Moraine). Vegetation belongs to the Shrub-Tussock Community.

Plate XIXB

Floating vegetation mat that was torn away from slope of "Isthmus Lakes" (on Chapman Lake Moraine). Field assistant is standing beside another semi buoyant mat that is slowly being undermined by thermokarst activity. Vegetation belongs to the Shrub-Tussock Community.

Plate XXA



Collapse pits behind triangulation station (right foreground) on shore slopes of Chapman Lake. Vegetation mat belongs to an ubiquitous Tall Tussock Community. "Apophysis Mtn." of "Cloudy Range" lies to south on central skyline.

Plate XXB

Chapman Lake's steep shoreline is caused by thermokarst activity. Island is remnant of a strip of land that was once part of the shoreline. Moraine is covered by a Shrub-Tussock Community in foreground. "Geodesy Dome" lies on right midground.

Sub-unit 3D). Lake coalescence elsewhere on the moraine has taken place since the air photography of 1951: the two "Isthmus Lakes" have since become one expanse of water, an interconnected multiple basin.

At the NF-NL-I moraine, lake basin development by such methods is not nearly so extensive. It is only one half the size of the CL-II moraine and is probably not underlain by extensive silts. None the less "Gull Lake" (Fig.7) appears originally to have been at least 4 separate basins, each the size of nearby "Arnica Lake". In the imminent future the chain of small lakes between "Saussurea" and "Arnica" lakes will be one continuous basin, for thermokarst activity is very active at this locality (Plate XIXA).

According to Bird (1967), and from observations on the Chapman Lake Moraine, thaw lakes continue to expand laterally until they shoal themselves or until their basins are drained. According to Hussey and Michelson (1966) the processes by which the basin is drained and a subsequent lake is formed is not clearly understood. Evidently the processes lead to the development of marshy circular depressions and bogs in the moraine. According to Bird (1967), ground ice will reinvade the area and tundra vegetation will develop to the point where all traces of the former lake vanish and a rebirth of the cycle is ultimately possible. At present the CL-II and the NF-NL-I moraines are in a stage where "initial surface residuals" are occupying terrain between the lakes and filled in depressions. Hence, not all areas within the moraines have been subjected to a thermokarst cycle as yet.

Wallace (1948) calculated the rate of lake-shore retreat by cave-in activity on the Tanana River area to be 5.8 to 19.0 cm per year; that is, the early mature stage of development is reached after 500 to 1600 years of activity. In the Blackstone flood plain area the process probably began after the Age I deglaciation. Possibly the cycle began at either the Hypsithermal interval (before 3500 yr. B.P.) or in the interim between the succeeding periods of rock glacier activity (2000 to possibly as recent at 670 yr. B.P.). However, there is no reason to suspect that the cave-in process did not begin before the Age I glaciation as far as Age II or older morainal localities are concerned.

Minor periglacial features are numerous in the area but are not mapped. Non-sorted mud circles (mud boils) were observed at Field Stn. Nos. 138, 151 and 222 on the moraines (Fig. 4). Aufeis (icings) develop in thicknesses as great as 5 m on the narrower river channels during winter (e.g. "Lil Creek" canyon). The ground icing variety and icing mounds were not observed by the writer but according to Bird (1967) they are typical of mountainous terrain

and are known from the Yukon and Alaska. The river icing variety is common on the extensive braided flood plain flats (Plate IB) of both the North Klondike and the Blackstone River and their larger tributaries. The ice persists throughout most of the summer as a 1-2 m thick shelf. During winter a combined subterranean and surficial freezing process is responsible for their development, according to Bird (1967). Some of the braided flood plain symbolized areas on the accompanying Quaternary map denote the sites of perennial expansive river icings. Nivation hollows (not of the protalus rampart type) are not prevalent as the light winter snowfall seldom permits sufficient snowbank development to withstand complete summer melt. Some nivation is vaguely discernible in the broad gullies of the "Rangifer", "Prospector", and "Agglomerate" ranges, but development of an eventual "incipient cirque" (Flint, 1957) at today's rate of activity is questionable. Ravins de gélivation (Cook, 1961) are also unknown within the map-area, although they may exist in the terrain underlain by quartzite and grit of the southern half of the map-area. Involutions under active development are common in most soil profiles developed on eolian silt. They are found on the NF-NL-I and on the CL-II moraines. Flint (1957) accounts for their development by a process of differential freezing and thawing. Tundra hummocks of the tussock hillock ("niggerhead") variety are found everywhere in the Blackstone drainage and were reported previously by Crawford (1959). They occur as vast fields on slopes mantled by silt. Usually the tussocks are 15 to 30 cm high and are made up of sedge culms of the genera Carex and Eriophorum. They grow from a tightly packed mass of roots and organic silt matter. During early summer the voids between the tussocks are filled with water while the thawing of the tussock itself does not occur until July. According to Hopkins and Sigafoos (1951) the active layer beneath the tussock is deeper than that of the surrounding depressions; at the onset of winter the unfrozen ground beneath the tussock is forced vertically upward into the tussock column.

Tor-like features (castellated outcrops), in view of confusion concerning their origin and definition, are extensively discussed by Bird (1967). Apparently two types are known: an upland form on horizontal surfaces or gentler slopes and a valley-sided form on steeper slopes. The classical tor is produced by differential chemical weathering under conditions of constantly warm temperatures and a high water table. Tor-like features, by contrast, are produced by differential frost-riving processes, and are a periglacial analogy to the classical tor. Periglacial "tors" are the residual features not affected by "altiplanation" (Eakin, 1916).

Bostock (1966) and Muller (1967) avoid tor terminology altogether; instead they use the term "castellated outcrops" for solitary granites or rock pillars standing 2 to 3 m above the surrounding debris-ladened ridge crests. Some of the outcrops beyond Bostock's (1966) Reid Glaciation still show striae on their upper surfaces as left by the previous "Klaza glaciation". In this arrangement Bostock relies heavily on these tor-like features to help delimit the extent of successive glaciations on the plateau surface. The validity of this approach may be challenged by subsequent workers, for there is some evidence from the eastern Canadian arctic that tors are not necessarily eliminated by the advance of a younger glaciation (Bird, 1967).

Within the map-area tors developed by the classical chemical weathering process are probably not present, but upland forms evolved by frost riving occur on ridge tops in the "Agglomerate Range", on spurs of ridges above Lomond Lake, and on "Panorama Ridge" (Plate VIA). Valley-sided tors are exceedingly numerous on "Angelcomb Peak" and "Enchanted Mountain" of the "Agglomerate Range" and on "Mt. Taber" and "Rake Mountain" of the adjacent "Rangifer Range" (Plate XXIIB). Some of these localities are below inferred limits of the "Age III glaciation" and the valley-sided type can occur below the limit of the "Age I ice advance". Hence it is not possible to use tors for marking glaciation limits in the study area. The tor-like features in every case are carbonate containing clasts (both volcanic and sedimentary) and, as Hopkins and Fyles (1966) and Cairnes (1912) point out, this rock type is unpredictable in respect to differential weathering in the arctic environment. The most reliable castellated outcrops for delimiting glaciations are gneisses and the resistant kinds of granitic and volcanic rocks. Since these resistant types have only limited axial exposure in the map-area the writer has chosen not to place reliance on the carbonate outcrops as a means of outlining the "Age III glaciation".

Map Unit 7 - Fluvial, Subaerial and Aerial (Gravitational) Facies

Late postglacial and modern day processes not directly associated with glacial or periglacial activity have been lumped into this category. However, the map unit does illustrate a series of gradational changes between the fluvial, subaerial, aerial (gravity) and other minor depositional environments. The broad diversity of elements represent upland, slope, and valley bottom environments. Figure 4 shows that the fluvial and subaerial derived portions occupy a narrow to broad continuous ribbon on the valley bottoms. They occupy about 5-10% of the land area enclosed by the map boundaries. The extent of the other deposits is more irregular and cannot be easily estimated.

The absolute age of the various sub-units is variable. Flood plain and associated features are of recent to less than 5000 years in age. The majority of the non-flood plain features are not covered by the "Rangifer Loess" (Fig. 10) that accompanied the last phases of the Age I deglaciation - hence, most features in this unit are of recent development (post Hypsithermal interval), but those features developed prior to this period and are still being developed are also included in Unit 7. There are a few older features (e.g. some landslides) in the unit but their age is difficult to establish.

Sub-unit 7A, 7B - Fans, Fan-head Trench and Bajada Deposits

With the exception of the trench features these deposits have been described under Sub-unit 4E. The features are produced by fluvial and sub-aerial processes whereby the intermittent forces of running water and gravity are responsible for their development in semi-submerged environments. Hence the boundary between fans and flood plain deposits (Sub-unit 7D) is often arbitrary.

Usually, the smaller fans (7A) are of Late Postglacial to modern age whereas the larger surfaces are either Early Postglacial distal outwash fans (3E), preglacial or Early Postglacial forms (4E). Size of fans has been used by Vernon and Hughes (1966) as a geomorphic criterion to distinguish between non-Age I glaciated and Age I glaciated valleys. The test is not infallible, for Late Postglacial fans as large as 2 km^2 occur upstream from the Age I Upper Blackstone Moraine. Their areal extent is similar to fans downstream from the moraine or as large as those in other older glaciated valleys. Vernon and Hughes (1966) note similar difficulties with this criterion in the Wind River area to the east (Fig. 5).

Fans of Sub-unit 4E are often breached by inset fans of Sub-unit 7A. The best example showing these two periods of fan development is at the base of "Enchanted Mountain" near the NF-NL-I moraine. If the recessed area does not take the form of a fan or apron, a linear trough lies in their place - sometimes designated a fan-head trench (Sub-unit 7B). If the trough is on the same gradient as the adjacent flood plain the fan-head terminology is dropped; hence, the feature is regarded as only a transitory stage to subsequent fan or flood-plain development. For this reason fan-head trenches are rare in the area; an example would be the 2-3 m deep trench bisecting the Aug.17-I outwash apron.

Due to variations in deposition, influences by other processes, permafrost, and slope gradient, not all fans on steeper slopes develop the typical

smooth apron shape. For example, mudflow-like bursts of angular gravel and mud were added to a fan of the North Fork Pass region during the spring thaw of 1964; the feature is in turn modified by solifluction activity and, as mentioned in Sub-unit 6A, it becomes arbitrary as to whether the feature should be grouped in the periglacial or subaerial facies. At the other extreme some upland alluvial fans grade into features known as alluvial cones (Sub-unit 7C) at the base of scarps; or, if the debris is blocky - talus cones. In the tundra portions of the map-area there are zones on hillsides that obviously mark greater than normal downslope movement of material. Processes contributing to the movement are in part solifluction, in part colluvial (see map Unit 8) and in part subaerial. These areas are depicted by a series of 1-3 km long, digitating "channels" that coalesce either upslope or downslope as shown at "The Highlands" and "Geodesy Dome" areas of Taiga Valley. Hence, Sub-unit 7A represents a diversity of forms, multiple processes and conditions.

Sub-unit 7C - Talus and Alluvial Cones

These features are well illustrated in Crawford's (1959) report. Talus cones are most prevalent about the vertically jointed monzonite stocks and the coarse clastic rock escarpments of the "Tombstone" and "Snowy" ranges. Alluvial cones are abundant in the Age I glaciated terrain underlain by fine-grained clasts. Away from the Age I glaciated zones alluvial and talus cones are not common; they grade into alluvial fans, nondescript talus sheets and colluvial deposits in these regions - all are distinguished arbitrarily. According to Wahrhaftig and Cox (1959) talus cones are commonly predecessors to lobate rock glaciers.

Sub-unit 7D - Flood Plain Deposits

What makes up a flood plain is arbitrary. The writer chooses to use the fourth definition in the AGI Glossary (1960 ed.)-"that portion of a river valley, adjacent to the river channel which is built of sediments during the present regimen of the stream and which is covered with water when the water overflows its banks at flood stage". This means that alluvial fans (7A) are gradational into flood plains whereas low level river terraces (Sub-unit 7i) are not.

Within the flood plain the usual elements of meander scars, point bar deposits, channel bars, oxbow lakes and clay plugs are present, especially in the Blackstone River system. Meander incision is decidedly more intense and widespread in the Blackstone than in the North Klondike drainage, evidently

owing to the steeper gradient of the latter. Braided channels exist in both systems at points where large tributary creeks enter into the system. For example, the largest zones in North Klondike occur at "Grizzly Creek", and "Lil Creek" and the most extensive areas of braiding in the Blackstone system occur at the mouths of "Foxy-Yakamaw" creek entrances, "Gunsmoke Creek" mouth, and downstream from the junction of the two main channels of the Blackstone River. The flood plain is widest at the mouth of the North Klondike River; here it is more than 5 km across whereas the average flood plain width for the Blackstone and North Klondike systems is slightly less than 1 km.

Péwé (1948) has developed a classification of subarctic flood plain development. Linear and advanced linear youthful stages are characteristic of the flood plain of the map-area, though some coalescent and scalloped (= final stage) stages are present in the Caldwell Lake area of the "main" Blackstone tributary.

Sub-unit 7E - Talus and Protalus Deposits

There is no hard and fast rule concerning the distribution of talus in the map-area other than they appear to be more extensive or pronounced in the terrain underlain by quartzite, grit and the igneous rocks. Crawford (1959) claims that talus is more common on northern slopes and is commonly encroaching "downslope onto grass covered residual soil". Talus is definitely less extensive in the carbonate terrain of the northern third of the map-area whereas it was found to occur as a thin veneer among the intermittent outcrops of the rounded ridge crests and slopes.

In the plutonic rock areas (Fig. 3), Crawford (1959) reports talus accumulation by exfoliation of the vertical faces of the stock along joint-controlled planes. In the sedimentary strata of the "Snowy Range" he reports and illustrates talus development on dip slopes in the form of thin veneers whereas the writer observed much thicker deposits below the range's western escarpment of grits. In the portion of the "Snowy Range" underlain by cherts and slates (Unit IX) there is little talus made up of large fields of angular flags. Ranges underlain by the fine-grained sedimentary rocks of bedrock Units IV, IX, and XIV also lack massive talus sheets; rather there is formed a fine-grained residual "soil", prone to downslope colluvial and mass-wasting processes.

Most talus in the map-area develops by piecemeal frost action; in regions of semi-permanent snowbanks elongate protalus mounds ("nivation ridges") are found on elevated basin floors. A number of these ridges were observed on the higher portions of the western escarpment of the "Snowy Range".

Sub-unit 7F - Paludal Deposits and Swamps

As previously mentioned, bogs associated with permafrost are generally most prevalent north of North Fork Pass, whereas swamps and marshes without permafrost features at present are common south of the pass.

Paludal deposits occur in most closed depressions and troughs and are found as distinct rims about the lakes on the east benches of the lower North Klondike valley and in the NF-SL-I depressions. In the absence of permafrost some small lakes on the morainal surface are slowly drained during the course of the summers, are partially filled in the following spring, and are invaded by a succession of sedges, mosses, grasses, willows and dwarf birch. Some ponds have been just recently drained whereas others are completely filled and grown over by a continuous vegetation mat (Field Stn. No. 136A, Table IB of Appendix IVC). The filling process requires about 7500 years (Table VI) for ponds on the NF-SL-I surface.

Between the morainal gravel ridges of the Age II Lower North Klondike Moraine 1-2 m of black humic silt ("muck") is exposed in abandoned meltwater channels; the same type of accumulation is observed on the floors of abandoned meltwater channels just south of North Fork Pass. On the bench areas of Tintina Valley the writer suspects that bogs may have developed by the rise of the permafrost beneath the developing protective cover of thick mosses, but subsequent degradation of permafrost by forest fires and climatic changes since the Age I glaciation has permitted them to degenerate into swamps that have been or are in turn being reinvaded by normal successional trends in the vegetation.

Sub-unit 7H - Landslide Deposits

Introduction

If there are any sub-units that defy the age limits set out for Unit 7 it is the complex array of landslide features found in the map-area. Age determination is difficult due to their zone of occurrence - usually on the mid slopes of most regions. Hence, morpho-stratigraphic relationships as used by Mudge (1965) are not too easily applied due to the lack of other distinct deposits of known age relationships in the mid slope zone. Since the lithology is variable in the region and the action of the periglacial cycle manifests itself quickly by several processes upon any type or size of surficial debris, age of landslides cannot always be inferred by distinctness of the form of debris. There is a gradation from landslide activity to

solifluction to rock glacier creep. This poses a recognition problem, as is perhaps best visualized by comparing the table of mass-wasting processes in Thornbury (1954, p. 84) with Varnes' (1958) landslide classification.

Recognition criteria for landslides are outlined by Mudge (1965) and have been extensively used in the present survey. However, his diagnostic features apply to many inactive rock glaciers as well. Features common to both are: traverse and longitudinal ridges, spoon-shaped depression at their source, size, enclosed bodies of water, scrubby vegetation, etc. Unless there is an anomalous elevation or south-facing orientation the two types of deposits cannot be satisfactorily distinguished. Some landslides are depicted by a "sharp" zone of removal, but this is not always preserved due to subsequent mass-wasting processes. The problem is complicated where rock glaciers have developed, for a time, in old slide zones (e.g. "Chisolm Creek" slide). Mudflow failures are also difficult to distinguish from tundra mudflows of solifluction origin.

Distribution and Types of Landslides

Surprisingly, the majority of landslides are found in the southern half of the map-area. Narrow elongate (1 km) surficial deposit type of slides are found in the Klondike valley at the YCGC Powerhouse and along their ditch system between the exits of the North Klondike River and Lee Creek. Incipient rotational slumps in Tertiary sediments (?) also occur above the ditch along most of its course between the powerhouse and the Lee Creek exit into the (South) Klondike valley. On the south side of the (South) Klondike valley a regular series of stepped terracettes (5-10 m high risers) occur as rotational slumps downdrops in the Flat Creek Beds. Eight kilometres north of the powerhouse the most extensive and spectacular slumping has occurred during at least two phases of activity in Tertiary sediments on the north slope of the Guilcher Creek valley. Over 6 km^2 of area has been disturbed in the map-area and this much again lies to the west of the map boundary. North of "Mischenko Lakes" on the North Klondike valley floor a subdued deposit 3.5 km long is oriented parallel to the axis of the valley; it appears to have been a thin surficial slide derived from the steep Age II glaciated slopes to the east. The feature may have slid fairly recently, since its location is on the flood plain.

Numerous slide zones in the mountainous portion of the North Klondike drainage commonly extend over 200 to as much as 450 m of relief and vary from 500 m to 2 km in length. The widths vary from 250 to 1000 m in the zone

of removal and increase up to 2.2 km at some spatulate-shaped toes of accumulations. Fragmental rock flows have breached the streams in the Benson, "Grizzly" and North Klondike valleys but anomalous deflections in drainage have not been long lived. On the other hand rotational slump forms have deflected the drainage to the opposite valley wall though this is glaringly apparent only at the pond-pocked "Labby Creek" slide of the "Snowy Range". The two types of slides (Varnes, 1958) can be distinguished usually by the elongate nature and thinly dispersed debris zone in the rock flow type, and by the deep-seated heel and massive accumulation toe in the rotational slump.

Due to the erosion susceptibility, gentle bedding attitudes, and gross lack of favourable structural planes, the carbonate terrain in the north third of the map-area is nearly devoid of landslide features. One small slide near the mouth of Cache Creek has deflected the stream to the south but the nature of the material involved was not investigated. Any other failures in Taiga Valley appear to have involved surficial materials only.

Time of Landslide Activity

The age of slides is suggested by conjectural morpho-stratigraphic relationships. The rotational slumps in the Tertiary sediments about the YCGC powerhouse are post Age II for they have disrupted the meltwater channels draining the Age II lower North Klondike ice lobe. Possibly the slumping in this region was an Age II interglacial event. If it is assumed that the breached fan at the mouth of the "Moose Creek" tributary once demarcated the aggradational level of the North Klondike valley during the late phases of the Age I glaciation, then the remnants of a neighbouring slide which the fan has transected must be at least as old as Age I (glacial phase); it is also younger than Age II for the failure occurred on valley walls previously scoured by the "Age II ice advance". Similarly, but not nearly so conclusively, a slide on the east slopes of "Edge Peak" nearby has also been breached by an old fan (4E type) whose escarped terminal apron is located at the Dempster Highway in the valley. At the north end of the map sheet a large slump adjacent to "Panorama Ridge" is masked by solifluction activity. The slumping has to be post Age IIA but estimates of its age are limited to the extent that the slump zone bears a normal spruce forest.

Many slides are postglacial (to Age I) for they are found as fresh scars on the over-steepened valley walls left by the waning "Age I ice advance" (e.g. Benson Creek valley). Other slide areas have not been reinvaded by the boreal spruce forest (e.g. near the mouth of the North Klondike River). A

multiple slide scar occurs on the upper reaches of the North Klondike River on the Age I valley wall opposite "Apophysis Mountain"; since an active rock glacier has developed in the fresh upper debris zone of this slide, the age is most likely post-Hypsithermal - the active rock glaciers being a product during the last millennium. According to Dr. D. Tempelman-Kluit (pers. comm.) the blocks of the slide have a size up to that of small houses on the valley floor, though none of this size crossed the river.

Failure Environment

The majority of landslides in the "North Klondike" and "Snowy Ranges" are either rotational slumps or fragmental rock flows. The triggering mechanisms are not clearly understood. All have occurred on over-steepened slopes created by differential scour during either or both of the Age I and Age II ice advances. Almost all slides are seated in terrain oblique to the dip of massive quartzites (Unit XVII), grits (Unit III) and gabbroic sills (Unit XX). A few occur in or near to incompetent slates of Units IX, 12, 13A and 14 (Table I), but even in some of these instances the bedding planes are dipping into the slopes. However, the slides usually occur where the above mentioned competent members overlie these weaker rocks. Many slides lie at the contact zones of thrust or high-angle faults. The zone of imbricate thrust and related faults is located in the western and northwestern "Snowy" Range", western "Prospector Range", throughout the "North Klondike Range" and in the non-igneous portions of the "Tombstone Range" (Fig. 3).

Landslides of large size are not known in the plutonic stock or terrain of incompetent rocks that underlie the "Cloudy", "Agglomerate", "Rangifer" and "Seela" ranges to the north. Hence, the failures south of the axis of the Southern Ogilvie Ranges appear to be controlled by an ideal arrangement of lithologic and tectonic circumstances.

Sub-unit 7i - Low River Terrace Deposits

Low river terraces have been discussed in conjunction with high level or raised river terraces (Sub-unit 4A) and flood plain deposits (7D). While devoid of a surficial secondary veneer in most valley bottoms, some East Blackstone River terraces were exposed to the "Rangifer Loess" depositions that occurred up to less than 5000 years B.P. (refer to Eolian Facies; map Unit 5). At the junction of the Blackstone Rivers silt of unknown stratigraphic relationships 15 to 20 cm thick layer on a low level terrace. In a few locales 2-3 m high terraces lie beside older and higher terraces (4A)

and outwash deposits (3E) in the Blackstone, North Klondike and O'Brien systems.

Attempts to date a two-level succession of low terraces at the mouth of the North Klondike River by dendrochronologic methods were unsuccessful as the trees attempted to be used for such a determination were all less than 150 years old. The upper of the two terraces is covered by colluvium and may be closer in age to the early Postglacial Sub-unit 4A terrace, since a higher yet terrace is found upstream as an incised bench in the outwash fan of Age II.

Map Unit 8 - Mixed Facies

The mixed facies is generated by the simultaneous or successive activity of different processes. The resultant deposit may consist of solifluction or other mass-wasting debris, colluvium, eolian silt and retransported portions of older deposits of other origin. The new accumulation may be variable in grain size, with or without permafrost, of sheet or elongated wedge form, and of a variety of topographic habitats. Rill deposits of deglacial origin are not included in this facies (see explanation under map Unit 2).

The sheet form of the mixed deposit is difficult to recognize on aerial photographs where lying on flat terrain. In this environment it is less than 1 m in thickness though almost always greater than 10 cm in thickness in all places except modern flood plain or other Unit 7 zones. On slopes in permafrost terrain, the sheet veneer is usually more than 20 cm thick and is marked by diagnostic "flow-lines" running normal to the contour line. Congeliturbation is a common process in the mixed deposit of the slope environment. On slopes of greater than 15-20° inclination the potential veneer is derived from freeze-thaw frost riving, and slope wash and is carried downslope to be accumulated as thick wedge shaped deposits in suitable catchment zones. There is no hard and fast rule concerning the origin, distribution or textural makeup of the mixed deposit - its characteristic is that it is retransported, and as such it lies either unconformably or disconformably on older deposits.

The age of the mixed deposit in the map-area is variable. Some may be as great as Age III whereas on most Age II deposits of primary origin the overlying mixed deposit, according to loess stratigraphy, may be less than 9600 (or 5000) years old for the sheet forms. A 5-metre thickness of retransported silt on an Age I surface near "Alces Lake" began to accumulate at 11,250 years B.P. (Table VI). Other mixed deposits in the map-area are probably much younger.

Mixed deposits cover about 50% of the area of those morainal termini examined in detail. Colluvium is the main component on the NF-SL-I, whereas convoluted silts of mixed origins, other than colluvial, are typical of the others. Descriptions of both types of secondary accumulations are part of the soil profile examination as given in Appendix III.

Map Unit 9 - Unclassified Deposits

About two-thirds of the map-area has not been mapped. Roughly one-half of the unmapped area is bedrock with thin veneers of mass-wasting debris and local pockets of thicker surficial accumulations. The other half is made up of extensive tracts of upland surfaces that are either heavily forested zones blanketed with a reworked loess veneer or are tundra zones shrouded with thick sheets of solifluction deposits. Both in the tundra and in the forest, zones of heavily-reworked till and associated deposits of older and more extensive glaciations are no doubt present, but ground surveys would be needed to fix the boundaries of these features.

INFERRED[1] QUATERNARY HISTORY OF THE NORTH KLONDIKE AND UPPER BLACKSTONE REGIONS

Introduction -- Pre-glaciation Topography

The topographic setting of the region prior to the onset of Quaternary events has to be surmised from the sequences of Cretaceous and Lower Tertiary tectonic events known to have occurred in the Ogilvie Mountains. According to Tempelman-Kluit (1966) and Gabrielse (1966) major mountain building in the Southern Ogilvie Ranges terminated with the Aptian orogeny of the late Lower Cretaceous Period; folding and faulting in the Taiga Valley and Central Ogilvie Ranges to the north was associated with the Laramide orogeny of late Upper Cretaceous and early Tertiary time; Tintina Valley developed its linear expression during the Laramide orogeny by extensive strike-slip faulting. The major topographic trends in the present landscape are parallel to the orientation of these major tectonic units. Erosion during the Tertiary Period amplified the relief of each of the above mentioned structural units. By the close of the period most of today's major valleys were probably developed by fluvial and mass-wasting cycles that were in turn controlled by local epeirogenic events.

Holmes and Lewis (1961) suggested that glaciation in the Eastern Brooks Range has only amplified the topographic expression of the pre-existing landscape. The effects of glaciation in the Southern Ogilvie Ranges was evidently similar, for there are few indications of major changes in landscape development by corrasion during the Pleistocene Epoch. One example, however, concerns Tintina Valley. Ice issuing forth from the North Klondike valley has nipped the western tip of the Stewart Plateau and has incised the Tintina Valley normal to its longitudinal trend (Fig. 2); the corrasion, however, may have

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[1] Evidence of early Pleistocene events are scanty whereas details and facts concerning events since the last ice advance (Age I) are abundant. Ideally, the reconstruction of the latest events should be given first and the least known should be given last in this section of the thesis. However, for discussion of Quaternary events for areas elsewhere in the northern Cordillera, the practice has been to deal with the oldest first and then follow with the progressively younger succession of events. The writer has chosen to comply with established practice in this respect. Much of the early history unfortunately must be based on few facts, circumstantial evidence and inference. Facts are given in preceding sections of this thesis and are not repeated herein. The chronologic relationships of events in this map-area to those elsewhere are discussed in a later section of this thesis and are summarized on Table XXVI within that section.

been controlled by a preglacial valley. Nonetheless there is a topographic anomaly in this region - the Klondike River would expectedly flow in Tintina Valley west of the map-area. Rather it has been diverted south of the valley, perhaps by early Pleistocene ice issuing forth from the Ogilvie Mountains to the north, into its present day course through the northern tip of the Klondike Plateau (Fig. 2).

Oldest Quaternary Glaciation(s)

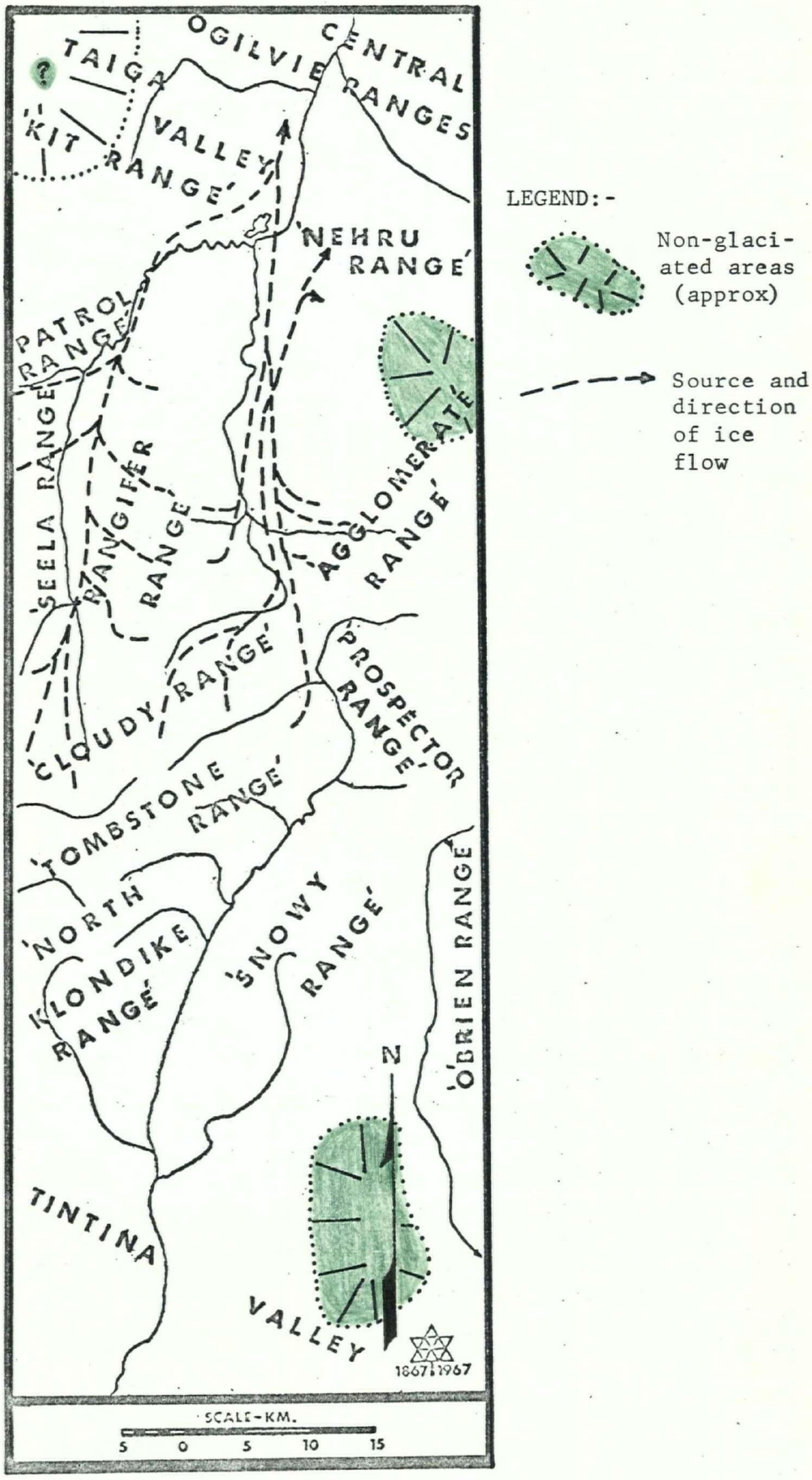
Apart perhaps from one exposure of highly weathered gravel in the lower North Klondike valley (Field Stn. No. 57) no record has come to light of early Quaternary events in the map-area. However, from circumstantial evidence it is likely that the Ogilvie Mountains were blanketed by at least one ice cap before the "Age III glaciation", for Bostock (1966) has shown that much of the Yukon Plateau adjacent to the Ogilvies was covered by the ice represented today by the exposures of Nansen drift. Also, possibly one older glaciation is found in the Brooks Range, central Alaska Range and in the Southwestern Yukon (Péwé et al., 1965; Krinsley, 1965). It seems inevitable that the map-area was covered by ice at a time when adjacent regions were blanketed far more extensively than at any time during the subsequent late Pleistocene Epoch. During these early glaciation(s) (possibly as late as the Age III) Tintina Valley was occupied by a lake (Dr. O. L. Hughes; pers. comm.) to the southeast of the map-area before being filled in with outwash gravels, McConnell's (1905) Flat Creek Beds, that originated from the Ogilvie Mountains.

"Age III Glaciation"

Events prior to the onset of ice advance during this glaciation are not known. Presumably the event was accompanied by eolian and periglacial activity, but in the map-area deposits of this nature were ultimately engulfed or obliterated by Age III ice.

Upland localities of erratics and pebbles in till located in the north portion of the map-area suggest that the Age III glaciers flowed from sources near the axis of the Southern Ogilvie Ranges (rather than the Central Ogilvie Ranges - refer to Fig. 13). Pebbles are not totally reliable indicators of ice source for they can be carried by pre-Age III processes to the north portion of the map sheet. Nonetheless the elevations of such indicators indicate that the Taiga Valley portion of the map-area was fed by a series of major outlet glaciers that coalesced with one another through passes such as

FIGURE 13 - Ice flow directions and ice sources during the Age III glaciation.



Seela to the west and the Michelle-"Gunsmoke" divide to the east. The elevation of lodgement till and surrounding erratics on "Panorama Ridge" dictates that the ice surface rose to more than 1230 m above the present mean sea level at Taiga Valley. Although gradients for the upper surface cannot be measured directly a minimal estimate as to height of the ice surface at North Fork Pass can be approximated by using gradients measured for the younger Age II ice surface[2] as determined in a previous section of this thesis. The calculation suggests that the ice surface at North Fork Pass was at least to as high as 1730 m (m.s.l.) and is presumed to be much higher to the west of the pass if the behaviour of the younger ice advances is a comparable indicator. The erratic located at 1950 m (m.s.l.) on the north ridge of "Horn Mtn." ("Cloudy Range") would certainly suggest this possibility.

Hence, at maximum ice development a mountain ice cap with nunataks is visualized. Possibly the ice cap generated local accumulation zones away from the higher massifs during the optimal time of its development. Towards the outer margins, the ice cap probably broke up into a series of outlet glaciers and intervening local névé supply zones. If the assumptions pertaining to the gradients of ice surfaces on the north slope are approximately correct, then on the south slope the outlet glacier of the lower North Klondike valley abutted against and possibly overrode a portion of the Klondike Plateau. Taiga Valley ice, on the other hand, proceeded (a) northward through the Central Ogilvie Ranges via the Blackstone valley, and (b) east-west into the Michelle and perhaps as far as the Ogilvie drainage basins. However, the extent of the north slope ice is not known to the writer. Northward, it probably reached Ogilvie Valley (Fig. 2), for it was augmented by local supply in portions of the Central Ogilvie Ranges. A more precise picture will be published by Dr. O. L. Hughes in the near future.

Areas not extensively blanketed by ice of the "Age III glaciation" occur in the area between Fish, Lee and O'Brien creeks. At this time upper Lee Creek, formerly a tributary of Fish Creek, may have been diverted into the headwaters of lower Lee Creek. At the Lomond Creek region far to the north it appears that the Lomond Creek outlet glacier (derived from the East Blackstone

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[2] Ice surface gradients of about 10 m/km were determined for the Age II glaciers in this region. Flint (1957) gives Greenland Ice Cap surface gradients of 0.5 to 10 m/km. Using the later figure, the elevation of ice in the North Fork Pass region is computed as 1730 m.. However this may be low, for the elevations of Age III ice indicators in Taiga Valley, as used in this rough approximation, do not denote the elevation of the upper ice surface.

region to the west) was not supplied by local ice and consequently terminated short of the eastern map boundary from lack of nourishment. The "Lateral Creek" tributary to the Lomond system appears to have been free of ice at this time for downstream from the junction of these two valleys, Vernon and Hughes (1966; Map 1171A - see Fig. 2) could not detect signs of glaciation.

The Age III deglacial history is scarcely known. Topography, if like that of the present, would permit large glacial lakes to develop in Taiga Valley during the late stages of deglaciation but conclusive evidence of such has not been uncovered to date. In at least the North Klondike portion of Tintina Valley aggradation accompanied deglaciation. Subsequent degradation by an "ancient" North Klondike River resorted the fill until an extensive flood plain was developed a few tens of metres above the present one. Presumably eolian activity accompanied deglaciation while periglacial activity waned; during the subsequent interglacial stage the former process was probably inoperative while the latter would have been confined to uplands if active at all.

"Age II and IIA Ice Advance(s)"

The history of ice advance in the north and south portions of the map-area is complicated by a two-fold sequence found in the north, but not apparent in the south. The lower North Klondike and neighbouring Fish and O'Brien valleys have not revealed any evidence to date to suggest two successive ice advances. Hence the following possibilities exist:

1) While the ice front was oscillating in the Blackstone valley region to the north, glacier termini on the south-facing sides of the Southern Ogilvie Ranges were in a more steady state. That is, the "Age II and IIA" ice advances are all part of the same episode in the Klondike valley region.

2) The North Klondike valley region experienced the same fluctuating ice front, but the second advance was greater than the first.

3) Ages II and IIA represent two entirely independent glaciations or ice advances involving nearly the same volume of ice for each, but the erosion period in the south between the two was generally extensive enough to remove the depositional evidence for the older "Age IIA ice advance".

4) The Age II correlation of the Lower North Klondike Moraine with the Chapman Lake Moraine is incorrect. The Lower North Klondike might be Age IIA and either the poorly developed recessional deposits about "Tom O'Hara Lake" or the well developed but upstream recessional deposits at the mouth of "Chisolm Creek" are the terminus of the Age II ice advance in the North Klondike valley.

Since the sub-Age IIA and Age II deposits in the northern portion of the map-area do not show differences in their degree of weathering, it appears that the

period of time between these two ice advances may have been relatively brief. Therefore, the first of the possibilities listed above is the one favoured by the writer and by Dr. T. L. Péwé (pers. comm.). However, since it is not certain that Age II and IIA ice advances belong to the same general episode, the writer prefers to relate the events during this general Age II-IIA time span as follows:

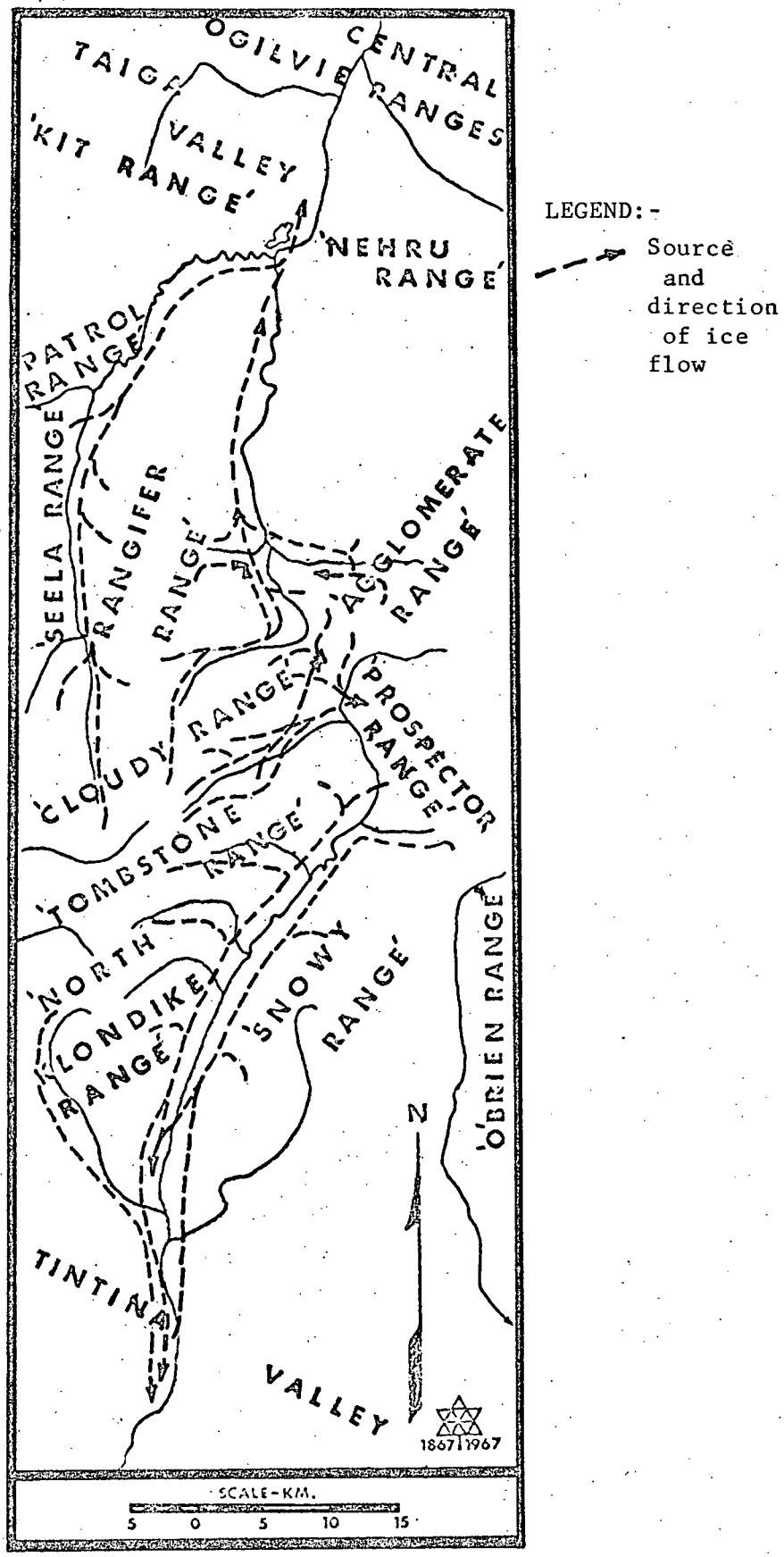
1) Initial glacial events in the map-area.
2) Maximum extent of Age IIA ice in the Blackstone valley.
3) Age IIA deglacial events in the Blackstone valley.
4) Age II glacial events in the Blackstone, lower North Klondike and nearby valleys.
5) Age II deglacial events.
6) Age II postglacial events.

Initial Glacial Events

The sequence of events leading up to a new period of glaciation are not well known. Ice presumably developed initially in the cirque areas on the higher mountains of the Southern Ogilvie Ranges and was most likely accompanied by intensified periglacial activity in the surrounding regions. Successive changes of pebble clast frequencies in Age II-IIA tills (Table V), erratics, and trends on aerial photographs suggest that much of the development of ice progressed downvalley from axial portions of the ranges that lie between the Blackstone and North Klondike drainage basins (Fig. 14).

According to the above surmise the stages of development of ice would have been limited to more or less independent valley glaciers evolving from a névé zone at the head of each basin. Present day topography suggests that the névé areas occurred in clusters that radiated from a common focus or ice centre. As the ice moved downvalley from these centres deposition of proglacial outwash preceded the ice; but in most regions this outwash was later removed by the ice, for during the early stages of the trunk and valley glaciers corrasion of valley floors was intensive. Ice centres would have been located eventually in each massif, but as glaciation continued the "Cloudy Range" and "Tombstone Range" centres combined to yield a "master centre" that in turn directly supplied firn to the trunk and through glaciers of the "main" Blackstone, Tombstone (to Chandindu) and North Klondike valleys. The northeast side of the centre was the source of the trunk glacier in the East Blackstone valley while the southwest side of the centre fed respectively the Benson and Little Twelve Mile arms of the North Klondike and Chandindu systems. Ultimately the East

FIGURE 14 Ice flow directions and ice sources during the "Age IIA and Age II glaciation(s)".



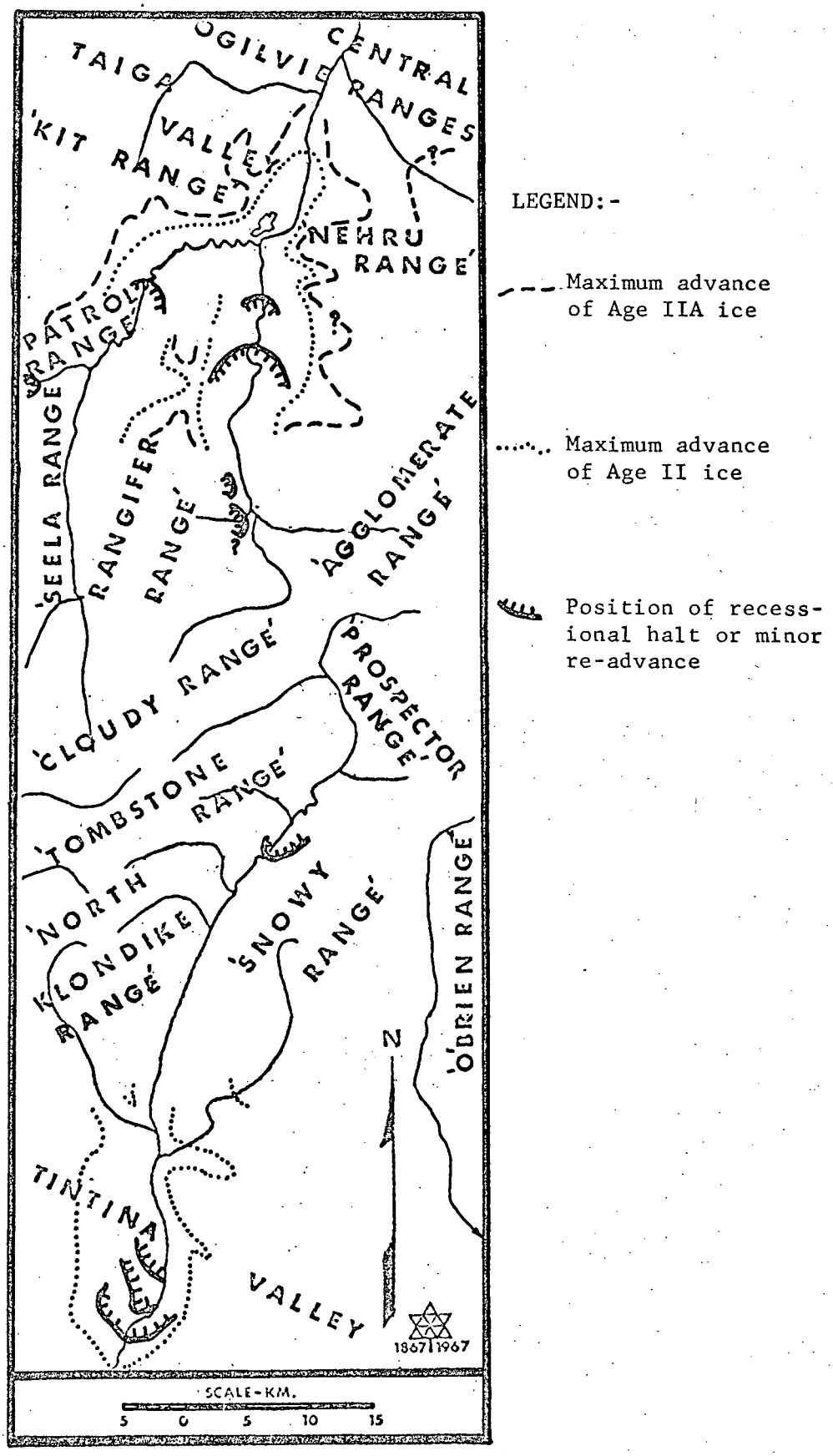
Blackstone and North Klondike valleys were filled with enough ice that they became interconnected by a thin névé zone in the North Fork Pass region. This névé also fed the West Hart trunk glacier system to the east and at maximum ice development the level (from erratic evidence) of ice rose to about 1500 m (m.s.l.) at the pass. To the west, in the "Cloudy Range" aerial photographs suggest that the general ice level was at least as high as today's 1800 m contour in the "master centre". The glaciers of the Age I ice advance also slope from this centre and, if a valid analogy, they support the trends on the aerial photographs concerning the Age II-IIA glaciers. The through glaciers would have been augmented by local ice of the outlying ranges or centres. As the ice reached Taiga Valley and Tintina Valley to the north and south respectively corrasional processes gave way to depositional ones beneath the ice.

During the existence of this transection glacier system, valley and trunk glaciers grew independently in the following: (1) in the Central Ogilvie Ranges from tributaries to the Blackstone drainage system, (2) in the "Nehru Range" from cirques at the headwaters of "Gunsmoke Creek", (3) in the "Snowy Range" from cirques on the eastern side of the Antimony Mtn.-"Mt. Robert Service" massif and (4) in the "O'Brien Range and valley from several ice centres. The last mentioned was remotely interconnected to the North Klondike trunk glacier by way of "Pack Saddle Pass".

Maximum Extent of Age IIA Ice in the Blackstone Valley

During the "Age IIA ice advance" the "main" Blackstone and East Blackstone glaciers coalesced in Taiga Valley around both the north and south side of "Geodesy Dome" (Fig. 15). This locality, particularly the south side, was probably an ideal area for the development of ice-marginal lakes. To the east and west of "Geodesy Dome" the ice stream in each valley of the Blackstone was high enough to spill over its brim so that small irregular digitations of ice grew into headwaters of the Ogilvie drainage to the west and the Lomond Creek tributaries to the east. At the north point of coalescence of the two trunk glaciers the ice stream was confined between the valley walls made up by "Chapman Hills" to the northwest and "Pilot Peak" to the east. Downstream from these sites ice again spilled over the brim of the valley walls into the tributaries of "Cache Creek" and "Gunsmoke Creek" valleys. The main terminus of the irregularly-shaped, piedmont ice lobe was located near the mouths of these two valleys. In fact, their drainage into the Blackstone may have been blocked by the snout of the glacier. However, conclusive evidence of deposition into a standing body of water, so created by this possible ice dam, is wanting.

FIGURE 15 Limits of the Age IIA and Age II ice advances and positions of temporary halts during the Age II deglaciation.



Glaciers in the nearby tributary valleys of the Central Ogilvie Ranges did not coalesce with this Age IIA ice terminus. Glacial-deglacial deposits left by this ice advance are part of the Taiga Valley Moraine.

Deglacial Events Related to the "Age IIA Ice Advance"

At the time transitional between optimum ice advance and deglaciation in Taiga Valley, ice marginal kames and hummocky deposits developed. Initially meltwaters drained into the Ogilvie, "Cache", "Gunsmoke", Lomond as well as the Blackstone drainage overflow channels but as the ice surface dwindled all meltwater was carried by the Blackstone River. During ice withdrawal outwash gravels choked the Blackstone and lower "Cache Creek" valley mouths. A small lake developed at the site of the present Chapman Lake possibly by the melting out of a large detached ice block in these gravels. Varve sections show that the small lake remained in existence for more than 150 years, possibly as long as 1000 years, while ice retreated upstream into each of the Blackstone valleys.

In the East Blackstone valley, ice probably withdrew as far south as the "Henry Creek" area, for a small pond developed on the ground moraine (presumed to be Age IIA) opposite "Curiosity Lakes". The distance of ice withdrawal into the "main" Blackstone valley is questionable and the history of withdrawal in other regions of the map-area is not known.

"Age II Ice Advance" in the Map-area

Ice resurgence in the northern portion of the map-area was not as extensive as in the previous advance (Age IIA). Figure 14 outlines the differences in area covered by the two advances in the Blackstone valley region. Whereas Age IIA ice spilled over the valley walls into other drainage systems, the "Age II ice advance" was effectively confined to the Blackstone valley. However, some Age II discharge water flowed into the adjacent Ogilvie, "Cache" and Lomond drainage systems. The snout of the Age II ice appears to have remained in equilibrium for a considerable time, for substantial amounts of ablation till and lateral moraines have been deposited in the Chapman Lake terminus zone.

The trunk glacier of the lower North Klondike developed much in the same way as did the Age II glacier in the Blackstone to the north. The ice lobe was confined by a high flat ridge to the east and rode the crest of a divide between the North Klondike and numerous tributaries of the main Klondike valley to the west. Digitations developed in the ice lobe at the Fish and "Hallenbeck" tributary entrances with ice spilling a short way into tributary valleys of the

Lee Creek drainage in both instances. The former blocked an unglaciated portion of Fish valley thus forcing drainage along the ice margin into the Lee Creek drainage. Farther south the east margin of the North Klondike lobe lay at a high level and meltwater from the ice surface drained into an unnamed creek between the North Klondike and Lee valleys (Plate VII). The snout of the lower North Klondike glacier terminated approximately 5 km south of "Linta Creek". Here an extensive outwash apron was deposited; its growth to the south has deflected the (South) Klondike River to the south wall of its valley.

In neighbouring regions, the Fish valley ice lobe, because of its limited ice source area, failed to join with that of the North Klondike. The glacier in the adjacent O'Brien valley, however, pushed its way out of the map-area to a terminus zone near the junction with the (South) Klondike valley.

During maximum glaciation of the lower reaches of the North Klondike, Fish and O'Brien ice lobes, a few unglaciated tributary valleys were blocked by ice. No doubt the glacier margins were lined by a chain of small ice-dammed lakes during this time; however, due to the subsequent periglacial environment, depositional evidence of their existence is not easily found. Other processes occurring in the non-glaciated areas probably included seasonal loess and fan deposition and periglacial activity.

Age II Deglaciation

The distribution of glacio-fluvial deposits and meltwater channels indicates that ice retreat accompanied ice downwasting during the deglaciation of both the Chapman Lake and lower North Klondike ice lobes.

In the case of the latter, downwasting appears to have been the dominant initial process for large channels appear to have developed in the ice lobe just north of "Linta Creek"; the inference is that ice surface sloped transversely from east to west towards these channels. Supraglacial debris would have been swept into this region as the ice front slowly retreated upvalley. Very little "dead ice" was developed during this initial withdrawal of ice.

After about 5 km of terminal recession and 2 km of lateral marginal shrinkage on the west the stagnating lobe either held its position for a considerable period of time or, less likely, readvanced slightly. At this stage vague channels suggest slight runoff on the eastern margin of the ice lobe as the ice surface began to develop (in transverse profile) a convex surface, but the main discharge of meltwater off the ice surface continued to be collected into the Guilcher and Rabbit overflow channels to the west and at the terminus of the ice snout in the "Linta Creek" region as well. Terminal retreat of the

stagnating ice lobe again halted after another 4 km of withdrawal upstream with accompanying downwasting. This later halt is marked by a large areal deposition of kame, hummocky gravel and eskeroid deposits between "Linta" and "Morrison" creeks. In this region ice stagnation was probably prolonged until the dead ice phase was reached before any more significant ice withdrawal was recorded.

Between "Morrison" and "Glacier" creeks the ice lobe gradually downwasted as denoted by a series of valley-wall lateral channels which suggest that the convexity of the ice surface increased at a rate greater than terminal retreat. Supraglacial debris was swept into marginal positions initially at the Fish Creek re-entrant and secondly at the junction of the Benson arm to the main North Klondike ice stream. By the time the snout of the glacier withdrew to the Benson valley entrance, the ice in the mid-reaches of the North Klondike ice stream had probably thinned some 150 to 200 metres. Meanwhile downstream, fluvial activity was resorting and downcutting through the outwash-choked valley floor.

The deglacial history of the mid-reaches of the North Klondike valley is not recorded by many deposits. The ice lobe may have undergone quick withdrawal until the "Chisolm" and "Grizzly" valley tributaries were reached. At this point the retreat of the ice lobe was temporarily halted; the stagnating ice lobe may even have undergone a brief period of slight readvance. At least considerable downwasting of the ice lobe occurred before retreat of its snout was resumed for large meltwater channels are located about a zone of outwash and related glacio fluvial debris. At about this time the ice connection between the East Blackstone, North Klondike and West Hart valleys was probably severed by downwasting of their common névé located at North Fork Pass. Meanwhile downstream, aggradation by retreatal outwash and contemporaneous inwash filled the valley floor though south of the mouths of Benson and Fish creeks downcutting through the slightly older outwash was probably taking place. Eolian activity was probably a deflational process in this region at this time - loess deposition in the early stages of deglaciation was confined to regions outside of the map-area.

The glacier snout withdrew to the "Schwarz Creek" area upon the renewal of extensive ablation. During this phase, the stagnating ice lobe developed an exceedingly convex surface, for marginal channels are extensive on the valley walls where the Dempster Highway begins its ascent to North Fork Pass; hence, retreat of the terminus would have been very slow in this region but eventually the entire valley upstream was cleared of ice. During these final

stages the entire North Klondike valley was subjected to fluvial downcutting while eolian deposition took place downvalley. Eventually though, loess deposition and degrading fluvial processes waned during the subsequent interglacial or interstadial time span.

In the north portion of the map-area the record of deglaciation is not nearly so complete. Initially the terminus of the Chapman Lake ice lobe underwent a period of extensive downwasting and outwash development, before the retreat of ice upvalley. Retreat was temporarily halted with either a slight ice re-advance or prolonged standstill of ice in the confined portion of the East Blackstone valley located between "Geodesy Dome" and "Erratic Ridge". Meanwhile in the "main" Blackstone valley to the west, vast expanses of hummocky ablation gravel and eskeroid complexes indicate that dead ice conditions developed on the slopes of "Fitzgerald Ridge".

A second recessional phase probably occurred in the East Blackstone valley at the "Caribou-Henry Creek" region. While ice downwasting was taking place here the downstream activities involved fluvial downcutting through the extensive ground moraine located near the mouth of the East Blackstone valley and at the former Chapman Lake terminus were in the path of meltwater runoff. Ice retreat, once renewed, probably continued more or less continuously until the north front of the Southern Ogilvie Ranges was reached, for little deglacial debris is apparent on the East Blackstone valley floor. While fans began to be built on the newly exposed valley floors (e.g. at "Henry", "Caribou" and "Ptarmigan" creeks in the East Blackstone valley) the trunk glacier of the East Blackstone system had degenerated into a series of independent lobes that occupied some tributary valleys for a prolonged period (e.g. "Whitehorse Creek" valley). It is not known whether this phase corresponds to the "Chisolm", "Schwarz" or other recessional positions in the North Klondike valley (Fig. 15).

The Age II deglaciation cycle ended when valley ice retreated to their respective cirques of origin. In the south portion of the map-area permafrost features probably waned and in the whole region the eolian cycle no doubt came eventually to a standstill. However, more palynological research is needed to substantiate these inferences.

Age II Postglacial Events

Throughout the map-area there is only a sparse record of Age II postglacial processes. Alluvial fans, outwash deposits and other early deglacial

features were resorted during the interval, as attested by raised terraces at a few localities in the Benson, North Klondike and Blackstone valleys. Thermokarst activity probably began to take place along lake margins as the permafrost slowly retreated. Basins on the Chapman Lake Moraine and other nearby moraines were no doubt undergoing enlargement by cave-in processes while bogs began to develop elsewhere. Hillslope periglacial features were no doubt also in a state of quiescence, but again only palynological studies can fill the void between the "Age II and Age I ice advances" and this information is yet to be collected and recorded.

"Age I Ice Advance"

Introductory Summary

The record of events during and since the last Pleistocene ice advance includes glaciation, deglaciation, periglacial activity, loess deposition and a host of other postglacial events. Glaciation probably began before 19,000 years B.P. and, according to Heusser (1960), reached a climax about 15,000 years ago; the cold tundra climate as marked by the sedges in the pollen profile (Appendix ID), persisted to about 12,000 years ago. However, deglaciation began at least 13,740 years B.P. (bog on Foxy Creek Moraine) and had already undergone one recessional halt before 11,250 years B.P. Colinvaux (1964) finds evidence from northern Alaskan bog studies to substantiate a beginning of a warming trend at 14,000 years B.P. Deglaciation terminated with the beginning of the "warm" Hypsithermal interval some 6000 (Heusser, 1960) to 7500 (inference; Appendix ID palynological data) years ago. Due to a cold and dry continental climate (dwarf birch in the pollen profile) deglaciation was very slow; hence, the smaller and independent glaciated valleys were probably ice free long before the disappearance of trunk glaciers in the larger valleys. The Hypsithermal interval persisted until 3000 years B.P. (Heusser, 1960), and since that time a complex series of events has occurred in the Late Postglacial period.

Ice Advance of Age I

Glaciation began with the renewed development of ice in many of the cirques that were inferred previously to be sources of ice in the Age II-IIA glaciation not eliminated during the subsequent interglacial interval. Glacierets were built up in most north, west and east-facing cirques occurring along the main axis of the Southern Ogilvie Ranges and in some north-facing cirques of the "Nehru" and Central Ogilvie Ranges. Cirques not occupied by ice harboured

semi-permanent but small snow banks or else, if lithologically favourable, rock glaciers, for the climate during this glaciation was intensely cold. Precipitation was light, for according to Vernon and Hughes' (1966) and Bostock's (1966) mapping to the east and southeast of this region, and inferences from cirque elevation data within the map-area, the prevailing moisture-laden clouds originated from the southeast - much of the moisture, therefore being taken from the clouds by a multitude of ranges located in the Coast, Cassiar, Pelly and Selwyn Mountains. Hence, unless suitably elevated, regions in the map-area acquired less snowfall, and glacier development was thereby retarded as compared to those regions to the east of the map-area. In place the environment was ideally suited for a host of periglacial activities in the vast tracts of surrounding non-glaciated areas.

During growth of cirque glaciers ice from adjacent basins coalesced to produce small valley glaciers as shown in Figure 4 and as amended in the portion of this paper dealing with "General Results". Some ice streams in turn joined to produce small trunk glaciers in a few valleys: namely - the O'Brien, North Klondike, East Blackstone, "Foxy", "main" Blackstone, Tombstone, Little Twelve Mile, "Wolf" and Benson valleys. The North Klondike and Tombstone valleys were interconnected by continuous ice, and the Little Twelve Mile, Benson and "Wolf" valley glaciers radiated from a common névé source.

All valley and trunk glaciers blocked drainage from smaller non-glaciated valleys to the extent that lateral drainage was sufficient to cut some valley-wall channels along the ice margins. Temporary ice marginal lakes probably developed in the "Arrow Creek" re-entrant of the "main" Blackstone valley, the upper portions of the East Blackstone valley ("Rangifer Valley" region), the "Pack Saddle Pass" region, and in numerous enclaves of the O'Brien valley. Tributary valley glaciers originating from the "Storm Mountain" cirque area reached the main "Yakamaw" valley floor to block its normal drainage. This created, most likely, ice-dammed lakes in an unnamed south-draining tributary of the northern "Agglomerate Range" and in the nearby upper reaches of "Yakamaw" valley. In the latter case the lake may have spilled eastward into the West Hart River system by way of "Char Creek".

At least some trunk glaciers reached their maximum position of advance simultaneously for, at the North Fork Pass area, meltwater derived from the south lobe of the hammerhead-shaped ice terminus met with meltwater derived from the smaller valley glaciers in the upper "Lil Creek" valley and the combined stream flow descended the previously (i.e. pre-Age I) developed "Lil Creek" canyon to be in turn dumped onto the surface of the glacier in the upper

North Klondike valley. In the O'Brien Creek valley, glaciers originating in the large cirques to the northeast of Antimony Mountain and "Mt. French" dumped their outwash against the snout of the "Upper O'Brien Glacier". This pattern of long-distance outwash transport and subsequent deposition is also shown in most tributaries to the North Klondike valley. Here, distal outwash fans occur on the main valley floor some 2 to 5 km from the tributary valley glacier snouts of their origin. In the Blackstone drainage to the north, glacier snouts terminated on broad valley floors and thus developed a proximally-located outwash apron.

Age I Deglaciation

According to the pollen profile (Appendix ID) glacial recession was probably initiated by a decrease in precipitation rather than by a significant increase in temperature. Retreat was at a sporadic rate, for evidence of at least two weakly developed series of recessional advances or ice standstills are found in most valleys. Some smaller valleys indicate an additional one or two recessional periods, but this is probably due to their size - that is, small glaciers have a highly sensitive response to slight variations in the moisture cycles whereas the larger do not visibly respond to this type of change. It is not known whether all recessional halts were synchronous from one valley to the next. The first halt in ice retreat was at least 11,250 years ago in the North Fork Pass area. During this retreat period valleys downstream from glacier termini were aggrading due to the influx of outwash debris carried by the increase in meltwater flow. In response to the burial of the flood plain by debris-loaded meltwaters valley-sided fans (both non-glacial and distal outwash types) were aggrading to new levels. Hence, the valley floors downstream from the termini were a vast expanse of barren gravels. From about 10,900 years (or earlier) to 9,600 years B.P. winds picked up the sand and silt components of the gravel to redeposit them as the "Blackstone Loess" at downstream localities. A second recessional ice advance or prolonged period of standstill might be synchronous with this eolian event.

Events occurring after the second (?) recessional phase of deglaciation included the development of a shallow ice marginal lake behind the NF-NL-I moraine, the invasion of the permafrost table (in the form of ground ice) into previously ice-covered terrain and into newly deposited loess sheets to the north of the North Fork Pass, landslide activity in the North Klondike drainage basin, and the development of recessional moraines at the mouths of cirques in smaller tributary valleys. Glacier retreat was not everywhere the same. For

example, the "Upper North Klondike Glacier" was slowly removed by downwasting and eventual stagnation, the "Upper Blackstone Glacier" slowly retreated upvalley leaving behind numerous but small detached ice blocks, and the "North Fork Pass Glacier", like many others, retreated upvalley leaving scarcely any detached ice blocks behind. By 6000-7000 years B.P., the main valleys were free of ice; "valley train" deposits, fans and deposits in valleys beyond the ice fronts were now being dissected by the fluvial cycle. Many corrasional lake basins developed in pater noster fashion on the upper reaches of the newly exposed valleys. A multitude of tarns were eventually revealed by loss of ice in the cirques - these are especially well developed in the regions of the "Cloudy", "Tombstone" and "North Klondike" ranges underlain by quartzite and crystalline rocks. Eolian deposition and periglacial activity also began to wane shortly thereafter. According to the pollen profile (increase of Alnus) the climate warmed slightly, with an accompanying increase in precipitation. The warming marks the beginning of the Hypsithermal interval, and in this region glacier ice may have been completely eliminated in even the most effectively-shaded cirques.

Hypsithermal Interval

Within this warmer spell the events must remain largely conjectural. Thermokarst activity would have been rejuvenated on the Chapman Lake and surrounding moraines and would be initiated on the NF-NL-I and the Upper Blackstone moraines. Slope solifluction probably increased in activity north of the pass while such activity probably waned in the lower regions of the North Klondike valley. The three low level rock glaciers on the western escarpment of the "Snowy Range" ceased activity at this time, if they had not already done so during the previous 5000 year interval.

Bogs thrived during this interval while loess activity continued to diminish in intensity. Some landslides may have occurred. Aggradational fluvial processes that had invaded the formerly glacier-covered valleys gave way to downcutting processes and low terrace development near the close of the interval. Heusser (1960) indicates that the Hypsithermal interval came to a close by 3000 years ago.

Late Postglacial Events

Since 3000 years B.P. the pollen record (Appendix ID) indicates a slight cooling of the climate without noticeable reduction in precipitation. According

to Wahrhaftig and Cox (1959) the time was now favourable for the development of the first cycle of Late Postglacial rock glaciers. They developed at elevations as low as 900 m (m.s.l.) in the terrain underlain by crystalline and coarse clastic rocks. Some older but dormant rock glaciers were probably reactivated at this time along with other periglacial processes and features. Loess deposition may have been reactivated in this or just prior to this period in the upper portions of the main valleys ("Rangifer loess"), for this material blankets fluvial sediments deposited 5070 years B.P., and has buried Brown Wooded soil profiles on the Foxy Creek Moraine. Ice wedges, in turn, invaded the "Rangifer loess" at the East Blackstone varved-silt locality. However, by 2000 years B.P. this brief cool period came to a close (Wahrhaftig and Cox, 1959).

At approximately 1600 years B.P. the first (?) eruptive phase of the "White River" volcanic ash was deposited as a thin film in the area. This ash deposition is associated with a warming period that persisted to about 1400 years B.P. (Rampton, 1967; Péwé et al., 1965). Hence, rock glaciers became inactive while thermokarst and solifluction processes were activated on valley bottoms, valley walls and some ridge crests - especially on the north slope of the Southern Ogilvie Ranges.

Since 1400 years B.P. the climate cooled sufficiently to permit the development of glacierets and the reactivation of many rock glaciers in what is known as the "Little Ice Age". This period of development reached its zenith just prior to 1680 A.D. according to Terasmae's studies on recent bogs immediately west of the south boundary of the map-area (in Dyck and Fyles, 1963). Since then deglacial and degradational periglacial processes have been in operation despite some indication of resurgence of ice elsewhere in the northern Cordillera at 1830 A.D. (Péwé, 1965). Weather records taken at Dawson since the turn of the 20th century suggest that degradational processes associated with permafrost and glacierets were operative especially well in the early 1930's and mid 1940's. Erosional processes occurring within the whole map-area have been in the modern past and are at present those governed by the mass-wasting and fluvial cycles.

PART TWO: INVESTIGATIONS OF CRITERIA FOR THE RECOGNITION OF RELATIVE AGES OF PLEISTOCENE MORAINE SEQUENCES

INTRODUCTION

Multiple glaciation studies in the western Cordillera of the Americas have been confronted with two tasks: (1) to correlate moraine sequences of one region to those of another, and (2) to establish the relative lengths of time between ice advances depicted by a series of moraines in that region. Both problems were approached, originally, by the examination of the degree of weathering of moraines or related features, followed by the establishment of a relative time scale related to weathering. In temperate regions these tasks generally involved the following studies: changes in morainal form due to various processes of erosion, increases in the depth of the soil profile; changes in surficial micro-texture, disintegration, and frequency of surface boulders; alterations of cobbles and pebbles in the zone of oxidation; the downvalley or lateral sequence of moraines; morphological changes in cirques, and many other criteria.

Multiple glaciation in the Cordillera was recognized before the turn of the century. For the best studied region, the Sierra Nevada, Blackwelder (1931) summarized the earlier work in his classic study of weathering differences of the deposits left by a four-fold ice advance on the eastern side of the range during the Pleistocene Epoch. Even at this early time Blackwelder attempted to correlate Sierra Nevada ice advances with other regions by comparing the sequence of moraines and the relative change in the degree of weathering. Since 1931, many investigations of multiple-glaciated areas have been directed toward establishing suitable criteria for recognizing the age of moraines and correlating them with other areas in the western United States. Summaries of this work are found in the various chapters of "The Quaternary of the United States" (ed. by Wright and Frey, 1965). Studies in South America of a similar nature, though not nearly so extensive, have been in progress since the early 1900's and are summarized to some extent by Flint and Fidalgo (1964) as a part of their studies in the differentiation of a three-fold sequence of moraines on the east slope of the Argentinian Andes.

In the region covered by the main bulk of the Cordilleran Ice Cap multiple glaciation in the coastal regions is indicated by only a two-fold morainal sequence and by stratigraphic evidence as summarized by Armstrong et al., (1965). Due to the extent of the ice cap and its coalescence with the Laurentide Ice Sheet(s) to the east (Glacial Map of Canada, 1958) the re-

cognition of multiple glaciation in that region cannot be approached by the methods outlined in the preceding paragraphs. However, on the northwestern periphery of the ice cap within the southern Yukon Territory, portions of which are non-glaciated, various investigators have recognized multiple glaciations on the basis of successive downvalley end moraines or lateral upslope drift limits, by the differences in the form and drainage pattern exhibited by each moraine in the sequence and by changes in freshness of the Schliffgrenze on valley walls. This work represents mainly casual field observations and aerial photo analysis, and only a very limited number of weathering criteria have been attempted, as shown by the work of Bostock (1952 and 1966), Krinsley (1965), Vernon and Hughes (1966), Muller (1967) and Rampton (1967).

Differentiation and correlation of the chronosequence of moraines in areas intermittently blanketed by ice in Alaska have been extensively investigated during the past 15 years (as summarized by Péwé et al., 1953 and 1965). Due to the variability of eolian cycle(s), the presence or absence of permafrost and the wide diversity of physiographic settings for each sequence of moraines it is recognized that many criteria used for correlation of and dating of moraines in temperate regions are not so conclusive or even unusable in the subarctic and arctic regions of the Cordillera. Permafrost retards chemical weathering; and loess, being susceptible to frost, acts not only as a refrigerator but also modifies the form of moraines according to the intensity and duration of the eolian cycle.

Within the Ogilvie Mountains, Vernon and Hughes (1966) differentiated in a qualitative manner the areas of "blue limit" (Age I) glaciation or ice advance from those involved only in the "red limit" (Age II) ice advances and older glaciations by: form of valley floor (smoothly U-shaped versus incised U-shape), relative sizes of valley wall fans, depth of oxidation of the solum developed on the moraines, size and surface characteristics of moraines, and distances of end moraines from probable ice sources (i.e. the downvalley succession). However, Vernon and Hughes admit that exceptions exist to the above stated general case. Most of these above-mentioned criteria were established in the valleys adjacent to or followed by the Dempster Highway. Fortuitously, the road runs through the chronosequence of moraines on both the south and north slopes of the Southern Ogilvie Ranges.

Other useful criteria suspected by Vernon and Hughes were not reported because of lack of conclusive quantitative data. The writer was employed by the Geological Survey of Canada to gather and analyze such data on the

"youngest" (Age I), "intermediate" (Age II) and, if practical, the "oldest" (Age III) moraines. Generally all criteria examined in this study have yielded either inconclusive or negative results; hence, the elaboration in the text to follow may appear rather brief. A few criteria were short circuited in analysis altogether for either lack of time in the field and/or in the office, or because of obvious field evidence that would invalidate the analysis. A quantitative expression of morainal form and of permafrost distribution were reduced in scope and have been analyzed together in Part 2A. Mechanical analysis of till samples and examination of pebble weathering constitute the investigations of Part 2B. Soil-profile genesis (Part 2C) and the successional development of vegetation on the moraines (Part 2D) make up the final two investigations. Of the criteria studied, the last mentioned is an approach not frequently attempted on a sequence of Pleistocene moraines.

PART 2A:- MORAINAL EXPRESSION AND PERMAFROST FEATURES AS POSSIBLE MEANS OF DISTINGUISHING THE SEQUENCE OF PLEISTOCENE MORAINES

Introduction

Form of morainal termini has been used by nearly all Alaskan and Yukon investigators in order to differentiate and correlate various ages of Pleistocene moraines. However, in most cases the distinctions are based on visual comparisons and have not been checked by quantitative methods. Exceptions are the frontal slope meansurements and bog to lake ratios on Illinoian and Wisconsinan moraines in the Big Delta area of the central Alaska Range (Péwé et al., 1965); and random point slope measurements by Rampton (1967) on a three-fold sequence of Pleistocene moraines in the southwest Yukon.

Permafrost features were used by Holmes and Lewis (1961) in the Eastern Brooks Range (Fig. 5) to help distinguish the youngest (late Wisconsin) moraines from older moraines downvalley. They observed that the youngest moraine lacked most types of periglacial features, whereas patterned ground blanketed the oldest, ground ice lay close to the surface in the older, and a variety of frost features was typical of the moraines of intermediate age. Krinsley (1965), on the other hand, reports the existence of permafrost close to the ground surface of Pleistocene moraines of all ages in the Shakwak Valley-Wellesley Basin region of the southwestern Yukon Territory (Fig. 5).

The purpose of this study was to evaluate quantitatively the morphological criteria tentatively established by Vernon and Hughes (1966) to differentiate the "youngest" (Age I) from the "intermediate" (Age II) moraines lying in the upper Blackstone drainage basin. At the time of their preliminary studies, drained closed depressions on the younger moraines were thought to indicate lack of permafrost, possibly due to an insufficient time span to permit its development. Some sort of quantitative approach was wanted to describe these permafrost differences in the two ages of moraines as well. However, in Part One of this thesis it is pointed out that important depositional and textural differences exist between some of the younger moraines. The differences between the north and south lobes of the North Fork Pass Moraine are discussed under map Unit 1A of Part One of this thesis; the resultant topographic expressions are clearly shown in Plates VIII and XXI. The north lobe of the North Fork Pass Moraine (NF-NL-I) was built in the same environment and by approximately the same relative proportions of the various primary and secondary depositional processes as the Chapman Lake Moraine (CL-II) and hence has a similar surficial appearance. On the other hand, the processes leading to the

Plate XXIA

Corrugated south lobe of the North Fork Pass Moraine from the summit of "Dall Sheep Mountain". "Tombstone Range" lies in the background.

Plate XXIB

Swell and swale relief on the north lobe of the North Fork Pass Moraine from the summit of "Angelcomb Mountain". "Blackstone Mtn." (left central skyline) and "Foxy Creek valley" (left centre) of "Rangifer Range" lie beyond the East Blackstone valley.

deposition, in a different environment, of the south lobe of the North Fork Pass Moraine (NF-SL-I) were quite distinct from those giving rise to the NF-NL-I moraine. The Foxy-I moraine is similar to the latter moraines in this respect. In addition the NF-NL-I moraine possesses similar types and distribution of permafrost and periglacial features as the CL-II moraine. The thermokarst cycle, in particular, contributes to a similar topographic end product (as it is today) in these two moraines. Therefore, the usefulness of analyzing copious survey profile data had to be re-assessed. In view of the above-mentioned differences and similarities, the writer reasoned that the presentation of dubious quantitative data might produce spurious results for the survey profiles were more apt to show differences in primary and secondary deposition on the moraines rather than differences in erosion as compared to a time factor. Hence, only a semi-quantitative to qualitative analysis is presented herein.

Methods

The writer and his assistants measured 2 or 3 profiles normal to the arcuate orientation of morainal crests on each of the NF-SL-I, NF-NL-I and the CL-II moraines as shown in Figures 6, 7 and 8. At least one profile was begun from each of a previously established bench mark located on each moraine. The profiles were run as straight sections thrcugh the moraine using a planetable-alidade and stadia method. Shots were taken at each point of change of slope and new instrument stations were established after 10 to 15 such readings. Each spot reading was recorded on the plane table map along with notes on the general geologic conditions of the immediate surroundings. Over a period of 15-16 days of surveying about 1000 spot elevations and distances were taken on the profiles.

Permafrost features were noted during these surveys and in the course of other investigations. Ground ice was not probed for on a systematic basis but was noted when performing soil pit analyses (refer to Part 2C). To a large extent the lack of surface drainage and the presence of the Tussock-Tundra (refer to Part 2D) were used as indicators of ground ice lying near the surface of the moraine. Other permafrost features such as ice wedge polygons, thermokarst cave-in activity and ice-cored palsen (s.lat.) bogs were easily distinguished on aerial photographs and in field examinations; they are shown in Figures 6, 7 and 8.

Results

The surveying data were not reduced to mathematical expressions or profiles because of shortage of time and because of the forementioned unexpected geologic complications. Instead, all data are presented in the format of Holmes and Moss (1955) as qualitative terms on Table XII. The data reveal that the NF-SL-I moraine is clearly distinct from other moraines (including its NF-NL-I counterpart). Permafrost of the ground ice variety was not found on the NF-SL-I moraine; if present there, it must be well below the surface. Hence, other surficial permafrost features have not developed and a few ponds on the moraine are able to drain during the course of the summer because of a lack of ground ice to act as an impermeable barrier. Moraines to the north are not only encased in ground ice but also have been secondarily subdued by deposition of eolian silt. Ground traverses reveal that this general subdued appearance is remarkably similar on the NF-NL-I, Foxy-I and CL-II moraines (cf. the frontispiece to Plate XXIB); the silt in turn is partly responsible for the rise of the permafrost table to the surficial portions of these morainal surfaces. Permafrost (as ground ice) was found in all instances within the surficial silts on both the NF-NL-I and the CL-II moraines. Where convoluted loess is absent from the till-crested portions of these two moraines the ground ice table lies just beyond the depth of practical digging on all moraines to the north of North Fork Pass. Thus the permafrost distribution is not related to age of moraine but rather to probable climatic and textural factors.

Table XII reveals the complication of differences in the amounts of various types of primary deposits from one moraine to the next. Supraglacially derived deposits (hummocky gravels; map Sub-unit 2F) are far more prevalent on the CL-II and NF-NL-I moraines and the latter is much different from the NF-SL-I moraine in this respect. Since this type of debris is porous, and as the area is climatically arid, there is little modification of form or texture of the hummocks after deposition. Consequently the profiles of the moraines will show irregularities that are not related to age. The environmental parameters responsible for the irregular deposition and distribution of the supraglacial gravels are discussed under map Units 1A and 2F in Part One of this thesis. Since the depositional and environmental history of the NF-NL-I moraine was similar to that of the CL-II, a comparison of their forms may be a more valid test for age progressive erosional changes. However, these two moraines show similarity in the development of superimposed drainage pattern, the degree of preservation of hummocky gravel, the thicknesses of loess (and its modifying influence), and the relative areal extent of thermokarst activity. What

TABLE XII Qualitative morphological characteristics of various aged moraines in the Blackstone - North Klondike drainage basins.

CHARACTERISTIC	MORAINE AND RELATIVE AGE					
	August 17th-I	North Fork - SL-I	North Fork - NL-I	Foxy-I	Chap.Lake - II	Ogilvie - III
Morainal Type Areal Size, Total Relief	Terminal Smallest, ca.10m.	Terminal ca.2sq.km., ca.40m.	Terminal Complex ca.8sq.km., ca.40m.	Terminal ca.1.7sq.km., ca.60m.	Terminal Complex ca.18-19sq.km., ca.60m.	Ground ca.7sq.km., -
External Form	Simple lobe	Corrugate lobed	Hummocky on swell and swale	Hummocky on broadly lobed to slightly corrugate	Hummocky on swell and swale	Hummocky on sheet
Form of Transecting Fluvial Feature	Narrow channel, shallow	Nil to very slight shallow	Broad channel mod. depth	Narrow and deep channel	Very broad channel, mod. depth	-
Profile of Snout	Gradual	Abrupt	Gradual	Gradual to mod.	Gradual	-
Outwash Apron	Present	Absent	Present	Present	Present	-
General Relief Appearance	Semi-subdued	Bold	Semi-subdued with intermittent superposed bold micro relief	Bold to semi-subdued	Semi-subdued with intermittent bold micro relief	Subdued
Compaction and Original Composition	Semi-loose till	Indurated till	Mod. indurated till and loose gravel	Indurated till and mod. loose gravel	Loose to mod. indurated till and loose gravel	Mod. indurated till
Boulders on Moraine Surface	Few, scarcely weathered	Very few, scarcely weathered	Very few, scarcely weathered	Few, scarcely weathered	Very few, scarcely weathered	Very few, scarcely weathered.
Surface Veneers	Nil	Little; colluvium in depressions and gullies, gyttja bogs	Much; involuted eolian silt on slopes, colluvium in gullies, peat bogs	Moderate; eolian sand and silt; peat bogs	Much; involuted eolian silt on slopes; colluvium in gullies; peat bogs	Moderate; eolian silt on slopes
Permafrost Table	Absent or deep below surface	Absent or deep below surface, never detected	Near surface in silts and bogs. Ice wedges present	Near surface in bogs not too deep elsewhere	Near surface in silts and bogs. Ice wedges present	Near surface in bogs; not too deep else where
Ice Flow Gradient	Downvalley	Upslope	Downvalley to level	Downvalley to level	Downvalley to level	-
Extent of Ablation Till or Hummocky Gravel Deposits (Fig. 6, 7 & 8)	Nil	Very few; less than 1% of surface	Mod. 15-20% of surface	Few; 5% of surface	Mod. 20-25% of surface	Very few
Thermokarst Activity (Cave-in)	Nil	None	Present-Active	Present-Inactive?	Present-Active	Present-Active
Pond Abundance	Nil	10/sq.km.	2.8/sq.km.	4/sq.km.	3/sq.km.	1.8/sq.km.
Seasonal Drainage of Ponds	-	Present in a few	Perhaps in one	?	Absent (?)	Absent
Bog Abundance (6D & 7F)	Nil	ca.4/sq.km.	0.9/sq.km.	2.4/sq.km.	1.8/sq.km.	0.3/sq.km. (?)

thermokarst differences (slopes around lake shores) that might exist between them may be related to the fact that the CL-II moraine occurs in an open physiographic setting and is underlain in part by lacustrine silts. The silts are susceptible to frost and assist in the evolution of numerous large depressions by thermokarst activity. Without knowledge of the full extent of these sub-till silts the writer cannot justify the comparison of profiles of the CL-II moraine with those of the NF-NL-I moraine (in a closed physiographic setting - comparatively speaking) nor can any significant conclusions be drawn from the bog and lake parameters given in Table XII. Hence, as far as this map-area is concerned permafrost and topographic criteria are not useful for distinguishing Age I from Age II morainal termini.

To compare Age IIA moraines with Age II, lateral moraines (where they exist on ridge crests or low divides) must be used, for the Age IIA moraines lack a distinct downvalley terminus. In these topographic settings both ages of lateral moraines are identical in: overall form, degree of modification of lake basins by thermokarst activity, superimposed drainage patterns, and other weathering features. Unfortunately comparably situated Age I and Age III lateral moraines do not exist in the map-area for additional comparison. However, an Age III lateral moraine 15 km north of the map-area (Fig. 2) appears to be much more subdued by solifluction than any Age II or Age IIA moraines within the map-area. Comparison of valley-sided lateral moraines (Plates VIII, XI, XIIB and XIIIA) indicate about the same form and degree of modification on the NF-NL-I types as to those of the CL-II moraine.

It is not meaningful to compare morainal features south of North Fork Pass with those to the north, because significant edaphic, climatic and vegetational differences exist between the two areas. Similarly it is not rewarding to compare Age I moraines south of the pass with Age II moraines at the mouths of large valleys on the south slope of the Southern Ogilvie Ranges, for generally the younger are located in the narrow mouths of tributary valleys whereas the older lie in broad valleys oriented transverse to ice flow. Because of the gross differences in areal extent of the two ages of moraines and because of a difference of environments of deposition it is probably not valid to compare their subsequent modifications for purposes of chronology or correlation.

Discussion

Strong reliance is placed on modifications of morainal topography, subsequent to their initial deposition, in the analysis of multiple glaciation for regions in Greenland (Washburn, 1965), the Yukon (Bostock, 1966, Krinsley,

1965; Muller, 1967) and Alaska (Péwé et al., 1953, 1965). Comparisons of morainal topographic expression against the time factor are justified only where deposits on the moraine, gradients of valley floor beneath the moraine, local physiography, local climate, and other environment factors are similar between those being studied. Within the boreal forest and maritime regions of the northern Cordillera significant differences in topographic modifications between Wisconsinan and Illinoian moraines, as well as between a few Late and Early Wisconsinan moraines, have been reported by the above authors. To some extent correlation of the chronosequences of moraines from one region to the next on the basis of topographic expression alone have been successful. However, the criterion is not infallible, for Fernald (1953) noted that physiographic differences between certain valleys of the upper Kuskokwim drainage basin led to glaringly different expression of moraines that are supposedly of the same age.

In the tundra regions of the northern Cordillera, modifications of moraines take longer periods of time than those to the south. Holmes and Lewis (1961) suggested that significant modifications can be inflicted only if sufficient length of warm periods exist between the ice advances or glaciations; the present interstadial period is neither warm enough nor long enough to produce them. Between the Early and the Late Wisconsin ice advances there was apparently an insufficiently short warm interval in the Eastern Brooks Range, for Holmes and Lewis have indicated that differences in erosional modifications of the Peters (younger) and Schrader (older) moraines are not too significant; the main differences in morainal character noted were due to the much smaller extent of the valley ice lobes rather than the younger age of the Peters moraine. In turn, Péwé (1965) did not demonstrate significant morphological differences between the Late Wisconsin Denali II and Early Wisconsin Denali I moraines in the alpine tundra regions of the Amphitheatre Mountains in the central Alaska Range, though he has shown differences between the Illinoian Delta and the undifferentiated Wisconsinan Donnelly moraines in the subalpine zone of the Delta River region on the north side of the range. Bogs ($0.8/km^2$) on the Delta outnumber those on the Donnelly ($0.4/km^2$), but the latter has nearly six times ($6.3/km^2$) as many kettle ponds as the former. These criteria cannot be universally applied, for Péwé et al. (1965) have found that the preservation of primary microrelief on Illinoian drift varies according to the physiographic region. Presumably they are suggesting that the microrelief may be well displayed on moraines lying in the arctic environment to the north. However, on the north slope of the St. Elias Mountains (in the boreal-subarctic environment) within the Yukon Territory, Krinsley (1965) notes that the steep hilly terrain of the Illinoian Donjek

Moraine is only slightly less "rough" than the Early Wisconsinan Snag Moraine (= Ruby Ice Sheet of Muller, 1967).

It is interesting that the NF-NL-I moraine (Late Wisconsin) is very similar in appearance to the Snag moraine, and that the CL-II and TV-IIA lobes resemble portions of both the Snag and Donjek moraines. Other similarites of moraines in the map-area to those reported elsewhere have been pointed out under the discussion of map Unit 1 in Part One of this report. When our Age I (Late Wisconsin) moraines are comparable in form to older moraines elsewhere, obviously there is a grave danger of faulty regional correlation of moraines if conducted on a topographic expression basis alone. For this reason the writer feels that as far as the Ogilvies are concerned the climatic and lithologic factors are too variable to permit correlations of moraines on the basis of form with those even nearby. The prime example is, of course, the NF-NL-I moraine, which is morphologically more comparable to the CL-II than to the NF-SL-I moraine.

Permafrost characteristics are equally variable and are in part also responsible for the differences in morainal topography. Where permafrost is more or less continuous, gross topographic changes due to normal erosional processes are slow to develop. If the permafrost is degrading, spectacular thermokarst features will modify the moraines; but where permafrost is absent, morainal modification with an established drainage network might develop instead and hence, there would be a different modification of the topographic expression. Permafrost has been shown by Péwé (1965), Krinsley (1965), Wheeler (1961), Vernon and Hughes (1966) and the writer to occur on Late Wisconsin (Age I) moraines within the northern Cordillera. However, not all Late Wisconsin moraines of the northern Cordillera are encased in permafrost. Holmes and Lewis (1961), a few of the above authors, and this report have shown that similar aged moraines in the subarctic environments can be devoid of permafrost. Since obviously detectable permafrost features are of only sporadic occurrence in the Age II moraines south of North Fork Pass, this criterion cannot be used as an indicator of moraine age. Permafrost has been shown by numerous authorities to develop in a time span less than Age I, and this is confirmed by the radiocarbon dates taken from frozen bogs on the Age I moraines (Table VI). The presence or absence of permafrost (as ground ice) is related to minor microclimatic differences and to the texture of potential enclosing materials rather than to relative time spans.

The Age III ground moraine surface in the map-area is surprising. Its till (on the gentler slopes) was not strongly reworked or modified; permafrost,

though present, was not within hand digging distance below the surface, and minor hummocks of ablation gravel (Sub-unit 2F) occur as distinct microrelief above the surrounding till. In fact the gravel hummocks are nearly as distinct as those on the Age I and II morainal termini. The ground moraine is no more dissected by drainage channels than the ground moraines of the Age IIA, Age II and tundra portions of the Age I though the upland physiographic environment of the Age III is partly responsible for this. Hence, the primary depositional relief on moraines can be preserved for long periods of time in the tundra environment (the north portion of the map sheet); morphological changes on the horizontal portions of moraines are apparently very slow. Nearly all field investigators in the northernmost Cordillera would agree with this inference, though many would point out that pre-Illinoian moraines show significant weathering modifications. In this regard Holmes and Lewis (1961), and Detterman (1953) have indicated that the oldest drifts on the north slope of the Brooks Range are frost-modified, intermittently-occurring smooth sheets with absolutely no microrelief preserved upon them.

PART 2B:- ANALYSES OF WEATHERING OF THE TEXTURAL COMPONENTS OF MORAINES AS AN AID TO THE DIFFERENTIATION AND CORRELATION WITH THE REGIONAL CHRONOSEQUENCE

Introduction

Weathering of textural components in or on a moraine has been examined using many approaches. The easier methods have involved: 1) study of boulder frequencies on the morainal surface; 2) examination of the degree of preservation of boulders on the surface or within the till; and 3) measurement of differences in till textures. There are many variations of analyses within each of the above methods, but the ultimate purpose is to establish differences in weathering as related to age. In continental western United States Blackwelder (1931), Nelson (1954), Holmes and Moss (1955), Birkeland (1964), Birman (1964), Rahn (1963)[1], and Sharp (1960) have used such methods to establish differences between chronosequences of Pleistocene moraines (Late Wisconsin to pre-Wisconsin). Occasionally granite weathering tests fail to distinguish the two (sometimes three) sequences of Wisconsin moraines but weathering of other rock types coupled with differences in soil genesis, moraine morphometry, or surface boulder frequencies indicate a progressive increase in weathering on the successively older moraines. Flint and Fidalgo (1964) found that the relative soundness of the granitic clast, when based on large samples, gave adequate distinction between three ages of Pleistocene till located on the eastern slope of the Argentinian Andes.

In the northern Cordillera similar work, but on a less extensive scale, has been attempted. Péwé (1953, 1965) noted a smaller quantity of and a greater amount of staining in schistose rock fragments of Illinoian moraines as compared with nearby Wisconsinan moraines; both sets of moraines were deposited by ice derived from the same source area within the central Alaska Range (Fig. 5). Granitic to clastic ratios on the surfaces of moraines in the Cook Inlet area were studied by Karlstrom (1965). He found that even Early and Late Wisconsin moraines could be differentiated in this manner. However, as far as the writer is aware, no examinations of textural weathering have been conducted to test whether such criteria could be used to distinguish moraines of these ages elsewhere. Krinsley (1965) noted that pebbles within the till of all Pleistocene moraines of the southwestern Yukon (Fig. 5) had

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[1] In October, 1964, Dr. D. A. Rahn elaborated on these methods in a special lecture at the University of British Columbia.

approximately the same textural appearance; Muller (1967) also has reported that the two younger tills in the same region are similar in respect to freshness. Holmes and Lewis (1961) and Detterman (1953) found a general decrease in surface boulders on the older (pre-Wisconsin) moraines in the Brooks Range, and noted the presence of angular clasts within the oldest tills. Bostock (1966) reported that in the central Yukon Plateau very rotten clasts are occasionally found in the oldest (Nansen) and the next younger (Klaza) drifts, and that striated clasts seem to be lacking in the former drift. Fyles (1950) studied the degree of weathering in various granite specimens taken from outcrops near Whitehorse and concluded that their relationships to time of glaciation was inconclusive; rather, the porous textures of some granitic rocks are more prone to weathering. The weathering was found to have taken place mainly by mechanical processes though some mineralogical decomposition was also noted. Cairnes (1912) emphasized the slowness of chemical weathering on one hand, and the intense mechanical frost splitting of especially fissile rocks on the other hand, for the western region of the Ogilvie Mountains.

This present study was confined to the examination of weathering of the pebble fraction in tills and the possible development of fines within the till. Except for the Aug. 17-I moraine, surface boulders are rare on moraines, regardless of age, in the northern half of the map-area. Hence boulder counts and weathering studies upon them were not undertaken. In areas of superposed ablation moraine or gravel hummocks, again, regardless of age, boulder sizes are not common. However, at these hummocks the field examination of the exposed larger-sized pebbles and cobbles indicated that the weathering was limited to slight oxidation stains on moraines of Age I, II or III. Evidence of age differential degree of sand blasting of these exposed larger fractions were not observed either. Hence it was concluded that there has been too little moisture on the gravel hummocks to permit or promote extensive weathering. Because of the possible longer period of moisture retention and of the abundance of material, weathering of the various components of the till was selected for study. The following features were examined in the "oxidized" portions of the till: a) the degree of preservation of striations on pebbles, b) the possible development of angularity or roundness of the pebbles, and c) the degree of chemical decomposition of pebbles. Also, non-oxidized till was examined by mechanical analysis in order to check for possible <u>in situ</u> development of fines (by freeze-thaw action) in the older tills or possible accumulation of fines (e.g. pre-glacial loess) in the progressively younger tills.

Methods

The collection of unoxidized till samples and pebbles from the oxidized portions of till has been described in Part One of this thesis. Sample sites were selected to cover the diverse geologic and geographic regions of the map-area. All sample sites listed on the tables to follow are shown in Figure 4. Mechanical analyses of the unoxidized tills were conducted by the Sedimentological Laboratory of the Geological Survey of Canada as also described in Part One. Pebbles and cobbles were examined for striations, surficial oxidation signs (including colours), angularity or roundness, and then cracked for identification as well as for further signs of decomposition or oxidation. Usually 100 pebbles from each sample site were examined, but samples larger or smaller than this were sometimes sorted (as shown in the tables).

Of striations, only randomly oriented patterns were recorded, for parallel striated fabric could conceivably be confused with slicken-sided surfaces; the two types of striations were noted in the clasts taken from the controversial Field Stn. No. 24 (see discussion of Sub-unit 1C; Part 1).

For angularity, pebbles were compared to standard shape diagrams[2] given in Compton (1962). Occasionally some rounded and subrounded clasts exhibited secondarily-produced fresh angular to subangular breaks. The writer interprets these pebbles as having possibly been rounded in a fluvial cycle prior to their being crushed during the glacial cycle. These two-cycle types were recorded (e.g. R + SA), since there existed the possibility that they might be more numerous in, and indicative of, the successively younger glaciations or ice advances.

Examination for chemical disintegration was conducted on each rock type within the sample, as shown in Figure 16. Some pebbles, other than the completely weathered ones, exhibit partial but simultaneous chemical attack externally and internally (i.e. within the matrix as well as external surface). These internal weathering features were inspected using a hand lens or 30 power binocular microscope. The examination for chemical weathering was also approached by employing Flint and Fidalgo's (1964) "test of soundness" method. For this, an additional sample of plutonic rocks - syenites, monzonites, diorites and gabbros (Units 16, 17, 18 in Table I) - were collected from each till locality within the zone of visual weathering. The degree of disintegration (or soundness) was measured by the pebble's resilience to a blow from

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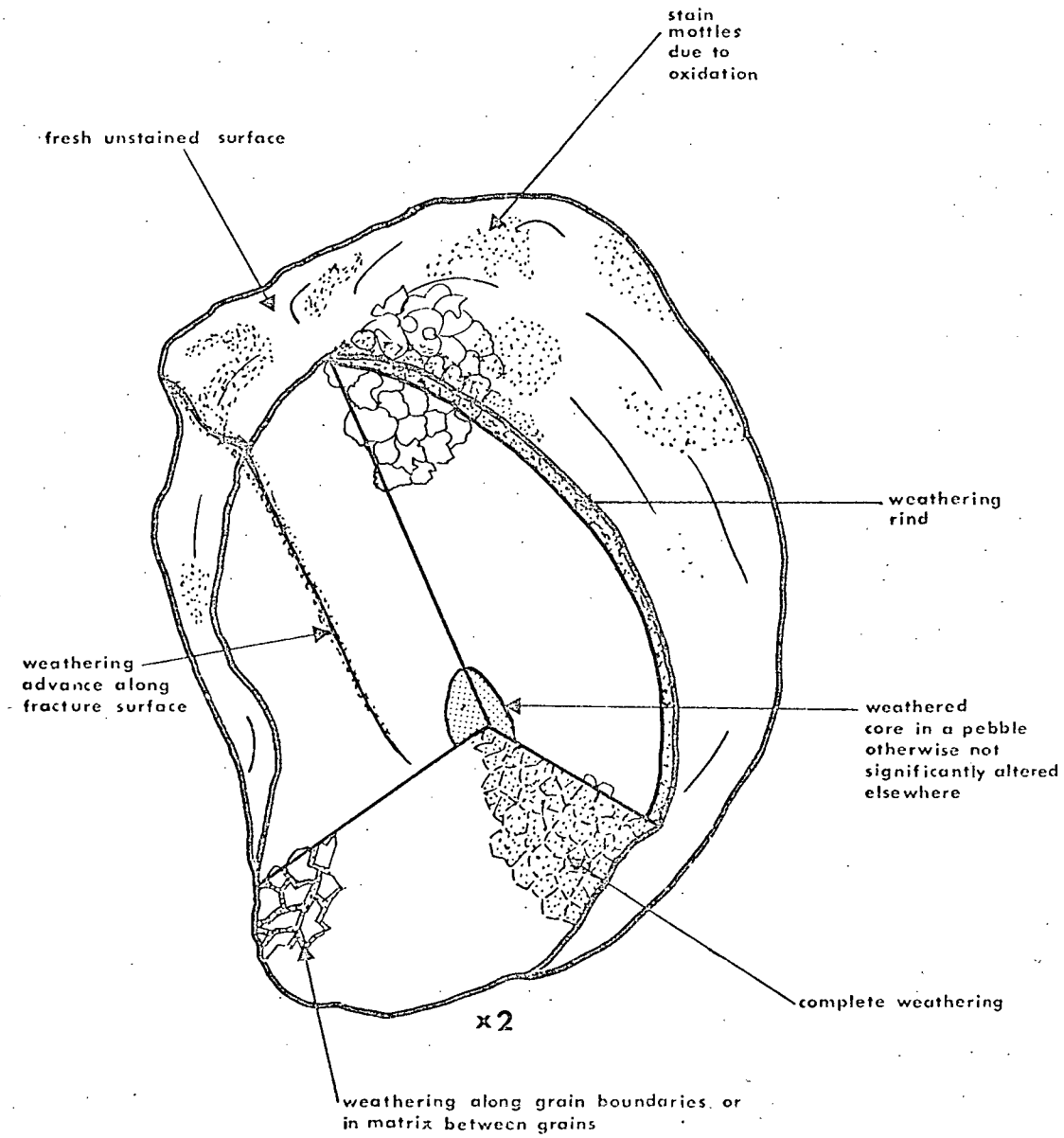
[2] In the tables WR = well rounded, R = rounded, SR = subrounded, SA = subangular, and A = angular.

FIGURE 16 Diagram of the various types of weathering of pebbles.



KR

a hammer. The pebble was placed on a clean iron anvil, struck, and the kinds of disintegration were classified as follows: crumbles easily, breaks with dull thud, breaks with a ring upon one blow, or breaks with two or more blows. Petrographic thin section examinations for mineralogical alteration were not conducted in conjunction with any of these tests because Tempelman-Kluit (1966) and Lambert (1966) have reported sericitization and saussuritization in the fresh plutonic rocks as they occur in outcrop on the Mt. Brenner and Tombstone stocks (Fig. 3).

Mechanical analysis data on the unoxidized till samples were first plotted as cumulative curves and histograms for each individual sample (Appendix IIA), and were then examined on an age group basis. The data were replotted on various types of three-pole diagrams to check for possible relationship of age to a specific gravel: sand: mud ratio. Weathering of oxidized till is not covered in this section of the report as it is more suitably approached from a pedological viewpoint (refer to Part 2C).

Results

Mechanical Analysis of Unoxidized Tills

Figure 17 indicates that distinction of Age I from Age II tills is not possible. Furthermore, the figure shows, from single samples, that the Age IIA and Age III tills may consist of approximately the same relative percentage component sizes as that of the average Age I and Age II till. On a regional basis (Figs. A and B of Appendix IIA), Age I tills south of North Fork Pass are coarser than those to the north and are roughly identical with Age II tills occurring south of the pass. Age I tills north of the pass are finer than most Age II tills, whereas Age II tills north of the pass are nearly identical with Age I and II tills south of the pass. Generally, the cumulative frequency curves fail to reveal the kind of good distinctions in different ages of till sheets that have been found elsewhere (e.g. continental till sheets in eastern and midwestern North America; Flint, 1957). Furthermore *in situ* development of "fines" with increase in age is apparently not occurring and a incorporation of Age II loess or lacustrine silts is not apparent in the Age I tills.

Figure B of Appendix IIA illustrates a distinct difference in the Age II and Age IIA tills as compared with samples taken at Field Stn. No. 240. The figure also shows that the Age II tills become increasingly richer in fine components in the upvalley direction, until the textural values of the Foxy-I

FIGURE 17 Enveloping Cumulative Curves Showing Range of Grain Diameters in Age I & II Tills (excluding particles > 64mm).

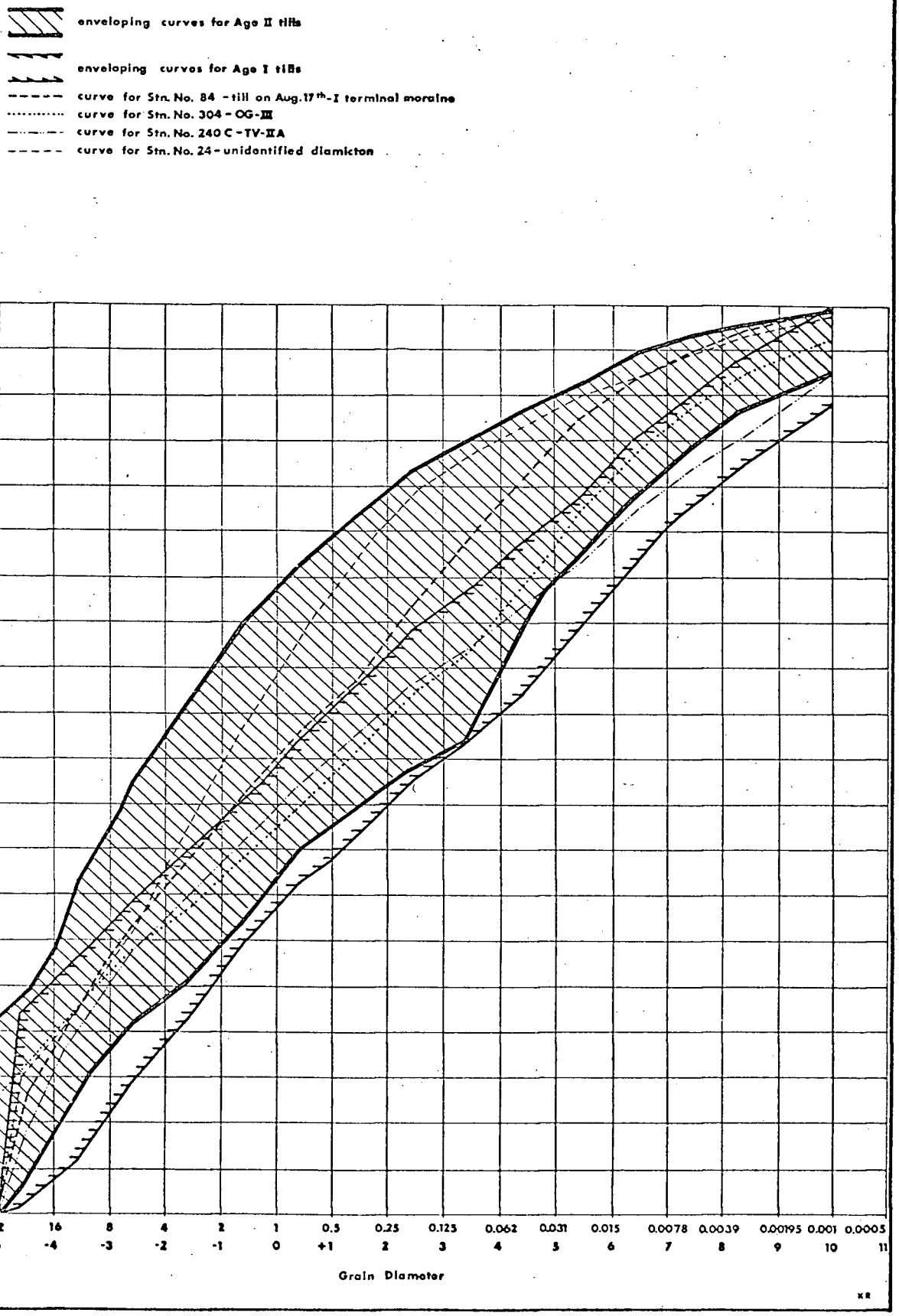
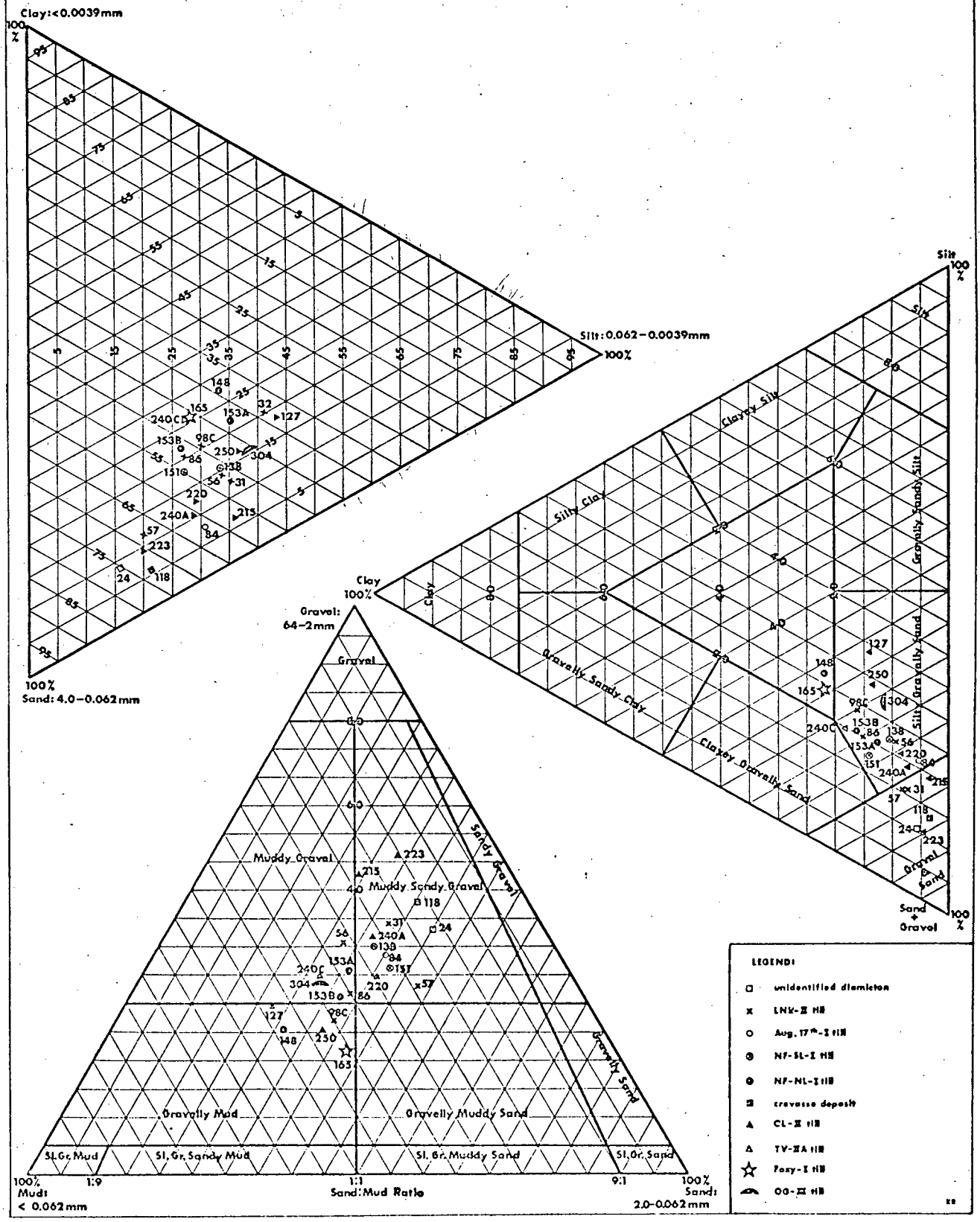


FIGURE 18 Three Pole Plots of Textures in Age I, II, IIA & III Tills



and NF-NL-I moraines are nearly reached. The Age III till (Stn. 304) is of finer texture than the Age II samples taken from the nearby CL-II morainal terminus (Stns. 220 and 223).

Plotting the gravel, sand, sand + gravel, silt, clay and clay + silt (mud) percentage components on three types of three-pole diagrams (Fig. 18) also shows that age group distinction of the tills is not possible; the plots generally confirm other distinctions as previously listed. These plots emphasize the more gravelly character of the tills of Chapman Lake morainal terminus as compared to all other tills in the region, and suggest that the controversial diamiction (sample No. 24) may in fact be actually a sandy till comparable in texture to others of nearby Age II relationships.

Pebble Striations

As shown by Table IV striae are found on about one quarter of the pebbles at every field station regardless of the age of the enclosing till. Where percentage frequency deviates from this value the differences can be accounted for by the variation in the rock types making up the till. The undivided plutonic rocks (Table XIII) are not favourable for preservation of striations, whereas cherts (Table XIV) and fine-grained clastics (Table XV) commonly retain striations. The quartzites (Table XVI) are unpredictable in this respect. Of the selected plutonic and volcanic rocks the data (Appendix IIB - Tables I, II and III) show that development and preservation (?) of striations are highest in the tills occurring at the north end of the map sheet. However, striations on the quartzite and grit rock types show nearly the reverse trend (Table XVI); they are commonly more evident in the clasts taken from the Lower North Klondike Moraine as compared to the moraines at the north end of the map-area. Glacial polish was rarely seen on any of the pebbles; some was observed on a few gabbros and cherts taken from samples of Age I, II and III tills north of the North Fork Pass but the results are too scant and vague to be quantified.

Angularity or Roundness

Many pebbles in the till were of a pentagonal form (as illustrated in Flint, 1957) and this is shown by the high abundances of subangular and subround shapes in nearly all clasts examined. Gross angularity results (Table IV) also indicate that the subround clasts increase in frequency in the down-valley direction at the expense of a slight decrease in the subangular and angular clasts. There are no significant differences between samples of Age I,

TABLE XIII % F. Angularity of all plutonic clasts*

FIELD STN. NO.	MORAINE AND AGE	ROUNDNESS OR ANGULARITY CLASSES**									% F. PRESERV. STRIATION	F.
		WR	R	R+SA	R+A	SR	SR+SA	SR+A	SA	A		
24	Tim. V (III?)	no plutonic rocks in sample										
31	LNK-II	0	4.5	0	1.1	19.1	13.5	0	60.7	1.1	4.5	89
32	LNK-II	0	0	0	0	32.0	4.9	1.9	59.2	1.0	2.9	103
56	LNK-II	0	0	0	0	0	0	0	50.0	50.0	0	6
57	LNK-II	no plutonic rocks in sample										0
86	LNK-II	0	0	0	0	0	0	0	99.1	0.9	0	105
98C	LNK-II	0	0	0	0	6.3	2.1	2.1	89.6	0	0	48
	Weighted % F.	-	1.1	-	0.3	15.1	5.1	0.9	75.5	2.0	2.0	
84	Aug.17-I	0	0	0	0	0	0	0	100.0	0	45.5	11
138	NF-SL-I	0	0	0	0	0	0	0	82.8	18.2	0	66
148	NF-NL-I	0	0	0	0	0	0	0	100.0	0	0	13
151	NF-SL-I	0	0	0	0	0	2.3	0	85.0	12.7	0	87
153A	NF-NL-I	0	0	0	0	33.3	0	0	66.7	0	0	6
153B	NF-NL-I	0	0	0	0	0	25.0	0	75.0	0	25.0	4
165	Foxy-I	0	0	0	0	0	50.0	0	0	50.0	100.0	2
	Weighted % F.	0	0	0	0	1.1	2.2	0	83.1	13.6	3.7	
127	CL-II	0	0	0	0	0	0	100.0	0	0	0	1
220	CL-II	0	0	0	0	40.0	0	0	60.0	0	10.0	10
223	CL-II	0	9.8	0	0	36.6	0	4.9	41.4	7.3	7.3	41
240A	CL-II	0	4.4	0	0	35.6	0	0	60.0	0	6.7	45
	Weighted % F.	0	6.2	0	0	36.1	0	3.1	51.5	3.1	9.3	
240C	TV.IIA	0	1.8	0	0	32.7	7.3	1.8	55.4	0	0	55
304	OG-III	0	0	0	0	42.8	0	0	57.2	0	28.6	7

* Includes gabbros and dolerites from sills; acidic and intermediate plutonic rocks from stocks -- Units XX - 16, XXIB - 18 respectively (Table I).

** SR+A, etc. refers to a subround plutonic rock subsequently modified by a fresh angular break.

TABLE XIV % F. Angularity in cherts.**

FIELD STN. NO.	MORAINE AND AGE	ROUNDNESS OR ANGULARITY↓ CLASSES									% F. PRESENCE OF STRIATIONS	F.
		WR	R	R+SA	R+A	SR	SR+SA	SR+A	SA	A		
24	Tint.V (III?)	Cherts were not found in the sample						-	-	-	-	0
31	LNK-II	0	0	0	0	25.0	37.5	0	37.5	0	25.0	8
32	LNK-II	0	0	0	0	0	0	0	66.7	33.3	66.7	3
57	LNK-II	0	0	0	0	16.7	0	12.5	70.8	0	33.3	24
86	LNK-II	0	0	0	0	0	0	0	70.0	30.0	20.0	10
98C	LNK-II	0	0	0	0	0	9.1	0	86.3	4.6	36.4	22
84	Aug.17-I	Cherts were not found in the sample					-	-	-	-	0	0
138	NF-SL-I	0	0	0	0	0	0	7.2	42.8	50.0	14.4	14
148	NF-NL-I	0	0	0	0	7.7	7.7	15.4	69.2	0	53.8	13
151	NF-SL-I	0	0	0	0	0	0	0	54.5	45.5	9.1	11
153A	NF-NL-I	0	0	0	0	0	0	0	93.3	6.7	6.7	15
153B	NF-NL-I	0	0	0	0	0	0	0	100.0	0	9.5	21
165*	Foxy-I	0	50.0	0	0	0	0	0	50.0	0	0	2
127	CL-II	0	0	0	0	0	0	33.3	33.3	33.3	33.3	3
220	CL-II	0	0	0	0	0	0	0	80.0	20.0	40.0	5
223	CL-II	0	0	0	0	0	0	0	100.0	0	0	2
240A	CL-II	0	0	0	0	0	0	0	83.3	16.7	33.3	6
250	CL-II	0	0	0	0	20.0	0	0	60.0	20.0	0	5
240C	TV-IIA	0	0	0	0	0	0	0	91.7	8.3	33.3	12
304	OG-III	0	0	0	0	0	0	0	100.0	0	50.0	2

↓ R+SA etc. indicates that a subangular surface has been superimposed on a rounded pebble shape.

* These samples are chert breccias. All other stations are standard black, grey and green cherts.

** Includes Units III, IV, IX, XIII, XV, XVII, XIXA of Green and Roddick (1962) or Units 4, 6, Rd.River Fm., Tahkandit Fm., Keno Hill Quartzite member, 14 of Templeman-Kluit(1966) in Table I.

TABLE XV % Frequency (F.) in angularity of the siltstones, argillites, shales* (± argillaceous, metamorphosed and limy) located in the tills.

FIELD STN. NO.	MORAINE AND AGE	ROUNDNESS OR ANGULARITY CLASSES**									% F. PRESERV. STRIATIONS	F.
		WR	R	R+SA	R+A	SR	SR+SA	SR+A	SA	A		
24	Tint.V (III?)	0	0	0	0	0	25.0	75.0	0	0	0	4
31	LNK-II	0	33.3	0	33.3	0	33.3	0	0	0	0	3
32	LNK-II	0	0	0	0	0	50.0	0	50.0	0	50.0	2
56	LNK-II	0	0	0	0	0	0	0	62.5	37.5	12.5	8
57	LNK-II	0	0	0	0	16.7	16.7	33.3	33.3	0	33.3	6
86	LNK-II	0	0	0	0	0	0	0	82.3	17.7	23.5	17
98C	LNK-II	0	0	0	0	0	10.0	0	80.0	10.0	50.0	10
84	Aug 17th-I	0	0	0	0	0	0	0	100.0	0	100.0	1
138	NF-SL-I	0	0	0	0	0	0	0	73.7	26.3	57.9	19
148	NF-NL-I	0	0	0	0	0	5.0	5.0	90.0	0	35.0	20
151	NF-SL-I	0	0	0	0	0	0	0	78.7	21.3	78.7	14
153A	NF-NL-I	0	0	0	0	15.0	10.0	0	75.0	0	60.0	20
153B	NF-NL-I	0	0	0	0	0	11.4	5.7	77.2	5.7	34.3	35
165	Foxy-I	0	0	0	0	0	0	0	66.7	33.3	0	3
127	CL-II	0	0	0	0	16.7	0	0	83.3	0	33.3	6
220	CL-II	0	0	0	0	9.1	0	0	72.7	18.2	36.4	11
223	CL-II	0	5.9	0	0	5.9	11.8	5.9	70.5	0	35.3	17
240A	CL-II	0	0	0	0	26.6	6.7	6.7	60.0	0	86.7	15
250	CL-II	0	0	0	0	0	16.7	16.7	66.6	0	50.0	6
240C	TV-IIA	0	6.3	0	0	18.7	6.3	0	68.7	0	87.5	16
304	OG-III	0	0	0	0	11.1	0	0	77.8	11.1	33.3	9

* Includes components from bedrock units I, IID, III, IX, XIII, XIV, XVII, XIXA and B - refer to Table I .

** SR+A, etc. refers to a subrounded clast subsequently broken by some process into partially sharp edge smaller clasts.

TABLE XVI % Frequency (F.) in angularity of the "quartzites" located in tills.

FIELD STN. NO.	MORAINE AND AGE	ROUNDNESS OR ANGULARITY CLASSES* WR	R	R+SA	R+A	SR	SR+SA	SR+A	SA	A	% F. PRESERV. STRIATIONS	F.
24	Tint.V. (III?)	1	5.2	9.7	15.5	17.5	18.6	22.7	6.2 / 35.1	3.1 / 39.2	25.8	97
31	LNK-II	0	7.4	5.9	4.4	27.9	10.3	4.4	39.7 / 55.8	0 / 8.8	30.9	68
32	LNK-II	0	1.4	0	0	10.1	5.8	0	73.9 / 78.3	8.7 / 8.7	13.0	69
57	LNK-II	0	11.1	3.7	0	38.9	11.1	1.9	33.4 / 48.1	0 / 1.9	33.3	54
86	LNK-II	0	0	0	0	3.7	5.6	1.9	81.6 / 87.1	7.4 / 9.3	5.6	54
98C	LNK-II	0	0	0	0	12.2	4.9	2.4	78.0 / 82.9	2.4 / 4.9	9.8	41
84	Aug.17-I	0	0	0	0	1.1	0	0	95.5 / 95.5	3.4 / 3.4	28.9	90
138	NF-SL-I	0	0	0	0	1.6	1.6	0	72.6 / 74.2	24.2 / 24.2	4.8	62
148	NF-NL-I	0	2.0	0	2.0	11.7	2.0	3.9	74.5 / 76.4	3.9 / 9.8	7.8	51
151	NF-SL-I	0	2.0	0	0	6.1	2.0	0	67.3 / 69.3	22.6 / 22.6	12.2	49
153A	NF-NL-I	0	0	0	0	19.5	9.8	0	70.8 / 80.4	0 / 0	4.9	41
153B	NF-NL-I	0	7.7	5.1	0	15.4	5.1	0	64.2 / 74.4	2.6 / 2.6	5.1	39
165	Foxy-I	too low in frequency (F.) to warrant consideration										
127	CL-II	0	0	0	0	15.0	5.0	20.0	50.0 / 55.0	10.0 / 30.0	30.0	20
220	CL-II	0	1.9	0	0	17.3	1.9	3.8	71.2 / 73.1	3.8 / 7.7	9.6	52
223	CL-II	1.6	3.1	0	0	21.9	4.7	0	67.2 / 71.9	1.6 / 1.6	9.4	64
240A	CL-II	0	0	0	0	18.9	3.8	1.9	66.1 / 69.8	1.9 / 3.8	7.5	53
240C	TV-IIA	0	0	0	0	20.0	11.4	0	62.9 / 74.3	5.7 / 5.7	20.0	35
304	OG-II	0	1.5	0	0	18.5	7.7	12.3	47.7 / 55.4	12.3 / 24.6	10.8	65

* SR+SA, etc. refers to a subrounded shape that has been subsequently modified by the younger break which in turn has been ground to a subangular edge. Total angular and subangular clasts are given on the lower right hand side of each A and SA column slots respectively. The upper left hand numbers refer to rocks showing no signs of a smoother, previously eroded surfaces.

** Represents Units II, XVII, XV of Green and Roddick (1962) or Units 1, 3, 13 of Templeman-Kluit (1966)-see Table I .

II and IIIthat occur approximately side by side geographically (e.g. North Fork Pass region).

Of the various clasts, Tables XIV and XV indicate that fine-grained clastics and cherts seldom develop beyond the subangular shape. The latter are slightly the more angular of the two groups; whereas, Tables XII and XV indicate respectively that plutonic and coarse-grained clastic rocks are commonly subround, if not round, in downvalley sample locations. Tables I, II and III in Appendix IIB also show this same downvalley increase in roundness of till pebbles. The various tabulated results indicate that, other than the quartzitic clasts of the controversial diamiction (sample No. 24 - Table XVI) the amount of multicyclic(?)[3] pebbles is low and they have an inconsistent pattern of occurrence. Hence, this aspect of pebble shape examination is also not an aid in discriminating the various ages of till.

Chemical Disintegration

Results of the chemical weathering examination are presented in Tables XVII, XVIII, and XIX and in Appendix IIC. On a gross basis (ignoring rock type) Appendix IIC indicates roughly the same degree of weathering, regardless of the type, in all ages and geographic groups of tills. Completely weathered clasts are everywhere rare, but do occur more frequently in the Age I group of tills. Some anomalies exist in the data (e.g. August 17th Creek Moraine) but these can be explained by the differences of susceptibility to weathering of the various types of clasts in the samples, and by the presence of an inherited weathered matrix (occurs in fresh outcrop showings) in others. For example, the Unit IV-5 volcanics and Unit III-1 grits (Table I) occur in their bedrock setting with a weathered matrix and for this reason gave inconsistent results as shown in Appendix IIC. This problem was partially circumvented by separating (Table XVIII) the light coloured Keno Hill Quartzites (Unit XVII-13) from the brown-matrixed grits, and examination of the various types of weathering that take place in a typical pebble as shown by Figure 16.

Weathering of granitic rocks reveals that almost all acidic clasts (Table XVII) have a yellow mottled surface and nearly all basic or gabbroic clasts (Unit XX-16) have intermittently orange-stained surfaces. Since

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[3] In some samples, a few pebbles show a well rounded appearance except for a "fresher" and more angular broken surface. The writer reasons that this condition is brought about either by rounding in a preglacial fluvial cycle with subsequent crushing by the glacial transport processes or by rounding during glacial transport with subsequent breaking by *in situ* frost shattering.

TABLE XVII Weathering of the plutonic stock producing clasts* located in tills.

FIELD STN. NO.	MORAINE AND AGE	% F. TYPE OF WEATHERING OBSERVED								STN. PEBBLE F.
		WEATHERING** COLOURS	SCATTERED ON SURFACE	FRACTURE, VEINLET	SCAT. IN MATRIX	CENTRAL CORE	OCCURS AS A RIND % F.	OCCURS AS A RIND THICK (mm.)	CONT. THROUGHOUT	NOT WEATHERED	
24	Tint.V (III?)	plutonic rocks absent in sample									0
31	LNK-II	Y,0	100.0	20.0	80.0	0	20.0	±	0	0	5
32	LNK-II	Y	85.7	14.3	100.0	0	0	-	14.3	0	7
56	LNK-II	plutonic stock rocks not present in sample									0
57	LNK-II	plutonic stock rocks not present in sample									0
86	LNK-II	0,Y-0,R-Bn	99.2	4.9	90.3	0	0	-	1.9	0	103
98C	LNK-II	0,Y-0	100.0	12.8	97.8	0	4.3	2mm.	14.9	0	47
84	Aug.17-I	plutonic stock rocks not present in sample									0
138	NF-SL-I	Y	98.4	3.1	90.8	0	0	-	0	0	65
148	NF-NL-I	Y	100.0	15.4	84.6	0	0	-	38.5	0	13
151	NF-SL-I	Y,0,Bn	97.7	2.3	76.8	0	0	-	8.1	1.2	86
153A	NF-NL-I	Y,0	100.0	20.0	80.0	0	20.0	±	40.0	0	5
153B	NF-NL-I	0,Bn	100.0	25.0	50.0	0	0	-	50.0	0	4
165	Foxy-I	Y	100.0	0	100.0	0	0	-	0	0	1
127	CL-II	0,Bn	100.0	0	100.0	0	0	-	0	0	1
220	CL-II	Y,Y-0	80.0	0	100.0	0	20.0	1mm.	0	0	5
223	CL-II	Y,0	97.0	12.1	72.8	0	9.1	2mm.	3.0	0	33
240A	CL-II	Y,Bn	84.6	5.1	79.6	0	2.6	3mm.	0	7.7	39
240C	TV-IIA	Y	76.9	7.7	71.2	0	3.0	2mm.	0	21.2	52
304	OG-III	Y	100.0	0	75.0	0	0	-	0	0	4

* Includes syenite, monzonite, hornblende pyroxenite, aplite, granite, augite diorite, alaskite ± porphyritic K-feldspars in each type, ± quartz in most (bedrock Units 17, 18).

** Y = yellow, 0 = orange, R = red, Bn = brown

TABLE XVIII Weathering in the white, grey, blue and greenish "quartzites"* located in the tills.

FIELD STN. NO.	MORAINE AND AGE	WEATHERING**	% F. TYPE OF WEATHERING OBSERVED								STN. PEBBLE F.
			SCATTERED ON SURFACE	FRACTURE, VEINLET	SCAT. IN MATRIX	CENTRAL CORE	OCCURS AS A RIND		CONT. THROUGHOUT	NOT WEATHERED	
							% F.	THICK (mm.)			
24	Tint.V III(?)	0,Y-0,Y	72.5	20.0	25.0	5.0	7.5	1.5mm.	2.5	0	40
31	LNK-II	0	60.0	27.5	22.5	2.5	10.0	2.5mm.	0	15.0	40
32	LNK-II	0,Bn-Bl,Y-0	45.5	20.4	18.2	2.3	2.3	2.0mm.	0	34.1	44
56	LNK-II	Too small a sample to warrant a comparison									-
57	LNK-II	R,0,Y-0	89.3	29.8	8.5	4.3	10.6	1.5mm.	0	4.3	47
87	LNK-II	0,Bn	100.0	31.6	78.9	0	15.8	2.0mm.	0	0	19
98C	LNK-II	0	100.0	35.7	92.8	7.2	0	-	0	0	14
84	Aug.17-I	Y,R-Bn,Bn,0	36.9	36.9	14.5	0	0	-	0	40.8	76
138	NF-SL-I	Y,0,Bn	100.0	46.7	46.7	0	3.3	3.0mm.	0	0	30
148	NF-NL-I	Bk,0,Bn	47.8	34.8	60.8	0	0	-	0	13.0	23
151	NF-SL-I	0,R-Bn	100.0	75.0	81.3	0	6.2	1.0mm.	18.8	0	16
153A	NF-NL-I	0,Bl,Bn	100.0	50.0	85.0	0	0	-	0	0	20
153B	NF-NL-I	0	84.3	36.9	52.6	0	5.3	3.0mm.	0	5.3	19
165	Foxy-I	0	66.7	50.0	33.3	0	33.3	3.0mm.	0	0	20
127	CL-II	0	57.2	42.8	42.8	0	42.8	2.0mm.	0	0	7
220	CL-II	R-Bn,Y,0	97.3	21.6	81.1	0	2.7	1.0mm.	0	0	37
223	CL-II	W,0,R-Bn,Bn,Y	47.6	16.4	62.3	1.6	9.8	1.7mm.	0	0	61
240A	CL-II	P-Bn,0,Y,Bn	81.6	36.8	79.0	0	10.5	2.5mm.	0	2.6	38
240C	TV-IIA	Y,0	93.3	30.0	83.3	0	3.3	0.5mm.	0	0	30
304	OG-III	0-Bn,Y,0,Bn	100.0	33.3	66.7	0	2.8	2.0mm.	0	0	36

* Includes :- metaquartzites, orthoquartzites, lime-cemented quartz sandstones, subgreywackes, and arkose of Unit XVII-13 (Table I).

** 0 = orange, Y = yellow, Bl = blue = Bk = black, R = red, Bn = brown, P = purple.

TABLE XIX Weathering of chert pebbles (bedrock Units -6, IX, 8, XIII, XV, 13) located in tills.

FIELD STN. NO.	MORAINE AND AGE	% F. TYPE OF WEATHERING OBSERVED								STN. PEBBLE F.
		WEATHERING** COLOURS	SCATTERED ON SURFACE	FRACTURE, VEINLET	SCAT. IN MATRIX	CENTRAL CORE	OCCURS AS A RIND		CONT. THROUGH-OUT	NOT WEATHERED	
							% F.	THICK (mm)			
24	TINT.V. III(?)	cherts not present in sample									0
31	LNK-II	Bl-Bk	62.5	37.5	0	0	0	-	0	12.5	8
32	LNK-II	Y	33.3	66.7	0	0	0	-	0	0	3
57	LNK-II	O, Gy	50.0	66.7	0	0	0	-	0	4.2	24
86	LNK-II	O	70.0	40.0	0	0	0	-	0	0	10
98C	LNK-II	R-B, Y-O, O-Y	77.3	54.5	9.1	0	0	-	0	22.7	22
84	Aug 17-I	-	cherts not present in sample								
138	NF-SL-I	O	92.8	64.3	7.1	0	0	-	0	0	14
148	NF-NL-I	O	46.1	71.9	0	0	0	-	0	0	13
151	NF-SL-I	O, Y, Bn	81.8	54.6	9.1	0	0	-	0	0	11
153A	NF-NL-I	O	66.7	86.7	6.7	0	0	-	0	0	15
153B	NF-NL-I	Y, RO, Y-Bn, O	90.4	66.7	4.8	0				4.8	21
165	Foxy-I	O, Gn	100.0	0	50.0	0	100.0	4 mm.	50.0	0	2*
127	CL-II	O	66.7	66.7	0	0	0	-	0	0	3
220	CL-II	Y, O-Bn	100.0	80.0	20.0	0	0	-	0	0	5
223	CL-II	O-Gn	100.0	100.0	0	0	0	-	0	0	2
240A	CL-II	Y, O	83.3	100.0	0	0	0	-	0	0	6
250	CL-II	Y	80.0	60.0	0	0	0	-	0	0	5
240C	TV-IIA	Bn, O, Y	91.7	58.3	16.7	0	0	-	0	0	12
304	OG-III	Y, O	100.0	50.0	0	0	0	-	0	0	2

* These two pebbles are chert breccias that may be part of the eugeosynclinal early Paleozoic volcanic suite (Unit IV-5).

** Bk = black, Y = yellow, Gy = grey, RB = redbrown, O = orange, Gn = green, Bn = brown, Bl = blue.

fractures are not common in these rocks little weathering of this type is present, although nearly all pebbles exhibit slightly stained feldspar components on even the freshly fractured surfaces. As would be expected, sample site C from Field Stn. No. 240 illustrated the minimum of weathering, as roughly 20% of its plutonic clasts show a complete lack of noticeable weathering. Paradoxically, completely weathered clasts are most numerous in the Age I tills while surface rinds are sometimes present in the CL-II samples. Hence, inspection of observable weathering in these clasts yields negative results as far as age relationships are concerned. Using a test for weathering that is dependent on the soundness of granitic clasts rather than on visual weathering, Table XX indicates that older tills to the north have pebbles in slightly better condition than those of Age I or those of Age II in the North Klondike valley. The gabbroic rocks from sites on the north slope of the ranges are decidedly tougher rocks to break, and this partly, but not wholly, accounts for this anomaly.

Weathering analysis of cherts (Table XIX) reveals that exterior surface mottling is variable, and if anything, is slightly less in the lower North Klondike valley ground moraine samples. Results of the examination for matrix and fracture weathering in cherts were roughly the same while non-weathered cherts were frequent in the lower North Klondike samples. Weathering rinds do not appear to develop readily in these rock clasts and weathering colours are generally confined to yellow and orange hues.

Weathering rinds appear most often in the coarse clastic rocks but exist at about the same frequency or occurrence in all age and geographic groups. The high values for Field Stn. No. 127 are not surprising - the sample was taken from almost a bog-type of environment and moisture persists at this site much longer throughout the year than at most other sites. Anomalous differences between the Age II site No. 240A and the presumed Age IIA No. 240C are reflected in their stratigraphic position; the latter, like samples from Field Stn. No. 153B, do not occur in the zone of present day oxidation, and apparently never had for any great length of time in the past. Surface mottling and fracture weathering within the Keno Hill Quartzite portion (Table XVIII) of the coarse clastic group are of about the same pattern as described for the cherts. As to be expected, matrix weathering is much more common than in cherts but the results are inconsistent as far as age or geographic groups are concerned. However, for the coarse clastics as a whole, Appendix IIC indicates that a central weathered core (weathering front) is slightly more prevalent within the quartzites of the Lower North Klondike Moraine. All

TABLE XX Soundness of plutonic clast located in upper-most till horizons.

FIELD STN. NO.	MORAINE AND AGE	% F. QUALITY OR STRENGTH				F.	COMMENTS***
		CRUMBLES W/O STRIKING	BREAKS WITH DULL THUD	BREAKS WITH 1 SHARP RING	BREAKS ON 2 OR MORE BLOWS		
24	Tint.V-III(?)	granitic clast not present in moraine (?).					Lack of - suggest either not a till or extreme age.
31	LNK-II	0	0	70.5	29.5	71	Mainly (90%) sill rocks
32	LNK-II	0	2.0	81.0	17.0	103	Mainly (90%) sill rocks
86	LNK-II	0	1.9	94.3	3.8	106	90% stock rocks
98C	LNK-II	0	2.0	96.0	2.0	48	100% stock rocks
84	Aug. 17-I	0	0	100.0	0	11	100% sill rocks
138	NF-SL-I	0	2.8	80.9	17.3	73	90% stock rocks
148	NF-NL-I	0	0	100.0	0	15	100% stock rocks
151	NF-SL-I	0	13.5	78.7	8.0	89	90% stock rocks
153A	NF-NL-I	0	20.0	60.0	20.0	5	Too small a sample.
153B	NF-NL-I	0	0	0	100.0	4	Ditto
165	Foxy-I	0	0	100.0	0	2	Ditto
127	Chap.L-II	0	0	100.0	0	1	Ditto
220	Chap.L-II	10.0	0	60.0	30.0*	10	Stock:sill = 50:50
223	Chap.L-II	0	0	82.6	17.7	46	Stock:sill = 80:20
240A	Chap.L-II	0	0	79.3	20.7	53	Stock:sill = 5:1
240C**	TV-IIA	0	0	78.9	21.1	57	Stock:sill = 12:1
304	Ogilvie-III	0	0	66.7	33.3*	6	Stock:sill = 5:1 Small sample

*** Sill rocks (Unit XX-16 = gabbro and diabase (dolerite).
Stock rocks = syenites, monzonites, minor granite, pyroxenite, and diorite.

* Almost all in this category are sill rocks. Generally, sill rocks are tougher than stock rocks on the north side of the crest of the Southern Ogilvie Ranges.

** 240C should be better preserved than 240A as it represents pebbles in bottom of section supposedly below zone of weathering.

analyses of coarse clastics, despite environmental and age variations of the enclosing moraine, fail to demonstrate any weathering relationships.

The Paleozoic volcanic rocks (Unit IV-5; Appendix IIC) yield strange results due to their weathered condition in even fresh outcrops. Rinds on these rocks are noticeable on the samples from the CL-II till but are not present on other sample areas.

The highest percentage of non-weathered clasts occur in the fine-grained clastic group (Appendix IIC), but ages of moraines are not recognizable on this basis. Other weathering criteria within this group are roughly similar to those of the quartzites and volcanics except that weathered central cores were not noticed in any specimens.

Discussion

Weathering of pebbles in moraines confirms the convictions of Dr. O. L. Hughes (pers. comm.); namely, differences are not obvious with respect to age of moraine. The lack of accumulation of fines in older tills corresponds to the findings of Holmes and Lewis (1961) in the Eastern Brooks Range but is opposite to that found by Detterman (1953) in the Central Brooks Range. That is, the character of the till is governed by the bedrock terrain through which the glacier passes and significant textural changes have not occurred since the deposition of that till. Angularity data confirm the textbook concepts of Flint (1957); that is, roundness of pebbles increases for those carried, subglacially, progressively farther away from their source of origin. This is somewhat unusual for in a periglacial region one would expect a higher percentage of angular clasts in the older moraines - especially in view of Cairnes' (1912) comments. Such a relationship is in fact suggested by Detterman whereby his older Sagavanirktok and Anatuvuk tills have a higher percentage of weathered and small rock fragments.

At the time these studies were begun the writer realized the general retardation effects of cold climate on chemical weathering, but felt that careful examination should produce numerically significant results for Fyles (1950) did note a little chemical weathering in granites near Whitehorse. Holmes and Lewis (1961) hinted at slight pebble weathering differences in the Chamberlin, Schrader and Peters tills of the Eastern Brooks Range, but indicated their usefulness for chronology was limited. Striations on glacial pebbles in the map-area are not eliminated by chemical weathering on even the samples from the older moraines. Even this, in view of Cairnes' (1912) comments with respect to chemical weathering in the cold climate, cannot be too surprising

and Krinsley (1965) found striations on pebbles of Pleistocene moraines of all ages in the Wellesley Basin-Shakwak valley region (Fig. 5). However, Detterman (1953) reported the reverse situation in the Central Books Range - striations were absent on pebbles examined from the oldest moraine.

In view of Flint's (1957) remarks concerning the early stage of chemical weathering -- "at an early stage a pebble may acquire a weathering rind in which brown iron oxides are conspicuous" -- the writer was convinced that internal inspection for rinds should reveal differences between pebbles of the Age I and Age III tills at least. However no such differences were found. The results show, incidentally, that weathering generally invades: first, the fractures, if present; second, the entire matrix; and finally, a distinctive rind is developed. Even when samples from the three or four ages of till are classified with respect to these intermediate steps in weathering, there are no abvious relationships. Hence, it is concluded thus. Due to (1) the cold climate, (2) the seasonal ground frost, and (3) the short period when water is available during each year, chemical weathering is progressing at a very slow rate within the map-area.

Weathering as indicated by the evolution of clay in situ within the older tills has also not occurred or is not detectable in the tills within the map-area. Birkeland (1964) noted the content of clay particles in the oldest drift of the Lake Tahoe area of the Sierra Nevada to be about three times greater than in the younger till. However, this is a temperate region and changes have apparently occurred that are lacking in colder climatic regions. Notwithstanding this, the writer reasoned that the converse relationship might be possible - that is, frost action might increase the amount of fines by grain splitting, as many northern pedologists are led to believe (e.g. Drew and Shanks, 1965). Detterman (1953), in fact, found this relationship in the Central Brooks Range. Our results show, however, that if this action takes place within the map-area it must be near or at the ground surface[4], for the mechanical analysis results do not even show an influx of clay or silt sizes with increasing age. Since the pebble shape data fail to show progressive age weathering by either: a) roundness due to chemical weathering, or b) angularity due to action of frost splitting, the writer concludes that the mechanical analyses corroborate the other analyses for weathering. Apparently the map-area lies within a region whereby a time span considerably greater than the absolute age of the Age III moraines is required to produce any significant weathering changes.

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[4] This possibility is explored, to some extent, in Part 2C of this report.

Because of the loess cycles that followed each age of glaciation one might visualize the mechanical analyses to show a silt incorporation to progressively younger tills - Holmes and Lewis (1961) suspected this in their interpretation of a silt-rich till sample from the "young" Peters moraines in the Eastern Brooks Range. The results for this region, however, indicate that either the Age I glaciers failed to reach loess depositional zones on the Age II surfaces or else their advancing outwash removed the loess before subsequent till deposition. There is some sign of the Foxy-I and NF-NL-I moraines having picked up a high percentage of fines, but in each case their glaciers moved through a source rock producing fine-particles.

Weathering of any significance in the area is shown only at Field Stn. No. 57. A gravel below the Age II till (Fig. 93) is completely disintegrated and shows a red-orange weathering hue (Plate XIV). This deposit,is, therefore, much older than Age III and may be equivalent to a similarly weathered Nansen drift recorded by Bostock (1966) in the Yukon Plateau at several locales.

In summary the apparent reluctance of Alaskan glacial geologists to quantify weathering observations on pebbles within the till or on the surface of Pleistocene moraines is justified by the lack of even incipient age distinctions found by this investigation. Either some factors are cancelling one another in the process of weathering or, more likely, insufficient time has passed to allow noticeable weathering in this cold and dry portion of the continent.

PART 2C:- PEDOLOGICAL CRITERIA AS A POSSIBLE METHOD OF DIFFERENTIATION OF THE CHRONOSEQUENCE OF PLEISTOCENE MORAINES

Introduction

Differentiation of moraines of different ages on a pedological basis has been approached in two ways by glacial geologists. Earlier workers (e.g. Blackwelder, 1931) used simple methods, usually a measurement of the depth of oxidation or depth of carbonate leaching. More recently geologists (e.g. Richmond, 1962b; Birkeland, 1964; and those referred to in Flint, 1957) have established differences between Wisconsin and older moraines by the degree of soil profile development. Of the two methods the latter is preferable for the investigator is required to thoroughly examine textures, moisture, lithology, slope, vegetation and other factors that control iron and carbonate movement in a profile. These factors are adequately covered, at least for the temperate regions, by Jenny (1941).

In the northern Cordillera there are few studies of soil development on Pleistocene moraines of various ages. Krinsley (1965) found that visible oxidation did not occur below 25 cm depth in any of his Late Wisconsinan, Early Wisconsinan, Illinoian, and pre-Illinoian moraines, whereas slight but distinct progressive age changes in the depth of leaching did occur. His studies were carried out in the permafrost-underlain Wellesley Basin area of the southwest Yukon Territory (Fig. 5). Péwé et al.(1965) concluded that Illinoian drift is usually enveloped by soil profiles several times deeper and more intensely weathered than those of Early Wisconsinan age; and the latter, in turn, are about twice as thick as the Late Wisconsinan. However, they reported that as altitude and latitude increase the differences in soil profile development on surfaces of different ages become less distinct. Brown and Tedrow (1964), for example, found Arctic Brown and Minimal Podzol soils on well drained sites on the north slope of the Brooks Range but could not detect significant differences in the development of these soil types on Pleistocene surfaces of various ages in the area. In the eastern Brooks Range Holmes and Lewis (1961) reported only faint soil profiles on three tills of ages varying from Early Wisconsinan to pre-Illinoian. Viereck (1966) noted a slight increase in near surface "fines", organics, nitrogen, and a decrease in pH with the progressive genesis of soil on five ages of outwash in the McKinely National Park region. The oldest outwash is Late Wisconsin in age.

These differences in results are not surprising, for numerous investigators (summary in Bird, 1967) have established that soil profiles develop more slowly

in colder climates. Several investigators (Hopkins and Sigafoos, 1951; Bliss, 1962 and Shacklette, 1963) doubt that arctic soils can attain the mesic "climax" type such as would occur in temperate regions. Tedrow et al.(1958), Tedrow and Harries (1960), Shacklette (1963) and Drew and Shanks (1965) acknowledge that a "polyclimax" soil profile may develop in a sequential evolution on a particular moisture or permafrost regime, but frost boils, involutions, thermokarst activity, etc. may destroy the profile completely. The cyclical process of polyclimax development then begins anew.

The numerous general soil studies made in Alaska have been summarized by Péwé (1965), Day and Rice (1964), and Shacklette (1963). Shacklette attempted to establish a relationship between soil type and plant communities in the boreal and tundra regions. Both he and Tedrow and Cantlon (1958) found that soil development is related to climate rather than parent material, and particularly to microclimate. Soil studies in the Yukon, however, are not so extensive. Drew and Shanks (1965) described zonal, intrazonal and azonal soils in the Firth River region (Fig. 1) and Mackay (1958b) investigated the origin of buried organic layers in soils nearby. Krajina (1963) carried out reconnaissance soil surveys in the Richardson Mountains and classified the various profiles according to the European designations of Kubiena (1953).

In this study particular emphasis was placed on soil profile development on the Late Wisconsin moraines (Age I) of the North Fork Pass region, as compared to soils on older moraines (Ages II and III) at Chapman Lake (Fig. 4). The first area lies within the Southern Ogilvie Ranges and the latter is situated in Taiga Valley (Fig. 2). Vernon and Hughes (1966) had found that Late Wisconsin tills ("blue limit" - Age I) were oxidized to depths of less than 30 cm, whereas older tills ("red limit" - Age II or older) are oxidized to at least 60 cm. These are average values established from a general survey; though the studies were concentrated in that part of the Southern Ogilvie Ranges opened up by the Dempster Highway. Therefore the prospects of recognizing a specific age of Pleistocene moraine by soil profile development seemed reasonable. However, the limited degree of weathering of the moraine surfaces and internal components (examined on a more gross basis in Parts 2A and 2B) indicate that gross profile changes are hardly to be expected, though there may be differences in the top few centimetres of soil.

The moraines, unfortunately do not all lie within the same lithologic and bioclimatic zones, and this makes analysis harder. In addition, secondary loess deposition has occurred on portions of some moraines. The Age I south lobe of the North Fork Pass Moraine (= NF-SL-I) lies about 230 m above the Age I August 17th Creek Moraine (Aug.17-I), but both are above timberline away from the zone

of detectable permafrost, and in the zone of Mesozoic clastic and intrusive rocks (Figs. 3 and 4). The Age I Foxy Creek Moraine (Foxy-I) lies at the mouth of a valley underlain by a Paleozoic, carbonate-enriched, volcanic rock suite, and is probably encased by sporadically occurring permafrost. The Age I north lobe of the North Fork Pass Moraine (NF-NL-I) is made up of mixed Paleozoic and Mesozoic clastic, carbonate-enriched volcanic, and intrusive rock types and lies in a zone of nearly continuous permafrost represented by a ground ice table usually close to the surface. The Age II Chapman Lake Moraine (CL-II) lies in a Paleozoic carbonate rock basin but was supplied by some Mesozoic intrusive and clastic rocks; the moraine is also in a zone of nearly continuous permafrost. The Age III Ogilvie Ground Moraine (OG-III) lies on carbonate terrain but has been developed from a diverse lithology derived from the axis of the Southern Ogilvie Ranges. Permafrost as represented by ground ice is probably continuous on this oldest moraine but occurs below the depth of practical digging; the exposed moraine is about the same elevation above sea level as the NF-NL-I moraine - or 150 to 175 m above the Chapman Lake Moraine.

Hence, in summary, permafrost zones occur in all three ages of moraines and the depth to its table varies from a few centimetres to more than three metres. Loess is associated with this permafrost distribution and represents surfaces younger than the age of the moraine. The loess blanket on the CL-II surface is only 9600 to 10,900 years old while the blanket on the Foxy-I and NF-SL-I may be less than 5000 years old. All loess surfaces have been churned or reworked by congeliturbation or other periglacial processes since their first deposition. Petrographic analyses (Lambert, 1966; Tempelman-Kluit, 1966) of the intrusive rocks known to occur in the moraines reveal a high percentage of minerals with calcium and sodium in their chemical composition. A variability in the environmental parameters promoting pedogenesis thus has to be considered.

Methods

Messrs. J. Day, H. Hortie and L. Farstad of the Dominion Soil Survey took the initiative in the organization of this phase of the project. Techniques and background in soil survey work necessary to this study were supplied by them.

The writer selected soil pit sites roughly in proportion to the areal size, topographic variation and parent material depicted by the 6 morainal surfaces. Hence, one profile was inspected on the rather uniform and small Aug. 17-I; six profiles each were examined on NF-NL-I and NF-SL-I; eleven soil pits were inspected on the CL-II, and two pits were sampled from the OG-III surfaces. In addition, one soil exposure was hurriedly viewed in a borrow pit on the Age II Lower North Klondike Moraine (LNK-II). At the time of the survey the Age IIA

moraine had not been recognized and thus not investigated. All moraines and soil pit sites are located on Figure 4. It was planned to have all soil pits dug on primary morainal surfaces but in fact about half of the profiles showed a secondarily deposited and much younger silt and organic accumulation (Figs. 6-8). Nonetheless, about a quarter of the sites were dug on primary glaciofluvial gravel (Sub-unit 2F of Figures 6, 7 and 8) while the remaining quarter occurred on morainal till of various textures and compactions (Sub-unit 1A or 1C). The difference in age between the gravel and till is very slight and is of no consequence to the aims of this study.

Profiles were examined and described according to the definitions and terminology adopted by the 1963 meetings of the National Soil Survey Committee (NSSC, 1963). While the designations and terminology in their format are easy and ideal for field use the classification of soil types is decidedly awkward for use in tundra regions. Too often soil profiles did not fit the central theme of the regosolic, gleysolic or organic soil categories because of intergradation and permafrost complications. The classification given by Tedrow et al.(1958) or by Kellogg and Nygard (1951) is designed for arctic and boreal regions. For this report it would have been advantageous to use their Alpine Meadow, Tundra Half Bog, and Bog Great Soil Groups for describing the intrazonal and azonal soil types found in this study area.

Soil horizons were usually tested for pH by use of a "Hellige" colour comparison field kit and were checked for $CaCO_3$ by the dilute HCl effervescence method. Colours, moist, were recorded in the notation of the Munsell (1954) system. C horizons within the profile were recognized by either the beginning of the zone of gleying below other colour-distinct horizons or by the beginning of a zone of no pedological development or further colour change in the parent material. That is, the zone of visible oxidation corresponds to the upper boundary of the C horizon - not as shown by the diagram in Flint (1957). Samples of each pertinent soil horizon were collected into polyethylene bags according to the directions of Mr. H. Hortie. All profile descriptions are written in standard format and are given in Appendix III; necessary environmental data are listed in the "B" tables of Appendix IVC.

Laboratory work involved the mechanical analysis of most horizons taken from the Brown Wooded soil profiles developed on gravel parent materials. The standard sieve and pipette methods were used for the analysis once organic matter was extracted using hydrogen peroxide. The work was carried out at the Sedimentology Laboratory facility at the Ottawa offices of the Geological Survey of Canada. Unfortunately time was not available for the necessary chemical analyses; hence, all results presented herein must be regarded as preliminary.

Results

Before dealing with the soil profiles the writer will analyze the depth of leaching and depth of oxidation data collected in conjunction with the soil and surficial geology surveys.

Depth of Oxidation and Leaching

Within the tills variable moisture conditions gave highly inconsistent results for depth of oxidation. In the mesic[1] Age I tills this zone varied in depth from 15 to 28 cm; the mesic to moist Age II tills ranged from 20 to 25 cm. Moist tills were oxidized to as deep as 51 cm on the Foxy-I and the OG-III moraines, and as shallowly as 5 cm on another Foxy-I site (No. 165). Leaching of $CaCO_3$ was not observed in any tills within the map-area.

As for the oxidation of gravels of ablation moraine origin (Sub-unit 2F), maximum depths varied from 10 cm for an Age II to possibly 51 cm for the OG-III gravel hummock. However, oxidation in the latter is indistinct beyond 18 cm level, and this is exceeded by the average of 20 cm for 5 Age I measurements. Leaching results taken from these gravel hummocks are equally inconsistent. Measurements varied from not detectable in Age I and Age III gravel hummocks, to at least 75 cm below the ground surface in another Age I hummock, and to 90 cm in one Age II hummock on the Chapman Lake Moraine. It should be pointed out that $CaCO_3$ did not form an continuous plane through the solum of any inspected soil pit; rather the carbonate only adhered to the bottoms of larger pebbles and cobbles in a more or less distinct zone and was absent from the surrounding finer particles.

Of the gravel terraces in the lower North Klondike valley, oxidation depths within the Age II group averaged 60-100 cm whereas the Age III were easily double that (Fig. 9); a very rotted and much older gravel (Field Stn. No. 57) was entirely oxidized. Depth of leaching in the same sequence of terraces is about 2 m for the Age II and 5 m for the Age III (Fig. 9). The oldest gravel was heavily encrusted with $CaCO_3$ throughout the exposure.

Hence, as far as the moraines are concerned, oxidation or leaching measurements do not appear to be useful for distinguishing ages in this region. South of the crest of the Southern Ogilvie Ranges these measurements may be useful on well drained gravel terraces.

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[1] Mesic is defined in the introduction of Appendix IVC.

TABLE XXI Classification, probable genesis, distribution and location of some field-investigated, soil-profile types in the North Klondike and upper Blackstone valleys.

SOIL TYPE *	MORAINE AND RELATIVE AGE: II INTERMEDIATE LOWER NORTH KLONDIKE	LATITUDE → YOUNG - I: AUG. 17th CK.	SOUTH LOBE OF NORTH FORK	FOXY CREEK	NORTH LOBE OF NORTH FORK	II INTERMEDIATE CHAPMAN LAKE	III OLD OGILVIE
PODZOLIC							
GREY WOODED ORTHIC (3.21)	-	PROBABLY NOT PRESENT	-	-	-	-	STN. 302? GRAVEL HUMMOCK
BRUNISOLIC							
BROWN FORESTED ORTHIC (4.11)	-	-	-	-	POSSIBLY STN 143 IN GRAVEL ON FLAT CREST	-	-
BROWN WOODED ORTHIC (4.21)		-	STN. 139 [1] IN GRAVEL ON HUMMOCK	STN. 164, 166 ** LOOSE TILL GRAVEL SLOPE, HUMMOCK	STNS. 140, 142 GRAVEL HUMMOCKS	STNS. 219, 212 GRAVEL HUMMOCKS	STN. 302? GRAVEL HUMMOCK
ACID BROWN WOODED ORTHIC (4.31)	STN. 98P(5¼) IN INDURATED TILL ON FLAT SURFACE ***	-	STN. 138 151 IN INDURATED TILL ON FLAT CREST	PROBABLY NOT PRESENT	STN. 143(?) [2] IN GRAVEL ON FLAT CREST	-	-
DEGRADED (4.32)	-	STN. 84 IN LOOSE TILL ON LOW ANGLE SLOPE	PRESENT 135 IN INDURATED TILL ON SLOPE	PROBABLY NOT PRESENT	-	-	-
REGOSOLIC							
ORTHIC (5.11)	-	-	-	STN. 166 IN SILT ON GRAVEL HUMMOCK	-	-	-
SUBARCTIC (5.1-/?) ***	-	PROBABLY NOT PRESENT	PROBABLY NOT PRESENT	NEAR STN. 165(?) COLLUVIAL SILT, SHALLOW GULLEY	STN. 141 SILT SLOPE	STNS. 213, 214, 222 (?) IN SILT ON SLOPES	-
GLEYED (5.1 -/8)	-	PROBABLY NOT PRESENT	STN. 136 COLLUVIAL SILT, SHALLOW GULLEY	STN. 165 IN TILL, FLAT RIDGE CREST	STN. 143 IN TILL ON FLAT CREST	STN. 223? FINE SAND ON FLAT CREST	STN. 304 TILL (OR SILT?), FLAT CREST
GLEYSOLIC							
GLEYSOL REGO (6.21)	STN. 98P IN SILT ON FLAT SURFACE; BURYING THE SOIL PROFILE ON THE TILL.	PROBABLY NOT PRESENT	STN. 137 IN GRAVEL, SLOPING BENCH	-	STN. 148 IN TILL, FLAT CREST	STNS. 221, 223(?) [3] LOOSE TILL, FINE SAND; SLOPE, FLAT CREST	STN. 306 NOT INVESTIGATED IN DETAIL
SUBARCTIC (6.2-/?)	-	PROBABLY NOT PRESENT	PROBABLY NOT PRESENT	-	-	STNS. 220, 222(?) FLAT CREST	-
ORGANOSOL							
EUTROPHIC (7.2)-(?)	STN. 99 NOT INVESTIGATED IN DETAIL	PROBABLY NOT PRESENT	STN. 119 NOT INVESTIGATED IN DETAIL	PROBABLY PRESENT	STN. 144 SILT BENEATH, ON SLOPE	STNS. 216, 218, 211 SILT, PEAT; SLOPE FLAT DEPRESSION	STN. 300 NOT INVESTIGATED IN DETAIL

SOIL — GENESIS

PERMEABILITY — MOISTURE

* NUMBERS REFER TO NSSC (1963) CODE.

** THESE PROFILES HAVE SINCE BEEN BURIED BY AN EOLIAN CYCLE AND A GLEYSOL OR REGOSOL HAS DEVELOPED THEREON.

*** THE C-LAYER IN THESE PROFILES IS ALSO GLEYED.

[1] THIS COULD BE AN ORTHIC SUBALPINE BROWN (4.61) OR AN ORTHIC ACID BROWN (4.31).

[2] THIS IS A PORTION OF A SPLIT PROFILE; IT COULD ALSO BE AN ORTHIC BROWN WOODED (4.2).

[3] HORIZONATION IS INDISTINCT OR GRADATIONAL; HENCE THESE MAY BE GLEYED REGOSOLS (5.1 -/8).

Soil Profiles

The various soil types distinguished in this survey and the moraines on which they are found is shown by Table XXI. Not any age of moraine is devoid of a soil order or great soil group. Some profiles are listed in two or more categories due to either the lack of laboratory data or the shortcomings of the NSSC (1963) soil classification scheme. The table indicates that Brown Wooded soils are developed in the Age I tills south of the North Fork Pass and have not been developed in tills on both Age I and Age II moraines north of this divide. However, very dry ablation moraine gravel hummocks have developed these advanced soil types regardless of age or geographic region. Particularly noteworthy is the fact that small amounts of eluviation are taking place within the A horizon of the Degraded Acid Brown Wooded soils developed on Age I tills beneath thick moss mats on both the Aug. 17-I and NF-SL-I moraines. The same condition may be developing on an OG-III ablation gravel hummock. In moist situations horizons have formed in all three ages of till as shown by the Gleysol Great Group in Table XXI. In the regosolic order subarctic types exhibited buried organic horizons that were most likely caused by downslope movement of the active layer as proposed by Mackay (1958b). This feature was also noted at Soil Site No. 141; in all cases the gleyed enclosing material is assumed to be of reworked eolian silt origin since relatively undisturbed silts occur elsewhere on the moraines and proximally located outwash. The profiles reveal a lack of gross pedological differences between the various ages of moraines, but indicate differences between permafrost and non-permafrost environments. The comparison of the soils on the slopes and flat crests of the two lobes of the North Fork Pass Moraine especially reveal this latter point.

Since Brown Wooded soils developed in xeric conditions on gravel parent material are fairly common throughout the morainal topography[2] the possibility of age progressive clay translocation through the various profiles can be tested by the mechanical analysis results presented in Table XXII. The results are presented in the format of Day and Rice (1964). The finest clay-particle size percentages (right hand columns) indicate that some clay may have moved into the B horizons at Soil Site Nos. 142, 212, and 302. The origin of this secondary enrichment is either from the in situ development of kaolin or related mineral

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[2] See Table XII for the relative abundance of occurrence of these gravel forms.

TABLE XXII Textural variations in Brunizolic and Podzolic soil profile horizons located on selected hummocky (ablation) moraine sites (map Sub-unit 2F) in the upper Blackstone valley drainage basin.

SITE NO.	MORAINE AND AGE	DEPTH (cm.)	HORIZON	GRAVEL TO FINES RATIO*	% TEXTURAL VARIATION IN FINE FRACTION							ANALYSIS BY: (G.S.C. Sed. Lab.)
					SAND	SILT				CLAY		
139	NF-SL-I	0-2.5	Ah	15.3:84.7	78.1	5.3	5.3	3.1	3.0	2.0	1.3	1.9	R.G.Kelly
		2.5-7.5	Bf	-	no data for remainder of soil profile							
140	NF-NL-I	0-2.5	Ah	13.5:86.5	79.2	4.8	6.2	3.9	2.2	1.2	0.8	1.7	G.Campbell
		25.-10	Bf or Bm	35.7:64.3	76.6	4.8	5.6	4.2	3.2	2.3	1.5	1.8	G.Campbell
		10-15	BC	41.6:58.4	90.4	2.2	1.9	1.2	1.2	1.1	1.2	1.4	G.Campbell
		15-90	C	32.2:67.8	81.0	2.7	3.2	2.8	2.0	2.4	2.2	3.7	G.Campbell
142	NF-NL-I	0-2.5	Ah	24.3:75.7	72.8	4.7	6.2	4.3	3.8	2.6	2.2	3.5	R.G.Kelly
		2.5-12.5	Bf or Bm	34.6:65.4	65.2	6.1	7.5	5.7	4.6	4.6	1.6	4.8	D.E.Field
		12.5-22.5	BC	-	no data for remainder of soil profile								
212	Chap.L-II	2.5-0	H or Ah	4.7:95.3	39.1	14.0	17.0	12.1	7.1	3.7	2.2	4.4	G.Campbell
		0-4.0	Bm	11.5:88.5	41.6	11.6	15.4	10.4	6.8	5.1	3.4	5.7	G.Campbell
		4.0-10	BC	23.6:76.4	54.5	14.0	12.2	7.4	4.6	3.1	1.8	2.3	G.Campbell
		10-28	C	42.0:58.0	78.6	6.7	4.5	3.1	1.5	2.1	1.2	2.3	G.Campbell
		28	II(?)C	83.7:16.3	87.2	3.0	2.5	1.6	1.3	1.1	1.0	2.3	R.G.Kelly
219	Chap.L-II	0-2.5	Ah	8.1:91.9	29.2	12.9	18.3	12.8	9.5	5.4	4.2	7.8	R.G.Kelly
		2.5-7.5	Bf	31.3:68.7	43.9	11.0	15.9	10.3	7.2	1.3	4.3	6.1	G.Campbell
		7.5-14	BC	No record	67.3	9.0	8.8	6.5	3.8	1.8	1.5	1.4	G.Campbell
		14-23	CB	52.2:47.8	77.9	5.9	5.6	3.9	2.9	2.1	0.1	1.3	D.E.Field
		23-38	C1	56.6:43.4	78.1	5.2	4.8	4.3	3.0	2.4	0.2	1.9	D.E.Field
		38-50	C2	56.6:43.4	86.9	3.5	3.0	1.7	1.2	1.2	0.2	2.3	D.E.Field
302	Ogilvie-III	0-7.5	AB	37.8:62.2	55.1	9.5	12.0	8.1	5.8	3.1	3.5	2.8	G.Campbell
		7.5-18	Bt	41.7:58.3	58.4	6.6	8.6	6.3	5.0	4.4	2.4	8.3	D.E.Field
		18-51	BC	61.0:39.0	72.6	4.8	4.8	3.8	2.8	2.8	1.3	7.0	D.E.Field
		51-90	C	56.0:46.0	71.0	5.5	6.0	4.4	3.0	2.5	1.0	6.8	D.E.Field
	* Size ranges (mm.) are:-			(+)4:(-)4	4.0-0.060	.060-0.030	.030-0.015	.015-0.0075	.0075-0004	.004-0.002	.002-0.001	(-)0.001	

by organic acids or other chemical attack or by the infiltration of loess[3]. Possibly the latter has occurred, for the movement of these fines has occurred sporadically on all three ages of profiles - that is, two other Age I and Age II profiles do not indicate illuviation. However, according to Mr. L. Farstad (pers. comm.) this is typical of subarctic zonal soil profiles regardless of the method of illuviation. The accumulation is obviously greater in the Age III hummock, but again this profile may have been subjected to more eolian cycles because of its greater age. On the other hand this accumulation may exist on paper only; unfortunately, the Sedimentology Laboratory staff chose the wrong moment to change laboratory schedules, for the technique of Messrs G. Campbell and D. E. Field cannot be guaranteed to be exactly identical - especially as regards pipetting. Supporting chemical and mineralogical analysis are needed to substantiate any translocation interpretations of the relative percentages of fine clay in the Ah, AB, Bm and Bt horizons.

Discussion

The results reveal that climate, as expressed in permafrost and in aridity, is the dominant controlling factor in soil genesis. Major soil profile development can be accomplished in an Age I time span and any additional time has failed to promote further significant pedogenesis. According to the NSSC (1963) Brown Wooded soils represent a stage of soil development between a Regosol and a Gray Wooded soil. Their lack of eluviation in the A horizon has been noted in the Fairbanks region by Péwé (1965), and apparently dry climate, youthfulness and calcium-rich parent material are the factors retarding translocation. With reference to the old but vague Age III profile additional analyses may or may not reveal the "climax" development to a Gray Wooded soil. If the analyses prove to be negative the Brown Wooded may represent one "polyclimax" (attainable in an Age I time span) for the region north of the North Fork Pass in the Ogilvie Mountains. Due to the presence of discontinuous eluviation in the Degraded Acid Brown Wooded profiles a podzolic climax may be found on older than Age I surfaces within the North Klondike valley, but if so, Soil Site No. 98P indicates that this may be on surfaces older than Age II.

The results also support the contention that soil types are not particularly related to parent material. Table XXI shows that: (a) Brown Wooded soils can

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[3] Loess does not occur as a distinct blanket on these ablation moraine gravel hummocks today (except Foxy Creek Moraine) but occurs in thicknesses approaching one metre on till surfaces surrounding these hummocky features.

develop on mesic tills or xeric gravels; (b) Regosols exist on old tills, young silts, or sand; and (c) Organic soils may occur on either silt or peat. Instead, soil types are more related or controlled by moisture and permafrost, as Shacklette (1963) demonstrates. Gleysols or Organic soils apparently are the "polyclimax" end product for the moist soil sites in this region and these too are attained in an Age I time span. The eventual genesis of the mesic soil type end product, as required by the classical concepts of soil climax, is not shown in the region to the north of the North Fork Pass, for xeric profiles remain as dry profiles and moist profiles develop into, if anything, wet profiles as demanded by the impermeable permafrost conditions. The wet environment is typical of soil profiles on all three ages of moraines as well.

Hence, within this survey the factors governing profile development are partially controlled by topography, partially controlled by parent material, partially controlled by vegetation, and predominantly controlled by climate. The time factor is virtually insignificant after about 9000 years of profile development as shown by Viereck (1966), Brown and Tedrow (1964), and this study (age of the "Blackstone Loess"). The important changes have taken place much before 9000 years; in fact, Viereck has shown by sequential profile development, that the greater portion of soil genesis takes place within the first few hundred years on gravel surfaces in permafrost terrain. Genesis is greatly inhibited once the insulating moss mat develops, for permafrost invades the terrain and production of organic acids by soil microorganisms is retarded. If loess invades the area as well its frost susceptible textures practically bring pedogenesis to a standstill. Within this study area indirect evidence leads the writer to believe that permafrost reinvaded the surficial zones soon after deglaciation, and this concept would receive support from Brown (1967) and Hopkins and Fyles (1966). Since the eolian cycle accompanied this reinvasion (Appendix ID) periglacial activity has kept the soils north of North Fork Pass from developing into either deep profiles or into climax situations.

In Alaska, pedogenesis was found to be a useful tool in the recognition and correlation of morainal sequences in the zone roughly south of the Yukon River valley (Fig. 1), while moraines in the Brooks Range did not reveal this progressive profile development. The results of our studies from within the sylvotundra (refer to Part 2D) zone of the Ogilvie Mountains are similar to those from the Brooks Range. Consequently, the failure of oxidation and leaching measurements to reveal sequential differences in the moraines can hardly be considered surprising.

PART 2D:- BOTANICAL RELATIONSHIPS AS A POSSIBLE CRITERIA FOR THE RECOGNITION OF PLEISTOCENE MORAINES

Introduction

General Statement

Vegetation studies were made to establish whether differences exist, on either a species or community level, among three ages of Pleistocene moraines: Age I moraines in the North Fork Pass district of the Southern Ogilvie Ranges, and moraines of Ages II and III located in the Chapman Lake region of the adjacent Taiga Valley to the north (Fig. 4). Dr. O. L. Hughes (pers. comm.) has indicated that the youngest (Age I) Pleistocene moraines were typically covered by "xerophytic and mesophytic types" while the older moraines were blanketed by "mesophytic and hydrophytic species". He ascribed this difference to the absence of permafrost on the younger moraines (apparently the south lobe of the North Fork Pass Moraine - Fig. 4) and the presence of permafrost, hence a higher water table, on the older moraines (apparently the Chapman Lake Moraine). The kinds and numbers of plants present on a given moraine depends partly on the rate of immigrations into the area, and partly on such factors as moisture, soil development and presence or absence of permafrost. All of these to some extent are time dependent, in that any local flora represents a stage in an historical process.

Successional Studies Related to Glaciation

Within North America plant successional studies on Pleistocene moraines of different ages are rare. Mr. R. Curry (pers. comm.) is at present making species density analyses of vascular plants on recent and Pleistocene glacial deposits in the Sierra Nevadas. He has observed marked sequential differences in vegetation on moraines up to 6000 years in age; however, he could not demonstrate significant differences in species density or successional development on older morainal surfaces. In an area somewhat north of Curry's studies, Birkeland (1964) found some vegetational differences between Late-Wisconsin moraines that Curry (pers. comm.) considers to be 7000 and 10,500 years old respectively. Apparently the time required to reach the climax plant community, from the initial colonization, varies from 7000 to 10,000 years in this region.

Raup (1947) related the factors of elevation, slope, exposure, moisture, bedrock geology and surficial deposits to the development of plant communities

in the Britnell Lake (Glacier Lake) region of the Mackenzie Mountains (Fig. 1). He distinguished forest, arctic alpine, timberline, Alaskan cordilleran and cordilleran vegetational species and discussed how these fit into Hultén's (1937) post-glacial dispersion theories (radiant-centra concept) by analyses of the species distribution patterns. He found that late-glacial and post-glacial surfaces can be distinguished by their plant communities in the boreal forest region of the southwestern Northwest Territories of Canada; but where older surfaces are involved the general climax has already been reached and there is no correlation between vegetation type and mature soil type. Curry (1962) found much the same pattern in the subalpine regions of Colorado, where Late Wisconsin till surfaces could be differentiated from younger colluvium-covered surfaces on a botanical basis.

In Mt. McKinley National Park, Alaska (Fig. 5), Viereck (1966) was able to differentiate five different ages of outwash surfaces on a successional community basis; the oldest surface (5000-9000 years B.P.) is Late Wisconsin in age and was considered to bear the "climax" vegetation in the region. The oldest outwash had permafrost just below the surface whereas the younger four did not. Viereck (1966) suggested that development of insulating mosses is the factor permitting a gradual rise of the permafrost table. He has also indicated that vegetational differences, if considered on a cover-abundance basis, may occur between Late Wisconsin moraines and older Pleistocene moraines in the same region (pers. comm.). The older moraines abound with ice wedge polygon ground while the younger exhibited "patterned ground only in the bottoms of shallow tundra ponds" located on the morainal surface. However, such surfaces have yet to be studied in detail anywhere in the northern Cordillera. Other (younger) successional studies in Alaska are reviewed by Viereck (1966).

Some 400 km southeast of the study area, Porsild (1951) carried out extensive plant community investigations along the then newly constructed Canol Road (Fig. 1). He attempted to establish phytogeographic provinces for the entire Yukon, but could carry it only to the tentative-boundary stage for lack of knowledge of the flora of the Ogilvie Mountains and other regions. He concluded with an hypothesis concerning the order and manner of plant migration, following deglaciation, into the Canol Road region, as follows:

1) Alpine floras are older than valley floras and must have survived above the 1200 m contour during the later Pleistocene ice advance; and
2) the West and Central Yukon Plateau (Fig. 5) was too dry and too effective a barrier to allow free interchange of species from the phytogeographic regions of the south to those of the north.

Hence, the current study not only explores the possibility of plant community development beyond the Late Wisconsin age but may also provide more information regarding postglacial dispersal and the makeup of the flora of the Ogilvie Mountains.

The Study Area

The region of investigation (Fig. 4) encompasses a variety of vegetation zones. The lower North Klondike valley lies within the zone of the main boreal forest. This gives way to a subalpine ecotone near "August 17th Creek"; this subalpine band gives way to an alpine tundra zone at the crest of North Fork Pass. Going north from the pass there is an interdigitation of subalpine and alpine types which give way to a sylvotundra[1] (Maini, 1966) enclave that occupies much of the Blackstone drainage basin south of the Central Ogilvie Ranges (Fig. 2). A taiga zone is found on major valley floors within the Central Ogilvie Ranges just north of the Chapman Lake Moraine (i.e. north of the sylvotundra). This unusual inverse geographic arrangement of these zones is probably due to local climatic peculiarities, and perhaps for this reason Maini (1966) refers to this type of zonation in the Cordillera as the "alpine forest - tundra ecotone". In the Yukon this ecotone occurs much farther south than it is shown in Bird's recent map (1967, p. 55). However, Drew and Shanks (1965) point out that the distribution of this transition zone is imperfectly known in the northern Cordillera and because of the physiography enclaves are to be expected.

The studies were carried out in the following regions:

1) Age I August 17th Creek Moraine (= Aug. 17-I), near the interdigitated "intrazone" of boreal forest and subalpine; permafrost and loess are not present and the dominant rock types in the loose till are quartzites and gabbro (Table V).

2) Age I south lobe of the North Fork Pass Moraine (= NF-SL-I) in the subalpine-alpine tundra intrazone; permafrost and loess blankets are absent and the moraine is made up of till composed chiefly of quartzites, grits and monzonites.

3) Age I north lobe of the North Fork Pass Moraine (= NF-NL-I) in the alpine-sylvotundra "intrazone"; permafrost is present at a shallow table depth in the convoluted silt regions of the moraine. The silt is probably a loess blanket less than 5000 years old. Till (generally beneath the silt) is made up of quartzites, grits, a variety of finer-grained clastic rocks, and a carbonate-enriched volcanic rock. Gravel hummocks are quite numerous on the moraine.

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[1] This ecotone is also known as the forest-tundra (Bird, 1967), wooded tundra, or lyesotundra. Normally, it occurs as a narrow belt between the treeless tundra and the taiga (= northern woodland zone) to the south of the treeline.

4) Age I Foxy Creek Moraine (= Foxy-I), near and similar to the above except for the dominant carbonate-enriched volcanics within the moraine. The moraine is at least 13,740 years old.

5) Age II Chapman Lake Moraine (= CL-II) in the sylvotundra with small patches of Picea glauca parkland on some lake and pond shores. The till is commonly blanketed with silt less than 11,000 years old and is encased by permafrost. It consists of quartzites, grits, monzonites and carbonate-enriched volcanics; gravel hummocks are quite numerous on the moraine.

6) Age III Ogilvie Ground Moraine (= OG-III) in the upland tussock portion of the sylvotundra and alpine tundra. The lithology of the till is as in No. 5 above, but the permafrost is not so near to the ground surface; a few gravel hummocks are present.

The form of the moraines is summarized in Table XII and has been discussed in Parts 1 and 2A of this report. Eolian cycles have sometimes buried vegetation but more often the associated periglacial cycle caused involution of the soil profile along with its vegetation mat. Soil types occurring on the moraines are discussed in Part 2C of this report.

There is a climatic and edaphic discontinuity between the NF-SL-I and the NF-NL-I moraines, as discussed in Part 1 of this report, which was not anticipated prior to the field work. These and other variations created an awkward situation, for the vegetation analysis had to deal with the two types of Age I morainal habitats, and the variations due to environment confused the attempts to relate variation due to time. Aerial photo-mosaics indicate that the two types of Age I moraine are equally numerous outside the study area. Hence, if vegetation communities of the NF-NL-I moraine are compared with the CL-II and OG-III morainal surfaces, at least the permafrost, loess and moisture variables can be ignored. Unfortunately it is not appropriate to compare the NF-SL-I moraine with the Age II morainal surfaces without permafrost (e.g. Lower North Klondike Moraine) for the two occur in totally different vegetation zones.

Botanical Investigations in Adjacent Areas

Hultén (1940) summarized the botanical collections in the northern Cordillera. Ogilvie (1890) and Cairnes (1914) reported on the plants of the westernmost portion of the Southern and Northern Ogilvie Ranges (Fig. 2). Macoun (1899 and 1906) and Campbell (1953) have described the flora of the Dawson and surrounding area, and Porsild (1951) has identified specimens from the North Klondike region. The collections included by Hultén (1941-1950) and Anderson (1959) to document the flora of Alaska and adjacent Yukon Territory regions, relevant to this study, were taken along the Yukon River. During "Operation Porcupine" by the Geological Survey of Canada, plants were collected in the Central and Northern Ogilvie Mountains but the results are not available.

Ecological studies within the Ogilvies are lacking.* Outside the study area the investigations by Porsild (1951), Raup (1947), Viereck (1966), Krajina (1963), Spetzman (1959), Drew and Shanks (1965) and Shacklette (1963) are relevant to the present work.

The problem of "climax" development of plant communities has been discussed in several Alaska botanical studies. Most writers, other than Spetzman (1959), agree that a climax mesic community (in the Clements' sense) does not usually develop there because of universal frost action and the presence of permafrost (Drury, 1956; Benninghoff, 1952; Shacklette, 1963; etc.). What constitutes a "climax" community for the subarctic and tundra regions is discussed by Churchill and Hanson (1958), Bliss (1962, 1956), Zach (1950), Sigafoos (1951), Raup (1951), Hopkins and Sigafoos (1951), and Spetzman (1959).

The position of the northern timberline in the northern Cordillera has been studied by many. Dessicating winter winds (Taber, 1943), the southern boundary of continuous permafrost (Hopkins, 1959), mid-summer temperatures (Hare, 1951), edaphic factors (Hustich, 1953), lack of favourable drainage and southern exposures (Drew and Shanks, 1965) have been designated as limiting factors.

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Methods

Vegetation Analysis

All vascular plants excepting grasses and some sedges were tentatively identified in the field. Final identifications were made during the summer

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* During 1964, some studies were briefly carried out by Hultén (1966) in the North Fork Pass region. In 1966, Porsild (1967) arranged to have extensive collections and studies made in this same region by a resident of Whitehorse.

and autumn of 1965[2]. A check-list of all species of plants found on morainal surfaces is given in Appendix IVA.

A 3.3 x 3.3 m quadrat within a 10 x 10 m plot was used for vegetation sampling. The sample plots were chosen in conjunction with the selection of station sites for pedological studies, as given in Part 2C of this report. A few other moraine surfaces (Site Nos. 119, 136A, 125A, 111, 152, and 306) adjacent to the formally established stations were also examined but not in the quadrat method. The sampling sites (as listed in Appendix IVB) are shown on the location map (Fig. 4) and on the detailed surficial geology maps (Fig. 6, 7 and 8). The sites represent the following geologic and topographic situations:

1) broad and rather flat surfaces of morainal ridge crest on till, till-like and silt substrata;
2) slopes exposed to the south, east and west, on till and silt;
3) hummocky gravel knolls (ablation till - map Sub-unit 2F);
4) north-facing slopes on till where the snow lies late into the season (snow-flush or snow-lie areas);
5) gully and depressional topography in silt and peat.

Lakeshore and stream-edge communities were not sampled because of the overriding influence of moisture on colonization and of the probable presence of a recent alluvial-paludal substrate. Both would mask any effect of the moraine underneath. Unfortunately comparable sites and plant communities could not readily be found on all moraines. The NF-SL-I moraine possessed characteristically different habitats from those to the north, and snow-lie communities were not discovered early enough in the following season on the NF-NL-I, CL-II and CG-III surfaces. Site No. 223 was found to straddle a moisture cline and had to be divided into A and B plots to accommodate the differences. The vegetational and environmental characteristics of the 35 sites examined are given in Appendix IVC.

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2. The identifications were completely rechecked by Mr. E.W. Easthame, which resulted in one major change and six minor changes in the writer's determinations; he also kindly identified all the grasses and most sedges. Certain troublesome genera were never satisfactorily identified or resolved; these are briefly discussed in Appendix IVD. Drs. W.B. Schofield and G. Otto identified respectively the mosses and lichens - unfortunately many of these were severely damaged through faulty handling, and prolonged transport, and analysis of these groups is incomplete. Vascular plant specimens are deposited in the University of British Columbia Herbarium and in the Phanerogamic Herbarium of the Plant Research Institute, Department of Agriculture, Ottawa, while all mosses are in the private collections of Dr. W.B. Schofield.

Quadrats were visited weekly during late June, July and August. In the 100 m^2 quadrat the percentage cover by each of the A, B, C and D layers[3] was visually estimated, as well as the percentage contribution to shade cover by each species of the A and B layers. In the inner 10 m^2 quadrat the relative cover-abundance of each species in the C-layer was similarly estimated with the aid of stem counts. As a result of difficulty in field recognition of bryophytes and lichens, only rough estimates for cover-abundance were made for species in the D-layer.

Following laboratory identifications of the plant material, the quantitative field data on percentage cover were converted into "species significance" (S.S.) values as outlined by Brooke (1966) and as shown in Appendix IVC. A master list of all vascular species on the sites sampled was prepared. Species significance values for each vascular species were listed by quadrat for each of the 35 sites examined and the flora of each sampling site was compared against all others in respect to species significance and presence or absence. A comparable table was prepared for the environmental data. The flora of each station was also compared with all other stations on a presence or absence of species basis by calculating an "index of floristic similarity" (as given in Brooke, 1966; p. 198)[4]. These indices (Appendix IVB) were scrutinized for consistency with the tentative grouping of sites determined by inspection. In this way, by trial and error, plant communities were organized from the various field station species lists.

In some instances subgroups within the major groups were also determined. In these cases, more attention was given to the presence or absence of the species having low cover-abundance values. Each subgroup developed is considered a community type - a particular sample site representing the community

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[3] The layers designate the following: A = trees greater than 5 m high; B_1 = saplings and shrubs of 2 to 5 m in height; B_2 = shrubs of 15 cm to 2 m in height; C = small woody plants of less than 15 cm in height and all herbaceous plants, and D = bryophytes and lichens.

[4] The index of floristic similarity is defined as:

$$K = \frac{2c}{a + b}$$

where K = index of floristic similarity
c = number of vascular species common to the sites being compared
a = total number of vascular species at one station
b = total number of vascular species at the other station

The index is used as a supplement device only in the overall determination of plant community groupings.

type is sometimes termed a "community individua". Cryptograms were not used for either level of grouping. This omission is not serious; for example, with Viereck's (1966) data the same groupings can be obtained without them as with them. All species are arranged in Table XXIII according to their average species significance value (S.S.) and frequency of occurrence (F.) within each established grouping. Cryptograms are included but in most cases, particularly for the mosses, their frequency and S.S. values should not be interpreted as quantitatively typical of the community being considered.

Results and Preliminary Discussion

Several possible relationships between the age of the moraines and their vegetation were examined:

1) species composition (presence or absence);
2) the relative amounts of shade-producing shrubs in the B_2 layer;
3) a community-type analysis; and
4) a comparison of species present with primary parent substrate materials.

Presence and Absence of Species on Morainal Surfaces

A tabulation (not reproduced in this report) of all species listed in "B" tables of Appendix IVC and in other localities listed in the checklist of Appendix IVA failed to reveal significant species differences between moraines of different ages. What it did indicate is a close similarity of flora between all moraines, regardless of age, north of the NF-SL-I, but a difference between two lobes of the youngest age: NF-NL-I and the NF-SL-I. This suggests that environment rather than age accounts for most of the differences between morainal floras in the area.

There were however a few differences that cannot be accounted for by incomplete search, or disrupted ground, as follows:

1) Parnassia palustris appears only on Age II and Age III moraines whereas Parnassia kotzebuei was located only on some of the Age I surfaces.
2) Gentiana algida, Mertensia paniculata, Carex podocarpa, Potentilla ledebouriana, Campanula lasiocarpa and Trisetum spicatum were observed on Age I but not on Age II and III moraines.
3) Silene acaulis was found only on the NF-NL-I moraine, and Linnaea borealis only on the CL-II moraine.

The reasons for these anomalies may be varied. Parnassia palustris is a calciphilic species and was found on moist, disturbed soil conditions; most Age I moraines investigated are not as lime rich as the older ones. Species

listed in item (2) are characteristic of either moist meadow or mesic[5] to xeric habitats. No moist meadows were surveyed on the older moraines, and they are scarce north of the pass. Campanula lasiocarpa is an oxylophyte and would not be expected on the moraines in Taiga Valley. As regards the other xeric species of group (2) and the two species in group (3), Shacklette (1963) showed that it is typical of xeric habitats to exhibit wide differences in the types of plants they support.

Thus the above differences are probably not related to age. Considering that more than 200 species were found on the moraines it is surprising that there was not more variability - especially considering the variation in the depth to the permafrost table, the intermittent occurrence of secondary depositional surfaces, and the edaphic discontinuity between moraines.

Canopy Analysis

Dr. O. L. Hughes (pers. comm.) suggested this test as a possible way of analyzing the various communities. The method uses data on canopy cover gathered for the more prolific species of the B_2 layer at the sample sites as given in the "A" and "B" tables of Appendix IVC. The B_2 layer consisted predominantly of Betula glandulosa, two species of Salix (planifolia and glauca) and some Ledum palustre decumbens. Minor components within this stratum are Rhododendron lapponicum, Vaccinium uliginosum and Potentilla fructicosa. The data are given in the tabulation below:

1	2	3	4	5
Moraine	No. of Sites	Average Canopy Cover	Canopy Cover (adjusted)	Birch : Willow Ratio
NF-SL-I	10	41%	50-60%	2.2 to 1
NF-NL-I	5	27%	...	1.7 to 7
Foxy-I	5	32%	...	0.85 to 1
Aug.17-I	Nil*	40-50%	...	ca.3 to 1
CL-II	10	26%	...	1.3 to 1
OG-III	3	38%	20-30%	0.83 to 1

* One half the total area of morainal surface was used.

The values in column 3 are unweighted. If the areal extent of the community (represented by each site) is taken into consideration, the NF-SL-I has an

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[5] Mesic is defined, as used in this investigation, in Appendix IVC.

average canopy-cover value of 50 to 60 percent (Quadrat Site Nos. 138 and 135, Appendix IVC, are typical of the overall vegetation on the moraine). On the other hand, the OG-III values are probably too high because the shrub-covered Quadrat Site No. 302 is not typical of the general character of the elevated and exposed moraine surface. Amended estimates are shown in column 4; the values for the remaining morainal surfaces are regarded as representative. Hence, there is no obvious relationship between morainal age and percentage shading by shrubs.

Another factor, examined in column 5 of the schedule above, is the ratio of amounts of cover contributed by the two dominant types of B_2 plants - birch and willow. Here again there are no greater differences between moraines of different ages than exist within Age I moraines. Among the youngest moraines, there is a tendency for birch to be commoner south of the permafrost zone (NF-SL-I and Aug.17-I).

Community Analysis

The community groupings used are as follows:

Grouping I(H-M) (Moist Shrub-Meadow Community Complex) - Meadow-like communities of generally hygric to mesic moisture conditions outside the zone of influence by permafrost. Meadow-type flowering forbs and the meadow sedge, Carex podocarpa, are characteristic of this unit.

Grouping II(M) (Late Snow-lie Communities) - Mesic, north facing snow-lie habitats occurring above the influence of the permafrost zone. Cassiope tetragona and showy forbs typify this unit.

Grouping III(H-M) (Tussock-Tundra Community Complex) - Mesic to hydric tundra-tussock type communities occurring in the zone of influence by permafrost on a variety of topographic situations. Carex Bigelowii and Eriophorum spp.are characteristic of this unit.

- IIIA Shrub-Tussock Community
- IIIB Heath-Tussock Community
- IIIC Tall Tussock Community
- IIID Wet Tussock-Strangmoor Community

Grouping O-II(X-M) - Mesic to xeric communities on tills and ablation gravel hummocks away from the zone of influence of permafrost.
- I-II(X) - Gravel Hummock Communities
- O-(X-M) - Shrub Thicket Community

The above communities are probably not all at the same level of phyto-sociological generalization. However, the dwarf birch, Betula glandulosa, is the overriding primary species in all. The important species of each grouping are given in Table XXIII. Calciphilic species denoted by a single asterisk, are quite common in units II(M), III and I-II(X) but are rare in the I(H) and

TABLE XXIII Cover(s.s.) and quadrat frequency (F) for floral species of inferred communities on morainal topography of three Pleistocene ages (I, II, III) in the Southern Ogilvie Ranges.[1]

SPECIES[3]	COMMUNITY GROUPING																	
	I(H-M)		II(M)		IIID[4,5]		IIIC[6]		IIIB		IIIA		II (X)		I(X)		0(X-M)	
	s.s.[2]	F.[2]	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.
CAREX PODOCARPA	2	100	+	67	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VALERIANA CAPITATA	1	100	-	-	+	50	+	60	+	33	-	-	-	-	-	-	-	-
PETASITES FRIGIDUS	1	100	-	-	-	-	1	80	1	66	1	100	+	50	-	-	+	25
MERTENSIA PANICULATA	1	100	-	-	-	-	-	-	-	-	+	33	-	-	-	-	-	-
SENECIO LUGENS	1	83	+	67	+	50	-	-	-	-	+	33	-	-	-	-	-	-
ARTEMISIA NORVEGICA SAXATILIS	1	83	+	33	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ACONITUM DELPHINIFOLIUM	1	83	-	-	+	25	-	-	-	-	-	-	-	-	-	-	-	-
POLEMONIUM CAERULEUM VILLOSUM	1	83	+	67	+	50	+	20	-	-	-	-	-	-	+	20	-	-
GENTIANA ALGIDA	+	83	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RUBUS INTERGRADE COMPLEX	+	83	-	-	+	25	-	-	-	-	-	-	-	-	-	-	-	-
AULACOMNIUM PALUSTRE	1	67	+	33	+	33	-	-	+	33	-	-	-	-	-	-	-	-
POLYTRICHUM COMMUNE	1	67	-	-	+	33	-	-	-	-	+	33?	-	-	+	20	+	25
ANENOME NARCISSIFLORA	1	67	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	50?
RHODIOLA INTEGRIFOLIA	1	67	+	33	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LAGOTIS GLAUCA	+	67	+	33	+	20	+	20	-	-	-	-	-	-	-	-	-	-
POTENTILLA FRUTICOSA	1	50	-	-	+	50	+	20	+	33	+	33	-	-	+	20	-	-
SOLIDAGO MULTIRADIATA	1	50	+	33	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RANUNCULUS NIVALIS	1	50	+	33	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GENTIANA GLAUCA	1	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VERONICA ALPINA VAR. UNALASCHENSIS	1	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LUZULA MULTIFLORA	1	50	-	-	-	-	-	-	-	-	-	-	+	50	-	-	-	-
CETRARIA ISLANDICA	+	50	+	33	-	-	+	25?	+	33?	-	-?	1	50?	-	-	+	25
LUZULA WAHLENBERGII	+	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CAREX PHYSOCARPA*	1	33	-	-	+	25	-	-	+	33	-	-	-	-	-	-	+	25
POA ARCTICA	1	33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SENECIO TRIANGULARIS	1	33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DODECATHEON SP	+	33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SENECIO CONGESTUS	+	33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DELPHINIUM GLAUCUM	+	33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

SPECIES	COMMUNITY GROUPING																	
	I(H-M)		II(M)		IIID~~4,5~~		IIIC		IIIB		IIIA		II (X)		I (X)		0 (X-M)	
	s.s.	F	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.
Salix pulchra	1	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Artemisia tilesii var. unalaschensis	+	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calamagrastis inexpansa	+	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cardamine pratensis	+	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Deschampsia caespitosa	+	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Equisetum arvense	+	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Luzula arcuata**	+	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Primula sp.	+	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ranunculus pedatifus?	+	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ranunculus scleratus? *	+	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sagina Linnaei	+	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Senecio alaskanus	+	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ditrichum flexicaule*	+	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Peltigera malacea	+	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tortula norvegica *	+	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hylocomnium alaskanum	3	67	5	100?	2	33	3	60	2	67	1	33	-	-	2?	60	3	50
Cassiope tetragona*	+	17	4	100	-	-	-	-	-	-	-	-	+	50	-	-	-	-
Dryas octopetala s.l.	+	17	3	100	+	25	-	-	1	67	+	33	+	50	3	80	+	25
Geum rossii*	1	50	3	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix reticulata *	1	67	3	100	2	100	+	60	2	100	+	33	-	-	+	20	-	-
Cardamine purpurea	+	17	2	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Parrya nudicaulis var. interior *	+	17	1	100	-	-	+	40	1	67	-	-	1	100	-	-	-	-
Anenome parviflora	+	33	1	100	-	-	-	-	+	33	-	-	-	-	+	20	-	-
Arenaria arctica	+	-	1	100	+	20	-	-	-	-	+	33	-	-	-	-	-	-
Antennaria angustata	+	17	1	67	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Equisetum scirpoides	+	17	1	67	+	40	+	40	+	33	-	-	-	-	-	-	-	-
Pedicularis capitata	+	17	1	67	-	-	+	20	+	33	-	-	+	50	-	-	-	-
Trisetum spicatum	1	67	2	67	-	-	-	-	-	-	-	-	-	+	+	20	+	50?
Dactylina arctica	+	17	1	67	-	--	-	-	-	-	-	-	-	-	-	-	-	-

COMMUNITY GROUPING

SPECIES	I(H-M)		II(M)		IIID4,5		IIIC6		IIIB		IIIA		II (X)		I(X)		0(X-M)	
	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.
Oxyria digyna	-	-	1	67	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Silene acaulis var. exscapa	-	-	1	67	-	-	-	-	-	-	-	-	-	-	1	40	-	-
Parnassia kotzebuei	+	50	+	67	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix pseudopolaris	+	33	+	67	-	-	-	-	-	-	-	-	-	-	-	-	+	25
Saxifraga punctata insularis	+	33	+	67	-	-	+	20	-	-	-	-	-	-	-	-	-	-
Lupinus arcticus	+	17	+	67	+	25	+	20	+	33	-	-	-	-	+	20	+	25
Anenome richardsonii	+	33	+	67	-	-	-	-	-	-	-	-	-	--	-	-	-	-
Astragulus umbellatus **	+	17?	+	67	-	-	+	20	-	-	-	-	-	-	-	-	-	-
Papaver macouni	+	17	+	67	-	-	-	-	-	-	-	-	-	-	--	-	-	-
Draba longipes	1	50	+	67	-	-	+	20?	-	-	-	-	-	-	-	-	-	-
Brachythecium sp	+	17	+	33	+	33	+	20	-	-	-	-	-	-	-	-	-	-
Drepanocladus uncinatus	+	17	+	33	-	-	+	20	-	-	-	-	-	-	-	-	-	-
Arctagrostis latifolia var. angustifolia	-	-	+	33	-	-	-	-	-	-	-	-	-	-	+	20	-	-
Arnica lessingi	+	17	+	33	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex scirpoidea *	-	-	+	33	+	25	-	-	-	-	-	-	-	-	-	-	-	-
Lloydia serotina	+	17	+	33	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Myosotis alpestris asiatica	+	17	+	33	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix Richardsonii	-	-	+	33	-	-	-	-	-	-	-	--	-	-	-	-	-	-
Castilleja pallida elegans *	-	-	+	33	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Erigeron uniflorus eriocephalus	-	-	+	33	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Poa leptocoma	-	-	+	33	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Erigeron humilis	-	-	+	33	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Saxifraga radiata	-	-	+	33	-	-	-	-	-	-	-	-	--	-	-	-	-	-
Taraxacum lyratum	-	-	+	33	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhododendron lapponicum *	-	-	-	-	2	100	1	60	2	67	+	33	+	50	+	40	-	-
Andromeda polifolia	-	-	-	-	2	100	-	-	-	-	-	-	-	-	-	-	-	-
Saxifraga hirculus	+	17	-	-	1	100	+	20	-	-	+	33	-	-	-	-	-	-
Eriophorum brachyantherum	+	33	-	-	2	100?	1	100	-	-	1	67	-	-	-	-	-	-
Polygonum viviparum	+	33	+	67	1	100	+	60	1	67	+	33	-	-	+	20	+	25
Picea glauca	-	-	+	33	+	100	+	20	+	67	-	-	+	50	-	-	+	50

COMMUNITY GROUPING

SPECIES	I(H-M)		II(M)		IIID 4,5		IIIC 6		IIIB		IIIA		II (X)		I(X)		0(X-M)	
	s.s. 2	F. 2	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.
TOFIELDIA PUSILLA	+	17	-	-	1	75	+	20	1	67	-	-	-	-	-	-	-	-
OXYCOCCUS MICROCARPUS*	-	-	-	-	+	75?	-	-	-	-	-	-	-	-	-	-	-	-
ERIOPHORUM CHAMISSONIS	-	-	-	-	+	50	+	20	+	33	+	33	-	-	-	-	-	-
RUMEX ARCTICUS	+	17	-	-	+	50	-	-	-	-	-	-	-	-	-	-	-	-
PEDICULARIS SUDETICA*	+	17	-	-	+	50	-	-	-	-	-	-	-	-	-	-	-	-
ERIOPHORUM ANGUSTIFOLIUM	-	-	-	-	+	50	-	-	-	-	-	-	-	-	-	-	-	-
SPAGHNUM CAPILLACEUM?	-	-	-	-	1	33	+	40	-	-	+	33	-	-	-	-	-	-
DICRANUM ELONGATUM	+	17	-	-	+	33	+	40?	-	-	-	-	-	-	-	-	+	25
AULACOMNIUM ACUMINATUM	-	-	-	-	+	33	-	-	+	33	-	-	-	-	-	-	-	-
OCHROLECHIA UPSALIENSIS	-	-	-	-	+	33	-	-	-	-	-	-	-	-	-	-	-	-
PINGUICULA VULGARIS?	-	-	-	-	+	25	-	-	-	-	-	-	-	-	-	-	-	-
PARNASSIA PALUSTRIS *	-	-	-	-	+	25	-	-	-	-	-	-	-	-	-	-	-	-
TRIGLOCHIN MARITIMA *	-	-	-	-	+	25	-	-	-	-	-	-	-	-	-	-	-	-
HEDYSARUM MACKENZII *	-	-	-	-	+	25	-	-	-	-	-	-	-	-	-	-	-	-
CAREX BIGELOWII	1?	17	-	-	5	100	6	100	2	67	6	100	-	-	-	-	-	-
EMPETRUM NIGRUM **	1	50	2	100	1	50	2	100	2	100	1	67	2	100	2	80	2	100
PEDICULARIS LABRADORICA	1	50	-	-	1	50	2	100	2	67	1	67	1	100	-	-	-	-
CETRARIA CUCULLATA	+	33	1	67	1	100	1	100	+	33?	1	67	2	100?	-	-	1	50
SAUSSUREA ANGUSTIFOLIUM s.l.	+	17	+	50	1	75	1	80	+	33	1	67	+	50	-	-	-	-
AULACOMNIUM TURGIDUM*	+	17	-	-	1	67	1	80	-	-	+	33	-	-	+	20	+	25?
PYROLA GRANDIFLORA	-	-	+	33	-	-	+	80	+	33	+	33	-	-	-	-	-	-
SAXIFRAGA HIERACIFOLIA VAR. RUFOPILOSA	+	17	+	33	+	25	+	60	-	-	-	-	-	-	-	-	-	-
RUBUS CHAMAEMORUS**	+	17	-	-	+	25	+	40	-	-	+	33	-	-	-	-	-	-
EQUISETUM VARIEGATUM*	-	-	-	-	-	-	+	40	-	-	-	-	-	-	-	-	-	-
ERIOPHORUM SCHEUCHZERI **	-	-	-	-	+	25?	+	40?	-	-	-	-	-	-	-	-	-	-
PELTIGERA APHTHOSA	-	-	-	-	+	33	+	50	-	-	+	33?	-	-	-	-	+	25?

SPECIES	COMMUNITY GROUPING																	
	I(H-M)		II(M)		IIID[4,5]		IIIC[6]		IIIB		IIIA		II (X)		I(X)		0(X-M)	
	s.s.[2]	F.[2]	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.
STELLARIA CRASSIFOLIA	+	17	-	-	-	-	+	20	-	-	-	-	-	-	-	-	-	-
POHLIA NUTANS?	-	-	-	-	-	-	+	20	-	-	-	-	-	-	-	-	-	-
DRYAS INTEGRIFOLIA *	-	-	-	-	1	50	1	80	2	100	-	-	+	100	-	-	-	-
ARCTOSTAPHYLOS ALPINA RUBRA	1	50?	1	67	2	100	2	80	2	100	1	67	1	100	1	60	2	50
PEDICULARIS LANGSDORFII *	+	33	+	67	1	100	1	100	2	100	-	-	-	-	-	-	-	-
GENTIANA PROPINQUA *	+	33	+	33	+	75	-	-	2	100	-	-	-	-	+	20	-	-
VACCINIUM ULIGINOSUM **	+	33	1	67	1	75	1	60	1	100	-	-	1	100	1	80	+	50
SENECIO ATROPURPUREUS	-	-	-	-	-	-	+	80	+	100	-	-	-	-	-	-	-	-
ARCTAGROSTIS LATIFOLIA VAR. ARUNDINACEAE	+	17	+	33	+	25	1	50	1	67	-	-	-	-	-	-	-	-
TOMENTHYPNUM NITENS *	-	-	-	-	+	33	+	20	1	67	-	-	-	-	-	-	-	-
SPHENOLOBUS MINUTUS	+	17	-	-	-	-	+	20	1	67	-	-	-	-	-	-	+	25
DICRANUM MUHLENBECKI	+	33	-	-	1	67?	+	20	1	67	-	-	1	50	+	40	-	-
DICRANUM BERGERI	-	-	-	-	+	33?	-	-	+	33	-	-	-	-	-	-	-	-
SALIX BARRATTIANA	+	17	-	-	-	-	-	-	+	33	-	-	-	-	+	20	-	-
DREPANOCLADUS SP.	-	-	-	-	-	-	-	-	+	33	-	-	-	-	-	-	-	-
SHEPHERDIA CANADENSIS *	-	-	-	-	-	-	-	-	+	33	-	-	-	-	-	-	-	-
ANENOME DRUMMONDI	-	-	-	-	-	-	-	-	+	33	-	-	-	-	-	-	-	-
SALIX PLANIFOLIA	2-3	83	3?	100?	3	100	3	100	3	67	4	100	+	50	4	100	3?	75?
LEDUM PALUSTRE DECUMBENS	+	17	1	67	2	100	1	100	2	100	2	100	1	100	1	80	1	75
CLADONIA AMAUROCRAEA	+	17	+	33?	-	-	1	50	1	33	2	100	-	-	-	-	-	-
POLYGONUM BISTORTA PLUMOSUM *	1	83	2	67	-	-	+	80	1	67	1	100	-	-	+	60	+	25
STELLARIA LONGIPES S.L.	2	83	1	67	+	25	1	80	+	33	1	100	1	50	1	60	1	100
CLADONIA MITIS	+	33?	1	67?	1	67	1	50?	1	33	2	67	-	-	-	-	-	-
DICRANUM SP.	-	-	-	-	-	-	-	-	-	-	+	33	-	-	-	-	-	-
PTILIDIUM CILIARE	?	17	-	-	-	-	+	20	-	-	+	33	-	-	-	-	-	-
VACCINIUM VITIS-IDAEA MINUS**	+	17	1	67	2	100	2	100	2	100	3	100	4	100	3	100	4	100
RHYTIDIUM RUGOSUM *	1	50	1	33?	+	33	3	60	2	67	1	25	4?	100	3	60	3	75
SALIX GLAUCA S.L.	-	-	-	-	2	75	3	80	2	75	1	33	3	100	-	-	1	50
FESTUCA ALTAICA	1	67	+	33	-	-	+	20	+	33	-	-	2	100	+	20	-	-
ALECTORIA NIGRICANS	-	-	-	-	-	-	-	-	+	33?	-	-	2	100?	1	60	+	50

(TABLE 23 cont'd)

SPECIES	COMMUNITY GROUPING																	
	I(H-M)		II(M)		IIID[4,5]		IIIC[6]		IIIB		IIIA		II (X)		I(X)		0(X-M)	
	s.s.[2]	F.[2]	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.
CLADONIA ALPESTRIS	-	-	+	33?	-	-	+	25?	+	33?	?	33?	2	50	-	-	+	25
ASTRAGULUS ALPINUS	-	-	-	-	-	-	-	-	-	-	-	-	+	50	-	-	-	-
CLADONIA UNCIALUS	-	-	-	-	-	-	+	25	+	33	-	-	1	50	+	20	-	-
SALIX ATHABASCENSIS?	-	-	-	-	-	-	-	-	-	-	-	-	+	50	-	-	-	-
LINNAEA BOREALIS	-	-	-	-	-	-	-	-	-	-	-	-	+	50	-	-	-	-
ARNICA LOUISEANA FRIGIDA*	-	-	-	-	-	-	-	-	-	-	-	-	+	50	+	20	+?	25?
MELANDRIUM APETALUM	-	-	-	+	25	-	-	-	-	-	-	-	+	50	-	-	-	-
POTENTILLA LEDEBOURIANA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	60	-	-
STEREOCAULON TOMENTOSUM	-	-	-	-	-	-	-	-	-	-	1	25	2	50	2	60	2	50
ALECTORIA OCHROLEUCA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	60	+	25
SALIX ARCTICA S.L.	-	-	+	33	-	-	-	-	-	-	-	-	-	50	1	60	+	25
CAMPANULA LASIOCARPA **	2	33	-	-	-	-	-	-	-	-	-	-	+	-	+	60	-	-
EPILOBIUM ANGUSTIFOLIUM	+	33	+	33	-	-	+	40	+	33	-	-	-	-	+	60	+	50
POLYTRICHUM PILIFERUM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	40	-	-
CALAMAGROSTIS CANADENSIS	+	33	-	-	-	-	-	-	-	-	+	33	-	-	+	40	+	25
CETRARIA NIVALIS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+?	40	+	25
BUELLIA SP. C.F. MORIOPSIS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	40	-	-
RHIZOCARPON SP.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	40	-	-
ABIETINELLA ABIETINA *	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	40	-	-
CLADONIA PYXIDATA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	20	-	-
ANENOME MULTICEPS?	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	20	-	-
BETULA GLANDULOSA S.L.	3	100	4	100	4	100	4	100	3	100	5	100	5	100	6	100	8	100
CLADONIA GRACILIS	+	33	1	33	+	33	+	25	1	67?	-	-	?	50?	+	20	3	75
CLADONIA RANGIFERINA	+	17	-	-	1	33	1	75	-	-	-	-	-	-	1	40	2	75
PLEUROZIUM SCHREBERI	?	17	-	-	-	-	1	20	+	33?	1	33	-	-	+	20	2	50
POLYTRICHUM JUNIPERINUM	+	17	-	-	-	-	+	20	-	-	1	33	-	-	+	40	1	50
CETRARIA RICHARDSONII	+	17	+	33	-	-	+	25	+	33	-	-	-	-	-	-	1	50
SPHAEROPHORUS FRAGILIS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	+	25
ANTENNARIA MONOCEPHALA	+	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	25
THAMNOLIA VERMICULARIS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	25
CLADONIA DEFORMIS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	25

COMMUNITY GROUPING

SPECIES	I(H-M)		II(M)		IIID[4,5]		IIIC[6]		IIIB		IIIA		II (X)		I(X)		0(X-M)	
	s.s.[2]	F.[2]	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.	s.s.	F.
ANTENNARIA COMPACTA*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	25
ALNUS CRISPA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	25
BETULA OCCIDENTALIS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	25
SALIX GLAUCA X INTERGRADES	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	25
ROSA ACICULARIS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	25
PEDICULARIS FLAMMEA*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	25
SAXIFRAGA TRICUSPIDATA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	25

1. COMMUNITIES ARE ARRANGED TO GIVE A PROGRESSION OF HYDRIC OR HYRIC MOISTURE CONDITIONS ON THE LEFT TO DRIER HABITAT ON THE RIGHT. DETAILS AS TO THE QUADRAT OR MORAINAL CONTRIBUTION TO EACH COMMUNITY GROUPING IS GIVEN IN THE APPENDICES.

2. S.S. IS THE AVERAGE SPECIES SIGNIFICANCE FOR THAT PARTICULAR SPECIES IN THE COMMUNITY GROUPING; F IS THE FREQUENCY OR THE PERCENTAGE OF QUADRATS OR SITES IN WHICH THE SPECIES IS FOUND IN THAT COMMUNITY GROUPING. THE S.S. VALUES ARE VERY ROUGH APPROXIMATIONS FOR THE LICHEN AND BRYOPHYTE SPECIES.

3. NOMENCLATURE IS IN THE ABBREVIATED AND CONSERVATIVE FORM; THE CHECK LIST IN APPENDIX IVA GIVES FULL NOMENCLATURE DETAILS. CALCIPHILIC SPECIES, OR REPORTEDLY SO (PORSILD, 1951, 1957) ARE MARKED BY A SINGLE ASTERISK (*); OXYLOPHYTES OR REPORTED ACIDOPHILES ARE MARKED BY A DOUBLE ASTERISK (**). MOST LICHENS ARE OF THE LATTER PREFERENCE; HENCE, NO DESIGNATIONS ARE GIVEN FOR THIS GROUP.

4. COMMUNITY INDIVIDUA No. 217 LIES WITHIN THIS GROUP; THE QUADRAT INCLUDED MINOR ELEVATED MESIC TO MODERATELY DRY PEAT MICRO HABITATS AS DELINEATED IN TABLE IIIB OF APPENDIX IVC. THE DRIER MICRO-HABITAT IS INCLUDED IN THE COMMUNITY GROUPING.

5. COMMUNITY INDIVIDUA No. 306 WAS NOT A FORMALLY INVESTIGATED QUADRAT; BRYOPHYTES AND LICHENS WERE NOT INVESTIGATED; HENCE THE AVERAGES FOR THE COMMUNITY GROUPING ARE BASED ON THE THREE REMAINING COMMUNITY INDIVIDUA AS FAR AS LICHEN AND BRYOPHYTE SPECIES ARE CONCERNED.

6. COMMUNITY INDIVIDUA No. 144's LICHENS WERE DAMAGED BEYOND ACCURATE IDENTIFICATION WHILE IN TRANSPORT AND STORAGE; HENCE THE LICHEN S.S. AND F. VALUES FOR THE COMMUNITY GROUPING ARE THE AVERAGE OF FOUR QUADRAT ANALYSES.

?. DENOTES EITHER UNKNOWN OR VERY APPROXIMATE S.S. VALUE OR THE POSSIBILITY OF A LOWER F. VALUE DUE TO A SPECIES IDENTIFICATION PROBLEM.

O(X-M) groupings. According to Shacklette (1963) the calciphiles Parrya nudicaulis, Arctostaphylos alpina, Equisetum variegatum, Carex scirpoidea, and Hedysarum mackenzii are probably not strictly dependent on calcium for their survival. Species designated as oxylophytes in the table are scattered throughout all groupings. The various quadrat sites making up a grouping are listed in the "B" tables of Appendix IVC.

Community Grouping I(H-M): Moist Shrub-Meadow Community Complex

This complex represents moist to wet habitats on the NF-SL-I moraine; a single stand from the Foxy-I moraine was also briefly examined. The habitats are slopes, troughs, flat-floored depressions and shallow gullies. Silt and sand of colluvial origin mixed with some organic debris characteristically underlies the vegetation mat. One site (No. 137) is on a **gravel surface of a kame terrace** deposited by the retreating ice front at least 11,250 years B.P. (Table VI), but most of the remaining sites are younger. Slope Site No. 122 is perhaps an older feature but its downslope portions have been reworked by fairly recent solifluction activity.

The areal extent of the Moist Shrub-Meadow Grouping is difficult to assess due to the variability of the topography the various stands occupy. Rough estimates indicate that it covers one quarter to one third of the NF-SL-I surface, while on the Foxy-I moraine it probably occupies less than 10% of the total area (excluding outwash surfaces). On the NF-NL-I moraine it was found as small enclaves, and certain elements of the community are definitely present on the CL-II moraine.

Vegetation within the Moist Shrub-Meadow Community Grouping is characterized by a continuous C-layer of grass, sedges and forbs. Carex podocarpa is the dominant species. One to 2 m tall Salix spp. and Betula glandulosa are interspersed through the C-layer, but never shade more than 25% of an individual stand and are only peripheral invaders in the mossy meadow habitats. Secondary species include forbs of Valeriana capitata, Petasites frigidus and Mertensia paniculata; Senecio lugens, Artemisia norvegica, Aconitum delphinifolium and Polemonium caeruleum are also generally present. Festuca altaica and Trisetum spicatum are important grass components of the community as well. Within the D-layer the mosses Hylocomium alaskanum, Polytrichum commune and Aulacomnium palustre are fairly conspicuous, whereas a variety of lichen species are scattered throughout. This community complex is nearly comparable to Porsild's (1951) "subalpine meadow habitat" as defined from the slopes of Mt. Sheldon in the Mackenzie Mountains to the east and to Spetzman's (1959) "tall-shrub stage" of the "Flood Plain Community" of the north slope of Alaska.

Orthic and Gleyed Regosols, and Orthic and Rego Gleysols are associated with this community complex. The former were found in younger colluvial silt-filled gullies whereas the latter were observed on gentle slope topography; organic soils can be expected in the flat basin containing meadow stands. The soil profiles are generally acidic throughout.

Community Grouping II(M): Late Snow-lie Communities

The mesic snow-lie communities are confined to northward facing slopes. Since permafrost is often found on these slopes, this community was not too prevalent on the moraines studied. Snow-lie communities are found on the Foxy-I moraine and occupy one vast expanse on the NF-SL-I moraine. Unfortunately the community was found too late in the season for detailed study on the other moraines.

In habitats occupied by this community, soil creep occurs on the drier upper slopes while solifluction is taking place on the more moist lower slopes. Despite the slightly unstable substrate, much of the habitat is a primary depositional surface; youthful secondary parent materials, if present, are confined to the basal portions of the slope. The age of the upper surfaces should be at least 11,250 years old at the NF-SL-I site and perhaps as much as 13,740 years old (Table VI) for the Foxy-I upper slopes. The areal extent of this community comprises about 5% of the total area of each of these two moraines. The areal extent would be much lower on the other moraines.

Because of the increase in moisture in the downslope portion of the habitats, a broad diversity of flora is expected in the community. In addition to dwarf birch, dominating species are Cassiope tetragona and Hylocomium alaskanum. While the heather increases in cover-abundance upslope the moss increases in density in the downslope direction. Important secondary species include Dryas octopetala (s.l.), Geum rossii, Salix reticulata, Empetrum nigrum and Cardamine purpurea in the C-layer. Salix planifolia, Trisetum spicatum, and Polygonum bistorta are also found on the slopes. While mosses are almost a continuous understory of the B_2 and C layers, lichens appear to be widely scattered in the D layer with no particular species predominance (Table XXIII).

Krajina (1963) has listed several snow-lie associations from the flanks of the Richardson Mountains to the north of the study area (Fig. 2). His "Cassiope tetragona - Hylocomium splendens var. alaskanum - (Dryas punctata) Association" of the Alpine Tundra Zone as found at 600 m above mean sea level resembles the community described here. However, his additional characteristic

cryptograms Dicranum elongatum and Peltigera aphthosa were not found on the slopes in this survey.

The one soil pit examined in the snow-lie habitat revealed a Brown Wooded profile. This soil is probably typical of the upper slopes, but on the lower slopes, Gleysols and Regosols in convoluted condition probably take its place. Krajina (1963) indicated a weakly podsolized soil profile in the comparable Richardson Mountain's community.

Community Grouping III(M-H): Tussock-Tundra Community Complex

This complex represents a gradational series of habitats that vary from bog conditions in swales, permafrost-encased silt on slopes, wet to mesic lobed-solifluction deposit areas, and expansive moist to mesic silt- or till-crested swells. The vegetation in turn is a gradational and superficially monotonous mosaic of tussock tundra that stretches from one topographic element to the next. The community complex occurs as a continuous carpet on permafrost terrain. Variation in the vegetation is related in part to the position of the permafrost table; its depth being governed by the presence or absence of frost-susceptible silt grain sizes and by the thickness of the insulating vegetation mat. Because of the continual disturbance created by the fluctuating permafrost table, the species are either those that can withstand extreme environmental changes or those that are able to quickly re-establish themselves.

Spetzman (1959), Shacklette (1963), Drew and Shanks (1965) and others record the extensive spread of the tussock tundra in the northern Cordillera. The tussock tundra covers more than 60% of the Foxy-I, NF-NL-I, CL-II, OG-III, and other Taiga Valley surface areas in this region of study.

Within the complex mosaic, several changes in vegetation character may be distinguished by a change in the cover-abundance of certain key secondary species. Species of significant cover-abundance in all subgroups include: the B_2 layer Ledum palustre decumbens, Salix planifolia, Salix glauca and Rhododendron lapponicum; the ground mat woody shrubs Salix reticulata, Arctostophylos alpina, and Empetrum nigrum; the mosses Hylocomium alaskanum and Rhytidium rugosum; the tussock sedges Carex Bigelowii[6], Carex physocarpa and Eriophorum spp.; and the forb Pedicularis labradorica. Colourful flowering herbs and shrubs of sporadic occurrence are Saussurea angustifolium, Polygonum viviparum, Stellaria longipes and Potentilla fructicosa; the lichens, Cladonia mitis and Cetraria cucullata, also occur in small numbers.

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[6] In this report Carex Bigelowii is considered the same as C. lugens - Appendix IVD.

Due to continual congeliturbation on slopes, and frost boils on flatter terrain, soil horizon development is almost wanting in the habitats supporting this complex. The high permafrost table inhibits drainage and if pedogenesis does take place the result is a weakly developed (Sub-arctic) Gleysol. Typically, partially decomposed organic matter builds up until an organic or bog profile develops beneath the moss, sedge and shrub mat - hence, pH's in the entire soil profile are commonly less than neutral despite the calcic nature of the moraines.

The separation of communities within this complex depends on the density of the development of sedge tussocks as opposed to the growth of heath mat, and on the ratio of shrub to tussock coverage. The main floristic differences are outlined in the following synopsis:

Species and Layer	S.S.-F. in Subgroup			
	IIIB	IIIA	IIIC	IIID
B_2 Layer				
Betula glandulosa	3-100	5-100	4-100	4-100
Salix planifolia	3-67	4-100	3-100	3-100
Vaccinium uliginosum	1-100	-	1-60	1-75
C Layer				
Carex Bigelowii	2-67	6-100	6-100	5-100
Pedicularis langsdorfii	2-100	-	1-100	1-100
Dryas integrifolia	2-100	-	1-80	1-50
Gentiana propinqua	2-100	-	-	+-75
Dryas octopetala	1-67	+-33	-	+-25
Parrya nudicaulis	1-67	-	+-40	-
Petasites frigidus	1-67	1-100	1-80	-
Polygonum bistorta	1-67	1-100	+-80	-
Pyrola grandiflora	+-33	+-33	+-80	-
Saxifraga hieracifolia	-	-	+-60	+-25
Eriophorum brachyantherum	-	1-67	1-100	2-100(?)
Andromeda polifolia	-	-	-	2-100
Saxifraga hirculus	-	+-33	+-20	1-100
Tofieldia pusilla	1-67	-	+-20	1-75
Oxycoccus microcarpus	-	-	-	+-75(?)
Pedicularis sudetica	-	-	-	+-50
D Layer				
Cladonia amaurocraea	1-33	2-100	1-50	-
Cladonia rangiferina	-	-	+-75	+-33

The chief characteristics of the four subdivisions are as follows:

Group IIIA -- Tussock-Shrub Community consists of low sedge tussocks in mesic to hygric conditions. The community is characterized by a high shrub to tussock ratio.

Group IIIB -- Heath-Tussock Community thrives in mesic conditions and probably represents the transition from tussock communities to xerophytic communities above the zone of influence of permafrost. Mats of Dryas spp. displace the Carex spp. in this grouping.

Group IIIC -- Tall Tussock or "Niggerhead" Community is developed on low-gradient hygric slopes with the permafrost table quite close to the ground surface, though thick organic horizons separate the latter from the vegetation. The community is characterized by a lower shrub coverage among the tall sedge tussocks.

Group IIID -- Wet Tussock-Strangmoor Community is found in a variety of hydric to hygric habitats. Consequently an additional array of hydrophytic species are found in this community.

None of these communities can be said to indicate a specific age of morainal surface. A phasic successional trend of perhaps B to A to C to D groups may exist, due to the periodic disruption of the habitat by congeliturbation.

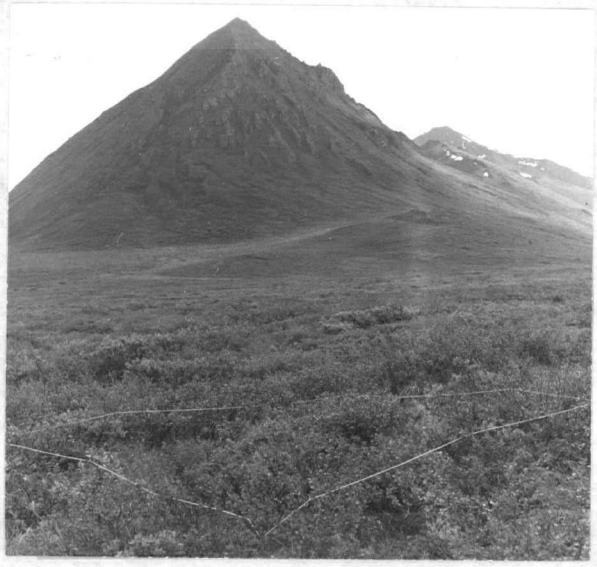
Shrub-Tussock Community - IIIA(M-H)

Species of this community are listed in Table XXIII. The community occurs intermittently on low gradient slopes and swells of the NF-NL-I and the CL-II moraines. Vegetation consists of scattered 5-15 cm high tussocks of Carex Bigelowii and Eriophorum brachyantherum around which low shrubs of birch and willow grow to average heights of 40 to 70 cm respectively (Plate XXIIA). The tussocks comprise about 30 to 40% of the coverage in the community. Mosses grow in a continuous carpet about the tussocks and underlie a scattered ground cover of Cladonia amaurocraea, Cladonia mitis, Cetraria cucullata and other rarer species. The community is distinguished from others by the almost total absence of Dryas spp., Vaccinium uliginosum and Picea glauca and by the low cover-abundance of Polygonum bistorta and Petasites frigidus.

Although soil profiles are characteristically very poorly drained in this subgrouping, permafrost was reached in only 2 of 4 soil pits. Those devoid of permafrost were located on exposed swells of till and exhibited a characteristic thinner (6-7 cm) protective L-F horizon; whereas permafrost sites were located on convoluted silt-laden slopes. Tentatively classified Gleysolic and Regosolic soils occur on the tills and silts respectively.

Comparable communities described in the literature are Viereck's (1966) "Low Shrub-Sedge Tussock-Moss Tundra" in the Mt. McKinley region and Drew and Shanks' (1965) "Upland Tussock Tundra" in the Firth River region and Krajina's (1963) "Betula glandulosa - Salix glauca - Ledum decumbens - Eriophorum vaginatum - Carex lugens - Dicranum elongatum - Cetraria cucullata Association" from the Subalpine Tundra Zone of the Richardson Mountains. Some species differences exist between these communities and those of the study area.

Plate XXIIA Shrub-Tussock Community - IIIA(M-H)



Quadrat Site No. 141 - north lobe of the North Fork Pass Moraine. Note typical mixed shrub overstory blanketing the morainal surface.

Plate XXIIB Tall Tussock or "Niggerhead" Community - IIIC(H)

Quadrat Site No. 144 - north lobe of North Fork Pass Moraine. Note typical scattered and lower density of shrub overstory, tussock C-layer of Eriophorum branchyantherum (white heads) and Carex Bigelowii clums (foreground).

Heath-Tussock Community - IIIB(M-H)

This community, like the previous, occupies swell crests and slopes, but in this case imperfect drainage conditions exist. As a result, the major tussock element is replaced by an ericaceous mat. The community can usually be found near the gravel hummock habitats on the Foxy-I, NF-NL-I and CL-II surfaces and in fact may represent the transition zone between tussock tundra and the xerophytic communities to be described. Occasionally the community marks the transition zone from a slope tundra community of IIIC to an undescribed community developed on dry debris recently produced by solifluction on, for example, the slopes of "Spruce Lake" (Fig.8). Because of the habitat limitation this community covers little area.

The vegetation of the Heath-Tussock Community consists of distinct mats of Dryas integrifolia and Arctostaphylos alpina amidst scattered clumps of Carex spp., Salix spp. and the usual dwarf birch. Interspersed minor species in the scattered shrub zone also include Ledum palustre 20 cm high, Vaccinium uliginosum and Rhododendron lapponicum. In the D layer, Tomenthypnum nitens, Sphenolobus minatus and Dicranum sp. occur regularly at most sites. Gentiana propinqua occurs as a diagnostic forb in the community while Pedicularis langsdorfii, Pedicularis labradorica, Senecio atropurpureus and Parrya nudicaulis are the showy species. Tofieldia pusilla and Arctagrostis latifolia var. arundinaceae are characteristic of moist pockets scattered in the stands.

Regosolic soils underlying this community are developed on a thick active layer above the permafrost. Since the organic horizon averages only 10 cm in depth and a thicker living ground mat occurs only sporadically, the pH of the upper solum of the profiles is high and this no doubt is reflected by the appearance of additional calciphilic species in the community (Table XXIII).

The Heath-Tussock may be similar to Drew and Shanks' (1965) Dryas bearing "drier island" community - a group, unfortunately, not described in detail by them.

Tall Tussock Community - IIIC(H)

Vegetation of this community is locally termed "niggerhead terrain". The shrub overstory is decidedly sparser than that of Subgroup IIIA as shown by Plates XXIIB & XXIIIB). The community is best developed on low angle slopes but it may occur in modified form on flats or crests in transition to any of the other subgroups of the broader Tundra-Tussock complex.

Since the active layer is less than 40 cm thick drainage is poor though open water does not usually develop between the tussocks. Low angle slopes facing all directions harbour vast areas of this community on the NF-NL-I, Foxy-I and CL-II moraines; it is the most extensive component of the vegetation mosaic on these moraines. The CG-III moraine surface may be blanketed by this type as well.

The elements that produce the tussocks are Carex Bigelowii and Eriophorum brachyantherum, the latter being somewhat less common. Up to 75% of a quadrat area can be blanketed by these 15 to 30 cm high tussocks, but the average is between 40 to 50%. Betula and Salix spp. occur in isolated thickets at heights of 40 to 80 cm respectively; their combined average canopy values are about 25 to 30%. Ledum palustre is the only regular scattered shrub component. A moss mat is almost continuous around the tussocks and underlies Vaccinium vitis-idaea, Empetrum nigrum and other minor low-shrub components. Cladonia rangiferina and Cetraria cucullata are scattered in clumps through the moss mat. Protruding through the mat are scattered but characteristic species such as Pyrola grandiflora, Saxifraga hieracifolia and Rubus chamaemorus. The last, like Petasites frigidus, is usually sterile. Table XXIII shows that the tall tussock group includes a large number of other species having low cover-abundance values.

Soils associated with the community are hampered in their development by a very high permafrost table. The dead vegetation hardly decomposes and thick organic accumulations generally are present. The L-F layer averages 25 cm in thickness and, in combination with the insulating qualities of the living tussocks, permits the permafrost table to maintain itself close to the surface. Within the thin active layer, congeliturbation appears to be a characteristic phenomenon, for organic streaks occur in the gleyed silts above the permafrost table. In areas having thinner organic coverage, the soil profile suggests a weak development of an Ah layer in what may be eventually a gleysolic soil - provided congeliturbation does not interrupt the process.

Spetzman's (1959) "Niggerhead Meadows", Drew and Shanks' (1959) "Upland Tussock Tundra" and "Sedge Meadow Terrace", Shacklette's (1963) "Arctic Tundra Soil Community" and Krajina's (1963) "Betula glandulosa - Vaccinium vitis-idaea - Vaccinium uliginosum - Ledum decumbens - Carex lugens - Dicranum elongatum - Cetraria cucullata Association" are all quite similar to this community subgrouping. The Shrub-Tussock (IIIA) Community may be a successional stage leading to this type. Over a period of time the insulating organic layer of Group IIIA thickens and consequently the permafrost table rises to produce

Plate XXIIIA Wet Tussock-Strangmoor Community - IIID(H-M)

Quadrat Site No. 217 - Chapman Lake Moraine. Note mesic ice-cored peat hummock of strangmoor type of bog; open water species at right midground were not included in the site analysis. Field assistant is preparing an organic soil profile on the hummock.

Plate XXIIIB Tall Tussock or Niggerhead Community - IIIC(H)

Quadrat Site No. 216 - Chapman Lake Moraine. Note scattered Salix glauca shrubs on continuous carpet of sedge (Carex Bigelowii) and moss. "Antler Lake" is in midground; Central Ogilvie Ranges lie in the background.

the environment needed for tall tussock growth (IIIC). Eventually, either the moisture drainage is completely retarded or congeliturbation disrupts the soil surface; if the former a Wet Tussock community evolves, and if the latter the bare soil surface undergoes renewed colonization leading eventually to a Heath-Tussock (IIIB), then a Shrub-Tussock and so on in the irregular phasic cycle.

Wet Tussock - Strangmoor Community - IIID(H-M)

This complex, despite its boggy nature, is found in a broad variety of topographic situations - swell, slope and swale. The community occupies at least one quarter of the area covered by the Group III complex. Itwas investigated only on the CL-II and CG-III moraines, but was observed also on the NF-NL-I surfaces and no doubt occurs in the smaller bog depressions of the Foxy-I moraine.

The inclusion of a bog habitat within this complex may be surprising but it should be recalled that Drury (1956) found a variety of communities on comparable bog situations in the Kuskokwim River region of Alaska (Fig. 1). Site No. 217 was established on a strangmoor with the typical mesic peat hummocks running through the open water or flark zone. Since the quadrat included the hummock and the transition zone to the flarken, the vegetation approximates the species in the Wet Tussock found elsewhere. The uninvestigated flarken appear to carry typical aquatic communities. Undoubtedly the bog communities comprise a complex of their own but they also overlap the tussock tundra communities.

Permafrost depths vary within this subgrouping; frozen conditions were encountered near the surface of the strangmoor quadrat but were not encountered on soil pits at the other sites. However, a high water table or standing water at the other quadrats suggest a permafrost table not too far beneath the ground surface. The community is a wetter variety of the previously described Tall Tussock Community. The saturated habitat may reflect the necessary environmental condition which permits prolific growth of those hydrophytic species with narrower environmental amplitude.

The C-layer shrubs Andromeda polifolia and Oxycoccus microcarpus are found in the saturated environment around the edges of the sedge tussocks. Saxifraga hirculus, Polygonum viviparum and Gentiana propinqua are found at most sites but Pyrola grandiflora, Pedicularis labradorica, Saxifraga hieracifolia and Rubus chamaemorus are more sporadic in occurrence. Picea glauca, up to 10 m in height, occur as scattered clumps about the peripheral margins of this community.

The bog site quadrat (Plate XXIIIA) was composed of a mesic group of species developed on irregular peat hummocks and was separated from the hydrophytic species by a transitional zone comprised of at least 12 species with broad environmental amplitudes as shown by the species list in Table IIIB of Appendix IVC.

Soils vary from organic or bog types to the weakly developed gleysolic mentioned under community IIIC. In the latter soil type the gravelly parent materials are capped by either a thick silt zone or a thin organic layer. Hence, a primary morainal surface may be colonized at Site No. 223. Peat ridges in the strangmoor type of bog habitat are as much as 60 cm above the surrounding open water of the flarken. Decomposition is not complete in the top 50 cm of accumulation; the peat in the hummock is derived from sedges and mosses.

Vegetation in the community is similar to the gradational zone mentioned by Drew and Shanks (1965) between their "Sedge Meadow Terrace" and "Bog Meadow Strangmoor". The peat ridges of the latter have species comparable to the Site No. 217 peat ridge; however, the edges of the flark zone at Site No. 217 appear to lack the characteristic sedge Carex aquatilis. The site is also comparable to bog communities described by Drury (1956). Site No. 306 is developed on a wet slope affected by solifluction. Not only does the stand show strong similarities to the "Bog Meadow Strangmoor" community, but it is also similar, at least in species composition, to Drew and Shanks' "Solifluction Fan with Scattered Spruce" community. Other similar types are Spetzman's (1959) "Wet Sedge Meadow" community, Shacklette's (1963) "Arctic Tundra Soil" communities, and several of Krajina's (1963) "anmoor" and "low centred polygon" associations.

Community Grouping O-II(X-M): Mesic to Xeric Communities

Communities of well drained habitats occur on gravel hummocks and till rises capped by Brown Wooded soil profiles. The two topographic elements harbour many species with similar cover-abundance values. However, the community on till is dominated by high canopy values of birch and willow and is characterized by a nearly continuous D-layer carpet; hence, it appears to be a group of its own (= Shrub Thicket Community). Several species occur irregularly within the community as typified by the low indices of similarity given in Appendix IVB. The Gravel Hummock Communities on the other hand are much more open and exposed (cf. Plate XXIVA and B).

Plate XXIVA Shrub-Thicket Community - O(X-M)

Quadrat Site No. 84 - August 17th Creek Moraine. Note the continuous D-layer ground mat of mosses and lichens interspersed with and beneath the overstory of the B_2 layer of Betula glandulosa.

Plate XXIVB Gravel Hummock Community - I(X)

Quadrat Site No. 142 - north lobe of the North Fork Pass Moraine. Note the partial cover of the D and C-layers and the stunted appearance and lower cover-abundance of the B_2 layer's Betula glandulosa (right hand side of photograph).

Gravel Hummock Communities - I-II(X)

Sparsely-vegetated, gravelly, well drained hummocks of map Sub-unit 2F occur on the crest of low rolling swells of most moraines north of North Fork Pass. Their distribution is indicated by Figures 6, 7 and 8 and by Table XII. Since these areas are above the zone of direct influence of permafrost, and are usually not blanketed by a veneer of loess, they are probably the most useful surfaces for studying the relation between plant cover and moraine age. Their drawback, of course, is that they are xeric habitats and consequently plants tend to occur erratically even on nearly adjacent habitats, as shown by Shacklette (1963) in the Eagle district of nearby Alaska.

Vegetation established on these surfaces must contend with severe exposure and aridity (Plate XXIVB). Similar communities are described by Shacklette (1963). The gravel surface demarcates not only a distinct change in some species (e.g. Silene acaulis) as compared with adjacent tussock tundra (e.g. Carex Bigelowii), but also a reduced vigour rating in other species that possess the broader environmental amplitude required for successful survival on both. For example, Betula glandulosa and Vaccinium uliginosum scarcely change in stand densities from one habitat to the next but do show the signs of the harsher xeric environment. An interfingering mosaic of vegetation can be found about the basal portion of the gravel mounds. For example, Saussurea angustifolia will gradually diminish in number on the gravel and Dryas octopetala gradually drops in cover-abundance on the surrounding tussock terrain.

The Gravel Hummock Communities (I and II) are dominated by scattered dwarf birch thickets and by an almost continuous ground mat of Empetrum nigrum, Arctosyaphylos alpina and Vaccinium vitis-idaea. Occasionally Vaccinium uliginosum, Rhododendron lapponicum and Ledum palustre occur between these two shrub levels. The D-layer mat is nearly continuous; Rhytidium rugosum usually develops under the shade of the shrubs while Stereocaulon tomentosum appears on the openly exposed gravel substrate; Alectoria nigricans is "sprinkled" amidst the exposed gravelly areas.

Comparison of the species lists in conjunction with specific cover-abundance figures on a stand to stand basis indicates that gravel hummock communities might be subdivided into I(X) and II(X) types. Salix glauca appears to be prevalent on the CL-II moraine (=IIX) sites (Plate XXVB) whereas the shiny leafed Salix planifolia prevails on the (=IX) Age I and Age III morainal sites. The former (IIX) sites also have floristic similarities in common with the surrounding tussock whereas the others (IX) do not. The Age I and Age III gravel

Plate XXVA Gravel Hummock Community - I(X)

Quadrat Site No. 142 - north lobe of the North Fork Pass Moraine. Note ground mat of Potentilla ledebouriana (yellow), Vaccinium vitis-idaea (wine flowers), Salix arctica, Stereocaulon tomentosum (white - lower left) and Cetraria nivalis (yellow lichen).

Plate XXVB Gravel Hummock Community - II(X)

Quadrat Site No. 212 - Chapman Lake Moraine. Note scattered B_2 layer of Salix glauca (taller) and Betula glandulosa (lower) on low ground mat of Cladonia spp. and Vaccinium vitis-idaea. Brown Wooded soil profile is being prepared for examination on left foreground.

habitats (IX) have species in common with the Shrub Thicket Community. Considerable variation, however, occurs from one gravel hummock to the next and the differences noted may be just fortuitous.

The CL-II Gravel Hummock Community (=IIX) are characterized in addition to the above mentioned species by the presence of Dryas integrifolia, Pedicularis labradorica, Parrya nudicaulis, Festuca altaica and Cetraria cucullata in low cover-abundance. The Age I and Age III Gravel Hummocks Community (=IX) may lack these species. Colourful mats of Potentilla ledebouriana (Plate XXVA) and Silene acaulis are abundant on the NF-NL-I sites. Species on the eolian sand-covered Foxy-I gravel hummocks are quite similar to the OG-III hummocks (Table VIIIB in Appendix IVC). The floristic variability in the I(X) community appears to be greater than in the II(X).

Ecological differences between the various sites can account for all floristic differences. The CL-II gravel hummocks have a higher pH, are exposed to longer hours of sunlight, have the lowest elevations and probably receive less rainfall. The sites at the North Fork Pass area lie beneath the cloudy crest of the Ogilvies and are subject to longer periods of shading throughout the summer day. Maycock and Mathews (1966) indicate the preference of Salix planifolia for moist locations and show that neighbouring Salix alaxensis (a species akin to Salix glauca) is restricted to the drier spots. Also, according to Raup (1959) Salix glauca prefers drier habitats. Very probably, therefore, different distributions of the species of willow found within this community are determined by moisture though they happen to be geographically separated in this instance.

Shrub Thicket Community - O(X-M)

Stands placed in this grouping cover at least two thirds of the Aug. 17-I and NF-SL-I morainal surfaces. Since the former occurs near timberline and the latter is within the alpine zone, high floristic similarities cannot be expected between the stands of this group. Furthermore, Site No. 135 occurs on a slope and Site No.151 tends to be on an exposed crest of the NF-SL-I moraine. No doubt further sampling would permit subdivision of this grouping.

Betula glandulosa attains its highest cover-abundance in the Shrub-Thicket Community. The shrub is usually 60 to 80 cm high and forms a dense stand. Salix planifolia, S. glauca and Ledum palustre occur as intermittent B_2 layer components as well, and some alder and wild rose are present on the Aug. 17-I moraine. The ground mat is made up of combinations of Arctostaphylos alpina

rubra, Vaccinium vitis-idaea, Rhytidium rugosum, Hylocomium alaskanum and Empetrum nigrum, with the mosses usually dominant. In addition Cladonia spp. and Stereocaulon tomentosum are significant components. The most common species on the ground mat is Stellaria longipes but it occurs in low density. Grasses and sedges are rare.

Some of the Brown Wooded soils demonstrate weak eluviation beneath the mosses in the habitat of this community grouping. However, soil profiles can be disrupted by frost action as shown by "mud boils" near the till crest on Site Nos. 138 and 151. The community is similar to Viereck's (1966) "Late Shrub Stage" or Spetzman's (1959) "low shrub stage" of the "Flood Plain Community".

Parent Material-Environment Analysis

The fourth way of analyzing for possible relationships between vegetation and moraine age is to correlate vegetation with primary deposited parent materials of glacio-fluvial and glacial origin. That is, only those surfaces not blanketed by a surficial and younger silt are compared. These surfaces are the gravel hummock habitats, the mesic till crests, the hygric till crests and the till surfaces on slopes that occur on any two of the three ages of moraines. The community analysis has already covered the gravel habitats, as these features all occurred in one complex. Table XXIII, Appendix IVB and the community analysis show that the minor floristic differences between these gravel habitats are not related to age.

The vegetation analysis does not permit such easy direct comparisons of the other parent materials. The pertinent floristic indices for each group of parent materials are shown by Table XXIV. In the hygric till crest environments, the vegetation is much the same for all ages of moraines as shown by the floristic indices and by comparing cover-abundance of key species on the field site lists of the "B" tables of Appendix IVC.

In the mesic to moderately dry till crest environments, Table XXIV-B indicates that indices of similarity between the NF-NL-I (No. 143) and the CL-II (Nos. 223B and 220) moraines is high, whereas the NF-SL-I and Aug.17-I (No. 84) values are highly inconsistent within themselves. The high indices of similarity between Site No. 138 and Sites 220, 223B and 143 are not indicative because the important tussock sedge species are wanting from the first mentioned. Hence, Table XXIV-B realistically indicates strong floristic correlations between the NF-NL-I and the CL-II moraines as far as mesic till habibats are concerned.

TABLE XXIV. Indices of vascular floristic similarity for quadrats on till.

A. HYGRIC TILL CREST ENVIRONMENT

QUADRAT NO.	223A	165	220	304	MORAINE AND AGE
223A	X	.59	.42	.72	CL-II
165	.59	X	.51	.55	Foxy-I
220	.42	.51	X	.42	CL-II
304	.72	.55	.42	X	OG-III

B. MESIC AND MODERATELY DRY TILL CREST ENVIRONMENT

QUADRAT NO.	223B	220	143	151	138	84	
223B	X	.36	.57	.38	.46	.37	CL-II
220	.36	X	.53	.56	.53	.24	CL-II
143	.57	.53	X	.47	.44	.29	NF-NL-I
151	.38	.36	.47	X	.53	.27	NF-SL-I
138	.46	.53	.44	.53	X	.40	NF-SL-I
84	.37	.24	.29	.27	.40	X	Aug.17-I

C. HYGRIC AND MESIC TILL SLOPE HABITATS ± SLUMPED

QUADRAT NO.	122	164	152	111	306	
122	X	.36	.36	.21	.34	NF-SL-I
164	.36	X	.71	.40	.34	Foxy-I
152	.36	.71	X	.31	.24	Foxy-I
111	.21	.40	.31	X	.20	NF-SL-I
306	.34	.34	.24	.20	X	OG-III

Tills on slopes are more difficult to evaluate in this type of analysis for a certain amount of minor slumping has unknown effects on vegetation colonization. The C portion of Table XXIV indicates that floristic differences exist between an Age III and the Age I habitats. However, the former is influenced by a permafrost zone nearby, whereas all the others are not. The C portion of Table XXIV also indicates floristic dissimilarity among the non-permafrost slopes; this anomaly suggests why a phytosociological approach is preferable for the purpose of comparing vegetation on surfaces of different ages.

Discussion

Analysis of botanical data by a species presence or absence basis, by shrub shade factors, by comparisons of plants on equivalent parent material, and by a community analysis all fail to show differences related to the chronosequence of the moraines. A reason for this lack of correlation is that successional development of plant communities may be completed in a time span shorter than the age of the youngest moraine under consideration (or about 14,000 or more years). Viereck (1966) suggested that the climax community for permafrost terrain in the northern Cordillera is a "low shrub tussock" type, while Spetzman (1959) makes it his similar "niggerhead" type. The related type in this study is the Tussock-Tundra Community Complex. If they are a true climax, the results of this study indicate that climax can be attained in about 5000 years, certainly less than 11,000 years. However, other Alaskan investigators, for example Shacklette (1963), are more cautious; they claim that no typical mesic climax in permafrost terrain can be reached and the above communities develop only a "polyclimax".

In any event results from this study clearly corroborate Viereck's (1966) conclusion that a vegetation "climax" developed within a time span of not more than 9000 years and possibly less than 5000[7]. The material upon which his "Climax Tundra" is developed is a surficial loess; hence, the development of the community may have occurred much later than the deposition of the 5000-9000 year old underlying outwash surface. Viereck (1966) postulates a rapid early succession of communities on newly exposed surfaces that after 200-300 years reaches a "Late Shrub Stage". From this time onward, a rising permafrost table determines a gradual shift to the "climax tundra" which is freely developed after no more than 5000-9000 years. He associates the rise in the permafrost

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[7] The absolute age depends upon the extent of the "Rangifer Loess" - see Part 1 discussion on the Unit 5 Eolian Facies.

with the increasing thickness of the insulating ground mat. Both "late shrub" and "climax tundra" types of vegetation are found in many quadrats established in the North Fork Pass region.

However, in the study area permafrost does not occur so predictably. While permafrost is present in the Age I moraines to the north of North Fork Pass, the evolution of a thick ground mat of moss at sites on the pass has failed to raise the permafrost table. Hence other factors must play a part. Elsewhere in this report it is shown that surficial loess, finer till textures, and possibly slight climatic differences may control the presence of permafrost near the surface within the Blackstone and North Klondike valleys. Hence, taking Viereck's analysis a few steps further the following is suggested: his "Late Shrub Stage" is a climax or polyclimax as long as neither loess or permafrost invade the community; and his "Climax Tundra" is a good designation, for there are few differences between tundra communities developed on Age III, Age II, Age I and younger surfaces occurring within the writer's study area[8]. Community Grouping III or the Tussock-Tundra Community complex, was found on all three ages of moraine in this study.

The problem of "climax" in the permafrost zone has been briefly reviewed in the introduction. Within the study area, it is obvious from the processes now occurring in the periglacial cycle that no single climax is likely to develop everywhere in the area. All the communities in the region are close to "steady state" as long as they are not disturbed by cryoturbation, congeliturbation, or thermokarst processes. The interactions of these processes on vegetation development are discussed by Benninghoff (1952). However, since these periglacial events do take place periodically, "climax" must be regarded as a series of repetitious cycles in several communities rather than a directional trend in succession. As Churchill and Hanson (1958) state " - - phasic cycles that occur in these communities resulting from frost action are considered to be within the framework of the broad concept of climax types as long as the cycles are not directional as they occur in succession". In the study area, the "phasic cycles" are occurring outside of as well as upon the permafrost-affected till zones. Hence, the concept of successional trends towards a "climax" will not be successful as an age indicator of these moraines, for long-enduring vegetation patterns are established in a time interval much

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[8] One wonders whether the development of moss was really the main cause of the rise of the permafrost in Viereck's study area. He mentions the gradual increase in eolian silt as the successional trend of communities develop; silt sizes are notoriously frost susceptible (Troll, 1944).

briefer than the age of the youngest moraine. The disrupting "phasic cycles" in the vegetational mosaic have a briefer time span yet, and thus are of no use in age correlation.

Because of phasic cycling and permafrost, a successional trend of development to the classical climax mesic community of the Clementsian concept cannot be demonstrated in this region of study - a fact demonstrated elsewhere in the northern Cordillera by Shacklette (1963), Drury (1956) and others. If anything, tussock tundra indicates a trend to the development of hydric conditions as indicated by the Wet Tussock-Strangmoor Community. That is, moisture continues to build up in the moss and tussock as permafrost prevents its removal by normal drainage.

The development of successional vegetation on the gravel hummocks would occupy less than the Age I time span. Since the greater proportion of such hummocks are not blanketed by loess or eolian sand, "phasic cycles" are probably absent and a constant (though not mesic) climax could theoretically be established. However, uniform climax community cannot be recognized for these habitats are dry, exposed and scattered. According to Bliss (1962), in such habitats physical environmental factors exceed biological competition; the end product vegetation is more apt to be a "random occurrence of plants with few distinct associations". Certainly this was the situation among the gravel hummocks within the study area; the specific differences found can in no way be construed to represent successional trends.

The results of this survey also indicate the close association between community grouping and climate as indicated by the presence or absence of certain permafrost features. The Tussock-Tundra Community covers only a small area at the North Fork Pass area, but it increases in the downvalley direction towards the Chapman Lake area some 40 km to the north. That is, a continuum of communities trending from boreal types in the south to subarctic-arctic types to the north coincides with probably permafrost or climatic gradients. In the sylvotundra about the Ennadai Lake region of the Canadian Shield, Larsen (1965) found a radical change in flora along an 80 km south to north transect and related these changes to the observed decrease in rainfall and temperature. Maini (1966), on the other hand, could find changes from the wide-ranging forest communities to the arctic tundra communities on northward facing slopes only, just to the west of Larsen's work. However, Larsen's type of precipitation pattern exists in the Ogilvies; the writer frequently encountered cloudy and wet conditions at North Fork Pass (the axial portion of the southern ranges) while sunshine occurred in the open Taiga Valley region to the north. Furthermore,

the permafrost features indicate a colder annual temperature in the Taiga Valley region as well. At any rate, arctic tundra communities were not confined to north slopes in this study area - contrary to Maini's findings.

Communities established in this survey exhibited varying relationships with soil, moisture, permafrost and parent materials. The Wet Shrub-Meadow Community was found on a variety of moist to wet parent materials away from the permafrost zone and were generally underlain by regosolic or gleysolic soil profiles. Snow-lie and Shrub-Thicket communities are developed on Brown Wooded soils overlying a till away from the permafrost influence. However, the Shrub-Thicket occurs occasionally on degraded varieties of the Brown Wooded Great Soil Group; eluviation takes place where a thick layer of moss covers the soil and where frost disturbances have not recently taken place. Shacklette (1963) noted the same phenomenon and attributed podzolization to the increased amount of water made available by the moisture retention qualities of the overlying moss mat. Gravel hummock communities I(X) and II(X) generally occur on Brown Wooded soil profiles - slight eluviation may have taken place in some profiles. One xeric stand, however, was found on an Orthic Regosol soil profile with a sandy parent material. The Tussock-Tundra Community occurs on a variety of organic, regosolic or gleysolic profiles; the permafrost-encased mesic to hydric parent materials are peat, reworked silt, or till.

Thus, communities show only a vague relationship to the soil profile. The mesophytic to xerophytic communities tend to be, but are not always, associated with the Brown Wooded soils. The hydrophytic communities are generally associated with the azonal and intrazonal soil types. Tedrow et al (1958), Raup (1947) and Shacklette (1963) found nearly the same relationships in the subarctic and arctic region of the northern Cordillera. The last author points out that " - - if we consider soils from the taxonomic standpoint as Great Soil Groups presumed to be established on a genetic basis the relationship of recognizable plant communities becomes vague, erratic and confusing - - - this is in part due to the difference in allowable ranges of variation that are inherent in the two sets of categories". Soil and vegetation development are more closely related to drainage or permafrost than they are to each other. In non-permafrost areas of the subalpine parkland zones (Brooke, 1966) and alpine tundra regions (Bliss, 1962), the correlation between soils and community types tends to exhibit a greater stability; such inter-relationships cannot be expected in subarctic and arctic regions, for extensive frost action creates unstable soil situations without always severely changing or disrupting the overlying vegetation mat.

GLACIAL CHRONOLOGY

INTRODUCTION

At present the most complete record known of the Pleistocene Epoch in the northern Cordillera is from the Cook Inlet area of coastal Alaska (Figs. 1 and 5). The alternating succession of glacial drift and marine transgression deposits covers a span of time from Nebraskan to Recent. Alaska investigators have been able to date a portion of this succession by radiometric methods. In addition, tills too old to be dated by ^{14}C techniques have been given relative ages deducted from quantitative ratios of certain weathering features. Furthermore, absolute dating by disequilibrium methods on shells in transgressive beds elsewhere along the coast has been found to be stratigraphically useful at Cook Inlet to confirm drift ages calculated by the preceding methods. The record as it now stands (Table XXV) shows strong correlation to long established chronologies in continental glaciated areas of Europe, North America and Siberia. This work has been summarized in the INQUA "Central and South Central Alaska" field conference guidebook by Karlstrom (1965).

Karlstrom's Cook Inlet chronology has been compared by Péwé et al. (1965) to most other inland glacial sequences known in Alaska, as shown in the left-hand columns of Table XXVI. All of these inland localities, however, suffer from a dearth of absolute age determinations earlier than Late Wisconsin. Illinoian till (100,000 - 170,000 yrs. B.P.), for example, is assigned this age "based upon similarities in surface expression and similarities of position in local glacial sequences to the Illinoian drift in the Kotzebue Sound, Nome and Cook Inlet areas" (Péwé et al., 1965). However, such age assignments are at times difficult, for it is realized that the preservation of Illinoian drift varies greatly in different physiographic settings. Not only does the surface expression of the moraines vary, but also, for example, the preservation of granitic clasts within the surficial portion of the drift can vary from non-weathered to totally rotten. Older drift, including the Illinoian, does not develop a diagnostic deep-weathered soil profile in the northern regions of Alaska.

To further complicate matters, a complete successional sequence of moraines is not always present in some Alaskan localities (Early Wisconsin may be missing), and in other areas Early and Late Wisconsin drifts are not easily separable. More often than not the Early Wisconsin is dismissed as having not been deposited, though in some cases recent "juggling" of sequences has created this hiatus perhaps unrealistically. Péwé et al. (1953) always included the

TABLE XXV Karlstrom's Correlation of Cook Inlet Quaternary Events to Continental Chronologies[1]

YRS B.P.	COOK INLET GLACIAL CHRONOLOGY	DATED MARINE TRANSGRESSIONS	CORRELATIONS WITH CONTINENTAL CHRONOLOGIES		
			NORTH AMERICA	N. EUROPE	SIBERIA
1450	Alaskan Glaciation: Tunnel Advs.; Tustumena Advs.	Girwoodian	"Little Ice Age"	Sub-Atlantic	
		Kasilofian		Sub-Boreal	Postglacial
5500			Altithermal	Atlantic	
9000		Kruzensternian	Cochrane	Boreal	
	Tanya Advs.			Pre-Boreal	
12,500	Skilak Advs.		Mankato or Valders	O & Y Dryas	
15,500	Naptowne Glaciation: Killey Advs.		Cary	Bolling	Norilsk (Sartan) Glaciation
19,000	Moosehorn Advs.		Class. Wisc.		
	Pre-Moosehorn Advs.		Tazewell	Older Wurm II Deposits	
			Morton, Roxana, Farmdale Loesses, Port Talbot		
38,000		Woronzofian		Gottweig	Karginian Trans.
48,000	Knik Glaciation		Pre-Classical Wisc.	Wurm I	Zyryanka
78,000		Pelukian	Sangamon	R/W	Kazantsevian Trans.
100,000					
170,000	Eklutna Glaciation		Illinoian	Riss	Yenessy
175,000		Kotzebuan	Yarmouth	M/R	Oplyuny-Samburg Beds
210,000	Caribou Hills		Kansan	Mindel	Bakhta
224,000		Middletonian	Aftonian	G/M	Panteleyev Beds
>224,000	Mount Susitna		Nebraskan	Gunz	Baikha
>2.7MY	Beginning of Quaternary*				

*. Personal communication, R.R. Curry, University of California at Berkeley.

[1] Adapted from Karlstrom, 1965.

TABLE XXVI Proposed correlation of the central Yukon Quaternary sequences to nearby Alaskan chronologies.[5]

YRS B.P.	Cook Inlet, Alaska	S.W.Yukon Plateau	Alaska Range		Brooks Range		Southern Ogilvie Mtns.				Eastern Yukon Plateau	
			Big Delta	Amphitheatre	Central	Eastern	Possibility A	B	C[1]	D	Possibility A	B
	Karlstrom, 1965; Péwé et al.,1965.	Krinsley[4] 1965.	Péwé et al., 1965; Péwé 1965.	Péwé et al., 1965; Péwé, 1965.	Porter, 1964; mod. by Péwé et al., 1965.	Holmes & Lewis, 1961; Péwé et al.,1965	This report[3]				Bostock, 1966, 1936; Péwé et al., 1958.	
125-1450	Tunnel I	Kaskawulsh II	Black Rapids	Glacial Adv.	Fan Mtn.	Cirque I	"Rock Gl.A" & "Little Ice Age"				?	
2000-3500	Tustumena	Kaskawulsh I			Alaph Mtn.	Cirque II	"Rock Gl.B" and Rangifer Loess"				?	
5000-9000	Tanya St.	Tchawsahmon IV	Summit L.	Glacial Adv.	Anivik or Echooka	?	Recessionals(?)				Non-correlated advances McMillan Plateau	
ca.9600-10,900							"Blackstone Loess"**					
12,500-13740*	Skilak St.	Tchwsahmon III	Donnelly	Denali II	Antler Valley	Peters	"North Fork-I"	(NF)	(NF)[2]	(NF)	Non-correlated advances N.E.of Minto Bridge, etc.	
15,300	Killey St.	Tchwsahmon II	Donnelly	Denali II	Anaya-kraurak	Peters	"Chapman L.-II"	NF	NF	NF	(McConnell)	McC.
19,000	Moosehorn St.	Tchwsahmon I	Donnelly	Denali II	Banded Mtn.	Peters	"Taiga Valley-IIA"	CL	NF	NF	McConnell	N.C. Adv.
> 19,000-< 38,000	Pre-Moosehorn	Snag II (Recess.)	Donnelly	?	-	?	-	-	CL	-	N.C. Adv. Willow Ck.	N.C. Adv.
48,000-78,000	Knik	Snag I	Donnelly	Denali I	-	Schrader	"Ogilvie-III"	TV	TV	CL	Reid	Reid
100,000 170,000	Eklutna	Donjek	Delta	Delta	Sagavanirk-tok	Chamberlin	?	Og.	Og.	TV	Klaza	Klaza
175,000-210,000	Caribou U.	Nisling	Darling Ck.	Darling Ck.	Anatuvuk	Weller	?	?	?	Og.	Nansen	Nansen
>224,000	Mt. Susitna	-	-	-	-	-	?	?	?	?	Unnamed older drift	Older drift

* Formerly the maximum published date for this stade was 13,300, but if the Foxy Moraine at North Fork Pass is correlative of this stade of ice advance the date may be 13,740 ± 190 yrs B.P.

** Associated with a prominent recessional phase moraine in the upper "main" Blackstone Valley (?).

[1] Currently favoured proposals by writer.

[2] Brackets indicate that main pulse of ice was prior, but recessional phases persist to this time interval.

[3] All nomenclature in this section of the table is strictly local; the Roman numeral behind the names refers to abbreviations used in the text of this thesis I = "blue limit" or last glaciation (stade), II = "red limit" or intermediate glaciation or ice advance or stade, IIA = older stade or glaciation, III = oldest recognized glaciation.

[4] Müller (1967) would term: all Tchwsahmons as St. Elias, all Snags as Ruby, and the combined Donjek and Nisling as the Nisling of unspecified pre-Wisconsin age.

[5] Various regions are located on Figure 5.

two-fold system of Early and Late Wisconsinan moraines, but a few moraines formerly assigned to the Early Wisconsinan have been redesignated as Illinoian in the 1965 diagnosis by Péwé et al. In the Central Brooks Range recent radiometric dating (Porter, 1964) has forced the reverse trend - the two-fold "Early and Late" sequence was subdivided into - four advances of the Late Wisconsin - the most recent being 9000 to 6000 yrs. B.P.

Part of the age designation problem centres about what time span constitutes the actual Early Wisconsin. Péwé et al. (1965) and Karlstrom (1965) now agree, at least for the time being, with Flint's (1963) diagnosis of the beginning of the Wisconsin Glaciation at approximately 70,000 years B.P.; the Early Wisconsin terminated about 48,000 years B.P. according to Karlstrom but lasted, perhaps, to as late as 30,000 years B.P. according to Péwé et al. (1965). Since absolute dates are few and far between for the Early Wisconsin time span, the relation of inland age relationships to the "standard chronosequence" of moraines, if it exists, will remain in question no matter what indirect analyses are attempted.

SURROUNDING GLACIAL CHRONOLOGY TO MAP-AREA

The published chronologies of investigated terrain pertinent to the North Klondike-Blackstone study area have been outlined in the introductory chapter of this report and are located on Figure 5. Some of these chronologies are listed in Table XXVI; however, a few comments are in order before regional correlations are attempted with this study area.

Firstly, the chronologies of Holmes and Lewis (1961) relied heavily on correlation of their Eastern Brooks Range sequence with a comparable sequence established previously in the Central Brooks Range (Detterman, 1953; Detterman et al., 1958), and to Holmes first-hand experience with the characteristics of the glacial sequence in the Johnson River area on the north slopes of the central Alaska Range. Since their publication in 1961, these supposedly comparable chronologies have been changed by Péwé et al. (1965) as previously mentioned. Thus, the correlation established between the two areas as based on similar morphological appearance of moraines has now been abandoned. Admittedly Holmes and Lewis complained about the lack of topographic correlation of their Weller Glaciation to the Sagavanirktok or Anaktuvuk in the Central Brooks Range, but they noted that correlation of old drift is bound to be awkward because differences in lithology, mass-wasting and thermokarst activity will most likely produce different "end" products on a long term basis.

Secondly, investigations in the Alaska Range are numerous and all are, at present, in agreement with one another. Since the region is not too distant from Cook Inlet, since the north slope glaciations can be vaguely related to radiometrically-dated loess sequences near Fairbanks, and since a fairly complete record of glacial advances exists throughout this region in the later portion of the Pleistocene Epoch, there is little doubt concerning the chronologies assigned by Péwé et al. (1965). Only two localities from the many that exist are indicated on Table XXVI. North of the north slope of the Alaska Range small valley glaciation sequences in the Yukon-Tanana Upland (Péwé and Burbank, 1960) would seem to provide a close link to the sequence in the western regions of the Southern Ogilvie Ranges. Unfortunately this work is based strictly on photo-geologic interpretation and has been published only in abstract form to date[1]. A two-fold morainal sequence representing an Illinoian and undivided Wisconsinan ages is indicated by morphologic and successional comparison with similar moraines in the Alaska Range.

Thirdly, Krinsley's (1965) investigations are not included in the summary tabulation by Péwé et al. (1965). Fortunately Krinsley has had field experience with the Cook Inlet sequences and he feels that, despite geographic distances and climatic differences, the complete sequence of moraines ties in with Karlstrom's chronology as shown in Table XXVI. The writer has made one adjustment in this correlation whereby the Snag II (recessional) has been tentatively correlated with the Cook Inlet pre-Moosehorn Ice Advance - a stade apparently not known to Krinsley at the time of his publication.

Unfortunately the above investigation is tarnished by a lack of co-operation between Krinsley and the Geological Survey of Canada; for Muller (1967) has overlapped about 50% of Krinsley's mapped area and in the process applied, unfortunately, the following confusing nomenclature: St. Elias Ice Advance (= Tschwsahmon undiff.), Ruby Glaciation (= Snag undiff.) and the Nisling Glaciation (= Donjek and Nisling non-divided). Though Muller's publication represents an impressive piece of mapping it suffers from not having been extended far enough north to pick up the older morainal termini. It makes no mention of Krinsley's investigations or the review paper by Péwé et al. (1965), because of the time lags between manuscript submittal and actual time of printing. As a result Muller's suggested chronology becomes incon-

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[1] The writer was able to discuss this area with Dr. T. Péwé. Manuscript maps and aerial photographs of the sequences of moraines were reviewed and compared to the sequence on the south slope of the Southern Ogilvie Ranges.

sistent, for his sequences are equated to Wahrhaftig's (1958) chronology established from the Nenana River area of the Alaska Range. Hence, Muller made the following assumptions: his St. Elias = Riley Creek of Late Wisconsinan; his Ruby = Healy Creek of Early Wisconsinan; and his Nisling = Browne Glaciation of pre-Illinoian ages. Why the lattermost was not assigned to Wahrhaftig's intervening Dry Creek Glaciation instead of the Browne is not stated. The Healy Creek (and Ruby) have since been assigned to the Illinoian by Péwé et al. (1965); hence, an Early Wisconsinan void develops if Muller's correlations are accepted. This void is undesirable when Krinsley (1965) can demonstrate morainal termini to spare to the north of Muller's mapping. For this reason the writer will confine his correlations to Krinsley's (1965) interpretation. This entire area is currently being re-evaluated by Rampton (1967) under the direction of Dr. O. L. Hughes of the Geological Survey of Canada.

Lastly, the work of Hughes (1966) fills in a few gaps existing between Bostock's (1966) and Vernon and Hughes' (1966) mapping. Strangely, the last two efforts are not tied into or referred to one another despite the fact that both were conducted by the Geological Survey of Canada and that their map areas have a common boundary as shown by Figure 5. Bostock mapped a sequence of four or more moraines on the Yukon Plateau but does not offer any correlations, whereas Vernon and Hughes tentatively placed the youngest or Age I "blue limit" (Fig. 4) as synchronous to the Wahrhaftig's (1958) Riley Creek advance (Late Wisconsin). The new work by Hughes (1966) suggests a "classical" Wisconsin age for the "blue limit" and for Bostock's McConnell Moraine, and a "pre-classical" Wisconsin for what is inferred by the present writer to be the Reid Moraine of Bostock (1966) and the Age II "red limit" (intermediate age) of Vernon and Hughes (1966). Hughes does not suggest an age for Bostock's older glaciations.

TENTATIVE GLACIAL CHRONOLOGY OF THE NORTH KLONDIKE - UPPER BLACKSTONE REGION

Pleistocene Age Data and Its Correlation

Radiocarbon dates useful for determining the absolute chronology of the moraines in this study area and adjacent regions are given in Table VI. The important dates in this table indicate that the Foxy-I and other nearby Age I moraines were deposited prior to 13,740 B.P. Date No. G.S.C. 331 on Table VI indicates that the morpho-stratigraphically equivalent McConnell Moraine (Bostock, 1966) is less than 46,580 years old. Hence, fitting these dates

into either Table XXV or Table XXVI leaves no doubt of Hughes' (1966) assignment of the "blue limit" (Age I) or McConnell Moraine to the "classical" or Late Wisconsin. From the Foxy-I bog date its reasonable to assume that the stade of maximum advance was prior to 14,000 years B.P. Heusser (1960) placed the time of maximum stadial advance of the Late Wisconsin at about 15,000 years B.P., while Karlstrom (1965) assigned maximum advance to the 19,000 year old Moosehorn Stade of Cook Inlet. The difference between these two opinions may reflect a time lapse in the more southern localities studied by Heusser. Hence, it appears to be a fair assumption to correlate the maximal advance of the glacier in the "Foxy Creek" basin with the Moosehorn or Tchwsahmon I stadial advances as shown in Table XXVI. It should be noted that lateral portions of the Foxy Creek and correlative North Fork Pass Moraine lack the boulder-strewn and reverse-slope characteristics of the supposedly equivalent Peters moraines of the Eastern Brooks Range.

The chronology and correlation of the "red limit" (Age IIA and Age II) is the next consideration. By extrapolation of the maps published by Vernon and Hughes (1966) and Bostock (1966) it is apparent that in some cases the "red limit" of the former work is a correlative of the Reid Moraine defined by the latter. The oldest radiocarbon date taken from a bog on this sequence of moraines is only 13,870 years B.P., but sample No. G.S.C. 181 (Table VI) indicates that a Snake River boulder till (northeast of Vernon and Hughes' mapping - Figs. 2 and 5), lying beyond a Late Wisconsin moraine, is older than 31,000 years. Though the writer is not familiar with the geology of this locality, presumably this till represents the next older morainal sequence in the area and should therefore be either Early Wisconsinan or Illinoian in age.

Herein lies the problem. Because of the apparent absence of Early Wisconsinan drift in some important Alaskan sequences there is no guarantee that it has to be present, or absent, in central Yukon Territory. Recognition of the Early Wisconsinan as compared to the Illinoian in much of Alaska has been dependent on surface form and weathering of the soil profile. According to Péwé et al. (1965) Illinoian moraines are "smoothly rounded ridges with irregular crests and gentle slopes devoid of primary microrelief features and are incised by consequent gullies" developed in thick layers of loess; kames, eskers, minor morainal ridges, etc. have been obscured by mass-wasting and colluvial deposition. More often than not Early Wisconsin morainal topography cannot be distinguished from the Late Wisconsin, though in central Alaska the two can be differentiated on the basis of a more deeply developed soil profile in the older. The soil profile characteristic, however, is not useful on the permafrost-encased north slope of the Brooks Range.

In the discussion of terminal moraines in Part 1 and in the results of Part 2A, 2B and 2C of this thesis it was demonstrated that the Age II Chapman Lake Moraine could not convincingly be distinguished from some Age I moraines in the North Fork Pass area by either microrelief, pebble weathering or soil profiles. Both ages of these similar-appearing moraines have much in common with the Schrader Moraine of the Eastern Brooks Range. Furthermore primary microrelief is well preserved on all of these. Considering this and a poor soil profile development, the Chapman Lake Moraine is tentatively assigned to an age no greater than Early Wisconsin. Hughes (1966) also suggests that the Reid Moraine of the Stewart Plateau is of this age. Since the Reid advance is in a geographic and successional position similar to the Age II Lower North Klondike Moraine, and since there is an abundance of primary relief ice contact features on at least the latter, it is probable that the two are of Hughes' (1966) Early Wisconsin designation. The soil profile on the till of the Lower North Klondike Moraine is also much thinner than the 1.2-2 metre thick profiles on the climatically-comparable Delta moraines assigned to an Illinoian age by Péwé et al. (1965).

The Age IIA Taiga Valley Moraine, however, has yet to be sorted out, for its primary features are also well preserved. Since the writer had difficulty in separating this sequence from the Age II sequence upvalley, the Chapman Lake Moraine (Age II) may only represent a recessional advance of the Age IIA Taiga Valley ice advance. Hence, the Taiga Valley would be Early Wisconsin, and the Chapman Lake would be of a slightly younger age. Such an arrangement is shown by the Snag I and Snag II (recessional) Moraines of presumably equivalent age relationships by Krinsley (1965) as indicated in Table XXVI. The age of this recessional advance is believed by the writer to be greater than 31,000 but less than 38,000 years B.P. The alternative view is to regard the Taiga Valley Moraine as Illinoian - thus acknowledging the preservation of primary microrelief of this age on the north slope's arctic type of environment. This would, of course, require modifications of the chronology in the lower North Klondike region.

The oldest drift (Age III) in the area is equally difficult to date. The well oxidized gravels beneath the Age II till in the lower North Klondike region would easily meet Illinoian or Sangamon Interglacial age criteria; however, the Age III Ogilvie Ground Moraine occurs scarcely modified on level upland localities on the north slope of the ranges. Soil profiles on this moraine are not noticeably different from those on the younger moraines, and despite the generally subdued appearance of the surface, some microrelief is preserved in the form of

hummocky ablation moraine. According to the accepted characteristics of old moraines in the northern Cordillera this feature should not be even as old as Illinoian, but taking the environment into consideration the feature probably represents a drift of Illinoian age. However, the feature resembles the descriptions of the ground moraine portions of the Chamberlin and pre-Illinoian Weller drifts as exposed on similar situations on the north slope of the Eastern Brooks Range. The older Weller drift exhibits some gravelly primary (?) relief as well (Holmes and Lewis, 1961).

In view of the erratic correlations between the map-area and the Eastern Brooks Range, and considering the recent changes in the Central Brooks Range chronology, it seems to the writer most likely that each of the glaciations designated by Holmes and Lewis (1961) has been misplaced by Péwé et al. (1965) in the chronologic sequence shown in Table XXVI. If the Peters ice advance is moved up to the 5000 to 9000 year old stadial position on the table, and all older sequences are correspondingly moved to the next younger position so that the Weller falls into the morainal sequences (Delta, etc.) of the Illinoian Glaciation, then the chronology would not only be morpho-stratigraphically comparable to this report, but also would better fit the chronosequence of moraines in the Central Brooks Range. The implication here is that the embarrassing absence of the Early Wisconsin Glaciation in the Central Brooks Range may be only an ephemeral artifact; that is, its Sagavanirktok and Anaktuvuk moraines could correspondingly be shifted up to younger glacial intervals in Table XXVI.

The age of the oldest surficial deposit (Fig. 9B) in the map-area remains highly conjectural on the Pleistocene time scale. Hughes (personal communication) questions whether they were even deposited in the Pleistocene Epoch; but since they are similar to Bostock's (1966) description of the Nansen drift, a Kansan or Nebraskan age is not impossible (Table XXV). This suggestion is based on the assumption that the younger Klaza drift is of the Illinoian Glaciation - a likely possibility provided that the successional sequence is as complete as Bostock's (1966) map would suggest.

Post-glacial Correlations

The second of two rock glacier advances and the ice advance of the "Little Ice Age" appear to fit similar Neoglacial events dated botanically and radiometrically in Alaska and in the southwest Yukon (Table XXVI) or for that matter, elsewhere in the world. The first rock glacier advance is not so well dated but also appears to be correlative to an earlier advance of post Hypsithermal age found elsewhere in Alaska and in the higher mountains of continental United

States (Outcalt and Benedict, 1965). No doubt some of the recessional moraines situated at the thresholds of some cirques in the Southern Ogilvie Ranges correlate with an "Early Post-glacial" ice advance as recorded in some Alaska Range localities. The 10,000 year old "Blackstone Loess" is of especial interest for most post-glacial loess appears to have been deposited 8000 years or less B.P. for localities near glaciated areas in Alaska. The 10,000 year old loess deposition in the map-area suggests a lack of prolonged stagnation of extensive ice masses in major valleys near to the axis of the Southern Ogilvie Ranges -- that is, much ice had totally melted away by the close of the Late Wisconsin stade. Such quick total melting was not reached in the moisture catching Chugach, Icefield, Alaska, and Brooks ranges (?) until a few thousand years later. Hence, post-glacial loess stratigraphy over vast regions must be used warily, for there appears to be a time lapse in its deposition following the last advance in the Late Wisconsin of the northern Cordillera.

Conclusion

The chronology developed in the foregoing has obviously been that of schedule C in Table XXVI. For the post-glacial there appears to be no controversy on the Hypsithermal (Altithermal) interval at 6,000 ($\pm$) to 3,000 years B.P. and a subsequent two-fold glacier and rock glacier cycle. However, the Pleistocene chronology begins with the assumption that the "North Fork Pass Ice Advance" reached its zenith at 19,000 ($\pm$) years B.P. Conceivably it may be only 15,500 ($\pm$) years B.P., and remotely possible is 12,500 ($\pm$) years B.P. The last is not likely, for a large portion of the "North Fork Pass Glacier" had wasted back beyond an inner set of recessionals (12,500 yr. B.P.?) by at least 11,250 years B.P. Since the bog date on the nearby Foxy Creek Moraine is 13,740 yr. B.P. possibility A of Table XXVI is not currently favoured.

Possibility B is more likely, but if the Snake River radiocarbon date (Table VI) is as significant as the writer believes then the Chapman Lake Moraine (at 17,000 years old) being a recessional of an ice advance older than 31,000 years, would not fit the chronology too well. Possibility D also has merit as it would fit most other surrounding regional chronologies given in Table XXVI; whereby the oldest glaciation (Ogilvie) would synchronize with the oldest glaciations found at most locales in Alaska and the Yukon. However, the writer is not convinced that the Age III Ogilvie Ground Moraine is the oldest; older erratics may be present in the area, and Vernon and Hughes (1966) remark on an older glaciation to the east of the region. Also this chronology (D) poses intolerable problems in the Lower North Klondike Moraine region. Not

only does Possibility C avoid these problems it also has support from two full chronologies found elsewhere (S.W. Yukon Plateau, Cook Inlet). Further support of this chronology is suggested by the presence of an uncorrelated moraine lying at Willow Creek between the McConnell and Reid Moraines on the Stewart Plateau (Bostock, 1966); the chronosequence of these moraines is similar to the NF-NL-I, CL-II and TV-IIA relationships found in the map-area. Such a proposed chronology would better explain the lack of gross weathering differences between the morainal sequences, as discussed in Part 2 of this report.

Despite the foregoing chronologic reasoning, none of the four correlation possibilities is impossible; all assumptions involve the correlation of events occurring in the rain shadow of the northern Cordillera, with events produced in an environment situated windward of the maritime air masses. Radiometric dating of the Pleistocene events in inland localities is far from satisfactory or sufficient, and at present they do not guarantee the synchrony of events over the widespread area; quick response to major climatic changes has been assumed to date. As far as the writer is aware stratigraphic correlation from an accurately dated moraine in a maritime locality with that of an inland locality has not yet been done, and unless the Pleistocene tephrochronology of the northern Cordillera is work out, such correlations may never be possible.

SUMMARY AND CONCLUSIONS

1) The Southern Ogilvie Ranges have been subjected to at least five distinct (?) ice advances during the Quaternary Period. One of these ice advances occurred in Recent times, but its development was limited to only a few cirques located on the axis of the ranges. During the Pleistocene Epoch ice cover was much more extensive and at one time reached higher than the 1950 m contour in at least the central portions of the ranges. As elsewhere in the northern Cordillera, each recognized advance of ice was successively less extensive than its predecessor. The volume of ice during any advance was perhaps slightly greater on the south slopes of the ranges than on the north slope. Glaciations and ice advances have only modified a drainage pattern developed probably during the latter part of the Tertiary Period. The only notable subsequent change in drainage appears to have taken place at the Lee Creek-Fish Creek area during an older Pleistocene glaciation. After the maximum development of each glaciation or ice advance, deglaciation was accompanied initially by a copious aggradation of debris on the valley floors. The volumes of outwash debris following the last two Pleistocene ice advances were nearly identical on both the north and south slopes of the ranges. As the deglacial interval passed into the succeeding interglacial or interstadial period aggradation on valley floors gave way to degrading fluvial conditions. Degradational fluvial activity is taking place within the map-area today.

The youngest (Age I) Pleistocene ice advance was limited to valley glaciers, such as occur in portions of the central Alaska Range today. The Age I glaciers developed in the headward portions of most tributary valleys of the Blackstone, North Klondike, West Hart, O'Brien and Chandindu drainage systems. At least two to three recessional phases, not necessarily synchronous from one valley to the next, took place in the waning stage of the Age I episode. Judging from elevations of cirque floors, lowest in the southeast, storm tracks responsible for the supply of precipitation during the late stages of the Age I ice advance must have approached from this direction. Hence moisture was probably derived from the cyclonic storm centres in the Gulf of Alaska.

The next older (Age II) ice advance is marked by morainal termini located much farther downvalley than the Age I ice fronts. This period of ice advance was characterized by trunk glaciers of low surface gradient (10 m/km) radiating from a common transection or through glacier system, such as are found in the Icefield Ranges today. The deglaciation of the trunk glaciers included at least two phases of recessional advance during the gradaul ice wasting period.

Ice terminus retreat accompanied downwasting, but few detached ice masses were produced during the deglaciation.

Above and surrounding the Age II Chapman Lake Moraine at the north end of the map-area an older but only slightly more extensive "Age IIA ice advance" is recorded by the intermittent occurrence of the Taiga Valley Moraine. The time span between the Age II and Age IIA was probably relatively short - the Age II Chapman Lake Moraine may be in fact only a recessional pulse of an overall "Age IIA Ice Advance".

The fourth and oldest known (Age III) Pleistocene ice advance blanketed most of the map-area as a mountain ice sheet with probable accompanying piedmont and outlet glaciers such as are shown by the ice cap on Axel Heiberg Island today. Aside from a few possible nunatak situations only two "windows", located on the eastern boundary of the map-area, escaped ice cover, but due to the lack of elevated flat-lying terrain the exact extent of the Age III ice may never be known. Morainal termini of this episode, if deposited or preserved, would lie outside the map-area.

2) Both continuous and discontinuous geomorphic processes have been and are taking place in the map-area. Continuous processes are those of the fluvial, colluvial, paludal-organic, and mass-wasting cycles, whereas glacial-deglacial, eolian and the periglacial division of the mass-wasting cycles make up the discontinuous processes. One to several facies and sub-facies of deposits are associated with each cycle and a few deposits were developed by two or more simultaneously-acting processes. The depositional history in the area is accordingly complex.

The glacial-deglacial cycle has been subdivided in the manner of Fulton (1963) into the glacial, stagnating, and dead phases (or facies of respective deposits) which indicate the regimen of ice during the deposition of a particular facies. The glacial facies denotes deposition by or in response to actively moving ice during the initial and optimum periods of development of ice in the glacial episode. Deposits characteristic of this facies are distributed throughout the length of most valleys on the lower walls and floors. The stagnating facies refers to deposition by or in response to a wasting ice surface - that is, actively moving ice where rate of ablation exceeds the rate of supply of ice. During the stagnating condition the surface of the glacier is convex-up in transverse profile; hence ice marginal drainage and deposition is typical. However, in the map-area deposits of the stagnating facies are most prominent at the terminal zones of former glaciers

within the map-area. The dead facies denotes deposition, mainly by water transport, around, on and under an inactive glacier or detached ice blocks. The surface of the ice is irregular in transverse profile; in shaded valleys a concave-up profile may have developed. Subglacial drainage and deposition is typical of but not limited to the dead ice phase. Eskers, crevasse deposits, kettled terraces and some ablation moraine hummocks denote deposition during the dead ice phase - that is, such features would most likely not survive in their distinctive forms if deposited while ice was actively moving. Within the map-area deposits of the dead ice phase are very sporadic in occurrence. Since polar type of ice is not conducive to subglacial drainage until final wastage, and during the deglaciation marginal retreat kept pace with ice surface downwasting, the dead ice phase had only limited opportunity to develop in the deglacial cycle. The record of detached or dead ice conditions are best preserved in the upper portions of the "main" Blackstone valley.

The eolian cycle was intermittently present in the map-area in association with the glacial-deglacial cycle. Loess covers most flat portions of the map-area and ventifacts were discovered only in regions near one Age II glacier terminus. Two loess sheets later than the "Age I ice advance" are recognized in the area; older loess sheets have been destroyed by mass-wasting (frost disturbance), colluvial and glacial activity. Deposition of the "Blackstone Loess" spanned a 1300 year interval about 10,200 years B.P. (Early Post-glacial or Late-glacial of Age I) while the "Rangifer Loess" appears to have been deposited during or at the close of the Hypsithermal interval about 3000-5000 (and earlier?) years B.P.

The fluvial cycle encompasses processes on both fluvial and subaerial environments. The fluvial environment is confined to the central axis of valley bottoms whereas the subearial environment tends to predominate on lower valley-wall slopes. However, the demarcation of facies spearating these two environments is arbitrary. Deposits of both occur throughout the valleys of the map-area and are recognized on a two-fold age basis whereby the older (Early Postglacial) are generally recognized by the presence of high escarpments and the younger (Late Postglacial) are typically devoid of any surficial debris such as loess, colluvium or solifluction deposit.

The paludal-organic and mass-wasting cycles are subdivided in this map-area into those that operate in the presence of a permafrost environment and those that would operate if the periglacial cycle were not present in the area. In the latter instance successional conversion of lakes and marshes into bogs are common only in the portion of the map-area lying south of the North Fork

Pass region. Of the mass-wasting processes those (e.g. solifluction lobes) associated with permafrost are spectacularly significant in the map-area. Landslide activity and talus accumulation are significant depositions independent of the presence of permafrost.

An ubiquitous mixed facies blankets the greater portion of the map-area. Debris is developed by the combined action of mass-wasting, eolian, colluvial and organic activity and accumulates as thin sheets or thick wedges on most land forms.

Use of the facies concept in mapping the deposits of the map-area was invaluable in that the broad diversity of processes, deposits, and erosion cycles could be fitted into a central framework relating environment to deposit. Also deposits of a gradational nature can better be visualized as to position in the erosion cycle, whereas without the facies framework they are apt to be defined or recognized as distinct entities. Rock glaciers, for example, are a gradational facies whereby components are derived by glacial, mass-wasting and other processes -- one facies may predominate over the others, depending on the environment of the particular locality. The glacial, stagnating and dead facies can all contain deposits of ablation gravel but again the local environment dictates which phase of ice regimen has been dominant at the time of its deposition. The stagnating and dead ice facies are also bridged by the kame to esker series (e.g. the elongate gravel ridges at the terminus zone of the Age II glacier formerly occupying the lower North Klondike valley). The two phases of the deglacial cycle are in turn connected gradationally to the fluvial cycle, for the distinction between retreatal outwash and fluvial terraces is arbitrary (Vernon and Hughes, 1966). Transitional phases between the fluvial, colluvial and mass-wasting cycles are exhibited by the fan to slopewash to alluvial cone sequence, or by the mixed facies mentioned previously. Hence deposition and erosion during the Quaternary Period in the map-area must be viewed as a gradational mosaic of processes. A facies concept probably best illustrates the complexity of the depositional history, but yet permits envisioning the sequence and relation of events. Admittedly outwash is difficult to fit into this concept, for no consistent cirterion was discovered in the map-area that would indicate whether outwash is of a glacial, stagnating or dead facies. This drawback, however, should not be considered as a major deterent in the possible use of the facies system.

3) Within the map-area the influence and the structural relationships of the bedrock lithology have exerted a remarkable control on the distribution and

orientation of landforms, surficial deposits and mass-wasting features[1]. The North Fork Pass region marks a zone of edaphic discontinuity between the north and south slopes of the Southern Ogilvie Ranges. Fine-grained bedrock is associated with a significantly smoother type of terrain on the north slope. Topography on the south slope is of a series of escarpments oriented normal to the dip of a series of coarse quartzitic clastics. Terrain underlain by bedrock susceptible to erosion or by faults is generally a valley, whereas igneous and quartzitic terrain make up the ridge crests and mountain massifs. The development of upland patterned ground features, felsenmeere, rock glaciers, talus cones and landslide features is restricted almost exclusively to the igneous and quartzitic terrain, whereas solifluction lobes are characteristic of regions underlain by fine-grained soft carbonate and altered volcanic clasts. Tills made up of components derived from the igneous and quartzitic terrain have a sandier texture than those derived from the soft fine-grained rocks. Permafrost, in turn, is developed as ground ice near the surface in the latter zone, for fine grain sizes are frost susceptible; hence lithology may indirectly control the distribution of permafrost that is located near the ground surface. The overall permafrost control is, of course, the ground temperature.

Structural trends in bedrock have influenced the development of: fluted and drumlinoid surfaces, cirque orientation, meltwater channels, cirque lakes, and rock glaciers. Fluted and drumlinoid surfaces are best developed where ice flow had been parallel to the structural trends. In the middle reaches of the North Klondike valley lateral channels are most obvious where meltwater was forced to flow parallel to the bedding in the fine-grained sequences of Unit 14 (Table I) or parallel to the thrust plane of the overlying Units 1 and 12. "Lateral Creek" of the Lomond Creek drainage basin flows in a canyon. During Age II-IIA ice advances meltwater flowed off the ice onto erosion-susceptible rocks marking the crest of an anticline. The canyon today marks the approximate crest of the structure. Cirques and rock glaciers are surprisingly well developed on west-facing escarpments of a series of southeast-dipping thrust plates -- on the dip surface, however, neither of these features is at all common. The escarpments are an ideal zone for supplying debris to the rock glaciers and this factor alone probably accounts for their lower elevations on the west-facing slopes. Cirque lakes are developed predominately in terrain underlain by crystalline and coarse quartzitic rocks characterized

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[1] Washburn (1965) observed a similar topographic-lithologic relationship in the Mesters Vig district of Northeast Greenland and Cairnes (1912) emphasizes the relationship of bedrock types to frost action susceptibility in his studies of terrain along the Alaska-Yukon boundary.

by broadly spaced and well developed joints. Such a lithologic environment is ideal for a plucking type of corrasion by glacier movement on the floor of cirques. Yet the rock exhibits a slower rate of mass-wasting than the fissile fine-grained sediments; hence, the lake basins are not rapidly filled in. Cirque lakes in pater-noster succession are found in those areas where valleys lie normal to an alternating succession of clastic and gabbroic rocks. Landslide activity in bedrock appears to be confined to the part of the map-area where thrust faults are numerous and where an incompetent fine-grained member of a coarse clastic series lies close to or on the slide plane.

4) Periglacial features and processes are the outstanding phenomena in the Southern Ogilvie Ranges and their activity is probably the most important geomorphic agent contributing to the general degradation of the landscape today. While some of the processes and features are lithologically controlled in their development, those in allochthonous materials have developed mainly or wholly in the north half of the area, probably because of the presence of permafrost near the surface. Yet seasonally developed phenomena such as sheet solifluction and river icings are widespread throughout the map-area and are not controlled by permafrost and lithology. Permafrost, manifested as ground ice, lies close to the ground surface in the northern half of the map-area, but its degradational tendency in this region today is made apparent by collapsed pingos, collapse pits, high-centred polygons, thermokarst activity, and slumps. The trend is by no means universal for low-centred polygons and palsen bogs (s.lat.) still exist in the northern portion of the map-area.

Unfortunately climatic records for the map-area are not available and it is difficult to prove by direct means the existence of a colder climate to the north of North Fork Pass. The occurrence of ground ice is in part dependent on grain size; frost-susceptible loess is much more extensive on the north slope and aids in the development of a shallow and easily detectable permafrost table to the north. However, cooler temperatures in the north are suspected to yield a more continuous permafrost distribution because of the higher average elevation of the Blackstone drainage as compared to the North Klondike, and because of the absence of a boreal forest. Physiographically, the North Klondike valley is oriented so that cold air is constantly draining from it into Tintina Valley and the Yukon basin; the Blackstone basin and Taiga Valley, on the other hand, are located so as to effectively hold cold air against the southern front of the Central Ogilvie Ranges. This explanation is not unique to this region alone as Baranov (in Hopkins and Fyles, 1966) and Washburn

(1965) have utilized similar theory for comparable situations in Siberia and Northeast Greenland respectively.

The periglacial cycle has waxed and waned since the "Age I ice advance". Since the first invasion of permafrost on to Age I moraines the subsequent degradation of permafrost must be regarded as a significant development in the late Quaternary history. The fact that permafrost exists on features (comparable to Age I) elsewhere in the subarctic has been recognized by many (e.g. in Hopkins and Fyles, 1966; and Brown, 1967). The time of postglacial permafrost invasion is assigned by them to a period 7000 to 12000 years B.P. The first postglacial thaw period as found by pedological studies in the Brooks Range by Tedrow or in the Seward Peninsula by Hopkins (in Radforth, 1966) or as found by stratigraphic relationship in the Tanana valley by Péwé (1965) occurred about 9000 to 7500 years B.P. This thaw period is vaguely suggested by a temporary decrease in the cold climate species in the pollen profile (Appendix ID) as taken from the north end of the map-area. Between 7500 years and 6000 years B.P. the climate was cooler, but soon after Tedrow and Walton (1964) have used a 5650 year old stratum containing alder (Alnus) leaves to show that the climate in the Central Brooks Range became warmer than that of today; this is corroborated by the strong appearance of Alnus sp. in the pollen profile (Appendix ID) at about this time as well. The next cooling period began since 5000 years before present, for a stratum of younger "Rangifer Loess" near North Fork Pass contains ice wedges and pore ice and 3100 year old bogs in the area contain ground ice. Also, if some of the dormant rock glaciers in the area are similar in time of development to those of the nearby Alaska Range (and more distant Colorado Front Range) it is suspected that periglacial activity resurged about 3000 years B.P. The cycle reportedly waned 2000 years B.P. as perhaps suggested by today's mature stage of expression of thermokarst activity on the Blackstone flood plain. At 600 years B.P.[2] the cycle waxed again for at this time rock glaciers were most likely re-activated synchronously with the development of some glacierets along the central axis of the Southern Ogilvie Ranges. Temperatures began to rise about 1670 A.D., likely accompanied by renewal of thermokarst activity, a degradation of ice wedge polygons and palsen features, rupturing of the asymmetrical pingo, and a lessening of rock glacier activity. Hence, inactive early Late Postglacial

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[2] This is a conservative figure; we know (Rampton, 1967) that glaciers of the "Little Ice Age" covered a 1400 year old volcanic ash in the upper tributaries of the White River basin (to the south of the Yukon Plateau). Wahrhaftig and Cox (1959) suggest a period of rock glacier development beginning 1000-1400 years B.P.

rock glaciers cannot always be separated by an elevation criterion from the inactive forms in the more recent phase of rock glacier activity. About half the total number of known rock glaciers are inactive today. The ratio of active and inactive ice wedges is also similar.

The historical waning of all periglacial features is not a synchronous event over the entire area. While lobed solifluction activity appears to be subdued and perhaps non-active below the 1200 m formline in the southern half of the map-area, the process is undergoing spectacular development in the northern half at present. Hence, the distribution and elevation of periglacial activity depends on the particular process, the orientation of the feature being produced, the microclimatic and microtopographic relations and the availability of materials of the right texture.

A few points concerning the periglacial cycle deserve particular mention. Firstly, thermokarst activity is active on all ages of moraines north of North Fork Pass. Such activity is easily recognized by "drunken forests" on lake shores, tension cracks on shore slopes and floating mats of vegetation on the lake. Moraines are ideal topography for the initiation of spectacular thermokarst activity and single large basins can be produced by the coalescence of cave-in activity on two or more adjacent smaller basins. Chapman Lake, for example, represents an area once made up of at least 18 small and unconnected basins, and the growth of the resultant large basin has not stopped - a few small lakes nearby will be adjoined to Chapman Lake by a common water level in the imminent future. Secondly, rock glaciers are not always developed by the secondary invasion of ice into talus cones, etc. Other modes of development in the map-area include the simultaneous piecemeal deposition of rock and snow during glacieret growth or recession, and the avalanching of snow and rock debris onto favourably oriented catchment zones. All possible intergrades between debris-free glacierets to debris-ladened glaciers to rock glaciers with only secondary ice exist in the map-area. Thirdly, fossil sand wedges southeast of the map-area and three lowly elevated rock glaciers in the "Snowy Range" suggest a cold arid climate during the Late Pleistocene Epoch. The wedges may have been developed solely by contraction and loess inwash - ice never being present. Finally, the writer concludes that strangmoors are found in the permafrost environment and that the geographic distribution of this type of bog overlaps that of palsen bogs (s.str.). Growth rates of all bogs in and near the map-area are quite variable though they tend to be less than half the rate of peat bogs found in more temperate regions.

5) Owing to (1) variability in the processes of deposition and in the environment of deposition, (2) variability in the extent of loess cover, and (3) variability in the distribution of permafrost (and its subsequent after effects), the writer was unable to convincingly demonstrate topographic or morphologic differences between the Age I and Age II morainal termini. The differences in surface form between the corrugated south lobe and the swell-and-swale north lobe of the hammerhead-shaped North Fork Pass Moraine, both of Age I, were greater than the differences between the Age I north lobe and the Age II Chapman Lake Moraine. The north lobe and the Chapman Lake Moraine were a result of similar depositional environments and similar subsequent modifications brought about by erosion and secondary deposition (loess). The time span between Age I and Age II ice advances was apparently not long enough to produce significant differences in the possible morainal modifications as listed in Table XII.

A few environmental differences between the two lobes of the Age I North Fork Pass Moraine have been covered in items 3 and 4. The most divergent factor is the slope of terrain on which the basal surface of the ice was moving and the associated slope of the top surface of the glacier. At the south lobe of the glacier ice was forced to push its way uphill to North Fork Pass, whereas to the north the ice flowed to its terminus or a surface that was level or tilting slightly downvalley. Hence, while the southern lobe of ice was building a set of arcuate ridged moraines composed of coarse sandy till, the north lobe was depositing a swell and swale ground moraine of muddy till. Because of the gradient of the upper ice surface, meltwater runoff flowed to the north carrying supraglacial debris with it. Since deglaciation, the differences between the two lobes of the moraine have been amplified by the invasion of permafrost and loess on only the north lobe of the moraine.

Permafrost should theoretically produce different degrees of modification on the Age I, II and III surfaces. However, the number of bogs, the areal extent of ice wedge pattern ground, and the depth of the ground ice do not reveal consistent differences on the three ages of moraines examined (excluding the south lobe of the North Fork Pass Moraine). Thermokarst activity, it is true, is more prevalent and has created steeper lake shores on the Age II Chapman Lake Moraine than on most other moraines. However, this activity is a cyclical event, as of yet incompletely understood, and is governed not only by a time factor but also by factors of initial relief, textures of media enclosing the ground ice, and exposure to insolation. Since the larger Chapman Lake Moraine is underlain in part by frost-susceptible, varved silts,

and is exposed to insolation for longer periods than is the north lobe of the North Fork Pass Moraine it is not possible to isolate the importance of the time factor as a cause of differences in the relief about lake peripheries as brought about by thermokarst activity. Variations in thicknesses of the loess veneer on the moraines and the presence of even more pronounced thermokarst activity on the exposed Age II-IIA lateral moraines on low ridges near Chapman Lake support the conclusion above.

6) The presence of permafrost in the moraines and the cold subarctic climate reduces the rate of chemical weathering to the extent that pebble components of identical clasts from Age I, II and III tills do not show perceptible differences in oxidation or other alteration. Preservation of pebble striae was found to be about two and one half times greater in the subarctic environment, regardless of age of enclosing till, than values given for temperate regions (e.g. Flint, 1957). Such findings serve only too well to support the relationship between cold climate (as manifested by permafrost) and chemical weathering that was expounded by Cairnes in 1912.

Yet mechanical weathering (splitting) of the pebble or the finer components has not shown detectable differences between the three ages of till - a fact that is surprising in view of Cairnes' (1912) remarks. Pebbles from oxidized zones on tills do not show a correlation of degree of roundness or angularity with age of till, and age of till does not correlate with the amount of "fines" within them. Either chemical factors are cancelling frost action factors, or the cold and arid climate of the subarctic impressively deters weathering. These results contrast strongly with the varied differences in the weathering of components of moraines of different ages in temperate regions. On the other hand these results agree with the statements concerning the slowness of weathering in or on moraines on the north slope of the Brooks Range.

7) Soil pit analyses on Age I, II and III moraines located on the northern half of the map-area reveal the existence of several soil varieties in each of the Organic soil, Regosol, Gleysol, and Brown Wooded soil orders. Some vague eluviation was discovered in a few profiles of the latter type. Climate, rather than parent material or age, appears to be the dominant factor governing the soil type produced, for all of the above-mentioned soil orders were found on all ages of moraines and in a variety of textures of parent materials. The presence of permafrost (as ground ice) has drastically inhibited and disrupted pedogenesis on most moraines. Horizon development of the soil profile does

occur in a few moist areas but no trend of development towards a mesic climax was found. Studies of possible eluviation within the Brown Wooded profiles developed on gravel hummocks, by analysis of clay-size particle translocation, did not yield any conclusive results with respect to the time factor. Supporting chemical analyses are needed for confirmation of any suspected indistinct trends in translocation of iron oxides or clay-sized components. Paradoxically, eluviation was found in a few soil profiles developed on Age I tills at and south of North Fork Pass, whereas this phenomenon was not observed on till of any age north of the pass. However, complete podzolization was never observed. Consequently the writer suspects that soil evolution reaches only a phasic polyclimax in the region, and from other data it appears that such a condition is attained in 14,000 ($\pm$) years of development (= possible date of first pedogenesis after the maximum advance of Age I glacial episode).

Data on oxidation and leaching depth likewise are not directly useful in showing the age of moraines in the map-area. These measurements, the leaching depth especially, are not reliable indicators when dealing in an environment with a variable permafrost factor. Chemical weathering is inhibited in the colder latitudes; hence, progressive changes in chemical alteration due to increasing time span are apt to be slight if all other factors are constant. Obviously other variable factors will have a greater influence on the downward migration of iron and carbonate components in the soil profile than will the time factor. These include the amount of the carbonate clasts in the parent material, the texture of the parent material, the presence of certain species of grasses with soil capillary systems (Shacklette, 1963), microclimate, topography, and moisture from snow, rainfall or degradation of permafrost. In the present investigation there are great variations in all of the above so no significant correlations were found between depth of oxidation and leaching and time. Hence, these simpler methods of measuring pedogenic change should be confined to deposits showing as many constants in environment as possible - e.g. thick loess deposits or well sorted terrace gravels located at a great distance from their suspected source of particle origin. Two ages (II and III) of gravel deposits near the mouth of the North Klondike valley do appear to show consistent differences in depth of oxidation and leaching.

In regions of the subarctic environment the problem of correlation of moraines by changes in the solum is best conducted by a complete soil profile analysis. In this method slight but useful variations are more apt to be recognized and in turn the variation caused by an unusual factor other than time is more likely to be perceived.

8) Vegetation studies reveal that the moraines of Ages I, II and III cannot be distinguished by the presence or absence of indicator species. Shrub coverage on all three ages of moraines is about the same, though the non-permafrost portion (south lobe) of the Age I North Fork Pass Moraine tends to have higher canopy values. Comparison of vegetation on moraines of different ages with equivalent types of habitats (drainage, parent material and topographic relationships) reveals the same kinds and relative proportion of species for all ages of the surface examined.

Four major community complexes were examined on the various ages of moraines. Two of these, a Snow Lie (Grouping II—M), characterized by Cassiope tetragona, and a complex non-subdivided Shrub-Meadow (Grouping I—H-M), characterized by Carex podocarpa, were found on the south lobe of the North Fork Pass and on the Foxy Creek moraines. Both communities are infrequent on the other moraines.

Mesic to xeric communities (Groupings, O, I and II complex) were found to have many characteristics in common, but could be subdivided on a shrub density basis. The mesic subdivision or Group O(X-M) Shrub-Thicket Community is heavily covered by Betula glandulosa and was found on till away from the zone of direct influence by permafrost - hence, on the Age I south lobe of the North Fork Pass and on the Age I August 17th Creek moraines. The xeric subdivision or Group I-II(X) Gravel Hummock Communities were located on well drained gravel knolls situated in exposed conditions; species tended to display erratic distributions in this harsh environment, but on the basis of the presence of Salix glauca upon only(?) the Age II Chapman Lake Moraine sites the xeric community is tentatively subdivided into I(X) and II(X) communities. However, differences in species density or occurrence between the two subgroups are felt to be due to local climatic, edaphic, and topographic differences, and this conclusion is perhaps fortified by the existence of the I(X) subgroup on both Age I and Age III gravel knolls.

The most widespread community complex within the region of study is the Tussock-Tundra or Group III complex - characterized by the sedges Carex Bigelowii and Eriophorum spp. On a species density basis the complex has been subdivided into four communities (A, B, C & D). They are respectively the Shrub-Tussock, Heath-Tussock, Tall Tussock or "Niggerhead", and the Wet Tussock-Strangmoor communities. The Tall Tussock or C variety is the most common and appears to be successionally related to the Shrub-Tussock or A type; possibly the C variety is the precursor to the Wet Tussock or D variety. The Heath-Tussock or B type appears to be confined to a transition zone between

the xeric communities and the other three subgroups of the Tussock-Tundra. The Tussock-Tundra complex was not found on the south lobe of the North Fork Pass or on the August 17th Creek moraines but is present on Age I, II and III moraines or in the zone of detectable permafrost.

The various communities outlined above show only a general correlation with the Great Soil Groups. Both vegetation and soils, however, are related to drainage as controlled partly by the parent material but more directly by the presence or absence of permafrost. Communities typical of the permafrost environment are dominant on all ages of moraines north of North Fork Pass. Correlation of successional development with age of moraine is impossible not merely because of the presence of permafrost, but also because of the constant disturbance of the soil and vegetation mat by associated periglacial processes. Hence, it appears that the vegetation on the moraines in the study area represents several polyclimax associations, for periglacial disturbance prevents successional development toward a single mesic climax community such as is postulated by Clementsian concepts for temperate regions. These "phasic climaxes" have developed in a time span less than 10,000-11,000 (perhaps less than 5000) years for the Tussock-Tundra and less than 14,000-15,000 (±) years (ca.= Age I time span) for the other community complexes. Therefore, successional or cyclical trends of development to any community grouping outlined in the preceding paragraphs cannot be related to any specific age of moraine. The results corroborate what Viereck (1966) found in his studies on the succession (Late Wisconsin to Recent) of Muldrow valley outwashes in Mt. McKinley National Park.

9) The investigation of the sequence of glaciations on both the north and south slopes of an inland range of the northern Cordillera appeared to be an attractive one initially, for it might put together in "one bundle" what is often accomplished in two separate investigations (by two separate research teams). However, despite the advantages offered by easy access, the investigation was frustrated by major environmental differences within the map-area. These differences probably exist between north and south slopes for most ranges of the northern Cordillera, and they are not likely to be appreciated or taken into consideration during early stages of investigation of the glacial geology of a region. Features identifying the age of moraines that are common to both slopes of subarctic ranges may never be found. Southern slopes may have a typical boreal or continental type of climate and vegetation, while the northern slopes exhibit the influences of the arctic tundra. Thus for a

study of the characteristics of multiple glaciation it is preferable to select an area where as many environmental variables as possible can be eliminated. Periglacial, edaphic, ecotonal, topographic, climatic, and other factors should be constant among the chronosequence of moraines to be studied. In this light the area surveyed in this report was obviously unsuitable. However, the area with a triple morainal sequence in the headwaters of the Ogilvie River (lying in Taiga Valley to the west of the map-area; Fig. 2) appears to be much more uniform, and in future some useful age criteria may well be established there. But of course any such criteria should not be expected to be applicable in different terrains - particularly the south slope of subarctic mountain ranges.

Among the possible criteria, the writer feels that the study of the differences in form of deposits at a morainal terminus is the most "left handed" approach to age determination in a series of glacial episodes. The very nature of such a study implies that a good moraine is always deposited at an ice terminus. Yet, this investigation shows that processes at a glacier margin have been variable in the Southern Ogilvie Ranges, and in at least one instance a morainal terminus may never have been deposits. Speight (1940) too has discussed the variability of deposition at ice fronts.

It has nevertheless been possible to establish a relative glacial chronology in the map-area. The geographic position of moraines in a progressive downvalley sequence of younger to older is one good criterion. If moraines of some ages are missing, this is readily discerned by examination of the Schliffgrenze. In the Age I glaciated areas such a zone has a "fresher" appearance on aerial photographs than one associated with Age II - provided comparisons are not made between opposite sides of an edaphic discontinuity. This criterion is universally used by investigators in the northern Cordillera, and it has been used by Washburn (1965) in Northeast Greenland as well as by others in other parts of the world. In valley bottoms not glaciated during Age I fans with sharp escarpments at their toes are typical, whereas fans of similar size upvalley, on terrain glaciated during Age I, show scarcely any escarpment. Correspondingly, the flood plains beyond the Age I portion of the valley are glaringly incised, while upstream the Age I portion of the valley floor may show a total lack of incision. Age I tributary valleys are U-shaped, whereas the older valleys show some V-shape profiling on the valley wall to floor interface. When these and other simply recognized criteria are available the study of morainal form is unnecessary unless Age III and older moraines are also present, and other evidence of their age is too fragmentary to permit definite decisions.

10) Absolute ages of the time of deposition of any moraine in the map-area has not been determined to date. However, comparison of the chronosequence of moraines in the map-area with those in surrounding areas suggests, tentatively, the following:

Age	Re	- Rock Glacier B and Glacierets of the "Little Ice Age" = Neoglacial; and Rock Glacier A = earlier Late Postglacial.
-		- Hypsithermal Interval (glacial activity absent).
-		- Recessional Moraines = Early Postglacial or Late Glacial.
Age	I	- "North Fork Pass Ice Advance" ("blue limit" or "youngest glaciation") = Late or "Classical" Wisconsinan.
Age	II	- "Chapman Lake Ice Advance" (lower "red limit" or "intermediate glaciation") = Recessional Advance of Early Wisconsinan.
Age	II	- Lower North Klondike Moraine ("red limit" undiff.) = Early Wisconsinan (undifferentiated).
Age	IIA	- "Taiga Valley Ice Advance" (upper "red limit" or "older glaciation") = Maximal Advance of Early Wisconsinan.
Age	III	- "Ogilive Glaciation" ("oldest glaciation") = Illinoian.
-		- Weathered gravels at Field Stn. No. 57 = Kansan (?), Aftonian (?) or Nebraskan (?).

The above schedule is suggested by the comparison of the sequence of moraines and by the comparison of some weathering characteristics on the moraines with those elsewhere. However the correlations must remain in doubt because of too few absolute ages older than 14,000 years B.P. from the inland localities in the northern Cordillera, because of the possible differential rate of weathering and the different types of weathering recognized in the northern Cordillera, and because of some confusing correlations in the Brooks Range. Also, if the time span between the deposition of the Age II Chapman Lake Moraine and the Age IIA Taiga Valley Moraine is greater than what the writer has inferred (less than a few thousand years) the latter moraine may be Illinoian while the Age III moraine would be Kansan. No matter which course is taken the writer believes that the Early Wisconsinan Ice Advance is represented by moraines in the map-area. In Alaska this is not regarded as always the case. However, selective areal presence or absence of this episode in parts of the northern Cordillera seems unrealistic, for where recognized, its extent or land coverage is far greater than that of the succeeding Late Wisconsin ice advance. In view of the inconsistencies of weathering of moraines found in this study, perhaps all data pertinent to the analysis of multiple glaciation of the northern Cordillera should be re-evaluated by a single panel of investigators.

Note: - references important to this thesis are marked with an asterisk *.

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Addendum
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APPENDICES

		Pages
APPENDIX I	Surficial survey tables; section descriptions; and peat bog-borelog and palynological results.	2A-7A 8A-9A 10A
APPENDIX II	Cumulative frequency curves; cobble-pebble angularity and weathering in glacial till tables.	12A-13A 14A-16A 17A-20A
APPENDIX III	Descriptions of soil profiles.	21A-53A
APPENDIX IV	Checklist of plant species (A); indicy of vascular floristic similarity table (B); environmental synthesis and related vegetation quadrat tables (C); notes on plant taxonomy (D);	54A-59A 60A 61A-119A 120A-124A

APPENDIX I

Features pertaining to the surficial geology survey (Part 1) are included in this Appendix. Appendix IA is a summary of parameters that are characteristic of the various surficial and erosional units used in the mapping of the map region. The textural and fabric columns of the table are derived from the textbooks of Flint (1957), Bird (1967), and Thornbury (1954); the dissertation and maps of Fulton (1962, 1963); the INQUA Guidebook for Field Conference F "Central and South Central Alaska" (edited by Dr. Troy L. Péwé, 1965); and the writer's findings from field investigations. Additional selected references have been used for some of the periglacial forms. Appendix IA should be used in preference to the discussions in Part 1 of the thesis if one is interested in the description of the unit or feature in question only.

Appendicies IC and IB, respectively, are fairly detailed field descriptions of exposures through a typical fan and a proglacial outwash over lying an important section of varved lacustrine silts. Lastly, Appendix ID is an abbreviated description of a pollen diagram prepared from counts on 24 selected samples taken from a logged core of a drill hole on a Chapman Lake Moraine (Age II) peat bog. Since the bog was probably evolved by a complex cycle of thermokarst and cave-in lake development and subsequent shoaling, the age difference between initial bog development and deposition of moraine is not known. The dated portions of the core are thought to be fairly accurate, but the factor of involution within the bog cannot be totally dismissed.

APPENDIX IA

TABLE OF SURFICIAL AND EROSIONAL UNITS AND THEIR CHARACTERISTICS IN THE MAP AREA

SUBUNIT DESIGNATION AND LOCALE EXAMPLE	TOPOGRAPHIC EXPRESSION		TEXTURE AND FABRIC OF MATERIAL				SHAPE
	RELIEF	SURFACE	BEDDING	SORTING	DOM.GRAIN SIZE	COMPACTION	
1A Terminal moraine e.g. "Foxy Creek"	mod. to high	gently rolling to corrugate	none	none	cobble to silt (till)	loose to indurated	± arcuate ridges max.ice position
1B Lateral moraine e.g. N.Lobe of North Fork Pass Moraine	mod.	irregular, ideally reverse slope to valley wall	none	none	cobble to silt (till)	mod. to indurated	isolated elongate ridges and benches parallel to ice flow
1C Ground moraine e.g. Lower North Klondike Valley	low	flat to gently rolling to billowy, with or without grooves, swell and swale	none	none	cobble to silt (till)	mod. to indurated	sheets, usually covered by colluvium etc.
1D Drumlinoid moraine e.g. Benson Creek	mod. to high	streamlined whaleback ridge and groove	poor	poor	cobble to silt (till)	very indurated	sheets
1E Proglacial outwash	nil	nil-underlies till or younger outwash	mod.	poor to mod(clean)	cobble to sand (gravel with till blocks)	loose	(apron to ribbon)
1C x IA or 1B intergrade e.g. "Fitzgerald Ridge"	mod.	billowy	none	none	cobble to silt (till)	indurated	elongate broadly arcuate sheets
2A Proximal outwash	low gradient	flat, ± pitted	mod.	none to mod. (± clean)	boulder to sand (gravel with till blocks)	loose	apron
2B Lateral meltwater channels e.g."Morrison Creek"Area	low gradient	bench or groove, steep walled	-	-	-	-	serpentine (meander) to straight
2C Overflow meltwater channel e.g. Rabbit Creek	low to moderate gradient	shallow to deep groove	-	-	-	-	straight to "sinuoidal"
2D Rill deposits.-assoc. with meltwater and rill channels e.g. Lower North Klondike Valley	low to mod.	flat to hummocky	none to mod.	poor to well (± clean)	lag boulders gravel to mud (ponded silts)	loose	sheets, ribbons, prisms, ± irregular

(APPENDIX IA cont'd)

SUBUNIT DESIGNATION AND LOCALE EXAMPLE	TOPOGRAPHIC EXPRESSION		TEXTURE AND FABRIC OF MATERIAL				SHAPE
	RELIEF	SURFACE	BEDDING	SORTING	DOM. GRAIN SIZE	COMPACTION	
2E Kame deposits (frontal and marginal) e.g. "The Highlands"	mod. to high	hummocky, smooth to pitted, cuspate lipped, slope away or towards valley wall, flat to convex	none to irregular	poor to erratic (± dirty)	cobble to clay (gravel, minor till lenses and blocks, ponded silts)	loose to semi-indurated	elongate prisms, sloping semi- benches, steep aprons, mesas, incomplete fans, en echelon-grooves.
2F Hummocky or ablation moraine deposits e.g. Chapman Lake area	mod.	hummocks, closed depressions, anastomosing ridges	none	poor (± clean)	cobble to sand (gravel, minor till stringers)	loose	irregular sheets, grouped or isolated mounds.
2G Recessional moraine and kame complex deposits e.g. upper Blackstone Valley	mod. to high	sharply to subdued convex, billowy to hummocky.	none to irregular	poor to erratic (± dirty)	cobble to clay (gravel, till)	loose to mod. indurated	elongate, ± arcuate prisms and furrows, intermittent mesas.
2 Intergrade e.g. lower North Klondike Valley	high	sharply to broadly convex, hummocky crested	none	mod. (clean)	cobble to sand (gravel)	loose	elongate prisms parallel to valley axis.
3A Eskers and Eskeroid complex deposits e.g. upper North Klondike Valley	mod.	convex to sharp crested ridges, ± hummocky and pitted	poor to moderate (x bedded, fore set beds)	poor to moderate (clean)	cobble to sand (gravel)	loose	sinuous ribbons, (sub parallel or anastomosing if complex) to ellipsoid patches.
3B Crevasse deposits e.g. "Yakamaw" Valley	mod.	irregular crested ridges convex ± hummocky	poor to none	poor (dirty)	cobble to silt (gravel)	loose	sub-parallel en echelon or angulate intersecting ridges
3C Kettled terrace deposits e.g. upper Blackstone Valley	mod	flat, closed depressions	well	well (clean)	cobble to sand (gravel)	loose	linear benchlike prisms
3D Lacustrine deposits e.g. Chapman Lake	low	flat to gently rolling, ± semi-pitted, fine texture, poor drainage	varves- ± disrupted	well	fine sand to clay	semi-indurated	sheets
3E Distal outwash "fan", valley train and re-treatal outwash deposits e.g. mid-regions of North Klondike Valley	low	slightly convex to flat, channel rilled.	mod.	none to moderate (dirty to clean)	cobble to silt	loose	fans, aprons, elongate prisms.
3F Overflow and sub-glacial channels; e.g. upper North Klondike Valley	low to steep grad.	grooved-smooth	-	-	-	-	straight to sinuoidal

(APPENDIX IA cont'd)

SUBUNIT DESIGNATION AND LOCALE EXAMPLE	TOPOGRAPHIC EXPRESSION		TEXTURE AND FABRIC OF MATERIAL				SHAPE
	RELIEF	SURFACE	BEDDING	SORTING	DOM.GRAIN SIZE	COMPACTION	
3F Associated rill deposits e.g. upper North Klondike Valley	low	hummocky to flat	none to moderate	poor to well (± clean)	boulder to clay (gravely)	loose	irregular patchy sheets and ribbons
4A /7i Terrace deposits e.g. lower North Klondike Valley	low	flat; high escarpment with 4A; non pitted	well	well (clean)	pebble to silt (gravel)	loose	prisms
4E /7A Fan deposits and Bajadas e.g. mid reaches of North Klondike Valley	low	gently convex; 4E with escarpment	mod.	none to mod. (dirty to clean)	boulder to silt (gravel, minor ponded silts)	loose	single fan or coalesced aprons
5 Loess deposits e.g. Chapman Lake outwash zone	low	subdued, slightly concave to convex, (veneers), fine texture, poor drainage swell and swale, (super posed recticulate ice wedge network)	none	well	fine sand to silt (Loess) occasional ventifact	loose to semi-indurated, usually frozen	sheets
6A Lobed solifluction deposits							
var. Soil Terraces(st) e.g. west escarpment of "Snowy Range"	low	flat to sloped, slightly hummocky, lipped escarpment	none	none	blocks to silt (tilloid)	mod.	prisms of elongate terraces
var. Lobate terraces (lt) e.g. North Fork Pass	low (on mod.grad.)	stepped, convex scalloped	none to poor	none	blocks to silt (tilloid)	mod.	sheets of lobes, contour length greater than down slope length
var. Soil lobes (sb) e.g. North Fork Pass	low (on mod.grad.)	stepped, tongues with upslope depression	none to poor	none	blocks to silt (tilloid)	mod.	sheets of lobes with contour length less than ½ of downslope length
var. Tundra mudflow (tm) "solifluction fan" e.g. North Fork Pass	low to mod. (on mod. grad.)	hummocky, conved elongate niche upslope, escarpment downslope terminus	none to mod.	poor to mod.	cobbles to silt (tilloid and gravel)	semi-indurated to loose	groups or isolated fans and aprons
6B Patterned ground							
var. Upland Forms e.g. "Edge Mtn."	low	stripes, steps, nets, polygons, circles	none	none to well	blocks, grit, silt	loose	sheets on flat shelves or low to mod slopes
var. Lowland Forms e.g. "Henry Creek"region	low	reticulate, low hummocks around concave centres or grooves about high centres; beaded	foliated in ice	none in silts	ice wedges in silt, sand, (and gravel)	frozen	sheets on flats, slight slopes or depressions, beaded drainage in stream channels as reticulate ribbons.

(APPENDIX IA cont'd)

SUBUNIT DESIGNATION AND LOCALE EXAMPLE	TOPOGRAPHIC EXPRESSION		TEXTURE AND FABRIC OF MATERIAL				SHAPE
	RELIEF	SURFACE	BEDDING	SORTING	DOM. GRAIN SIZE	COMPACTION	
6C Rock glaciers e.g. "Tombstone Range"	mod. to high	convex, hummocky arcuate transverse ridges downstream, longitudinal swell and swale upstream	none	none	blocks to grit with interstitial ice	frozen to loose on surface	tongues, spatulate aprons, lobate benches
Debris covered glaciers e.g. Cloudy Range	mod. to high	convex hummocky, collapse pits, meandering furrows upstream, short straight furrows downstream at snout.	mod.	poor to mod.	blocks and grit on and enclosed on ice	frozen to loose on surface	tongues without conspicuous transverse ridges
Glacierets e.g. "Monolith Mtn."	low to mod.	concave to convex ± smooth	well	none	ice, minor debris	frozen	tongues, crescents
6D Peat bogs var. palsen and strang types (p) e.g. Chapman Lake	low	hummocky (palsen), ridged (strang), grater-like	mod to well	mod.	peat, ice silt	frozen	ditto
6E Pingos and Pingo remnants e.g. near Caldwell Lake	high	incised domes or irregular hummocks collapse topog.	poor to well	none to mod.	ice and silt to sand	frozen	isolated hemisperical mounds
6F Felsenmeere e.g."Edge Mtn."	low	flat to rolling	none	none	angular blocks	none	sheets
Thermokarst - thaw lake topography e.g. North Lobe of North Fork Pass Moraine	mod.	escarpments about lakes, serrate margins, drunken forests, tension cracks, floating matts on lakes	-	-	silt (and ice)	-	embayments, etc.
7A see 4E -	-	-	-	-	-	-	-
7B Fan head trenches e.g. Central Ogilvie Ranges	low gradient	flat bottoms, steep walls, channel scours	none	poor	gravel on floor	loose	straight channels
7C Alluvial and Talus cones e.g. "Snowy Range"	high gradient	convex	none	poor	blocks, grit	loose	steep aprons; ± coalesced
7D Flood Plain deposits e.g. Blackstone River	low gradient	flat, meander scours and channels	mod to well	mod to well	boulder to silt (gravel, minor mucky peat, local ponded silts)	loose	ellipsoid areas connected by anastomosing ribbons
7E Talus and Protalus deposits	low, mod. grad.	irregular hummocky to isolated convex ridges ± lipped.	none	poor	blocks	loose	irregular sheets or elongate mounds.

(APPENDIX IA cont'd)

SUBUNIT DESIGNATION AND LOCALE EXAMPLE		TOPOGRAPHIC EXPRESSION		TEXTURE AND FABRIC OF MATERIAL				SHAPE
		RELIEF	SURFACE	BEDDING	SORTING	DOM. GRAIN SIZE	COMPACTION	
7F	Paludal deposits (swamps, marshes shallow ponds etc) e.g. lower North Klondike Valley	low	flat	poor to mod.	poor	humic silt or "muck"	oozy	ellipsoids ± irregular
7H	Landslide Deposits e.g. August 17th Creek Valley	mod. to high	raw headward depressions, transverse ridged or hummocky accumulation toe with ± closed depressions and longitudinal furrows	none	none	blocks if bedrock failure, sand, silt gravel (tilloid) if surficial deposit failure	loose to mod. indurate	spoon shape depressions with tongue, lobed spatulate shaped toe
7i	see 4A	-	-	-	-	-	-	-
8	Colluvial and mast-wasting debris	low, low to mod. grad.	subdued; flow lines parallel to fall line of slope; ± low hummocks veneers	poor	poor	silt predominates some tilloid	loose to mod. indurate.	extensive to irregular sheets, elongate lenses and prisms.

Appendix IB

STRATIGRAPHIC SECTION AT FIELD STATION # 215
CHAPMAN LAKE, TAIGA VALLEY REGION.

Distance from Top of Section in Metres	Thickness of Unit in Metres	Contact Relations	Field Description
0-0.3	0.3		FINE DARK SAND OF EOLIAN ORIGIN; CAPPED BY SOIL WITH SHALLOW PROFILE.
		UNC.	
0.3-1.0	0.7		BURIED SOIL PROFILES; AT LEAST 3 F-H LAYERS VAGUE SUGGESTION OF A DEEPER FOURTH PROFILE; SERIES OF SOMEWHAT MOTTLED SILTY LOAMS BETWEEN EACH ORGANIC LAYER-ROLLS EASILY INTO A WIRE, STICKS TO ONE'S FINGER.
		DISC.	
1.0-1.8	0.8		TILL OF CHAPMAN LAKE MORAINE; PINCHES OUT IN SECTION; MUNSELL COLOUR MOIST IS 2.5Y3.5/2, SANDY MATRIX, POORLY INDURATED.
		UNC.	
1.0 TO 1.8-2.1	0.3-1.1		DIRTY, MODERATELY SORTED BUT RANDOM PACKED, WELL ROUNDED GRAVEL OF PRO-GLACIAL ORIGIN; POORLY BEDDED.
		DISC.	
2.1-5.8	3.7		GENERALLY A MEDIUM SAND WITH OCCASIONAL LENSES OF COARSE SAND OR GRANULES.
		GRAD.	
5.8-8.2	2.4		VARVED SILTS; DARKER LAYERS FINER GRAINED; BEDDING WITH SLIGHT UNDULATIONS THAT RESEMBLE CAMBER FLEXURES; GRAIN SIZE DECREASES UPWARD IN EACH VARVE, BUT SOME COARSER GRAINED PORTIONS SHOW MELT SEASON FLUCTUATIONS OR VARIATIONS IN GRAIN SIZE; 150 ± 10 VARVES IN THIS UNIT.
		GRAD.	
8.2-8.5	0.3		MEDIUM SAND.
		GRAD.	
8.5-12.2	3.7		VARVED SILTS WITH ACTUAL CLAY GRAIN SIZES IN THE DARKER LAYERS; SOME VARVES 7.5 CM. IN THICKNESS; IRREGULARITY IN SOME DUE TO SHEARING ACTION OF SLUMP - CAUSED BY PERMAFROST.
		GRAD.	
12.2-18.3 OR RIVER LEVEL	6.1		SLUMPED SILT AND FINE SAND RETAINING VARVE STRUCTURE APPEARANCE; CONSIDERABLE DIGGING WOULD BE REQUIRED TO OBTAIN TRUE PICTURE OF THIS PORTION OF THE UNIT.

Appendix IC

STRATIGRAPHIC SECTION OF FRONTAL SCARP OF THE "HENRY CK." FAN, E. BLACKSTONE RIVER.

Distance from Top of Section in Metres	Thickness of Unit in Metres	Contact Relations	Field Description
0-0.3±	0.3±		DEGRADED BROWN WOODED OR INCIPIENT PODZOL SOIL, I.E. AEJ LAYER IS PRESENT (NSSC, 1963).
0.3± - 0.5	0.2±	GRAD.	MIXTURE OF GRAVEL AND SILT MATRIX OR POCKETS OF GRAVEL IN SILT. SILT IS WITH AIR HOLES, HAS A PLATY TO BLOCKY STRUCTURE, NON-BEDDED. $CaCO_3$ THROUGH ENTIRE UNIT ON THE UPPER SURFACE OF THE PEBBLES; UNIT IS EITHER A MINOR MUD FLOW OR IS A CONVOLUTED EOLIAN SILT HORIZON THAT HAS PICKED UP PEBBLES FROM GRAVEL AND BELOW.
0.5-0.7±	0.2±	DISC.	BURIED PODZOL SOIL CONSISTING OF: A 5CM. H HORIZON, A 7.5 CM. AE HORIZON AND A 5 CM. B HORIZON; IN CERTAIN PORTIONS OF THE SOIL PROFILE ONLY THE H HORIZON IS PRESERVED.
0.7±-1.3	0.6±	GRAD.	DIRTY GRAVEL THAT IS PARTIALLY THE BC AND PARTIALLY THE C HORIZON TO THE ABOVE; TOP 10 CM. OF LAYER IS A MUCH CLEANER GRAVEL, BUT HAS THICK $CaCO_3$ ON THE UNDER SIDE OF EACH PEBBLE; VERY LITTLE $CaCO_3$ ON THE DIRTIER GRAVEL SIZES.
1.3-1.6	0.3	DISC.	SILT OR VERY FINE SAND; VERY OXIDIZED OR MOTTLED, AND SHOWS A PLATY STRUCTURE; BEDDING IS NOT APPARENT, THOUGH GRAVEL LENSES AND STRINGERS ARE PRESENT; SILT IS PROBABLY A FLOOD PLAIN TYPE OF DEPOSITION, AND LATER, UNCOMPACTED GRAVEL WAS SWEPT INTO IT.
1.6-2.5	0.9	DISC.	GRAVEL; TOP 0.5 METRES IS QUITE COARSE AND SHOWS $CaCO_3$ CRUSTS ON THE UNDERSIDES OF MOST BOULDER SIZES; GRADES INTO A 0.4 METRE THICK FINE PEBBLE AND GRANULE SIZED SUB-UNIT; SORTING IS POOR IN THE TOP SUB-UNIT BUT MODERATELY GOOD IN THE LOWER; BOTH ARE POORLY BEDDED.
2.5-2.8	0.3	GRAD.	SAND; NOT ENOUGH EXPOSURE TO WARRANT DESCRIPTION.

APPENDIX 1D

PROFILE ANALYSIS OF STATION # 211 PEAT BOG BORE LOG *

Depth (M.)	Description And Brief Palynological Results
0-1.45	Bog peat; increase in arboreal pollen-especially Picea and Alnus, gradual increase of Rubus chamoermorus and Cyperaceae species in the declining non-arboreal pollen. Salix species increase rapidly upward in the profile.
1.45-2.20	Fen peat[1]; arboreal pollen gradually increases on erratic basis and then declines higher up in the profile - Betula is the dominent pollen producer. Except for the Ericaceae all non-arboreal pollen gradually dimishes as the profile depth decreases. Picea is very scarce and Rubus chamaermorus is absent.
1.55-1.65	Sample of fen peat dated at 9620 ± 150 years B.P. (GSC # 310)
2.20-2.45	Silt = "Blackstone Loess"; decrease in arboreal pollen, increase in Cyperaceae species of the non-arboreal pollen. Picea and Rubus chamoermorus is absent.
2.45-2.70	Silty peat; increase in Betula and Salix species of the arboreal pollen; decrease in Cyperaceae species in the non-arboreal pollen and Lycopodium selago spores. Picea is very scarce and Rubus chamaermorus is absent.
2.45-2.60	Sample of silty peat dated at 10,900 ± 150 years B.P. (GSC # 311).
2.70-3.05	Silty sedge peat; rapid increase in arboreal pollen - especially Betula sp; decrease in Graminae, Cyperaceae and other non-arboreal species. Picea is absent.
3.05-3.65	Silty sedge peat; arboreal pollen content is very low and is slowly decreasing; Cyperaceae and Graminae species very abundant. Picea is scarce and Ericaceae species as well as Rubus chamaermorus are again absent.
3.65-4.0	Silt, some plant detritus; pollen frequency very low for all species.
3.85-4.0	Sample of organic bearing silt dated at 13,890 ± 180 years B.P. (GSC # 296).

* Profile results in tentative and preliminary form were made available by Dr. O. Hughes and Dr. J. Terasmae of the Geological Survey of Canada. The latter will give a more detailed analysis of the profile in a forthcoming bulletin on the Late Pleistocene palynology of the Ogilvie Mountains.

[1] "Fen" as defined by Drury (1956) is a grassy or reed marsh - as contrasted from a peat or heath bog.

APPENDIX II

Data presented in the weathering and size analysis sections of Part 2 is largely dependent upon or can be further illustrated by "raw" data enclosed herein. The data is divided for convenience into three subsections as follows:

			pages
APPENDIX IIA	-	Mechanical Analysis	12A-13A
Figure A	-	Cumulative frequency curves for Age I tills.	
Figure B	-	Cumulative frequency curves for Age II, IIA and III tills.	
APPENDIX IIB	-	Angularity and Striation Preservation	14A-16A
Table I	-	Lower Paleozoic Volcanic Rocks (Unit IV-5).	
Table II	-	Sill-forming Rocks of Unit XX-16.	
Table III	-	Plutonic Stock-forming Rocks (Unit XXIB-18).	
APPENDIX IIIC	-	Weathering Characteristics	17A-20A
Table I	-	All Pebble-cobble Clasts.	
Table II	-	All Arenites and Rudites.	
Table III	-	Lower Paleozoic Volcanic Clasts - (Unit IV-5).	
Table IV	-	Fine-grained Clastic Rocks.	

For comparative purposes the cumulative curves have been enveloped into regional groups; the stations in the B and C appendices have been arranged from south to north in age groups. All stations are located in Figure 4 in the introduction of the thesis; some stations are also found on the 1:50,000 Quaternary map while others are found on Figures 6, 7 and 8.

FIGURE A Mechanical Analysis of Age I Till (APPENDIX IIA)

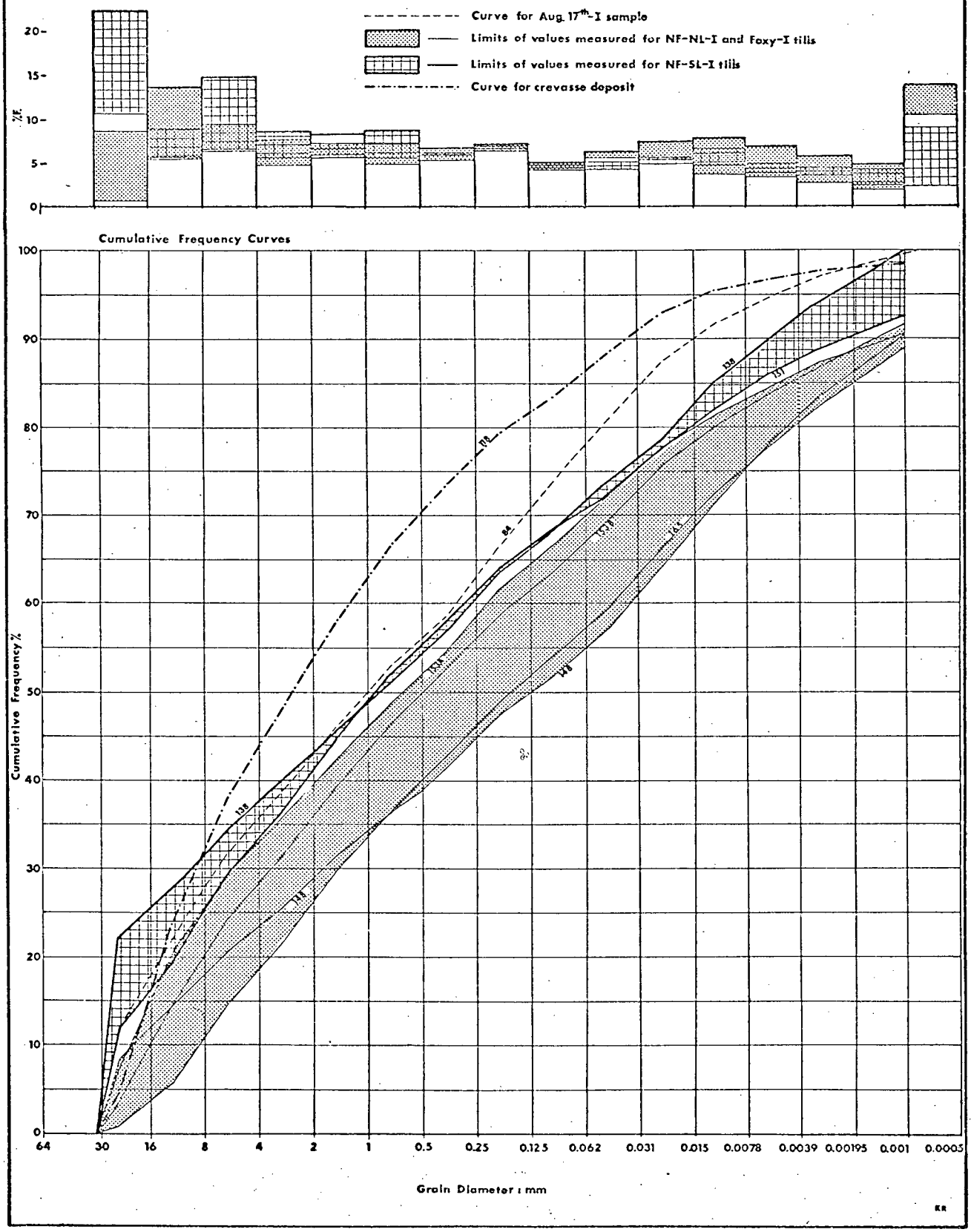
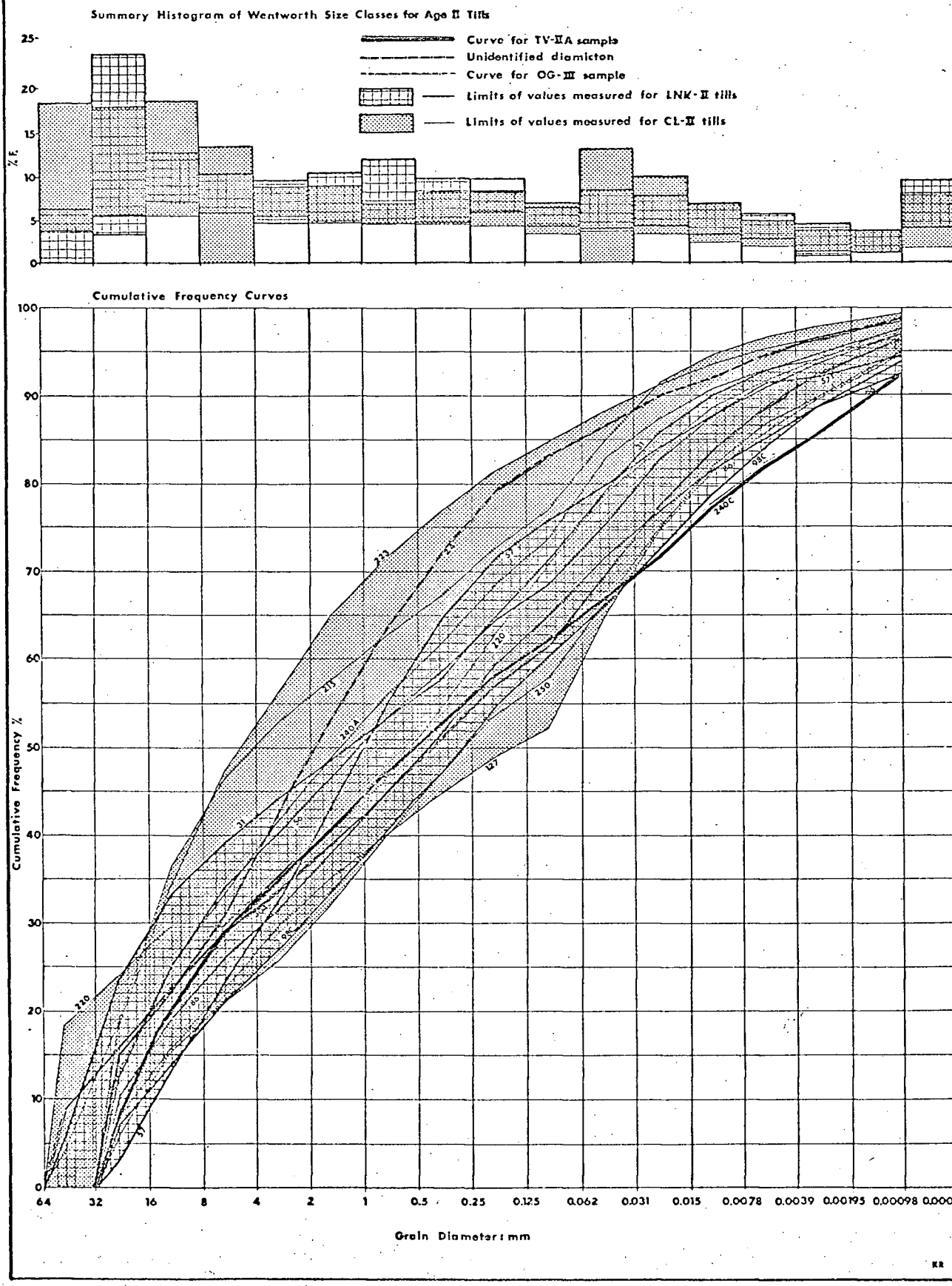


FIGURE B Mechanical Analyses of Age II, IIA, & III Tills (APPENDIX IIA)



(APPENDIX IIB)

TABLE I STRIATION PRESERVATION AND ANGULARITY OF THE PALEOZOIC VOLCANIC ROCKS (UNIT IV-5).

STATION NO.	MORAINE* AND AGE	ROUNDNESS[1] IN % FREQUENCY									% F. STRIAE	TOTAL[2] F.
		WR	R	R+SA	R+A	SR	SR+SA	SR+A	SA	A		
24	TINT.V-III(?)	0	0	0	0	0	0	0	50.0	50.0	0	2
31	LK-II	0	0	0	0	100.0	0	0	0	0	0	1
32	LK-II	0	0	0	0	0	0	0	0	0	0	0
57	LK-II	0	0	0	0	0	0	0	0	0	0	0
86	LK-II	0	10.0	0	0	10.0	0	0	80.0	0	10.0	10
98C	LK-II	0	0	0	0	20.0	0	20.0	60.0	0	60.0	5
84	A.17-I	0	0	0	0	0	0	0	0	0	0	0
138	NF-SL-I	0	0	0	0	0	0	0	0	0	0	0
148	NF-NL-I	0	0	0	0	10.0	0	0	90.0	0	50.0	10
151	NF-SL-I	0	0	0	0	25.0	0	0	75.0	0	50.0	4
153A	NF-NL-I	0	0	0	0	16.7	8.3	16.7	58.3	0	8.3	12
153B	NF-NL-I	0	0	0	0	0	0	20.0	60.0	20.0	0	5
165	FOXY-I	0	0	0	0	6.4	3.9	1.3	83.3	6.4	18.0	78
127	CL-II	0	1.4	0	1.4	4.4	5.8	7.2	59.4	14.5	27.5	69
220	CL-II	0	0	0	0	33.3	11.1	0	55.6	0	0	9
223	CL-II	0	0	0	0	75.0	0	0	25.0	0	0	4
240A	CL-II	0	0	0	0	27.3	0	9.1	63.6	0	45.4	11
240C	TV-IIA	0	3.6	0	0	21.4	0	3.6	85.8	21.4	42.8	28
304	OG-III	0	7.7	0	0	23.1	7.7	7.7	53.8	0	30.8	13

[1] BY VISUAL COMPARISON TO STANDARD ANGULARITY CHARTS; WR = WELL ROUNDED, R = ROUNDED, SR = SUBROUNDED, SA = SUBANGULAR, A = ANGULAR; SOME ROCKS EXHIBIT TWO PHASES OF ANGULARITY - HENCE, SR +SA ETC.

[2] THIS IS THE TOTAL NUMBER OF AUGITE BASALTS, GREENSTONE, ANDESITE, TUFF AND VOLCANIC AGGLOMERATES IN A STATION SAMPLE OF 100-200 ROCKS.

* THE ABBREVIATIONS REPRESENT THE FOLLOWING: TINT.V. = TINTINA VALLEY OF QUESTIONABLE RELATIONSHIPS, LK = LOWER NORTH KLONDIKE, A.17 = AUGUST 17TH CREEK, NF = NORTH FORK PASS, NL = NORTH LOBE, SL = SOUTH LOBE, FOXY = FOXY CREEK, CL = CHAPMAN LAKE, T.V. = TAIGA VALLEY, AND OG = OGILVIE GROUND MORAINES.

(APPENDIX IIB)

TABLE II * STRIATION PRESERVATION AND ANGULARITY IN THE SILL-FORMING ROCKS OF UNIT XX-16

STATION NO:	MORAINE AND AGE	ROUNDNESS IN % FREQUENCY									% F. STRIAE	TOTAL F.
		WR	R	R+SA	R+A	SR	SR+SA	SR+A	SA	A		
24	TINT.V-III(?)	0	0	0	0	0	0	0	0	0	0	0
31	LK-II	0	4.8	0	1.2	17.9	13.1	0	61.8	1.2	4.8	84
32	LK-II	0	0	0	0	32.3	5.2	2.1	59.4	1.0	3.1	86
56	LK-II	0	0	0	0	0	0	0	50.0	50.0	0	6
57	LK-II	0	0	0	0	0	0	0	0	0	0	0
86	LK-II	0	0	0	0	0	0	0	50.0	50.0	0	2
98C	LK-II	0	0	0	0	0	0	0	100.0	0	0	1
AVERAGE-LK-II		0	2.1	0	0.5	24.3	8.5	1.1	60.3	3.2	3.7	0
84	A.17-I	0	0	0	0	0	0	0	100.0	0	45.4	11
138	NF-SL-I	0	0	0	0	0	0	0	100.0	0	0	6
148	NF-NL-I	0	0	0	0	0	0	0	0	0	0	0
151	NF-SL-I	0	0	0	0	0	0	0	100.0	0	0	1
153A	NF-NL-I	0	0	0	0	100.0	0	0	0	0	0	1
153B	NF-NL-I	0	0	0	0	0	0	0	0	0	0	0
165	FOXY-I	0	0	0	0	0	100.0	0	0	0	100.0	1
AVERAGE-I's		0	0	0	0	9.5	9.5	0	81.0	0	28.5	0
127	CL-II	0	0	0	0	0	0	0	0	0	0	0
220	CL-II	0	0	0	0	40.0	0	0	60.0	0	20.0	5
223	CL-II	0	16.7	0	0	37.3	0	0	50.0	0	37.3	8
240A	CL-II	0	0	0	0	33.3	0	0	67.7	0	33.3	6
AVERAGE-CL-II		0	5.3	0	0	36.8	0	0	57.9	0	31.6	0
240C	TV-IIA	0	0	0	0	33.3	0	0	66.7	0	0	3
304	OG-III	0	0	0	0	33.3	0	0	66.7	0	66.7	3

* REFER TO PREVIOUS TABLE FOR EXPLANATION OF SYMBOLS; SILL ROCKS INCLUDE GABBRO, DOLERITE OR DIABASE; ± QUARTZOSE, ± PORPHYRITIC. AVERAGE FIGURES ARE WEIGHTED VALUES OF % FREQUENCY.

(APPENDIX IIB)

TABLE III* STRIATION PRESERVATION AND ANGULARITY IN THE PLUTONIC STOCK-FORMING ROCKS (UNIT XXIB-18).

STATION NO.	MORAINE AND AGE	ROUNDNESS IN % FREQUENCY									% F. STRIAE	TOTAL F.
		WR	R	R+SA	R+A	SR	SR+SA	SR+A	SA	A		
24	TINT.V-III(?)	0	0	0	0	0	0	0	0	0	0	0
31	LK-II	0	0	0	0	40.0	20.0	0	40.0	0	0	5
32	LK-II	0	0	0	0	28.6	0	0	57.2	14.2	0	7
56	LK-II	0	0	0	0	0	0	0	0	0	0	0
57	LK-II	0	0	0	0	0	0	0	0	0	0	0
86	LK-II	0	0	0	0	0	0	0	100.0	0	0	103
98C	LK-II	0	0	0	0	6.4	2.1	2.1	88.4	0	0	47
AVERAGE-LK-II**		0	0	0	0	4.3	1.2	0.6	93.3	0.6	0	0
84	A.17-I	0	0	0	0	0	0	0	0	0	0	0
138	NF-SL-I	0	0	0	0	0	0	0	81.6	18.4	0	65
148	NF-NL-I	0	0	0	0	0	0	0	100.0	0	0	13
151	NF-SL-I	0	0	0	0	0	2.3	0	84.9	12.8	0	86
153A	NF-NL-I	0	0	0	0	20.0	0	0	80.0	0	0	5
153B	NF-NL-I	0	0	0	0	0	25.0	0	75.0	0	25.0	4
165	FOXY-I	0	0	0	0	0	0	0	0	100.0	100.0	1
AVERAGE-I's**		0	0	0	0	0.6	1.2	0	84.1	14.1	0.6	-
127	CL-II	0	0	0	0	0	0	100.0	0	0	0	1
220	CL-II	0	0	0	0	40.0	0	0	60.0	0	0	5
223	CL-II	0	9.1	0	0	36.3	0	6.1	39.4	9.1	6.1	33
240A	CL-II	0	5.1	0	0	35.9	0	0	59.0	0	0	39
AVERAGE-CL-II**		0	6.4	0	0	35.8	0	3.9	50.0	3.9	2.6	0
240C	TV-IIA	0	1.9	0	0	32.7	7.7	1.9	55.8	0	0	52
304	OG-III	0	0	0	0	50.0	0	0	50.0	0	0	4

* REFER TO PREVIOUS TABLES FOR EXPLANATION OF SYMBOLS; STOCK ROCKS INCLUDE ALL VARIETIES OF SYENITE AND MONZONITE; APLITE, PYROXENITE AND DIORITES ARE A MINOR COMPONENT.

** AVERAGES ARE WEIGHTED; THE FIGURES FOR THE YOUNG MORAINE EXCLUDE 153B AS THE SAMPLE IS BELOW 153A AND POSSIBLY BEYOND ZONE OF WEATHERING.

TABLE I - WEATHERING CHARACTERISTICS FOR ALL PEBBLE-COBBLE CLASTS IN SELECTED SAMPLES OF TILLS. (APPENDIX IIC)

STATION NO.	MORAINE[1] AND AGE	TYPE OF WEATHERING[2] IN % FREQUENCY: SURFACE MOTTLE	FRACTURES, VEINLETS	MATRIX, CEMENT	CENTRAL CORE	RIND ON OUTER SURFACE: % F.	AV. THICK	COMPLETELY WEATHERED	NO WEATHERING
24	TINT.V-III(?)	77.5	66.2	18.9	2.7	5.4	1.5 MM.	4.5	3.6
31	LK-II	77.0	28.0	42.0	3.0	6.0	1.5 MM.	0	9.0
32	LK-II	72.0	28.0	39.0	3.0	8.0	1.0 MM.	7.0	18.0
56	LK-II*	92.0	12.0	56.0	0	0	-	0	0
57	LK-II	93.0	38.0	12.0	1.0	7.0	1.0 MM.	5.0	2.0
86	LK-II	83.0	29.0	61.0	1.0	7.0	3.0 MM.	0	5.0
98C	LK-II	93.0	44.0	63.0	3.0	1.0	2.0 MM.	5.0	5.0
84	AUG 17TH-I	47.0	28.0	19.0	0	8.0	2.0 MM.	3.0	30.0
138	NF-SL-I	94.0	47.0	65.0	0	1.0	3.0 MM.	3.0	1.0
148	NF-NL-I	55.0	47.0	46.0	0	2.0	1.0 MM.	2.0	10.0
151	NF-SL-I	99.0	44.0	58.0	0	5.0	2.5 MM.	6.0	1.0
153A	NF-NL-I	88.0	46.0	55.0	1.0	5.0	3.0 MM.	5.0	0
153B	NF-NL-I	90.0	41.0	45.0	1.0	6.0	4.0 MM.	3.0	5.0
165	FOXY-I	99.0	22.0	66.0	0	22.0	3.0 MM.	9.0	0
127	CHAP.L.-II	86.0	56.0	54.0	1.0	10.0	3.0 MM.	10.0	0
220	CHAP.L.-II	96.0	24.0	71.0	0	8.0	1.5 MM.	2.0	0
223	CHAP.L.-II	91.0	27.0	75.0	1.0	12.0	2.0 MM.	1.0	0
240A	CHAP.L.-II	85.0	39.0	59.0	0	6.0	2.5 MM.	0	6.0
250	CHAP.L.-II*	84.0	36.0	8.0	0	8.0	1.0 MM.	0	0
240C	T.V.-IIA	97.0	43.0	59.0	0	6.0	2.0 MM.	0	0
304	OGILVIE-III	99.0	31.0	71.0	0	9.0	2.5 MM.	0	0

1 ABBREVIATIONS ARE EXPLAINED IN APPENDICIES IIA AND IVC.

2 THESE ARE VISIBLE CHARACTERISTICS AS SHOWN BY FIGURE 16.

* ALL VALUES ARE BASED ON 100-110 DETERMINATIONS FROM EACH STATION WITH THE EXCEPTION OF THESE TWO; IN THIS CASE ONLY 25 PEBBLES WERE EXAMINED.

TABLE II - WEATHERING CHARACTERISTICS[1] FOR ALL ARENITES AND RUDITES OF PEBBLE-COBBLE SIZES IN SELECTED SAMPLES OF TILLS. (APPENDIX IIC)

STATION NO.	MORAINE AND AGE	WEATHERING COLOURS[2]	TYPE OF WEATHERING IN % FREQUENCY								TOTAL F.
			SURFACE MOTTLES	FRACTURES, VEINLETS	MATRIX, CEMENT	CENTRAL CORE	RIND ON OUTER SURFACE % F.	RIND ON OUTER SURFACE AV.THICK	COMPLETELY WEATHERED	NO WEATHERING	
24	TINT.V.-III?	Y,Y-O,O,R-O,R-BN	80.0	65.2	19.0	3.2	6.3	1.5 MM.	2.1	4.2	95
31	LK-II	Y,O	76.4	25.0	54.4	4.4	2.9	1.5 MM.	0	12.3	68
32	LK-II	Y-O,O,RBK,BN-BK	64.7	20.6	45.6	4.4	2.9	1.3 MM.	1.5	25.0	68
57	LK-II	Y,O,Y-O,R	90.5	28.3	15.1	3.7	7.5	1.5 MM.	0	1.9	53
86	LK-II	O,BN,R-BN	98.2	31.5	88.9	1.9	13.0	3.0 MM.	0	0	54
98C	LK-II	O,Y,BN	93.2	36.4	95.4	6.8	2.3	2.0 MM.	0	0	44
84	AUG 17TH-I	Y,O,R-O,R-BN,BN	42.6	35.7	19.1	0	0	-	0	30.9	84
138	NF-SL-I	O,BN,Y	84.4	36.6	74.7	0	1.4	3.0 MM.	2.8	0	71
148	NF-NL-I	O,BK,BN,O-BN	51.0	32.7	75.5	0	2.0	2.0 MM.	2.0	8.2	49
151	NF-SL-I	O,R-BN,P,Y-BN,BN	98.0	36.7	85.7	0	8.2	5.0 MM.	6.1	0	49
153A	NF-NL-I	O,B1,BN	100.0	39.0	100.0	0	2.4	3.0 MM.	2.4	0	41
153B	NF-NL-I	O,Y,BN,BK,R	87.2	28.2	74.4	0	5.1	5.0 MM.	2.6	5.1	39
165	FOXY-I	INSUFFICIENT QUANTITY IN SAMPLE									
127	CHAP.L.-II	O,BN,R-BN	71.4	47.6	71.4	0	14.3	2.0 MM.	0	0	21
220	CHAP.L.-II	Y,O,R-BN	98.3	18.0	85.2	0	1.6	1.0 MM.	0	0	61
223	CHAP.L.-II	Y,O,R-BN,BN	95.3	21.9	87.8	1.6	1.6	2.0 MM.	0	0	64
240A	CHAP.L.-II	O,Y,BN,P-BN	80.4	37.3	74.5	0	7.8	3.0 MM.	0	2.0	51
240C	T.V.-IIA	Y,O,O-BN,BN	94.3	28.6	85.7	0	2.9	0.5 MM.	0	0	35
304	OGILVIE-III	O,O-BN,Y,BN,R	100.0	29.2	81.5	0	7.7	2.5 MM.	1.5	0	65

1 REFER TO PREVIOUS TABLE FOR EXPLANATION OF THE SYMBOLS, ETC.

2 Y = YELLOW, O = ORANGE, R = RED, BN = BROWN, P = PURPLE, B1 = BLUE, BK = BLACK, GN = GREEN, GY = GRAY

TABLE III - WEATHERING CHARACTERISTICS OF THE LOWER PALEOZOIC VOLCANIC CLASTS[1] - UNIT IV-5 (APPENDIX IIC)

STATION NO.	MORAINE AND AGE	WEATHERING COLOURS	TYPE OF WEATHERING IN % FREQUENCY								TOTAL F.
			SURFACE MOTTLES	FRACTURES, VEINLETS	MATRIX, CEMENT	CENTRAL CORE	RIND ON OUTER SURFACE % F	RIND ON OUTER SURFACE AV. THICK	COMPLETELY WEATHERED	NO WEATHERING	
24	TINT.V.-III(?)	R-BN	100	0	0	0	0	-	10.0	0	2
31	LK-II	-	0	0	100.0	0	0	-	0	0	1
32	LK-II	NOT PRESENT IN SAMPLE									
56	LK-II	NOT PRESENT IN SAMPLE									
57	LK-II	NOT PRESENT IN SAMPLE									
86	LK-II	O,Y,P-BN	100	40.0	50.0	0	0	-	0	0	10
98C	LK-II	P,BN,R-BN	100	80.0	100.0	0	0	-	0	0	5
84	AUG 17TH-I	NOT PRESENT IN SAMPLE									
138	NF-SL-I	NOT PRESENT IN SAMPLE									
148	NF-NL-I	O,P-BK	90.0	60.0	60.0	0	0	-	0	0	10
151	NF-SL-I	GN,GY	100.0	50.0	100.0	0	25.0	1 MM.	0	0	4
153A	NF-NL-I	O,P,GY	100.0	41.6	83.3	0	0	-	0	0	12
153B	NF-NL-I	BN	100.0	40.0	80.0	0	0	-	0	0	5
165	FOXY-I	BN,O,P-BN	100.0	24.3	57.7	0	0	-	3.9	0	78
127	CHAP.L.-II	BN,O,P	94.2	58.0	53.7	1.4	7.2	3.5 MM.	14.5	0	69
220	CHAP.L.-II	O,BN	88.9	22.2	66.7	0	11.1	2.0 MM.	22.2	0	9
223	CHAP.L.-II	O,BN	100.0	50.0	75.0	0	25.0	2.0 MM.	0	0	4
240A	CHAP.L.-II	BN,Y,O	81.8	45.4	63.6	0	0	-	0	9.1	11
240C	T.V.-IIA	P-BN,O	100.0	35.7	53.6	0	17.9	2.5 MM.	0	0	28
304	OGILVIE-III	O,R-O,BN	100.0	46.1	61.6	0	0	-	7.7	0	13

1 INCLUDES AUGITE BASALTS, ANDESITES, AGGLOMERATES, TUFFS, GREENSTONE AND UNIDENTIFIED FELSITE. FOR EXPLANATION OF SYMBOLS REFER TO PREVIOUS TWO TABLES OF THIS APPENDIX.

TABLE IV - WEATHERING CHARACTERISTICS OF THE FINE-GRAINED CLASTIC ROCKS TAKEN FROM SELECTED SAMPLES OF TILLS.* (APPENDIX IIC)

STATION NO.	MORAINE AND AGE	WEATHERING COLOURS	TYPE OF WEATHERING IN % FREQUENCY								TOTAL F.
			SURFACE MOTTLES	FRACTURES, VEINLETS	MATRIX, CEMENT	CENTRAL CORE	RIND ON OUTER SURFACE % F.	RIND ON OUTER SURFACE AV. THICK	COMPLETELY WEATHERED	NO WEATHERING	
24	TINT.V.III?)	O,R-BN	100.0	100.0	75.0	0	0	-	25.0	0	4
31	LK-II	O,BN	100.0	33.3	33.3	0	0	-	0	0	3
32	LK-II	BN	50.0	0	50.0	0	0	-	0	0	2
56	LK-II	Y,O,BN,R-BN	87.5	25.0	37.5	0	0	-	0	0	8
57	LK-II	O,R-O	66.7	66.7	66.7	16.7	0	-	0	0	6
86	LK-II	BN,O,R-O	64.7	64.7	17.6	0	0	-	0	24.4	17
98C	LK-II	Y-O	90.0	60.0	30.0	0	0	-	0	10.0?	10
84	AUG 17TH-I	-	0	0	0	0	0	0	0	100.0	1
138	NF-SL-I	O	89.4	52.6	31.6	0	0	-	5.3	5.3	19
148	NF-NL-I	O,R-O,R-BN	65.0	55.0	0	0	5.0	0.5	0	20.0	20
151	NF-SL-I	Y,O,BN,R-BN,P	100.0	85.8	71.4	0	0	-	0	0	14
153A	NF-NL-I	Y,O,BN,B1-BN,Y-GN	75.0	55.0	10.0	0	5.0	5.0 MM.	5.0	0	20
153B	NF-NL-I	O.B1-BK,BN	74.3	34.3	8.6	0	0	-	0	8.6	35
165	FOXY-I	O,P-BN	100.0	0	33.3	0	0	-	0	0	3
127	CHAP.L.-II	O,B1	83.3	25.0	16.7	0	0	-	0	0	6
220	CHAP.L.-II	O,Y-O	72.8	27.3	27.3	0	0	-	0	18.2	11
223	CHAP.L.-II	BN,O,W	94.0	35.3	41.2	0	11.8	1.0 MM.	0	0	17
240A	CHAP.L.-II	Y,Y-O,BN,O,R-BN	80.0	26.8	33.3	0	0	-	0	13.3	15
250	CHAP.L.-II	Y	50.0	16.7	0	0	0	-	0	33.3	6
240C	T.V.-IIA	O,BN,GN	87.5	75.0	12.5	0	0	-	0	0	16
304	OGILVIE-III	O,B1	88.9	55.6	33.3	0	11.1	2.0 MM.	0	0	9

* REFER TO TABLES ON PREVIOUS PAGES FOR EXPLANATION OF SYMBOLS; ROCKS INCLUDE ARGILLACEOUS, LIMEY AND METAMORPHIC EQUIVALENTS OF ARGILLITES, SHALES AND SILTSTONES. CHERTS ARE NOT CONSIDERED IN THIS TABLE.

APPENDIX - III

Soil Profile Descriptions

The following moraines located in the vicinity of the Dempster Highway region of the Ogilvie Mountains were investigated pedologically: Lower North Klondike of Age II, August 17th Creek of Age I, south and north lobes of the North Fork Pass (Age I), Foxy Creek of Age I, Chapman Lake of Age II and Ogilvie of Age III. Profile descriptions are organized by moraines (and their relative south to north position,) by ascending NSSC (1963)* soil type code numbers within the moraine, and by ascending field station (site or pit) numbers within the soil type. Hence, the profiles are organized according to the outline below.

		pages
Appendix III-A	Lower North Klondike Moraine - station 54	84A
Appendix III-B	August 17th Creek Moraine - station 84	25A
Appendix III-C	North Fork Pass Moraine - South Lobe	26A-31A
	4.31 Profiles - stations 138, 151	
	4.32 Profile - stations 135	
	4.61 or 4.21 Profile - station 139	
	5.1 -/8 Profile - station 136	
	6.21 Profile - station 137	
Appendix III-D	North Fork Pass Moraine - North Lobe	32A-37A
	4.21 Profiles - stations 140, 142	
	4.31 and 5.1 -/8 - station 143	
	5.1 -/7 Profile - station 141	
	6.21 Profile - station 148	
	7.12 Profile - station 144	
Appendix IV-E	Foxy Creek Moraine	38A-40A
	4.21 Profile - station 164	
	5.11 on a 4.21 Profile - station 166	
	5.1 -/8 Profile - station 165	
Appendix III-F	Chapman Lake Moraine	41A-51A
	4.21 Profiles - stations 212, 219	
	5.1 -/7 Profiles - stations 213, 214	
	5.1 -/8 Profile - station 223	
	5.1 -/8 x 6.2 -/7 - station 222	
	6.21 Profile - station 221	
	6.2 -/7 Profile - station 220	

7.2 x 5.1 -/7 - station 216, 218
7.12 Profile - station 217

Appendix III-G Ogilvie Ground Moraine 52A-53A

3.2 x 4.2 - station 302
5.1 -/8 Profile - station 304

Terminology in the profile descriptions follows the form given and described in the National Soil Survey Committee report for 1963. All horizon designation, textural terminology, structural terminology landscape description, soil moisture notes, soil consistence determination, and soil type classification follow their outline. Soil consistence was determined on wet samples; colours were numerically determined by comparison of a moist sample to the Munsell Soil Colour Charts (1954); pH was tested in the field by use of standard agricultural "Hellige" pocket pH kits, and parent materials were described in standard geological terminology. About one half of the sites were inspected by Mr. H. Hortie of the Dominion Soil Survey, and horizons were sampled as per his instructions. Since time became a key element of worry in this report chemical analysis of the samples was cancelled and the samples are now in the hands of Mr. H. Hortie for future laboratory analysis. However, some clay translocation analysis on the Brunizolic profiles were carried out by the sedimentation laboratory in the Ottawa offices of the Geological Survey of Canada. The results are recorded within the text of the thesis.

In an effort to avoid needless repetition the main body of environmental data which normally accompanies soil profile data has been spelled out once only. In this case the data was essential for phytosocialogical analysis of the botanical data and has for the most part been included in the "A" tables of Appendix IVC. For location of specific soil plot environmental data the reader should examine the introductory pages of Appendix IVC. For sake of simplicity horizon colours have been omitted by name in the profile descriptions to follow. For those readers not versed with the Munsell (1954) colour chart system the following will be of help.

Yellowish Red	- 5YR 5/6
Red	- 2.5YR 5/6 and 5.5/8
Dark Red	- 2.5YR 3/6
Reddish Brown	- 5YR 4.5/4
Dark Reddish Brown	- 2/5YR 2/4; 5YR 2/2, 2.5/2, 3/2, 3/3. 3.5/3 and 3.5/4

Dark Brown	- 7.5 YR 3/2, 3.5/2, 10YR 3/3, 3.5/3 4/3 and 4/2.5
Very Dark Brown	- 10YR 2/2, 2.5/2 2.5 1 1/2 and 2/3
Olive Brown	- 2.5Y4/1
Dark Yellowish Brown	- 10YR 4/4
Very Dark Greyish Brown	- 2.5 Y 3/2, 3/2; 10YR 3/2 and 3.5/2
Dark Gray Brown	- 2.5 Y 4/2, 4.5/2; 10YR 4/2, 4.5/2 and 4/2.5
Greyish Brown	- 10YR 5/2
Dark Olive Gray	- 5 Y 3/2
Very Dark Gray	- 2.5 Y 3/1; 5 YR 2.5/1; 10YR 2.5/1, 3/1 3.5/1 & 3/1.8
Dark Gray	- N 4/0, 4.5/0; 2.5 YR 4/0; 5 Y 3.5/1; 7.5 YR 4/0; 10 YR 4/1
Gray	- 2.5 Y 5.5/0; 10 YR 5/1 and 5.5/1
Light Gray	- 10 YR 7/2
Bluish Gray	- 5 B 6.5/1

Soil colours were the main criteria used in the differentiation of the various horizons. Chemical data will be needed to verify these determinations. Hence, many soil classifications in the Appendices to follow must be regarded as tentative.

* refer to Appendix IVC for further explanation.

(APPENDIX III-A)

Station or Soil Pit Site No. 54 (98P)

Moraine and Relative Age - Lower North Klondike-II. NSSC Code No. 5.1-/$_8$ on 4.2

Environment -

Microtopography (NSSC,1963) - B. Slope and aspect - slight to 135°
Relief - ± flat climate - Dfc (Köppen)
Stoniness (NSSC,1963) - 0-1 drainage - moderate to imperfect
Erosion (NSSC,1963) - W 1, E 1, + 7.5 cm.

Vegetation - spruce forest overstory; unidentified continuous moss ground matt

Field Soil Type Designation (NSSC,1963) - Gleyed Regosol on Brown Wooded (?)

Site visited by Mr. H. Hortie of the Dominion Soil Survey? - No

Recommended Laboratory Analysis - pH, clay translocation, cations, organics, free Fe, clay mineralogy.

PROFILE DESCRIPTION

Horizon Code	Depth (cm.)	Moist Munsell Colour	Field pH	Textural, Structural, and Other Horizon Characteristics
L-F	20-2.5	-	-	Living ground matt of moss in gradational contact to -
H	2.5-0	-	-	Humus layer in sharp contact to -
IC or (I Cz)	0-7.5	-	-	Gleyed silt of eolian origin; rootlets present in sharp contact to -
IIH	7.5-8.5	-	-	Buried humus horizon intermittently present in sharp contact to -
IIAh(?)	7.5-12.5	-	-	Sandy loam with rootlets present in gradational contact to -
IIBf	12.5-20	-	-	Sandy gravel showing a blocky to platy structure; rootlets present in gradational contact to -
IIBC or IICB	20-25	-	-	Slightly oxidized, dirty gravel with rootlets present in gradational contact to -
IIC	25-	-	-	Till of muddy to sandy gravel texture.

NOTES:

This is a typical buried Brown Wooded soil profile so prevalent throughout the Lower North Klondike Valley. Time did not permit thorough examination of the profile. However, the horizons were sampled and sent to Mr. H. Hortie of the Dominion Soil Survey at the Winnipeg offices. Under forest cover the C horizon in the overlying silt is frozen.

(APPENDIX III-B)

Station or Soil Pit Site No. 84

Moraine and Relative Age - August 17th Ck.-I. NSSC Code No. 4.32

Environment - refer to "A" Tables of Appendix IVC

Microtopography (NSSC,1963) - A-B or D-E for moraine as whole
Relief - slightly less than 80 m.
Stoniness (NSSC,1963) - 5
Erosion (NSSC,1963) - W 1, E 1, +

Vegetation - refer to "B" Tables of Appendix IVC

Field Soil Type Designation (NSSC,1963) - Degraded Acid Brown Wooded

Site visited by Mr. H. Hortie of the Dominion Soil Survey? - No

Recommended Laboratory Analysis - clay translocation, pH, free Fe, cations, % organics, clay mineralogy.

PROFILE DESCRIPTION

Horizon Code	Depth (cm.)	Moist Munsell Colour	Field pH	Textural, Structural, and Other Horizon Characteristics
L-H	2.5-0	-	-	Thin moss and lichen litter on a humus horizon; roots present; sharp contact to -
Ae	0-5.0	10YR5/2 to 10YR5.5/1	-	Weak, structureless, slightly sticky, slightly plastic, organic-rich loam; roots present; sharp contact, when present, to -
Ah	0-5.0	5YR2/1	-	Granular, moderately developed, medium platy loam; slightly sticky; slightly plastic; organic rich; in gradational contact, when present, to -
Bf	5-10	7.5YR4/4	-	Granular, moderately-developed fine angular blocky breaking to platy, sticky, plastic loam; rootlets present; in gradational contact to -
BC	10-15	10YR4/4	-	Moderately developed medium to coarse subangular blocky, slightly sticky to sticky, plastic gravelly loam; rootlets present; in gradational contact to -
CB	15-22.5	10YR3.5/2	-	Moderately-developed medium to coarse subangular blocky, sticky,plastic dirty gravel; rootlets present; in gradational contact to -
C	22.5 -	10YR3/1	-	Sandy till; very firm.

NOTES

The eluviated Ae horizon is not always present.

(APPENDIX III-C)

Station or Soil Pit Site No. 138

Moraine and Relative Age - North Fork Pass-South Lobe-I. NSSC Code No. 4.31

Environment - refer to "A" Tables of Appendix IVC

Microtopography (NSSC,1963) - a-f (undulatory)
Relief - 4-5 m.
Stoniness (NSSC,1963) - 4
Erosion (NSSC,1963) - W 1, E 1.

Vegetation - refer to "B" Tables of Appendix IVC

Field Soil Type Designation (NSSC,1963) - Orthic Acid Brown Wooded

Site visited by Mr. H. Hortie of the Dominion Soil Survey? - Yes

Recommended Laboratory Analysis - pH, free Fe, % organics, cations, clay mineralogy, clay translocation.

PROFILE DESCRIPTION

Horizon Code	Depth (cm.)	Moist Munsell Colour	Field pH	Textural, Structural and Other Horizon Characteristics
L-H	5.0-0	-	-	Cryptograms on thin humus horizon; in sharp contact to -
Ah	0-2.5	$5YR2.5/_2$	-	Platy breaking to blocky, sticky, plastic clayey loam; in gradiational contact to-
Bf or Bm	2.5-10	$7.5YR4/_4$	-	Medium platy breaking to medium granular, slightly sticky, plastic sandy loam; in gradational contact to -
BC	10-18	$10YR3/_3$	-	Subangular blocky sandy loam; slightly sticky; non-plastic; in gradational contact to -
CB	18-28	$10YR4/_2$	-	Discontinuous clayey coarse sand; sticky; non-plastic; in gradational contact to -
C	18-28 to -	$10YR3/_3$	-	Clayey till (muddy sandy gravel-Folk, 1965).

NOTES:

"Mud boils" from frost action are present in the surrounding area. This may explain the occurrence of an Ah horizon beneath a Bf layer on some walls of the pit. Discontinuous eluviation is visible in the Ah horizon.

(APPENDIX III-C)

Station or Soil Pit Site No. 151

Moraine and Relative Age - North Fork Pass - South Lobe-I. NSSC Code No. 4.31(?)

Environment - refer to "A" Tables of Appendix IVC

Microtopography (NSSC,1963) - a-g (undulatory)
Relief - ca. 20 m.
Stoniness (NSSC,1963) - 4-5
Erosion (NSSC,1963) - W 1, E 1 (no recent accumulations)

Vegetation - refer to "B" Tables of Appendix IVC

Field Soil Type Designation (NSSC,1963) - Orthic Acid Brown Wooded (?)

Site visited by Mr. H. Hortie of the Dominion Soil Survey? - No

Recommended Laboratory Analysis - clay translocation, pH, free Fe, cations, % organics, clay mineralogy.

PROFILE DESCRIPTION

Horizon Code	Depth (cm.)	Moist Munsell Colour	Field pH	Textural, Structural and Other Horizon Characteristics
L-F	5-2.5	-	-	Living ground matt in gradational contact to -
H or Ah	2.5-0	$5YR2/_2$	-	Organic rich loam in gradational contact to -
Bf or B C	0-2.5	$7.5YR3.5/_2$	-	Medium blocky, slightly sticky, plastic sandy loam; in gradational contact to -
BC or CB	2.5-15	$10YR3/_2$	-	Subangular blocky, non-sticky, plastic sandy loam; in gradational contact to -
C	15-	$10YR3.5/_2$	-	Pisolitic, indurated till (muddy sandy gravel - Folk, 1965).

NOTES:

Despite water retention characteristics of the soil pit after heavy rains there was no visible evidence of gleying in the profile.

(APPENDIX III-C)

Station or Soil Pit Site No. 135

Moraine and Relative Age - North Fork Pass - South Lobe-I. NSSC Code No.4.32

Environment - refer to "A" Tables of Appendix IVC

Microtopography (NSSC,1963) - e (undulatory)
Relief - 4-5 m.
Stoniness (NSSC,1963) - 3-4
Erosion (NSSC,1963) - W 1, E 1

Vegetation - refer to "B" Tables of Appendix IVC

Field Soil Type Designation (NSSC,1963) - Degraded Acid Brown Wooded

Site visited by Mr. H. Hortie of the Dominion Soil Survey? - Yes

Recommended Laboratory Analysis - % organics, free Fe, cations, clay translocation, pH, clay mineralogy.

PROFILE DESCRIPTION

Horizon Code	Depth (cm.)	Moist Munsell Colour	Field pH	Textural, Structural, and Other Horizon Characteristics
L-F	5-0	-	-	Living ground matt of mosses and well decomposed humus in moderately sharp contact to -
Aej	0-1.5	10YR5/1	4.5	Coarse platy, sticky, plastic loam; discontinuous; in sharp contact to -
Bf	0 or 1.5-7.5	10YR4/4	5.7	Coarse subangular blocky, silty loam; in gradational contact to -
BC	7.5-20	10YR4/2.5	6.0	Coarse subangular breaking into angular blocky, grittyloam; in gradational contact to -
C	20-	10YR4/2 to 10YR3/2	6.0 to 6.5	Pisolitic till with silt skins on the pebble fraction; induration increases with depth; no rootlets present.

NOTES;

Profile shows greater extent of weathering than Age II till of the Chapman Lake Moraine. Some involutions are discernible in the oxidized surficial portion of the profile. Suspect fairly strong leaching of cations in the profile.

(APPENDIX III-C)

Station or Soil Pit Site No. 139

Moraine and Relative Age - North Fork Pass-South Lobe-I. NSSC Code No. 4.61 or 4.21

Environment - refer to "A" Tables of Appendix IVC

Microtopography (NSSC,1963) - b-f (undulatory)
Relief - ca. 50 m.
Stoniness (NSSC,1963) - 3-4
Erosion (NSSC,1963) - W 1, E 1 - eolian accumulation not apparent

Vegetation - refer to "B" Tables of Appendix IVC

Field Soil Type Designation (NSSC,1963) - Orthic Subalpine Brown (?)

Site visited by Mr. H. Hortie of the Dominion Soil Survey? - No

Recommended Laboratory Analysis - pH, % organics, clay translocation, free Fe, cations, clay mineralogy.

PROFILE DESCRIPTION

Horizon Code	Depth (cm.)	Moist Munsell Colour	Field pH	Textural, Structural, and Other Horizon Characteristics
L-H	2.5-0	-	-	Living ground matt mixed with a thin humus layer in gradational contact to -
Ah	0-2.5	5YR3/3	-	Subangular blocky, cobbly sandy loam; slightly sticky; plastic; rootlets present; gradational contact to -
Bf	2.5-10	7.5YR4/4	-	Granular structureless sandy loam; scarcely sticky; plastic; rootlets present; gradational contact to -
BC or CB	10-28	10YR4/4	-	Granular structureless, coarse cobbly sand; scarcely sticky; nonplastic; rootlets present; in gradational contact to -
C	23-	-	-	Coarse, poorly sorted, non-bedded, dirty gravel (ablation or hummocky till) with clay skins on boulder tops.

NOTES:

Calcium carbonate crust on bottoms of cobbles in Bf, BC and C horizons, but never present in the "fines" of any horizon.

This is one of very few hummocky gravel profiles on the south lobe of the North Fork Pass Moraine.

(APPENDIX III-C)

Station or Soil Pit Site No. 136

Moraine and Relative Age - North Fork Pass-South Lobe-I. NSSC Code No. 5.1-/8

Environment - refer to "A" Tables of Appendix IVC

Microtopography (NSSC,1963) - b-e generally; B for gulley locality of site
Relief - 4-5 m.
Stoniness (NSSC,1963) - 0-1
Erosion (NSSC,1963) - W 1, E 1, + complex

Vegetation - refer to "B" Tables of Appendix IVC

Field Soil Type Designation (NSSC,1963) - Gleyed Regosols (3 profiles)

Site visited by Mr. H. Hortie of the Dominion Soil Survey? - Yes

Recommended Laboratory Analysis - pH, % organics.

PROFILE DESCRIPTION

Horizon Code	Depth (cm.)	Moist Munsell Colour	Field pH	Textural, Structural, and Other Horizon Characteristics
L-F	7.5-0	-	-	Humus and living vegetation in sharp contact to -
Cg	0-23	mottles = 7.5YR4/2 matrix = 7.5YR4/4	-	Platy, slightly sticky, plastic mottled silty to clayey loam in sharp contact to -
IIF	23-25	-	-	Dark, discontinuous, organic rich horizon in sharp contact to -
IICg	23-56	mottles = 10YR3.5/3 matrix = 10YR4/2.5	-	Platy, slightly sticky, plastic, mottled silty to clayey loam; no roots present; in sharp contact to -
IIIF	56-58	-	-	Dark, discontinuous, organic rich horizon in sharp contact to -
IIICg	56-	mottles = 10YR4/2 matrix = 10YR4/3	-	Platy, slightly sticky; slightly plastic, silty to clayey loam.

NOTES:

There are a few pebbles to boulders in each Cg horizon in the form of a stone line appearance.

This is a slope wash environment. Pit records three periods of colluviation. Mottling increases with depth in the soil profile.

(APPENDIX III-C)

Station or Soil Pit Site No. 137

Moraine and Relative Age - North Fork Pass-South Lobe-I. NSSC Code No. 6.21

Environment - refer to "A" Tables of Appendix IVC

Microtopography (NSSC,1963) - b-e generally; C locally.
Relief - 4-5 m.
Stoniness (NSSC,1963) - 2
Erosion (NSSC,1963) - W 1, E 1, +(?) if top layer is of eolian origin.

Vegetation - refer to "B" Tables of Appendix IVC

Field Soil Type Designation (NSSC,1963) - Rego Gleysol

Site visited by Mr. H. Hortie of the Dominion Soil Survey? - Yes

Recommended Laboratory Analysis - % organics, pH, cations.

PROFILE DESCRIPTION

Horizon Code	Depth (cm.)	Moist Munsell Colour	Field pH	Textural, Structural, and Other Horizon Characteristics
L-F	12.5-7.5	-	-	Non-decomposed moss matt in gradational contact to -
H	7.5-0	-	-	Blocky, greasy, well-decomposed "muck" in sharp contact to -
Ahg	0-5	mottles = 5YR3.5/4 matrix = 10YR3.5/1	5.7	Moderately-developed fine to medium granular loam; organic rich; slightly convoluted; in gradational contact to -
Cg(IorII)	5-65	-	6.0-6.7	Subangular blocky, slightly sticky, plastic, gravelly loam; in fairly sharp contact to -
C (IIorIII)	65-	-	-	Silty or clayey till.

NOTES:

Feature appears to be a minor kame bench capped perhaps by a thin eolian or colluvial derived silt.

Underlying till is impeding drainage and creating the gleying conditions.

(APPENDIX III-D)

Station or Soil Pit Site No. 140

Moraine and Relative Age - North Fork Pass-North Lobe-I. NSSC Code No. 4.21

Environment - refer to "A" Tables of Appendix IVC

Microtopography (NSSC,1963) - b-e
Relief - 5 m. local, 50 m. surrounding terrain
Stoniness (NSSC,1963) - 2-3
Erosion (NSSC,1963) - W 1, E 1

Vegetation - refer to "B" Tables of Appendix IVC

Field Soil Type Designation (NSSC,1963) - Orthic Brown Wooded

Site visited by Mr. H. Hortie of the Dominion Soil Survey? - Yes

Recommended Laboratory Analysis - clay translocation, pH, free Fe, cations, % organics, clay mineralogy.

PROFILE DESCRIPTION

Horizon Code	Depth (cm.)	Moist Munsell Colour	Field pH	Textural, Structural, and Other Horizon Characteristics
L-H	2.5-0	-	-	Thin living matt mixed with dark humus in gradational contact to -
Ah	0-2.5	10YR2/3	4.7	Blocky to granular, slightly sticky, slightly plastic sandy loam; in gradational contact to -
Bm or Bf	2.5-10	7.5YR4/4	6.0	Very weakly-developed subangular blocky breaking to granular pebbly sandy loam; in gradational contact to -
BC	10-15	10YR3/2 -10YR3/3	6.5	Single grained, structureless pebbly sand in sharp contact to -
C	15-	10YR4/1 -10YR3/1	7.0-7.5	Coarse cobbly and dirty gravel with stringers of tilloid material; cobbles with thick calcium carbonate crusts on their bottom surfaces.

NOTES:

Calcium carbonate was not detected in the sandy matrix of the parent material.

(APPENDIX III-D)

Station or Soil Pit Site No. 142

Moraine and Relative Age - North Fork Pass-North Lobe-I. NSSC Code No. 4.21

Environment - refer to "A" Tables of Appendix IVC

Microtopography (NSSC,1963) - b-e
Relief - 5 m. local; 50 m. surrounding terrain
Stoniness (NSSC,1963) - 2-3
Erosion (NSSC,1963) - W 1, E 1

Vegetation - refer to "B" Tables of Appendix IVC

Field Soil Type Designation (NSSC,1963) - Orthic Brown Wooded

Site visited by Mr. H. Hortie of the Dominion Soil Survey? - Yes

Recommended Laboratory Analysis - clay translocation, pH, free Fe, cations, % organics, clay mineralogy

PROFILE DESCRIPTION

Horizon Code	Depth (cm.)	Moist Munsell Colour	Field pH	Textural, Structural, and Other Horizon Characteristics
L-H	5-0	-	-	Living matt with dark humus horizon in gradational contact to -
Ah	0-2.5	$10YR3/_{3.5}$	-	Medium granular to structureless, sticky, slightly plastic, pebbly sandy loam; rootlets present; in gradational contact to -
Bf or Bm	2.5-12.5	$5YR4.5/_{4}$	-	Medium granular to structureless, slightly sticky, plastic, pebbly sandy loam; minor rootlets present; in gradational contact to -
BC	12.5-27.5	$10YR3/_{3}$	-	Granular to structureless coarse pebbly sand; clay skins on pebbles and cobbles; no roots present; in gradational contact to -
C	22.5-	$10YR3/_{2}$	-	Poorly sorted, clean, non-bedded gravel; tops of boulders with only a slight clay skin.

NOTES:

Calcium carbonate not detected anywhere in profile nor to as deep as 1 metre below L-H horizon.

(APPENDIX III-D)

Station or Soil Pit Site No. 143

Moraine and Relative Age - North Fork Pass-North Lobe-I. NSSC Code No. 4.31 and 5.1-/8

Environment - refer to "A" Tables of Appendix IVC

Microtopography (NSSC,1963) - b-e generally; locally - A.
Relief - nil locally, 50 m. in surrounding terrain
Stoniness (NSSC,1963) - 2-3
Erosion (NSSC,1963) - W 1, E 1

Vegetation - refer to "B" Tables of Appendix IVC

Field Soil Type Designation (NSSC,1963) - Split Profile: Orthic Acid Brown Wooded and Gleyed Regosol

Site visited by Mr. H. Hortie of the Dominion Soil Survey? - Yes

Recommended Laboratory Analysis - for Regosol - nil; for Brown Wooded portion of profile - free Fe, pH, % organics.

PROFILE DESCRIPTION

Horizon Code	Depth (cm.)	Moist Munsell Colour	Field pH	Textural, Structural, and Other Horizon Characteristics
For Brown Wooded Profile:				
L-F	5-0	-	-	Living matt and non-decomposed litter; in gradational contact to -
Ah	0-2.5	5YR3/2	4.5	Granular to structureless loamy sand in gradational contact to -
Bf	2.5-12.5	7.5YR4/4	6.0	Granular to structureless coarse sand;
C	10-25	10YR3/2	-	Non-bedded, poorly sorted, fairly clean gravel; in sharp contact to -
IIC	25-	-	6.5	Clayey till showing signs of congeliturbation
For Regosol Profile:				
L-H	5-0	-	-	As in above L-F horizon
Cg	5-40	-	6.5	Gleyed till; no calcium carbonate present.

NOTES:

In order to reconcile above difficulties site 148 was established some 60 metres further to the west.

(APPENDIX III-D)

Station or Soil Pit Site No. 141

Moraine and Relative Age - North Fork Pass-North Lobe-I. NSSC Code No. 5.1-/7

Environment - refer to "A" Tables of Appendix IVC

Microtopography (NSSC,1963) - b-e (regionally); locally - D.
Relief - 50 m.
Stoniness (NSSC,1963) - 0
Erosion (NSSC,1963) - W 1, E 1, + 1 m.

Vegetation - refer to "B" Tables of Appendix IVC

Field Soil Type Designation (NSSC,1963) - Sub-arctic Regosol

Site visited by Mr. H. Hortie of the Dominion Soil Survey? - Yes

Recommended Laboratory Analysis - pH, % organics.

PROFILE DESCRIPTION

Horizon Code	Depth (cm.)	Moist Munsell Colour	Field pH	Textural, Structural, and Other Horizon Characteristics
L-F	7.5-0	-	-	Living ground matt with little decomposition; gradational boundary to -
Cg	0-58.5	mottles = 10YR4/3 matrix = 10YR4/1	5.5-7.5	Mottled, sticky, plastic, platy breaking to blocky clay loam; no roots present; convolutions of H layer organics throughout; because of permafrost, sharp boundary to -
Cgz	58.5-	-	-	Gleyed silt of eolian origin in permafrost.

NOTES:

Active layer above permafrost has underwent considerable involution.

Surrounding areas probably develop shallower active layer, for the pedological study has increased the seasonal melting at this site.

(APPENDIX III-D)

Station or Soil Pit Site No. 148

Moraine and Relative Age - North Fork Pass-North Lobe-I. NSSC Code No. 6.21

Environment - refer to "A" Tables of Appendix IVC

Microtopography (NSSC,1963) - b-e (regionally); A-locally.
Relief - 50 m.
Stoniness (NSSC,1963) - 2-3
Erosion (NSSC,1963) - W 1, E 1 - no secondary deposition

Vegetation - refer to "B" Tables of Appendix IVC

Field Soil Type Designation (NSSC,1963) - Rego Gleysol

Site visited by Mr. H. Hortie of the Dominion Soil Survey? - No

Recommended Laboratory Analysis - % organics, free Fe, cations, pH.

PROFILE DESCRIPTION

Horizon Code	Depth (cm.)	Moist Munsell Colour	Field pH	Textural, Structural, and Other Horizon Characteristics
L-H	5-0	-	-	Moss in fairly sharp contact to -
Ah	0-5	$10YR3/_3$	-	Medium blocky, slightly sticky, plastic loam; gradational contact to -
AB	5-12.5	$10YR3/_2$	-	Granular to structureless, slightly sticky, plastic pebbly loam; in gradational contact to -
Cg	12.5-30.5	$10YR4/_1$	-	Gleyed till; in gradational contact to -
C	30.5-	$10YR2.5/_{1.5}$	-	Till.

NOTES:

Soil pit is a replacement survey for problems encountered at Site 143.

(APPENDIX III-D)

Station or Soil Pit Site No. 144

Moraine and Relative Age - North Fork Pass-North Lobe-I. NSSC Code No. 7.12

Environment - refer to "A" Tables of Appendix IVC

Microtopography (NSSC,1963) - b-e (regionally); locally - D.
Relief - 50 m.
Stoniness (NSSC,1963) - 0
Erosion (NSSC,1963) - W 1, E 1, + 65 cm. of eolian silt.

Vegetation - refer to "B" Tables of Appendix IVC

Field Soil Type Designation (NSSC,1963) - Low Nutrient Bog - shallow

Site visited by Mr. H. Hortie of the Dominion Soil Survey? - Yes

Recommended Laboratory Analysis - pH, % organics (C), nitrogen.

PROFILE DESCRIPTION

Horizon Code	Depth (cm.)	Moist Munsell Colour	Field pH	Textural, Structural, and Other Horizon Characteristics
L	36-15	-	-	Living undecomposed moss; gradational contact to -
F	15-0	-	-	Recognizable compressed organic material; decomposition taking place; in sharp contact to -
IICggg	0-15	10YR3/2	-	Silty clayey loam; in sharp contact to -
IICgggz	15-	-	-	Silt; no roots; organic convoluted streaks present.

NOTES:

H horizon may have been dragged into the IIC horizons by congelitubation.

(APPENDIX III-E)

Station or Soil Pit Site No. 164

Moraine and Relative Age - Foxy Ck.-I. NSSC Code No. 4.21

Environment - refer to "A" Tables of Appendix IVC

Microtopography (NSSC,1963) - b-f (undulatory); locally-F.
Relief - 5 m. locally; 50-75m. for entire moraine
Stoniness (NSSC,1963) - 3-4
Erosion (NSSC,1963) - W 2, E 1

Vegetation - refer to "B" Tables of Appendix IVC

Field Soil Type Designation (NSSC,1963) - Orthic Brown Wooded

Site visited by Mr. H. Hortie of the Dominion Soil Survey? - No

Recommended Laboratory Analysis - pH, clay translocation, free Fe, cations, % organics.

PROFILE DESCRIPTION

Horizon Code	Depth (cm.)	Moist Munsell Colour	Field pH	Textural, Structural, and Other Horizon Characteristics
L-F	5-2.5	-	-	Living ground matt with a slightly decomposed root layer in fairly distinct contact to -
H or Ah	2.5-0	5YR2.5/1	-	Structureless, oozy, organic loam; slightly sticky; slightly plastic; rootlets present; in gradational contact to -
Bf	0-5	5YR3.5/4	-	Subangular blocky, slightly sticky, plastic loam;rootlets present; in gradational contact to -
BC	5-10	7.5YR4/2	-	Medium subangular blocky breaking to granular, sticky to slightly sticky, plastic, sandy loam; rootlets present; in gradational contact to -
CB or Cg	10-41	mottles = 5YR3.5/3 matrix =10YR4/2	-	Very slightly mottled (1%), weakly developed medium sub-platy to subprismatic, sticky, plastic, clayey loam; rootlets present; in gradational contact to -
C	41-	10YR4/2	-	Loose semi-slumped till or very clayey gravel with clay skins on the top surface of the cobble and boulder fractions; rootlets absent.

NOTES:

Despite very calcium carbonate-rich pebble clasts in the moraine no reaction was observed to indicate an accumulation of carbonate in the soil profile.

(APPENDIX III-E)

Station or Soil Pit Site No. 166

Moraine and Relative Age - Foxy Ck.-I. NSSC Code No. 5.11 on 4.21

Environment - refer to "A" Tables of Appendix IVC

Microtopography (NSSC,1963) - b-f (knobby)
Relief - 5 m.
Stoniness (NSSC,1963) - 4-5
Erosion (NSSC,1963) - W 1, E 1, + 10 cm. (see profile desc.)

Vegetation - refer to "B" Tables of Appendix IVC

Field Soil Type Designation (NSSC,1963) - Orthic Regosol burying an Orthic Brown Wooded

Site visited by Mr. H. Hortie of the Dominion Soil Survey? - No

Recommended Laboratory Analysis - clay translocation, pH, cations, % organics, free Fe.

PROFILE DESCRIPTION

Horizon Code	Depth (cm.)	Moist Munsell Colour	Field pH	Textural, Structural, and Other Horizon Characteristics
L-H	5-0	-	-	Heath and moss matt on a thin humus horizon in fairly distinct contact to -
C	0-10	10YR4/2	-	Weakly-developed medium to coarse sub-angular blocky breaking to granular, slightly sticky to sticky, non-plastic to slightly plastic loamy sand; few rootlets present; in fairly distinct contact to -
IIF	10-12.5	-	-	Dark humus horizon in fairly distinct contact to -
IIBf	12.5-17.5	7.5YR4/2 to 7.5YR4/4 to 5YR3.5/4	-	Angular blocky, slightly sticky to plastic, silty loam; rootlets present; in gradational contact to -
IIBC	17.5-28	10YR3.5/2	-	Blocky, slightly sticky, plastic sandy loam; calcium carbonate in fractures of shale cobbles; in gradational contact to-
IIC	28-	-	-	Dirty, poorly sorted, non-bedded gravel; with blades and disc shapes in pebble sizes; calcium carbonate on bottoms of cobbles but not in fine matrix.

NOTES:

This is a hummocky gravel land form dervied by ablation of the glacier ice that was carrying a load of superimposed gravel.

(APPENDIX III-E)

Station or Soil Pit Site No. 165

Moraine and Relative Age - Foxy Ck-I. NSSC Code No. 5.1-/8

Environment - refer to "A" Tables of Appendix IVC

Microtopography (NSSC,1963) - b-f generally; locally A.
Relief - 50-75 m. for entire moraine
Stoniness (NSSC,1963) - 1-2
Erosion (NSSC,1963) - W 1, E 1

Vegetation - refer to "B" Tables of Appendix IVC

Field Soil Type Designation (NSSC,1963) - Gleyed Regosol

Site visited by Mr. H. Hortie of the Dominion Soil Survey? - No

Recommended Laboratory Analysis - pH, % organics.

PROFILE DESCRIPTION

Horizon Code	Depth (cm.)	Moist Munsell Colour	Field pH	Textural, Structural, and Other Horizon Characteristics
L-H	20.5-0	-	-	Living ground matt of Tussock sedges on a dark humus horizon in gradational contact to -
Cgg	0-5	mottles = $5YR5/_6$ matrix = $2.5Y6/_0$ to $5B6.5/_1$		Strongly gleyed till in gradational contact to -
Cg	5-50 or deeper	as above to $2.5Y4.5/_2$	-	Gleyed till with a decrease in mottling; calcium carbonate not detected.

NOTES:

The soil profile is almost on intergrade to an organic soil and to gleysol. At isolated instances the L-H layer exceeds 30 cm. in thickness; horizonization is vaguely suggested by a gradational change in colours.

(APPENDIX III-F)

Station or Soil Pit Site No. 212

Moraine and Relative Age - Chapman Lake-II NSSC Code No. 4.21 (?)

Environment - refer to "A" Tables of Appendix IVC

Microtopography (NSSC,1963) - a-e (knobby)
Relief - 8-20 m. general; 3-4 m. local
Stoniness (NSSC,1963) 3-4
Erosion (NSSC,1963) - W 1, E 1, + possibility of surficial accumulation

Vegetation - refer to "B" Tables of Appendix IVC

Field Soil Type Designation (NSSC,1963) - tentatively Orthic Brown Wooded

Site visited by Mr. H. Hortie of the Dominion Soil Survey? - Yes

Recommended Laboratory Analysis - clay translocation, pH, free Fe, cations, clay mineralogy.

PROFILE DESCRIPTION

Horizon Code	Depth (cm.)	Moist Munsell Colour	Field pH	Textural, Structural, and Other Horizon Characteristics
L-F	5-2.5	-	-	Living ground matt and slightly darker semi-decomposed layer in gradational contact to -
H or Ah	2.5-0	5YR3/3	4.5	Structureless, plastic, slightly sticky, organic-rich silty loam; high % of roots present; in gradational contact to -
Bf or Bm	0-4	7.5YR3/2	8.0	Coarse blocky breaking to platy, slightly sticky, plastic, silty loam with pebbles; few rootlets present; in gradational contact to -
BC	4-10	2.5Y3.5/2	6.5	Coarse platy, plastic, sticky, pebbly sandy loam; few rootlets present; silt skins on top surface of some of the boulders; calcium carbonate on the bottoms of cobble sizes in gradational contact to -
IIC or C	10-28	2.5Y3/1	8.2	Clean, poorly sorted, poorly bedded, gravel with sandy lenses; silt skins on cobble upper surfaces and calcium carbonate on underneath surfaces; no roots
IIC or IIIC	28-	-	-	Gravel with calcium carbonate at heaviest concentration on under surface of pebbles at 90 cm; pit dug to 138 cm.

NOTES:

Calcium carbonate could not be detected in the "fines". There is a possibility that the fines in the top 10 cm. of the profile are partial loess dilution. Soil temp. of Bf horizon was 9.4°C in late July/1964.

Station or Soil Pit Site No. 219 (APPENDIX III-F)

Moraine and Relative Age - Chapman Lake -II NSSC Code No. 4.21

Environment - refer to "A" Tables of Appendix IVC

Microtopography (NSSC,1963) - a-e (Knobby)
Relief - 8-20 m. generally; 3-4 locally.
Stoniness (NSSC,1963) - 3-4
Erosion (NSSC,1963) - W 1, E 1

Vegetation - refer to "B" Tables of Appendix IVC

Field Soil Type Designation (NSSC,1963) - Orthic Brown Wooded

Site visited by Mr. H. Hortie of the Dominion Soil Survey? - Yes

Recommended Laboratory Analysis - cations, pH, to organics, clay translocation free Fe.

PROFILE DESCRIPTION

Horizon Code	Depth (cm.)	Moist Munsell Colour	Field pH	Textural, Structural, and Other Horizon Characteristics
L-H	2.5-0	-	-	Living ground matt on a thin dark humus, gradational contact to -
Ah	0-2.5	5YR3.5/3	4.5	Structureless, non-sticky, plastic, organic rich silty loam; roots present in grad. contact to -
Bf or Bm	2.5-7.5	5YR3.5/3 ?	5.0	Weakly developed medium subangular blocky breaking to fine granular, sticky, plastic pebbly silty loam; roots present; in gradational contact to -
BC	7.5-14	10YR4/3	6.0	Fine granular blocky, slightly sticky, cobbly granular silty sand; few rootlets present; in gradational contact to -
CB	14-23	10YR3.5/2	6.5	Slightly platy, slightly sticky, plastic cobbly sand; few rootlets present-
C1	23.38	10YR2.5/2	8.0	Dirty, nonplastic, non sticky gravel, calcium carbonate on lower surface of fractions; in gradational contact to-
C2	38	-	8.0	Clean gravel with calcium carbonate on surfaces of pebbles - no carbonate rx. detected on the fine to as deep as 50cm.

NOTES:

Mechanical analysis of the profile does not show any trace of clay movement in the profile. Na^{+} ion movement in profile is suspected from pH indications.

Station or Soil Pit Site No. -213 (APPENDIX III-F)

Moraine and Relative Age - Chapman Lake -II, NSSC Code No. 5.1-17

Environment - refer to "A" Tables of Appendix IVC

Microtopography (NSSC,1963) - a-e; locally D
Relief - 20m.
Stoniness (NSSC,1963) - 1
Erosion (NSSC,1963) - W 1, E 1, + 1m or more of eolian silt.

Vegetation - refer to "B" Tables of Appendix IVC

Field Soil Type Designation (NSSC,1963) - Sub-Arctic Regosol

Site visited by Mr. H. Hortie of the Dominion Soil Survey? - No

Recommended Laboratory Analysis - pH, to organics, mechanical analysis of the C, Cg and Cgg horizons.

PROFILE DESCRIPTION

Horizon Code	Depth (cm.)	Moist Munsell Colour	Field pH	Textural, Structural, and Other Horizon Characteristics
L-H	10-0	-	-	Tussock ground matt and dark humus horizon in fairly distinct contact to -
C	0-2.5	10YR3.5/3	-	Fine blocky, slightly sticky, plastic loam; roots present; in gradational contact to -
Cg	2.5-7.5	Mottles = 10YR4/4 gley = 10YR 4/1 matrix = 10YR 3.5/3	-	Slightly sticky, plastic loam; roots pres mottled and partially gleyed; in grad. contact to -
Cgg	7.5-23	mottles= 10YR 4/4 gley = N 4.5/- matrix = 10YR 3/2	-	Heavily mottled and gleyed, plastic clay; rootlets present; in gradational contact-
F-H and Cg	23-76	-	-	Buried F-H horizon in stringers of silt due to convolution; in gradational contact to-
Cz	76-	-	-	Silt with occasional pebble or cobble; on August 5, 1964.

NOTES:

The occasional pebble to cobble sizes found throughout the horizon are probably derived by congeliturbation from the suspected underlying till.

(APPENDIX III-F)

Station or Soil Pit Site No. 214

Moraine and Relative Age - Chapman Lake-II. NSSC Code No. 5.1-/7

Environment - refer to "A" Tables of Appendix IVC

Microtopography (NSSC,1963) - a-e generally, locally-D.
Relief - 20 m.
Stoniness (NSSC,1963) - 0
Erosion (NSSC,1963) - W 1, E 1, + 1 m. or more eolian silt accumulation.

Vegetation - refer to "B" Tables of Appendix IVC

Field Soil Type Designation (NSSC,1963) - Sub-arctic Regosol

Site visited by Mr. H. Hortie of the Dominion Soil Survey? - No

Recommended Laboratory Analysis - pH, % organics, mechanical analysis of the Cg, Cgg, etc. horizons.

PROFILE DESCRIPTION

Horizon Code	Depth (cm.)	Moist Munsell Colour	Field pH	Textural, Structural, and Other Horizon Characteristics
L-H	10-0	-	-	Tussock ground matt, on dark humhus layer in distinct contact to -
Cg	0-5	matrix = 10YR3/2	-	Slightly mottled, fine blocky, slightly sticky, plastic loam; roots present; in gradational contact to -
Cgg	5-10	10YR3/1	-	Structureless, strongly gleyed, non-sticky, slightly plastic loam; root-lets present; in gradational contact to -
F-H	10-62	mottles =2.5YR2/4 gley =10YR3/1 matrix =10YR3/3	-	Buried F-H horizon in stringers of plastic, slightly sticky, organic-rich silt; in gradational contact to -
Fz-Hz and Cgz	62-	-	-	Frozen horizon as described above - Aug 2/1964.

NOTES:

Buried organic horizons are due to convolution as carried out by congeliturbation.

(APPENDIX III-F)

Station or Soil Pit Site No. 223

Moraine and Relative Age - Chapman Lake-II. NSSC Code No. 5.1-/8 or 6.21

Environment - refer to "A" Tables of Appendix IVC

Microtopography (NSSC,1963) - a-e; locally-A
Relief - 20 m.
Stoniness (NSSC,1963) - 3-4
Erosion (NSSC,1963) - W 1, E 1, ± 10 cm. of eolian or colluvial fine sand

Vegetation - refer to "B" Tables of Appendix IVC

Field Soil Type Designation (NSSC,1963) - tentatively - Gleyed Regosol

Site visited by Mr. H. Hortie of the Dominion Soil Survey? - Yes

Recommended Laboratory Analysis - pH, % organics, mechanical analysis.

PROFILE DESCRIPTION

Horizon Code	Depth (cm.)	Moist Munsell Colour	Field pH	Textural, Structural, and Other Horizon Characteristics
L-H	5-0	-	-	Tussock and heath ground matt with dark humus horizon in fairly sharp contact to -
Cg	0-5	mottles = $2.5Y4/_4$ matrix = $2.5Y4/_2$ for upper and $5Y3/_2$ for lower	- 8.0	Structureless, weakly plastic, non-sticky, gleyed, sandy "loam"; in gradational contact to -
C	5-10	$10YR3/_1$	7.0	Structureless, non-sticky, plastic, sandy loam in faintly discernible contact to -
IIC	10-	$5Y3.5/_1$	-	Blocky, sticky, plastic, air-holed tilloid.

NOTES:

IIC is probably a gradation between ground moraine and ablation or hummocky moraine till. Water lies in the lower portion of the soil pit.

Station or Soil Pit Site No. 222 (APPENDIX III-F)

Moraine and Relative Age - Chapman Lake -II. NSSC Code No. 5.1-/7 x 6.2-/7

Environment - refer to "A" Tables of Appendix IVC

Microtopography (NSSC,1963) - a-e (undulatory); locally-A
Relief - 8-20 m.
Stoniness (NSSC,1963) -0
Erosion (NSSC,1963) - W 1, E 1, +1 m. or more convoluted colian silt.

Vegetation - refer to "B" Tables of Appendix IVC

Field Soil Type Designation (NSSC,1963) - Intergrade of Sub-Arctic Gleysol and Regosol

Site visited by Mr. H. Hortie of the Dominion Soil Survey? - No

Recommended Laboratory Analysis - % organics, pH,

PROFILE DESCRIPTION

Horizon Code	Depth (cm.)	Moist Munsell Colour	Field pH	Textural, Structural, and Other Horizon Characteristics
L-H	7.5-0	-	-	Moss and grass hummocks on a poorly differentiated dark humus horizon in gradational contact to -
AC or Bm	0-5	10YR3.5/2	6.2	Weakly-developed fine subangular blocky breaking to granular, plastic, slightly sticky, loam; organic convolutions present; rootlets present; in gradational contact to -
Cg and F-H	5-15	mottles = 2.5YR3/6 matrix = 10Y2.5/2	-	Subplaty, plastic, slightly sticky mottled loam; organic convolutions present; in gradational contact to -
Cgg and F-H		mottles = 2.5YR5.5/8 matrix = 10YR3/2	6.2	Subplaty, strongly gleyed and mottled, slightly sticky loam with organics in gradational contact to -
C and Fz-Hz		2.5Y3/2	7.0	Amorphous frozen plastic, slightly sticky with organic convolutions; rootlets still present to this level. July 29/64.

NOTES:

The profile is one gradational change from top to bottom; hence the problems with the classification.

(APPENDIX III-F)

Station or Soil Pit Site No. 221

Moraine and Relative Age - Chapman Lake-II. NSSC Code No. 6.21 (?)

Environment - refer to "A" Tables of Appendix IVC

Microtopography (NSSC,1963) - a-e; locally - D.
Relief - 20 m.
Stoniness (NSSC,1963) - 3-4
Erosion (NSSC,1963) - W 1, E 1

Vegetation - refer to "B" Tables of Appendix IVC

Field Soil Type Designation (NSSC,1963) - Rego Gleysol (?)

Site visited by Mr. H. Hortie of the Dominion Soil Survey? - Yes

Recommended Laboratory Analysis - cations, % organics, free Fe, pH.

PROFILE DESCRIPTION

Horizon Code	Depth (cm.)	Moist Munsell Colour	Field pH	Textural, Structural, and Other Horizon Characteristics
L-H	5-0	-	6.0	Moss and herbaceous ground matt on a poorly developed humus horizon in gradational contact to a weakly developed -
Ah	0-5	$10YR3/_2$	6.2-6.5	Granular, slightly sticky, plastic, loam with pebbles; many rootlets; in gradational contact to -
AB	5-10	$10YR3/_{1.5}$	7.5	Platy, non-sticky, non-plastic, gutty silt with coarser fractions; many rootlets; in gradational contact to -
Cg(?)	10-20	$10YR3/_2$	8.0	Platy, slightly plastic, slightly sticky till; silt skins on the top surface of the cobbles; rootlets present; in gradational contact to -
C	20-	$10YR3/_1$	8.0	Non-sticky sandy till.

NOTES:

Soil profile located on what appears to be the margin of an old dry solifluction lobe. Hence, soil pit dug further to the east-see station 213.

(APPENDIX III-F)

Station or Soil Pit Site No. 220

Moraine and Relative Age - Chapman Lake-II. NSSC Code No. 6.2-/7

Environment - refer to "A" Tables of Appendix IVC

Microtopography (NSSC,1963) - a-e; locally -.A.
Relief - 8-20m general; locally 0
Stoniness (NSSC,1963) - 0-1
Erosion (NSSC,1963) - W 1, E 1, + 35 cm. - 100 cm. eolian silt

Vegetation - refer to "B" Tables of Appendix IVC

Field Soil Type Designation (NSSC,1963) - Sub-arctic Gleysol

Site visited by Mr. H. Hortie of the Dominion Soil Survey? - Yes

Recommended Laboratory Analysis - pH, % organics, clay translocation, free Fe, cations.

PROFILE DESCRIPTION

Horizon Code	Depth (cm.)	Moist Munsell Colour	Field pH	Textural, Structural, and Other Horizon Characteristics
L-H	10-0 5-0	-	-	Moss matt on indistinct humus horizon in gradational contact to -
Ah	0-5 0-5	10YR3/3	6.5	Weakly-developed, medium subangular blocky breaking to granular, plastic, slightly sticky loam; in fairly distinct contact to -
Cg and L-F	5-43 5-25	Matrix =2.5Y3.5/2	7.0 8.0	Amorphous, plastic, silty clay with about 30% organic convolutions; no roots present in clear cut or gradational (lower figures) contact to -
Cggz	43- 25-33	mottles =10YR4/3 gley =2.5Y3.5/0	8.0	Heavily mottled (60%) plastic clays in distinct contact to -
IICz?	? 33-	10YR3.5/2	-	Till.

NOTES:

Two profiles within 50-100 m. of one another examined. The Cg horizon also contains the rare cobble derived from the till by congeliturbation activity.

Station or Soil Pit Site No. 216 (APPENDIX III-F)

Moraine and Relative Age - Chapman Lake -II. NSSC Code No. 7.2 or 5.1-/7

Environment - refer to "A" Tables of Appendix IVC

Microtopography (NSSC,1963) - a-e; locally-C
Relief - 20 m.
Stoniness (NSSC,1963) - 1
Erosion (NSSC,1963) - W 1, E 1, +10-50cm of eolian accumulation.

Vegetation - refer to "B" Tables of Appendix IVC

Field Soil Type Designation (NSSC,1963) - High Nutrient Bog or Sub-Arctic Regosol

Site visited by Mr. H. Hortie of the Dominion Soil Survey? - No

Recommended Laboratory Analysis - pH, % organics, mechanical analysis, free Fe, nitrogen.

PROFILE DESCRIPTION

Horizon Code	Depth (cm.)	Moist Munsell Colour	Field pH	Textural, Structural, and Other Horizon Characteristics
L-F	30.5-25.5	-	-	Tussock sedge and moss matt in gradational contact to -
H	25.5-0	-	7.7.	Humus horizon, partially decomposed to decomposed; contains occasional cobble; fairly distinct contact to -
C	0-10	10YR3.5/1	7.5	Weakly-developed platy, slightly sticky, slightly plastic granular to sandy silt; rootlets present;
C+F	10-20	5YR2.5/1	7.0	Structureless, plastic, slightly sticky, organic silt (due to involution); not every where present in profile; in gradational contact to -
C	10-51	10YR3.5/1	8.0	Weakly structural, sticky, plastic, silt; occasional granule and numerous pebbles to cobbles; rootlets present; in gradational contact to -
Cz (and F)	51-	10YR2.5/1	8.0	Frozen silt with granule and pebbles; slightly sticky to sticky, perhaps 10-15% organics present.

NOTES:

A 30cm. L-H horizon is the NSSC distinguishing criteria between bog and regosolic soils; this pit site fluctuates about 30cm. and hence is prone to either soil category classification.

(APPENDIX III-F)

Station or Soil Pit Site No. 218

Moraine and Relative Age - Chapman Lake-II. NSSC Code No. 7.(?)

Environment - refer to "A" Tables of Appendix IVC

Microtopography (NSSC,1963) - a-e; C-locally.
Relief - 10 m.
Stoniness - o
Erosion (NSSC,1963) - W 1, E 1, + unknown thickness of eolian silt.

Vegetation - refer to "B" Tables of Appendix IVC

Field Soil Type Designation (NSSC,1963) - (?) Organosol-undifferentiated.

Site visited by Mr. H. Hortie of the Dominion Soil Survey? - Yes

Recommended Laboratory Analysis - % organics, pH, nitrogen.

PROFILE DESCRIPTION

Horizon Code	Depth (cm.)	Moist Munsell Colour	Field pH	Textural, Structural, and Other Horizon Characteristics
L	38-31	-	-	Moss and tussock matt in gradational contact to -
L-F	31-0	-	6.2	Dead litter and undecomposed organic accumulations with the occasional 5cm. thick stringer of silt; temp. = 4.4°C; in fairly sharp contact to -
Cz	0-	10YR3/1	6.5	Silt - temp. = (-)3.3°C on July 30/1964.

NOTES:

Due to involutions of silt in the organic layers this profile could be classified as an Sub-arctic Regosol.

(APPENDIX III-F)

Station or Soil Pit Site No. 217

Moraine and Relative Age - Chapman Lake-II. NSSC Code No. 7.12

Environment - refer to "A" Tables of Appendix IVC

Microtopography (NSSC,1963) - a-in bog; a-e-generally
Relief - 1-1.5 m. locally
Stoniness (NSSC,1963) - 0
Erosion (NSSC,1963) - W 1, E 1, + peat depth of (?)

Vegetation - refer to "B" Tables of Appendix IVC

Field Soil Type Designation (NSSC,1963) - Low Nutrient Bog

Site visited by Mr. H. Hortie of the Dominion Soil Survey? - Yes

Recommended Laboratory Analysis - pH, % organics, nitrogen.

PROFILE DESCRIPTION

Horizon Code	Depth (cm.)	Moist Munsell Colour	Field pH	Textural, Structural, and Other Horizon Characteristics
L	61-51	-	-	Living and recently dead moss and sedge
L-F	51-0	-	-	Partially decomposed horizon with involutions of H horizon in 51-26 cm. zone.
Fz	0-	-	-	Frozen peat of bog moss and marsh sedge types.

NOTES:

This is a non-calcareous strangmoor as defined by Drew and Shanks (1965) or Drury (1956).

(APPENDIX III-G)

Station or Soil Pit Site No. 302

Moraine and Relative Age - Ogilvie Ground-III. NSSC Code No. 3.2 or 4.2

Environment - refer to "A" Tables of Appendix IVC

Microtopography (NSSC,1963) - b-d
Relief - 3 m. for gravel hummock; 100 m. regionally
Stoniness (NSSC,1963) - 3-4
Erosion (NSSC,1963) - W 1, E 1

Vegetation - refer to "B" Tables of Appendix IVC

Field Soil Type Designation (NSSC,1963) - Gray Wooded or Degraded Brown Wooded (?)

Site visited by Mr. H. Hortie of the Dominion Soil Survey? - No

Recommended Laboratory Analysis - clay translocation, pH, % organics, cations, clay mineraology, free Fe.

PROFILE DESCRIPTION

Horizon Code	Depth (cm.)	Moist Munsell Colour	Field pH	Textural, Structural, and Other Horizon Characteristics
L-F	5-2.5	-	-	Mixed ground matt in gradational contact to -
H	2.5-0	$5YR2/_2$	-	Humus horizon of decomposed organics and some mineral matter in fairly distinct contact to -
AB	0-7.5	$10YR3.5/_3$	-	Weakly-developed medium platy breaking to granular, plastic, slightly sticky, silty loam; rootlets present; in gradational contact to -
Bt	7.5-18	$10YR4/_{2.5}$	-	Granular, sticky, plastic, sandy loam; rootlets present; in gradational contact to -
BC	18-51	$10YR4/_2$	-	Dirty, non-plastic, slightly sticky gravel in gradational contact to -
C	51-	$10YR3/_2$	-	Dirty, sandy gravel; locally with cleaner lenses.

NOTES:

Calcium carbonate not detected anywhere in profile. Ae horizon is definitely not present; hence soil classification is very difficult. Both categories suggested above demand a visibly lighter coloured horizon above the Bt.

An eolian silt origin for the fines in the AB and Bt cannot be totally excluded despite the lack of a detectable buried H horizon. The mechanical analysis curves would suggest this to be possible by only an infiltration of loess with the top most gravel solum.

Station or Soil Pit Site No. 304 (APPENDIX III-G)

Moraine and Relative Age - Ogilvie Ground -III NSSC Code No. 5.1-/8

Environment - refer to "A" Tables of Appendix IVC

Microtopography (NSSC,1963) b-d (rolling swells), locally-B.
Relief - 100 m. or more for moraine sheet in area.
Stoniness (NSSC,1963) - 2
Erosion (NSSC,1963) - W 1, E 1

Vegetation - refer to "B" Tables of Appendix IVC

Field Soil Type Designation (NSSC,1963) - Gleyed Regosol

Site visited by Mr. H. Hortie of the Dominion Soil Survey? - No

Recommended Laboratory Analysis - mechanical analysis of the Cg horizon, mineralogy of the Cg horizon, % organics, PH, cations.

PROFILE DESCRIPTION

Horizon Code	Depth (cm.)	Moist Munsell Colour	Field pH	Textural, Structural, and Other Horizon Characteristics
L-H	7.5-0	-	-	Mixed tussock, moss and heath matt on vague humus horizon in quite distinct boundary to -
Cg	0-20	mottles = 2.5YR3/6 gley = 2.5YR4/0 matrix = 10YR3.5/1	-	Mottled and gleyed, structureless, slight sticky, plastic, silty loam; rootlets quite common; occasional cobble present, gradational contact to -
Cgg	20-51	mottles = 10YR5/6 gley = 7.5YR4/0 matrix = 10YR3.5/1	-	Heavily gleyed and lightly mottled, amorph sticky, plastic, clayey loam; rootlets common; in gradational contact to -
II(?)C	51-	10YR3/1.5	-	Very clayey till.

NOTES:

Calcium carbonate not detected in the profile nor was permafrost found in the digging of the pit.
Origin of the Cg layers could possibly be eolian - cobbles in the horizon being brought up from till by congeliturbation.

APPENDIX IVA

CHECK LIST OF PLANTS[1]

The check list is arranged alphabetically and includes those species mentioned in the text, or Appendix IVC station lists, and hence, their localities will not be repeated. This list also includes vascular species collected on valley bottom or walls that were not used in the multiple glaciation analysis; this would include random collections from the surfaces of fans, solifluction lobes, lake shores and river flood plains; these will be geographically located. The check list does not include species from uplands, ridges or mountain tops; a few such collections were made in the "Agglomerate", "Prospector" and "Nehru" ranges, and it is planned to publish these occurrences in a forthcoming issue of the Canadian Alpine Journal.

Nomenclature of the vascular plants basically follows Wiggins and Thomas (1962) unless the species concerned does not occur within the limits of their text. For the isolated instances in which an absence from Wiggins and Thomas (1962) has occurred the writer has successively relied upon the following for final nomenclature: Polunin (1959), Porsild (1957), Porsild (1951), Raup (1947), Hultén's (1941-1950) volumes, the 1959 reprint of Anderson's earlier works, and the 1955-1964 volumes of Hitchcock et al. The willow (Salix spp.) were also checked against the fine contribution of Raup (1959). The genera Antennaria and Dryas were diagnosed with varying success according to Porsild's (1947, 1950 respectively) diagnosis. All of the above texts had little Ogilvie Mountain floral collections at their disposal for consultation prior to their respective publication. Since the area is a botanical unknown and is in a zone of confluence of several phytogeographic regions (Porsild, 1951) or "radiants" (Hultén, 1937) there were many identification problems;** some of which are briefly reported in Appendix IVD.

Nomenclature of the Lichenes and Bryophytes is from the authoritative analysis of Dr. G. Otto and Dr. W. B. Schofield of the University of British Columbia. References pertaining to their nomenclature will not be quoted in this check list.

** Porsild (1967), for example, shows the identification problems with the genus Draba as found in the North Fork Pass region and as compared to known circumpolar species.

LICHENES

ALECTORIA NIGRICANS (L.) NYL.
A. OCHROLEUCA (EHRH.) NYL
BUELLIA SP.- PROBABLY B. MORIOPSIS (MASS.) TH.FR.
CETRARIA CUCULLATA (BELL.) ACH.
C. ISLANDICA (L.) ACH.
C. NIVALIS (L.) ACH.
C. RICHARDSONII HOOK
CETRARIA SP.
CLADONIA ALPESTRIS (L.) RABENH.
C. AMAUROCRAEA (FLOERKE) SCHAER.
C. DEFORMIS (L.) HOFFM.
C. GRACILIS (L.) WILLD. VAR. CHORDALIS (FLK.) SCHAER.
C. MITIS SANDST.
C. PYXIDATA (L.) FR.
C. RANGIFERINA (L.) WEB.
CLADONIA SP.
C. UNCIALIS (L.) WEB.
DACTYLINA ARCTICA (RICHARDS.) NYL.
OCHHROLECHIA UPSALIENSIS (L.) MASS.
PELTIGERA APHTHOSA (L.) WILLD.
P. MALACEA (ACH.) FUNK
RHIZOCARPON SP.
SPHAEROPHORUS (STEREOCAULON) FRAGILIS (L.) PERS.
S. TOMENTOSUM FR.
THAMNOLIA VERMICULARIS (SW.) ACH.

BRYOPHYTA[2/]

ABIETINELLA ABIETINA (HEDW.) FLEISCH.
AULACOMNIUM ACUMINATUM (LINDB. & ARM.) PARIS
A. PALUSTRE (HEDW.) SCHWAEGR.
A. TURGIDUM (WALD.) SCHWAEGR.
BRACHYTHECIUM SP.
DICRANUM BERGERI BLAND
D. ELONGATUM SCHLEICH
D. MUHLENBECKII B.S.G.
DICRANUM SP.
DITRICHUM FLEXICAULE (SCHWAEGR.) HAMPE
DRAPANOCLADUS LYCOPODIOIDES (BRID.) WARNST. FOUND AT "SQUARE LAKE" IN THE CHAPMAN LAKE MORAINE
DRAPANOCLADUS SP.
D. UNCINATUS (HEDW.) WARNST.
HYLOCOMIUM ALASKANUM (LESQ. & JAMES) KINDB.
PLEUROZIUM SCHREBERI (WILLD.) MITT.
POHLIA NUTANS? (HEDW.) LINDB.
POLYTRICHUM COMMUNE HEDW.
P. JUNIPERINUM HEDW.
P. PILIFERUM HEDW.
PTILIDIUM CILIARE (L.) HAMPE HEPATICAE
RHYTIDIUM RUGOSUM (HEDW.) KINDB.
SPHENOLOBUS MINUTUS (CRANTZ.) STEPH.
SPAGHNUM CAPILLACEUM (WEISS) SCHRANK
SPAGHNUM SP.
TOMENTHYPNUM NITENS (HEDW.) LOISKA
TORTULA NORVEJICA (WEB.) WAHL.

TRACHEOPHYTA

ACHILLEA BOREALIS BONG. - AT SOCCONY-MOBIL CAMP JUST SOUTH OF "PILOT CK." JUNCTION TO THE EAST BLACKSTONE RIVER AND AT STN.240 NEARBY, ON OUTWASH APRONS OF THE CHAPMAN LAKE AND FOXY TERMINAL MORAINES.

ACONITUM DELPHINIFOLIUM D.C.

ALNUS CRISPA (AIT.) RAUSCH SUBSP. SINUATA (REGEL.) HULTÉN

ANDROMEDA POLIOFOLIA L.

ANENOME DRUMMONDI? S.WATS.

A. MULTICEPS? (GREENE) STANDLEY

A. NARCISSIFLORA L. SUBSP. INTERIOR HULTÉN

A. PARVIFLORA MICHX.

A. RICHARDSONII HOOK.

ANTENNARIA ANGUSTATA GREENE

A. COMPACTA MALTE

A. MONOCEPHALA D.C.

ARCTAGROSTIS LATIFOLIA (R.BR.) GRISEBACH VAR. ANGUSTIFOLIA (NASH) HULTÉN VAR. ARUNDINACEA (TRIN.) GRISEB.

ARCTOSTAPHYLOS ALPINA (L.) SPRENG. SUBSP. RUBRA (REHDER AND WILSON) HULTEN

ARENARIA ARCTICA STEV.

ARNICA ALPINA (L.) OLIN SUBSP. ATTENUATA (GREENE) MAGUIRE VAR. LINEARIS HULTÉN - ON DISTURBED GRAVEL OF BORROW PIT NEAR CHAPMAN LAKE.

A. LESSINGII GREENE

A. LOUISEANA FARR. SUBSP. FRIGIDA (MEYER) MAGUIRE

ASTER SIBIRICUS L. - AT STN.240 IN SLUMPED TILL EXPOSED BY RIVER DOWN CUTTING, ON OUTWASH APRON OF CHAPMAN LAKE TERMINAL MORAINE, AND AT SOCCONY-MOBIL CAMP.

ASTRAGULUS ALPINUS L.

A. UMBELLATUS BUNGE

ARTEMISIA NORVEGICA SUBSP. SAXATILIS (BESS.) HALL AND CLEMENTS

ARTEMISIA TILESII LEDEB. SUBSP. TILESII SUBSP. UNALASCHENSIS (BESS.) HULTÉN

BARBUREA ORTHOCERAS LEDEB. - ON SHORES OF "SQUARE LAKE" IN THE CHAPMAN LAKE MORAINE

BETULA GLANDULOSA MICHX. - FOR THE MOST PART VARIETAL DETERMINATIONS OMITTED; HOWEVER: VAR. GLANDULOSA VAR. SIBIRICA (LEDEB.) BLAKE

B. OCCIDENTALIS HOOK.

CALAMAGROSTIS CANADENSIS (MICHX.) BEAUV.

CALAMAGROSTIS INEXPANSA A. GRAY

CAMPANULA LASIOCARPA CHAM.

CARDAMINE PRATENSIS L.*

CARDAMINE PURPUREA CHAM. AND SCHLECHT.

CAREX BIGELOWII TORS.

C. PHYSOCARPA PRESL.

C. PODOCARPA R.BR.

C. SCIRPOIDEA MICHX.

CASSIOPE TETRAGONA SUBSP. TETRAGONA (L.) D.DON.

CASTILLEJA PALLIDA (L.) SPRENG. SUBSP. ELEGANS (OSTENFELD) PENNELL

CHENOPODIUM CAPITATUM (L.) ACHERS. - AT SOCCONY-MOBIL CAMP.

CORNUS CANADENSIS L - ON OUTWASH APRON OF THE UPPER NORTH KLONDIKE MORAINE

CREPIS NANA RICHARDS - ON OUTWASH FAN OF FOXY CREEK MORAINE.

DELPHINIUM GLAUCUM S.WATS.

DESCHAMPSIA CAESPITOSA (L.) BEAUV. - FOR THE MOST PART VARIETAL DETERMINATIONS OMITTED; HOWEVER: VAR. GLAUCA (HORTN.) SAM.

DESCURAINIA SOPHIOIDES (FISCHER) E.O. SHULTZ. - AT STN.240 ON SLUMPED TILL.
DODECATHEON SP. (PROBABLY FRIGIDUM CHAM. & SCHLECHT) - SPECIMENS DESTROYED.
DRABA LONGIPES RAUP. See footnote No. 1 in Appendix IVD.
DRABA? SP. - SPECIMENS DESTROYED BEFORE EXACT IDENTIFICATION COULD BE CONFIRMED
DRYAS INTEGRIFOLIA VAHL.
DRYAS OCTOPETALA L. S.L. - FOR THE MOST PART 'SPECIES' (S.ST.) NOT SORTED OUT; HOWEVER:
D.ALASKENSIS A.E.PORSILD
D.CRENULATA JUZ.
D.OCTOPETALA L. S.ST.
EMPETRUM NIGRUM L.
EPILOBIUM ANGUSTIFOLIUM L.
E. LATIFOLIUM L. - ON ACTIVE FLOOD PLAIN OF EAST BLACKSTONE RIVER NEAR 'TWO MOOSE LAKE'.
EQUISETUM ARVENSE L.
E. SCIPOIDES MICHX.
E. VARIEGATUM SCHLEICH.
ERIGERON ANGULOSUS GAUD. VAR. KAMTSCHATICUS (D.C.) HARA - AT STN.240 ON SLUMPED TILL.
E. HUMILIS GRAH.
E. UNIFLORUS L. SUBSP. ERIOCEPHALUS (VAHL.) CRONQ.
ERIOPHORUM ANGUSTIFOLIUM HONCKENY (NOT ROTH.)*
E. BRACHYANTHERUM TRAUTV.
E. CHAMISSONIS C.A. MEY (= E. RUSSOLEUM FRIES)*
E. SCHEUCHZERI? HOPPE (OR MODIFIED E. BRACHYANTHERUM)
EUTREMA? EDWARDSII R.BR. - SPECIMENS DESTROYED BEFORE FINAL DETERMINATION - ON COLLUVIUM FILLED DEPRESSION IN THE SOUTH LOBE OF THE NORTH FORK MORAINE.
FESTUCA ALTAICA TRIN.
F. RUBRA L. VAR. LANUGINOSA MERT. - AT STN.240 ON SLUMPED TILL.
GENTIANA ALGIDA PALL. *
G. GLAUCA PALL.
G. PROPINQUA RICHARDS
GEUM ROSSII (R.BR.) SERINGE
HEDYSARUM MACKENZII RICHARDS
HORDEUM JUBATUM L. - ALONG ROAD SIDE JUST NORTH OF "FOXY CREEK" CROSSING.
LAGOTIS GLAUCA GAERTN.
LEDUM PALUSTRE SUBSP. DECUMBENS (AIT.) HULTÉN
LINNAEA BOREALIS L.
LLOYDIA SEROTINA (L.) S.WATS
LUPINUS ARCTICUS WATS - ALSO ON CHAPMAN LAKE MORAINE
LUZULA ARCUATA WAHLENBERG
L. MULTIFLORA (RETZ) LEJEUNE
L. WAHLENBERGII RUPR.
LYCOPODIUM SELAGO L. VAR. APPRESSUM DESV. - NEAR STN.223 IN PEAT BOG ON CHAPMAN LAKE TERMINAL MORAINE.
MATRICARIA MATRICAROIDES (LESS.) PORTER - AT SOCCONY-MOBIL CAMP ON E.BLACKSTONE RIVER.
MELANDRIUM APETULUM (L.) FENZL. (SYN. = GENUS LYCHNIS)
MERTENSIA PANICULATA (AIT.) G.DON
MYOSOTIS ALPESTRIS SCHMIDT SUBSP. ASIATICA VESTERGR.
NUPHAR POLYSEPALUM ENGELN. - "DRYAS LAKE" ON CHAPMAN LAKE MORAINE.
OXYCOCCUS MICROCARPUS TURCZ. EX.RUPR.
OXYRIA DIGYNA (L.) HILL
PAPAVER MACOUNI GREENE
PARNASSIA KOTZEBUEI CHAM. AND SCHLECT.
P. PALUSTRIS L.
PARRYA NUDICAULIS (L.) REGEL VAR. INTERIOR HULTÉN
PEDICULARIS CAPITATA ADAMS
P. LABRADORICA WIRSING
P. LANGSDORFII FISCH.EX.STEVENS
P. FLAMMEA L. - UNCONFIRMED SPECIES IDENTIFICATION

PEDICULARIS CAPITATA ADAMS
P. SUDETICA WILLD.
P. VERTICELLATA L. - ON THE RIVER BANKS NEAR THE SOCCONY-MOBIL CAMP.
PETASITES FRIGIDUS (L.) FRIES - USUALLY VARIETAL DETERMINATION OMITTED BUT;
VAR. FRIGIDUS
VAR. NIVALIS (GREENE) CRONQ.
P. SAGITTATUS (BANKS) A.GRAY - ON BANKS OF STREAM THAT DRAINS "GULL LAKE" ON NORTH LOBE OF NORTH FORK MORAINE.
PICEA GLAUCA (MOENCH) VOSS.*
PINGUICULA VULGARIS? L. (POSSIBLY THIS IS P. VILLOSA L.)
POA ALPIGENA (FR.) LINDM. - ON SHORES OF "COTTONWOOD LAKE" IN THE CHAPMAN LAKE TERMINAL MORAINE.
P. ARCTICA R.BR.
P. LEPTOCOMA HULTÉN
POLEMONIUM CAERULEUM SUBSP. VILLOSUM (RUD.) BRAND. *
POLYGONUM BISTORTA L. SUBSP. PLUMOSUM (SMALL) RICHARDS
P. VIVIPARUM L.
POPULUS TACAMAHACCA? MILL. (OR P. TRIOCARPA TORR. AND GRAY) - AT "COTTONWOOD LAKE" IN THE CHAPMAN LAKE MORAINE.
P. TREMULOIDES MICHX.
POTENTILLA FRUTICOSA L.
P. LEDEBOURIANA PORSILD
P. MONSPELIENSIS L. - AT SOCCONY-MOBIL CAMP.
P. PALUSTRIS (L.) SCOP. - ON SHORES OF "BOG LAKE" IN THE CHAPMAN LAKE MORAINE.
PRIMULA SP. - SPECIMENS DESTROYED BEFORE FINAL IDENTIFICATION.
PYROLA GRANDIFLORA RADIUS
RANUNCULUS FLAMMULA L. VAR. FILIFORMIS (MICHX) HOOK.- ON DRAINED POND BOTTOM IN THE SOUTH LOBE OF THE NORTH FORK PASS MORAINE, AND SHORES OF "COTTONWOOD" AND "SQUARE LAKES" IN THE CHAPMAN LAKE MORAINE.
R. NIVALIS? L. - SPECIMEN DESTROYED BEFORE FINAL CONFIRMATION OF IDENTIFICATION.
R. PEDATIFUS? SMALL DITTO
R. SCELERATUS? L. DITTO
RHODIOLA INTEGRIFOLIA RAF. (SYN. = GENUS SEDUM) *
RHODODENDRON LAPPONICUM (L.) WAHL.
ROSA ACICULARIS LINDL. SUBSP. SAYI (SCHW.) LEWIS
RUBUS ARCTICUS L. - AT SOCCONY-MOBIL CAMP.
R. ARCTICUS L. x R. ALASKENSIS BAILEY x R. ACAULIS MICHX. - INTERGRADE.
R. CHAMAEMORUS L.
RUMEX ARCTICUS TRAUTV. - NOT POLYGONUM ALASKANUM (SMALL) WIGHT
SAGINA LINNAEI PRESL.
SALIX ARCTICA PALL. S.L. - SOME NOT GIVEN A VARIETAL DETERMINATION BUT;
VAR. TORULOSA (TRAUTV.) RAUP
S. ATHABASCENSIS? RAUP - OR POSSIBLY A MODIFIED S. RICHARDSONII
S. BARRATTIANA HOOK.
S. GLAUCA L. VAR. ACUTIFOLIA (HOOK.) SCHNEIDER
SALIX GLAUCA x S. BEBBIANA SAG. x S. ARBUSCULOIDES ANDERS - INTERGRADE.
S. PLANIFOLIA PURSH
S. PULCHRA CHAM. VAR. PULCHRA
S. PSEUDOPOLARIS FLOD.
SALIX PSEUDOPOLARIS FLOD x S. ARCTICUS PALL. - INTERGRADE.
S. RETICULATA L.
S. RICHARDSONII HOOK.
SAUSSUREA N.SP.? - ON OLDER SLOPES ABOVE UPPER NORTH KLONDIKE TERMINAL MORAINE ON WEST SIDE OF VALLEY BELOW "EDGE PK".
S. ANGUSTIFOLIA (WILLD) D.C.
S. VICIDA HULTÉN VAR. YUKONENSIS (PORSILD) HULTÉN
S. VICIDA HULTÉN x S. ANGUSTIFOLIA (WILLD) D.C. - INTERGRADE.

SAXIFRAGA HIERACIFOLIA WALDST. AND KIT. VAR. RUFOPILOSA HULTÉN
S. HIRCULIS L.
SAXIFRAGA PUNCTATA L. SUBSP. INSULARIS HULTÉN
S. RIVULARIS L. - ON SLOPES ABOVE UPPER NORTH KLONDIKE MORAINE.
S. TRICUSPIDATA ROTTB.
SENECIO ALASKANUS HULTÉN
S. ATROPURPUREUS (LEDEB.) B. FEDITSCH
S. CONGESTUS (R.BR.) D.C.
S. LUGENS RICHARDS *
S. TRIANGULARIS HOOK.
SHEPHERDIA CANADENSIS (L.) NUTT.
SILENE ACAULIS L. VAR. EXSCAPA (ALL.) D.C.
SOLIDAGO MULTIRADIATA AIT.
SPIREA BEAUVERDIANA SCHNEID. - ON WEST SLOPES AT 1500 METRE LEVEL ABOVE UPPER NORTH KLONDIKE TERMINAL MORAINE.
STELLARIA CRASSIFOLIA EHRH.
S. LONGIPES - USING PORSILD (1957) THIS POLYMORPHOUS SPECIES HAS BEEN SUBCLASSIFIED INTO THE FOLLOWING "RACES"; ALL HAVE BEEN IDENTIFIED ON THE NORTH FORK PASS AREA.
S. CILIATOSEPALA TRAUTV.
S. LAETA RICHARDS
S. MONANTHA HULTÉN
TARAXACUM CERTETORPHORUM? (LED.) D.C. - ON OUTWASH FAN OF FOXY CREEK MORAINE.
T. LYRATUM (LED.) D.C.
TOFIELDIA PUSILLA (MICHX.) PERS.
TRIGLOCHIN MARITIMA L.
TRISETUM SPICATUM (L.) RICHT. *
VACCINIUM ULIGINOSUM L.
V. VITIS-IDAEA L. SUBSP. MINUS (LODD.) HULTÉN
VALERIANA CAPITATA PALL. EX. LINK
VERONICA ALPINA L. VAR. UNALASCHENSIS CHAM. AND SCHLECHT.
ZYGADENUS ELEGANS PURSH. - ON SLOPES ABOVE, BUT NEAR "RANOCH LAKE" AND LOMOND LAKE.

* THESE SPECIMENS NOT ONLY OCCUR ON THE MORAINES AS LISTED IN APPENDIX IVB STATION SHEETS, BUT ARE ALSO FOUND IN SMALL QUANTITIES AT NON-BOTANICAL STATION LOCALITIES ON THE NORTH LOBE OF THE NORTH FORK PASS MORAINE.

1/ INCLUDES 23 SPECIES OF LICHENES, 23 SPECIES OF BRYOPHYTA AND 168 SPECIES OF TRACHEOPHYTA - 14 SPECIES ARE DOUBTFUL IDENTIFICATIONS.

2/ ALL ARE MUSCI EXCEPT WHERE INDICATED.

APPENDIX IVB INDICES OF VASCULAR FLORISTIC SIMILARITY FOR FIELD STATION COMMUNITY INDIVIDUA ON THE CHAPMAN LAKE, NORTH FORK, FOXY AND AUGUST 17TH MORAINES.

COMMUNITY GROUPINGS

	I (N-M)						II (M)			III D (H-M)				III C (H)					III B (M-H)			III A (M-H)			II (X)		I (X)					O COMPLEX (X-M)			
STN. NO.	119	136	136A	137	122	125A	152	111	164	306	304	223A	217*	216	222	218	144	214	223B	221	165	220	141	143	219	212	302	166	139	140	142	138	151	135	84
119	x	.53	.50	.54	.41	.39	.24	.20	.26	.23	.22	.22	.14	.24	.19	.20	.30	.18	.13	.17	.22	.11	.36	.20	.13	.19	.11	.13	.14	.17	.10	.10	.16	.08	.16
136	.53	x	.63	.45	.31	.26	.16	.13	.16	.13	.10	.10	.04	.10	.10	.07	.17	.08	.04	.14	.10	.09	.17	.13	.08	.17	.05	.08	.09	.05	.17	.09	.17	.11	.08
136A	.50	.63	x	.55	.22	.39	.29	.18	.34	.13	.21	.10	.18	.26	.28	.18	.35	.31	.18	.31	.25	.29	.34	.27	.26	.30	.21	.30	.24	.28	.27	.41	.35	.23	.21
137	.54	.45	.55	x	.44	.53	.40	.36	.48	.31	.33	.33	.28	.39	.28	.28	.39	.33	.32	.36	.33	.23	.32	.30	.18	.21	.21	.32	.19	.19	.22	.22	.32	.18	.14
122	.41	.31	.22	.44	x	.41	.36	.18	.36	.34	.37	.27	.21	.32	.24	.32	.29	.23	.25	.24	.34	.27	.25	.22	.16	.30	.20	.20	.27	.22	.21	.30	.25	.10	.16
125A	.39	.26	.39	.53	.41	x	.52	.24	.68	.43	.46	.51	.42	.58	.44	.45	.42	.39	.38	.46	.51	.29	.41	.40	.24	.29	.27	.44	.31	.28	.27	.37	.30	.21	.18
152	.24	.16	.29	.40	.36	.52	x	.31	.71	.24	.29	.26	.29	.35	.34	.40	.30	.25	.30	.34	.34	.26	.21	.31	.27	.30	.28	.36	.32	.25	.31	.31	.21	.22	.21
111	.20	.13	.18	.36	.18	.24	.31	x	.40	.20	.30	.26	.27	.20	.22	.23	.23	.25	.39	.35	.26	.07	.11	.36	.22	.28	.30	.28	.26	.31	.18	.19	.29	.11	.17
164	.26	.16	.34	.48	.36	.68	.71	.40	x	.34	.39	.36	.32	.40	.42	.40	.36	.36	.39	.42	.41	.23	.24	.34	.30	.25	.31	.42	.32	.29	.34	.24	.27	.18	.24
306	.23	.13	.23	.31	.34	.43	.24	.20	.34	x	.83	.67	.49	.60	.54	.53	.42	.46	.53	.51	.51	.38	.34	.40	.38	.45	.32	.45	.29	.16	.20	.32	.27	.15	.19
304	.22	.10	.21	.33	.37	.46	.29	.30	.39	.83	x	.72	.57	.65	.55	.54	.43	.50	.58	.55	.55	.42	.38	.49	.42	.50	.41	.42	.33	.23	.22	.31	.26	.17	.25
223A	.22	.10	.28	.33	.27	.51	.26	.26	.36	.67	.72	x	.61	.65	.59	.54	.55	.58	.50	.52	.59	.42	.42	.49	.29	.38	.36	.46	.33	.23	.17	.40	.34	.22	.29
217	.14	.04	.18	.28	.21	.42	.29	.27	.32	.49	.57	.61	x	.57	.43	.48	.44	.48	.57	.39	.50	.39	.39	.51	.35	.31	.43	.48	.39	.24	.27	.42	.31	.29	.30
216	.24	.10	.26	.39	.32	.58	.35	.20	.40	.60	.65	.65	.57	x	.71	.70	.62	.71	.65	.65	.68	.55	.46	.53	.46	.50	.37	.46	.30	.25	.28	.41	.43	.30	.23
222	.19	.10	.28	.28	.24	.44	.34	.22	.42	.54	.55	.59	.43	.71	x	.64	.47	.65	.63	.62	.48	.46	.33	.44	.54	.54	.41	.42	.37	.23	.26	.44	.30	.28	.29
218	.20	.07	.18	.28	.32	.45	.40	.23	.40	.53	.54	.54	.48	.70	.64	x	.62	.76	.61	.62	.64	.55	.42	.56	.39	.57	.38	.44	.39	.19	.27	.47	.44	.35	.26
144	.30	.17	.35	.39	.29	.42	.30	.23	.36	.42	.44	.55	.44	.62	.47	.62	x	.63	.60	.51	.47	.56	.57	.65	.38	.38	.50	.49	.38	.30	.34	.41	.50	.40	.22
214	.18	.08	.31	.33	.23	.39	.25	.25	.37	.46	.50	.58	.48	.71	.65	.76	.63	x	.62	.58	.58	.70	.52	.56	.43	.52	.36	.48	.32	.37	.30	.51	.54	.33	.33
223B	.13	.04	.18	.32	.25	.38	.30	.39	.39	.53	.58	.50	.57	.65	.63	.61	.60	.62	x	.67	.50	.36	.37	.57	.53	.47	.55	.47	.49	.27	.28	.46	.38	.39	.37
221	.17	.14	.31	.36	.24	.46	.34	.35	.42	.51	.55	.52	.39	.65	.62	.62	.51	.58	.67	x	.52	.42	.25	.44	.54	.50	.46	.42	.33	.27	.30	.36	.30	.22	.33
165	.22	.10	.25	.33	.34	.51	.39	.26	.41	.51	.55	.59	.50	.68	.48	.64	.47	.58	.50	.52	x	.51	.42	.53	.42	.50	.36	.54	.37	.27	.26	.49	.43	.28	.29
220	.11	.09	.29	.23	.27	.28	.26	.07	.23	.38	.42	.42	.39	.55	.47	.55	.56	.70	.36	.42	.51	x	.49	.53	.43	.55	.33	.42	.35	.35	.38	.53	.56	.38	.24
141	.36	.17	.34	.32	.25	.41	.21	.11	.24	.34	.38	.42	.39	.46	.33	.42	.54	.52	.37	.25	.42	.49	x	.57	.32	.37	.35	.37	.36	.34	.28	.46	.43	.39	.26
143	.20	.27	.27	.30	.22	.40	.31	.36	.34	.40	.49	.49	.51	.53	.44	.56	.65	.56	.57	.44	.53	.53	.57	x	.40	.46	.62	.56	.47	.39	.30	.44	.47	.44	.29
219	.13	.08	.26	.17	.16	.30	.27	.22	.30	.38	.42	.29	.35	.46	.54	.38	.38	.43	.53	.54	.42	.43	.32	.40	x	.53	.41	.37	.43	.29	.45	.51	.49	.31	.32
212	.19	.17	.30	.21	.30	.30	.30	.28	.30	.45	.50	.38	.31	.50	.54	.57	.38	.52	.47	.50	.50	.55	.37	.46	.53	x	.48	.42	.42	.35	.33	.51	.43	.31	.32
302	.11	.05	.21	.21	.20	.27	.28	.30	.31	.32	.41	.36	.43	.37	.41	.38	.50	.36	.55	.46	.36	.33	.35	.62	.41	.48	x	.62	.58	.48	.37	.54	.36	.47	.41
166	.13	.08	.30	.32	.20	.45	.36	.28	.42	.45	.42	.46	.48	.46	.42	.44	.49	.48	.47	.42	.54	.42	.37	.51	.37	.42	.62	x	.42	.47	.39	.51	.49	.28	.42
139	.14	.09	.29	.19	.27	.31	.32	.26	.32	.29	.33	.33	.39	.30	.37	.39	.38	.32	.49	.33	.37	.35	.36	.47	.43	.42	.58	.42	x	.62	.52	.33	.38	.38	.42
140	.17	.05	.28	.19	.22	.28	.25	.31	.29	.16	.23	.28	.29	.25	.23	.19	.30	.37	.27	.27	.27	.35	.34	.39	.29	.35	.48	.47	.62	x	.50	.51	.42	.36	.41
142	.10	.17	.27	.22	.21	.27	.31	.18	.34	.20	.22	.17	.27	.28	.26	.27	.34	.30	.28	.30	.26	.38	.28	.30	.45	.33	.37	.39	.52	.50	x	.49	.46	.25	.28
138	.10	.09	.41	.22	.30	.37	.31	.19	.35	.32	.31	.40	.42	.41	.44	.47	.41	.51	.46	.36	.49	.53	.46	.44	.51	.51	.54	.51	.33	.52	.49	x	.53	.44	.40
151	.16	.17	.35	.32	.25	.30	.21	.29	.27	.27	.26	.34	.31	.43	.30	.44	.50	.54	.38	.30	.43	.56	.43	.47	.49	.43	.36	.49	.38	.42	.46	.53	x	.29	.27
135	.08	.11	.23	.18	.11	.21	.22	.17	.18	.15	.17	.22	.29	.30	.28	.35	.40	.33	.39	.22	.28	.38	.39	.44	.31	.31	.47	.28	.38	.36	.25	.44	.29	.x	.23
84	.16	.08	.21	.14	.16	.18	.21	.17	.24	.19	.25	.29	.30	.23	.29	.26	.22	.33	.37	.33	.29	.24	.26	.29	.32	.32	.41	.28	.42	.41	.28	.40	.27	.23	.x

NOTE: 1) FOR EASE OF COMPARISON - YELLOW OCHRE ▢ COLOUR DENOTES K VALUES OF GREATER THAN .70; ▢ LIGHT GREEN DENOTES VALUES OF .60-69; ▢ BLUE DENOTES VALUES OF .50-59; AND ▢ PINK DENOTES VALUES VARYING FROM .40 TO .49. A K-VALUE OF .50 IS CONSIDERED TO BE A GOOD CORRELATION.

2) COMMUNITY GROUPINGS ARE NUMBERED SO THAT III DENOTES A "CLIMAX" SITUATION: H = HYDRO PHYTIC, M = MESOPHYTIC, AND X = XEROPHYTIC COMMUNITIES. A, B, C, D DENOTE SUBGROUPS IN THE "CLIMAX COMMUNITY."

* STN. 217 IS A PEAT BOG WITH MESIC MICROHABITATS - THE DATA INCLUDES THESE MESIC SPECIES IN THE DETERMINATION OF THE K VALUE.

APPENDIX IVC

ENVIRONMENTAL AND STATION (QUADRAT) VEGETATION TABLES

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A. Explanatory Notes for Environmental Tables

1) Locality - Quadrat or plot numbers are located as follows:

100 series - refer to stations on moraines in the North Fork Pass area of Relative Age I (or about 13,800 years old);

200 series - refer to stations on the Chapman Lake Moraine of Relative Age II (or greater than 13,800 years and certainly less than 78,000 years old);

300 series - refer to stations on the Ogilvie Ground Moraine of Relative Age III to the north of Chapman Lake; the absolute age is not known but is certainly older than 78,000 and less than 210,000 years old;

84 - is a station on the August 17th Moraine to the south of and lower in elevation than the North Fork Pass area. The age is an assigned 13,800 years.

Latitudes and longtidues are interpolations from a 1:250,000 "Dawson" contour map prepared from a minimum of ground survey control by the Surveys and Mapping Branch of the Department of Mines and Technical Surveys. A 10 second approximation is about the best degree of accuracy that can be expected for most stations. Elevations are aneroid traverse readings carried from formally leveled bench mark control points. Elevations are known to the nearest 3 cm. for the latter.

The moraines are designed as follows:

August 17th Moraine - Aug 17th-I	- 1 station
Foxy Creek Moraine - Foxy-I	- 4 stations
North Fork Pass Moraine	
north lobe - NF-NL-I	- 5 stations
south lobe - NF-SL-I	- 10 stations
Chapman Lake Moraine - Chap.Lake-II	- 11 stations
Ogilvie Ground Moraine - Ogilvie-III	- 3 stations

2. Physiography - Parent material of the quadrat site is a non-genetic description as given by Folk (1965); it can be regarded as a substitute indication of Profile Stoniness (NSSC, 1963 or Brooke, 1966). As some of the parent material is till their mechanical analyses can be located in tables and figures included in the main body of the thesis. Landform is a moraine; the "micro" form of the quadrat site is described as a gulley, channel, ridge, crest, basin, slope etc. of this moraine. Relief shape is a microscale description of the quadrat site; profile refers to the shape at right angles to the contour line and contour refers to the shape parallel to the contour lines. Slope gradient refers to the average ground surface inclination and was measured by Brunton Compass. Slope above plot is the slope distance above the plot to a topographic divide (Brooke, 1966) from which ground water or erosional material may originate. Distances were measured from the 1:25,000 scale aerial photos.

3. Bed Rock Geology - refers to the consolidated rock material known or suspected to make up the morainal debris at that particular site. In the sites mantled by eolian silt or sand the geology is probably meaningless as far as nutrient sources are concerned. Since only a few sites were investigated on a pebble count basis a great deal of inference is used in depicting geological source materials. The geology is keyed to Templeman-Kluit's(1966) analysis of the structural and petrographic relationships in the core of the Central Ogilvie Range - the source area for most of the rocks. The bed rock unit numbers are his designations and are listed in Table I of Part One of the thesis. Rock types listed in the tables to follow are arranged in diminishing order (L.toR.) of frequency in the pebble to cobble size fractions of that particular soil pit station. The abbreviations are as follows:

Qtzt. = quartzite metamorphosed, grits; Ch. = cherts of black, green and brown colours; Stst. = siltstones; Bas. = basalt; if calcium carbonate rich = CO_3 Bas.; Monz. = monzonites of the plutonic rock group - generally sodium and calcium enriched; Gab. = gabbro of the plutonic group - calcium rich rocks; Gr. = granitic rocks in the broad sense - encompasses syenite, granite, monzonite, diorite, gabbro and pyroxenites; Ss = sandstone of usually quartz deficient or of mixed mineralized makeup; some Ss are of calcium carbonate (CO_3) cementation; Ls - Limestone; Arg. = argillite; Tf = tuff or agglomerate.

4. Climate - Macroclimate refers to Küppen's world wide climatic classification as defined in Strahler's (1965) textbook.
The designation is as follows:

D climates = average temperature of the coldest month below minus 3.0°C and the average temperatures of the warmest month above 8.3°C
f = no distinct dry season, driest months with sufficient precipitation.
c = cool short summer, less than 4 months with average temperature above 8.3°C.
ET climate = warmest month with an average temperature less than 8.3°C.

Normally the D climate prevails but undoubtedly there are summers when the monthly means fall short of the 8.3°C requirement. The winter months have decidedly little water equivalent precipitation so that the area is bracketed by the two classes of climate. Wind exposure ratings are based on a scale of 10 and are estimated on basis of topographic position and vegetation density. For example, an isolated knoll with a single dwarf birch or willow would be an exposure rating of 10 to the A or B layer of vegetation whereas a mat of Empetrum interspersed in sedges beneath a continuous shrub layer in a well protected basin would have an exposure rating of 0 for the C layer. Hence, separate ratings are made for the three strata: i.e. 0 or -, 9, 7 refers to exposure on the A or tree layer, B or shrub layer and C or herb layer respectively. Snow duration is an estimate determined from local verbal information regarding length of the snow cover season. The general value was adjusted by the writer to meet the expected value from topographic peculiarities:- i.e. exposed knolls and south facing slopes were diminished while north facing snow lie (or snowflush) situations were correspondingly increased in duration.

5. Strata Coverage - Strata are defined in No. 4 above and the total of the A, B, and C layers can exceed 100% for the former two layers are aerial shade cover estimates in the quadrat. The D layer is not included in this analysis.

6. Plot Coverage - refers to the area covered and exposed to free air by: gravel and sand (including boulder sizes), decayed debris and standing pools of water.

7. Soil - Soil classification follows the code systems given in the National Soil Survey Committee of Canada (1963) report (herein known

as NSSC). The code numbers refer to the following:

3.2	Gray Wooded of the Podzolic Order
4.2	Brown Wooded of the Brunisolic Order
4.3	Acid Brown Wooded of the Brunisolic Order
4.6	Subalpine Brown of the Brunisolic Order
5.1 -/7	Sub-Arctic Regosol of the Regosolic Order
5.1 -/8	Gleyed Regosol of the Regosolic Order
6.1 -/7	Sub-Arctic Humic Gleysol of the Gleysolic Order
6.21	Rego Gleysol of the Gleysolic Order
6.2 -/7	Sub-Arctic Gleysol
7.1 & 2	Low and High Nutrient Bogs of the Organic Soils

A full field description of the soil profiles is located in Appendix III. Humus and Max. Rooting Depth pH values are those determined by field colourmetric methods only. Parent Material refers to the unconsolidated deposit or facies from which the solum develops; the description is of genetic implications in order to give an idea of compaction, permeability and age relationship. The description of these facies is found in Part I of the thesis or in Appendix I in abbreviated format. Drainage designations refer to the classes established in NSSC. Depth to Permafrost (or other impermeable horizon) is a measurement which excludes the thickness of the L-F layer of the soil profile; measurements were taken on July 31, 1964 and do not necessarily imply this thickness of active layer every year. Some measurements may be a talik layer - the true permafrost (herein abbreviated Pf) horizon being below an aquifer some few centimeters to meters in thickness below the underlying talik zone. Hygrotope refers to a moisture regime status in the soils as established by Brooke (1966). The classes are as follows (in direct quotation from Brooke):

"Hygrotope class	Characteristic
Very Dry - Dry	Knolls and peaks of lithic soils on convex relief or ridge crests. Soils are shallow and well-drained.
Moderately Dry	Well-drained soils on convex relief of upper slopes or strong glacial tills of convex or straight relief. Seepage absent during snow-free periods.
Mesic	Medium textured soils of straight or shallow convex relief. Soils have good drainage and seepage is absent or rarely present. If present, seepage is deep in the profile and occurs only temporarily following prolonged heavy rain during the snowfree period.
Hygric	Moderate to imperfectly drained soils of straight or concave relief. Gleying is evident in the soil profile and seepage is usually present, the maximum water level in soil may be at or near the surface for part of the snow-free period.

Hydric	Soils with imperfect to very poor drainage. Soils are saturated or inundated for most of the year, i.e. concave or straight relief usually on lower slopes, spring water, swamps and moors.

Hygrotope classes refer to the general moisture regime status during snow-free periods and not to moisture conditions immediately following snow-melt, prolonged rains or dry periods." Those plots with a variability of moistured conditions are so marked.

8. Other - Special features considering origin of lithology or soil profile peculiarities are given in this category.

B. Explanatory Notes for Vegetation Tables

1. Designation of the community groupings is by Roman numeral; sub groupings by capital letter; and moisture conditions by H = hydric or hygric, M = mesic, X = xeric or dry. The Roman numerals do not necessarily imply a progression to a "climax community" although III is certainly a climax grouping. II (X) is also a climax community and appears to be closely related to I (X); the other groupings are not fully understood.

2. Species ratings in the community individua (or stand) are represented by an isolated plot (or quadrat) follow the Domin-Krajina scales as listed by Brooke (1966). They are not the Hult-Sernander system as employed by Vierëck (1966). The three figures for each species (e.g. 2, 1, 3) refer to species significance, sociability, and vigor respectively.

Species Significance (s.s.) is a combined scale for abundance and dominance; Brooke (1966). The numerical scale is as follows:

+	Very sparsely present, dominance very small	= Hult-Sernander		r
1	Sparsely present, dominance small	= "	"	+
2	Very scattered, dominance small	=)"	"	1
3	Scattered to plentiful	=)		
4	Often, dominance 1/20 to 1/5 of plot	=)"	"	2
5	Often, dominance 1/5 to 1/4 of plot	=)		
6	Any number of individuals, dominance 1/4 to 1/3 of plot	=)		
7	Any number of individuals, dominance 1/3 to 1/2 of plot	=) "	"	3
8	Any number of individuals, dominance 1/2 to 3/4 of plot	=)"	"	4
9	Any number of individuals, dominance over 3/4 of plot	=)"	"	5
10	100% of plot	=)		

Data was left in the Domin-Krajina form; no attempt was made to convert it into corresponding "cover value" (Brooke, 1966) for each species and eventually to an overall cover value for the species of all plots designated to a particular community grouping. s.s. values for the D layer species are exceedingly approximate, and were derived from photo inspection and vague recollection.

Sociability (soc.)		Vigor (v.)	
+	Growing singly	0	None
1	Grouped or Tufted, groups up to 16 sq.cm.	+	poor
2	Group larger, up to 1/16 sq.m. or 225 sq.cm.	1	fair
3	Group 1/8 to 1/4 sq.m.	2	good
4	Group 1/3 to 2/3 sq.m.	3	excellent
5	Group 1 to 2 sq.m.		
6	Group 5 to 20 sq.m.		

Vigor data is based on the growth of the particular species at a plot as compared to its most luxuriant growth in the entire region. For example, the dwarf birch, in good form, develops nutlets for reproduction, is about two metres in height and would have a 3 rating. However, on some isolated knolls of gravel the shrub is a scant 30 cm. high; is with few nutlets and thus would have a 1 rating. Those plants that do not flower are given a 0 rating.

3. Species are arranged vertically for each table as follows: (Brooke, 1966)

a) by strata

A layer - trees over 5 metres high
B layer - B_1 saplings and shrubs of 2 to 5 metres in height
B_2 shrubs of 5 cm. to 2 m. in height
C layer - small woody plants of less than 15 cm. in height and all herbaceous plants
D layer - Bryophytes and lichens

b) by decreasing species significance value within strata
Ideally all stations or plots of the same community grouping should be on one single page table, but time was a decided factor in the avoiding of this useful compilation.

4. For sake of simplicity Station Nos. of the vegetation plots are the same as the soil pit Station Nos. as given in Appendix III. Originally the vegetation plots were of an independent numbering system - any institution working with the herbarium specimens collected from this survey should keep in mind the following translations: 105=140, 122=139, 303=302, 223A & B=200, 305=304, 206=220, 207=221, 208=222, 209=214, 202=216, 203=217, 204=218, 125=164, 124=165, 123=166, 207=213, 103=138, 106=141, 109=143, 107=144, 104=151, 205=219, 108=142, 201=212, 101=135, 102=136, 102A=136A or 102x103=136A, 100=137.

TABLE 1A - ENVIRONMENTAL DATA FOR COMMUNITY GROUPING I (H-M) (APPENDIX IVC)

PLOT DATA						
PLOT OR QUADRAT NO.	119	136	136A	137	122	125A
MORAINE & RELATIVE AGE	NF-SL-I	NF-SL-I	NF-SL-I	NF-SL-I	NF-SL-I	FOXY-I
LATITUDE (°N	64° 33' 20"	64° 34' 00'	64° 34' 00"	64° 34' 00"	64° 33' 40"	64° 39' 30"
LONGTTUDE (° -' -")W	138° 15' 00"	136° 15' 20"	138° 15' 20"	138° 15' 30"	138° 15' 00"	138° 24' 00"
ELEV. (M.MSL.)	1300	1265	1305	1235	1275	1215±5
PHYSIOGRAPHY						
PARENT MATERIAL (FOLK, 1965)	HUMIC SILT	SLIGHTLY GRANULAR MUDDY SAND	COLLUVIUM?	MUDDY GRAVEL	MUDDY SANDY GRAVEL COLLUVIATED	SLIGHTLY GRANULAR MUD
LAND FORM	MELT WATER CHANNEL	BROAD GULLEY	BASIN	SLOPING BENCH	SLOPE OR MORAINAL RIDGE	GULLEY BETWEEN ARCUATE LOBES OF TERMINAL MORAINE
RELIEF SHAPE = PROFILE	UNDULATORY	SLIGHTLY CONCAVE	STRAIGHT	± STRAIGHT	STRAIGHT TO SLIGHTLY CONCAVE	± STRAIGHT
- CONTOUR	± STRAIGHT	SLIGHTLY CONCAVE	CONCAVE	± STRAIGHT	SLIGHTLY CONCAVE	± CONCAVE
EXPOSURE OR ASPECT (_°)	FLAT	235°	FLAT	300°	045°	90 100
SLOPE GRADIENT (_°)	± 0	SLIGHT (5°)	0	5°	20-30°	5-10°
SLOPE ABOVE PLOT (M.)	0	100	5-10	250	5-10	100
GEOLOGY (REFER TO TABLE I)						
DOM.REPRES. UNITS (T-K, 1966)	SEE STN.151	SEE STN.138	SEE STN.138	SEE STN.138	1, 18, 13, 7	SEE STN.165
DOM.ROCK TYPES	AS IN STN.151	AS IN STN.138	AS IN STN.138	AS IN STN.138	QTZT., MONZ., CH.	AS IN STN.165
CLIMATE						
MACROCLIMATE (KÖPPEN)	DFC OR ET	DFC OR ET	DFC OR ET	DFC OR ET	DFC OR ET	DFC OR ET
WIND EXPOSURE (A, B, C) LAYERS	-, 6, 2	-, 6, 3	-, 6, 4	-, 7, 4-5	-, 7-5, 5-1	-, 6, 3
SNOW DURATION (MONTHS)	7½	8	7-8	8	8-9	CA.8½
STRATA COVERAGE (%)						
A	0	0	0	0	0	0
B	CA.30	30	CA.20 *	40	50-60	CA.30
C	CA.80	95	95	CA.60	80	CA.50
D	CA.30	50	50	CA.40	90	CA.65
PLOT COVERAGE (% EXPOSED)						
BY GRAVEL AND SAND	CA.1-2	0	0	0	0	CA.10
BY DECAYED DEBRIS	0	0	0	0	0	-
BY WATER	CA.10	0	0	0	0	5
SOIL						
TYPE (NSSC-1963)	ORGANOSOL?	5.1 -/8 *	5.1 -/6 **	6.21	PROBABLY 4.21-4.2 -/8	NOT INVESTIGATED PROBABLY 5.1 OR 6.2
HUMUS THICK. (CM.)	NOT MEASURED	7.5	SOIL	12.5	NO SOIL	-
HUMUS PH	NOT MEASURED	NOT TESTED	PIT	NOT TESTED	PIT	NOT TESTED
PARENT MATERIAL	SILT DEPOSIT, SILT AND SAND	SLOPE WASH COLLUVIUM	ANALYSIS	OLD * COLLUVIUM	ANALYSIS	COLLUVIUM
DRAINAGE (NSSC-1963)	POORLY DRAINED	IMPERFECTLY DRAINED	OMITTED	MODERATELY WELL DRAINED	WELL TO IMPERFECTLY DRAINED *	IMPERFECT
DEPTH TO PF ON JULY 31 - (CM.)	NOT DETECTED	NOT DETECTED	OMITTED	64 (NOT PF)	NOT DETECTED	PRESENT (?) *
HYGROTOPE - BROOKE (1966)	HYDRIC	HYGRIC	MESIC±	HYGRIC	MESIC TO HYGRIC	HYGRIC
MAX.DEPTH LIVING ROOTS (CM.)	NOT RECORDED	NOT RECORDED	-	-(CONFINED TO L-F)	-	-
pH @ MAX.ROOTING DEPTH	NOT RECORDED	NOT RECORDED	-	5.7 IN AHG	-	-
OTHER	MARSHY AREA WITH LOCAL DRY HIGH SPOTS.	*BURIED PROFILES, STONE LINER AT UNCONFORMITIES.	*ON OUTER PERIPHERY ONLY. ** SURMISAL	*COULD BE A MINOR KAME TERRACE.	*SLOPE IS A CONSTANTLY CHANGING,	THIS IS THE LOWER EXTENTION OF #124 SLOPE PLOT; *ICE IN NEARBY CREEK EXPOS.

TABLE IB - COMMUNITY GROUPING 1 (H-M) - STN. 119 (APPENDIX IVC)

NO. OF PLOTS - RECCE.CHECK OF WHOLE TOPOGRAPHIC SURFACE -			
PLOT NO.	119		
MORAINE & RELATIVE AGE	NF-SL-1		
PLOT SIZE (M^2.)	PLOT NOT ESTABLISHED		
EXTENT (M^2.)	CA. 60,000		
COMMUNITY INDIVIDUA SPECIES	S.S.*	SOC.	V.
B_2 LAYER (SALIX NOT TOO ABUNDANT AND NOT IDENTIFIED)			
BETULA GLANDULOSA	6	5	3
POTENTILLA FRUCTICOSA	1	+	3
SALIX SP.	NO DATA		
C LAYER			
CAREX PODOCARPA	3	2	3
FESTUCA ALTAICA	3	1	3
EMPETRUM NIGRIUM	2	2	3
MERTENSIA PANICULATA	2	+	3
MYOSOTIS ALPESTRIS ASIATICA	2	+	3
RUMEX ARCTICUS	2	2	3
SENECIO LUGENS	2	+	3
SALIX RETICULATA	2	+	3
GENTIANA ALGIDA	2	1	3
PETASITES FRIGIDUS VAR. NIVALIS	2	+	2
ANENOME NARCISSIFLORA	2	+	3
RANUNCULUS NIVALIS	2	+	3
VALERIANA CAPITATA	2	+	3
DRABA LONGIPES?	2	+	3
POLEMONIUM CAERULEUM VILLOSUM	2	+	3
PEDICULARIS LABRADORICA	2	+	3
RHODIOLA INTEGRIFOLIA	2	1	3
ANENOME RICHARDSONII	2	+	3
RUBUS SP. (HYBRID)	2	+	2
STELLARIA MONANTHA	2	-	-
GEUM ROSSII	2	1	3
STELLARIA CRASSIFOLIA	2	2	3
SOLIDAGO MULTIRADIATA	2	+	2
ERIOPHORUM BRACHYANTHERUM	2	1	3
POLYGONUM BISTORTA PLUMOSUM	2	+	3
ACONITUM DELPHINIFLORUM	2	1	3
ARTEMISIA TILESII UNALASCHENSIS	2	+	3
STELLARIA CILIATOSEPALA	2	+	3
RANUNCULUS SCELERATUS?	1	+	-
SENECIO CONGESTUS?	1	+	-
LAGOTIS GLAUCA	1	+	2
SAGINA LINNAEI	1	+	2
GENTIANA GLAUCA	1	+	3
CAMPANULA LASIOCARPA	1	+	3
DELPHINIUM GLAUCUM	1	+	3
ARTEMESIA NORVEGICA SAXATILIS	1	+	2

* VERY ROUGH GUIDE ONLY - NOT INVESTIGATED WITH A NUMERICAL APPROACH

STN. 119 (CONT'D) (APPENDIX IVC)

C LAYER (CONT'D)	S.S.	SOC.	V.
CARDAMINE PRATENSIS	1	+	3
LUZULA WAHLENBERGII	1	+	3
LUZULA MULTIFLORA	1	+	3
DODECALTHEON SP.	+	+	3

D LAYER - INCOMPLETE COLLECTION AND NUMERICAL ANALYSIS

RHYTIDIUM NEGOSUM	3	2	3
CLADONIA MITIS	2	-	3
POLYTRICHUM COMMUNE	1	2	3
DICRANUM MUHLENBECKII	1	-	-
PTILIDIUM CILIARE	NO DATA		
PLEUROZIUM SCHREBERI	NO DATA		

TABLE 1B - COMMUNITY GROUPING 1 (H-M) - STN. 136 (APPENDIX IVC)

NO. OF PLOTS	1
PLOT OR QUADRAT NO.	136
MORAINE & AGE	NF-SL-1
PLOT SIZE (M^2.)	100
EXTENT (M^2.)	10,000

COMMUNITY INDIVIDUA SPECIES	S.S.	SOC.	V.
B_2 LAYER			
SALIX PULCHRA VAR. PULCHRA (NOT S.PLANIFOLIA)	6	5	3
BETULA GLANDULOSA (VAR. SIBIRICA)	2	3	2
C LAYER			
STELLARIA MONANTHA	3	1	3
VERONICA ALPINA VAR. UNALASCHENSIS	3	+	3
RHODIOLA INTEGRIFOLIA	3	1	3
CAREX PODOCARPA?	3	2	3
FESTUCA ALTAICA	2	+	3
CALAMAGROSTIS INEXPANSA	2	1	3
ARTEMESIA NOVEGICA SAXATILIS	2	+	2
SENECIO TRIANGULARIS	2	1	3
RANUNCULUS NIVALIS?	1	+	3
RANUNCULUS PEDATIFUS	1	+	3
ANENOME NARCISSIFLORA VAR. INTERIOR	1	+	3
POLEMONIUM CAERULEUM VILLOSUM	1	+	3
VALERIANA CAPITATA	1	+	3
GENTIAVA GLAUCA	1	+	3
ANENOME RICHARDSONII	1	+	3
ANENOME MULTICEPS?	1	+	3
POLYGONUM BISTORTA PLUMOSUM	1	+	3
ACONITUM DELPHINIFLORUM	1	+	3
SOLIDAGO MULTIRADIATA	1	+	3
EPILOBIUM AUGUSTIFOLIUM	1	+	+
PETASITES FRIGIDUS	1	+	+
LUZULA WAHLENBERGII	1	1	3
LUZULA MULTIFLORA	1	1	3
TRISETUM SPICATUM	1	4	2
MERTENSIA PANICULATA	+	+	3
RUBUS SP. (HYBRID)	+	+	2
SENECIO ALASKANUS	+	+	1
D LAYER - VERY APPROXIMATE ESTIMATE ONLY			
HYLOCOMIUM ALASKANUM	4	2	3
RHYTIDIUM RUGOSUM	3	2	3
CLADONIA GRACILIS	2	1	2
POLYTRICHUM COMMUNE	2	2	3
DICRANUM ELONGATUM	2	-	2
PLEUROZIUM SCHREBERI	2	-	2
AULACOMMIUM PALUSTRE	2	-	2
SPHENOLOBUS MINATUS	2	-	2

TABLE IB - COMMUNITY GROUPING I (H-M) - STN. 136A (APPENDIX IVC)

NO. OF PLOTS - RANDOM SURVEY OVER ENTIRE MEADOW			
PLOT OR QUADRAT NO.	136A (BETWEEN 136 & 138)		
MORAINE & AGE	NF-SL-I		
PLOT SIZE (M^2.)	QUADRAT NOT ESTABLISHED		
EXTENT (M^2.)	6000		
COMMUNITY INDIVIDUA SPECIES *	S.S.	SOC.	V.
B_2 LAYER			
BETULA GLANDULOSA	2	3	2
SALIX PLANIFOLIA (OR S.PULCHRA)	1	2	2
C LAYER			
ARCTOSTAPHYLOS ALPINA RUBRA	3	2	2
FESTUCA ALTAICA	2	2	3
SOLIDAGO MULTIRADIATA	2	+	3
SENECIO TRIANGULARIS	2	1	3
RHODIOLA INTEGRIFOLIA	1	1	3
POLEMONIUM CAERULEUM VILLOSUM	1	+	3
VALERIANA CAPITATA	1	+	3
PEDICULARIS SUDETICA	1	+	3
ARTEMESIA NORVEGICA SAXATILIS	1	+	3
ACONITUM DELPHINIFLORUM	1	+	2
ANENOME NARCISSIFLORA VAR. INTERIOR	1	+	3
VERONICA ALPINA VAR. UNALASCHENSIS	1	+	3
STELLARIA LAETA	1	+	3
EMPETRUM NIGRUM	1	2	3
EPILOBIUM ANGUSTIFOLIUM	1	+	0
GENTIANA GLAUCA	+	+	2
PETASITES FRIGIDUS	+	+	0
RUBUS SP. (HYBRID)	+	+	3
LUZULA WAHLENBERGII	+	1	3
CAREX PODOCARPA	+	1	2
TRISETUM SPICATUM	+	+	3
CALAMAGROSTIS CANADENSIS	+	1	3
SENECIO LUGENS	+	+	3
PEDICULARIS LABRADORICA	+	+	3
ANENOME PARVIFLORA	+	+	3
MERTENSIA PANICULATA	+	+	3
D LAYER			
HYLOCOMNIUM ALASKANUM	6	2	3
RHYTIDIUM RUGOSUM	2	1	3
POLYTRICHUM COMMUNE	2	1	3
POLYTRICHUM JUNIPERINUM	1	1	3
AULACOMNIUM TURGIDUM	+	-	-
CETRARIA CUCULLATA	1	+	3
DITRICHUM FLEXICAULE?	1	+	3
CLADONIA AMAUROCRAEA	-	1	2
CETRARIA ISLANDICA	+	+	3

*VERY APPROXIMATE NUMERICALLY

TABLE 1B - COMMUNITY GROUPING 1 (H-M) - STN. 137 (APPENDIX IVC)

NO. OF PLOTS	1
PLOT OR QUADRAT NO.	137
MORAINE & AGE	NF-SL-I
PLOT SIZE (M^2.)	100
EXTENT (M^2.)	15,000

COMMUNITY INDIVIDUA SPECIES	S.S.	SOC.	V.
B_2 LAYER			
SALIX PLANIFOLIA	5	4	2
BETULA GLANDULOSA	4	3	2
POTENTILLA FRUCTICOSA	1	+	2
C LAYER - (BY FAIRLY ACCURATE COUNTS)			
RHODIOLA INTEGRIFOLIA	3	1	3
STELLARIA LAETA	3	1	3
POA ARCTICA	3	2	3
CARDAMINE PURPUREA	2	+	3
LLYODIA SEROTINA	2	+	3
PARRYA NUDICAULIS	2	+	3
DRABA LONGIPES	2	+	3
ANENOME NARCISSIFLORA	2	+	3
POLYGONUM BISTORTA PLUMOSUM	2	+	3
SENECIO LUGENS	2	+	3
GENTIANA PROPINQUA	2	+	3
CAREX PODOCARPA	2	1	3
MERTENSIA PANICULATA	2	1	3
EMPETRUM NIGRUM	2	1	3
PETASITES FRIGIDUS (VAR. NIVALIS & VAR. FRIGIDUS)	2	+	1
GENTIANA ALGIDA	2	1	3
CAREX BIGELOWII	2	2	3
ANENOME PARVIFLORA	1	+	2
SALIX RETICULATA	1	+	2
RANUNCULUS NIVALIS?	1	+	2
DODECATHEON SP.	1	+	3
PEDICULARIS LANGSDORFII	1	+	3
VALERIANA CAPITATA	1	+	3
ACONITUM DELPHINIFLORUM	1	+	2
POLEMONIUM CAERULEUM VILLOSUM	1	+	3
EPILOBIUM ANGUSTIFOLIUM	1	+	2
LUZULA MULTIFLORA	1	+	2
TRISETUM SPICATUM	1	+	2
LAGOTIS GLAUCA	+	+	3
PARNASSIA KOTZEBUEI	+	+	2
RUBUS SP. (HYBRID)	+	+	2
POLYGONUM VIVIPARUM	+	+	3
ARTEMISIA NORVEGICA SAXATILIS	+	+	3
GENTIANA GLAUCA	+	+	3
DESCHAMPSIA CAESPITOSA	+	+	+

STN. 137 (CONT'D) (APPENDIX IVC)

D LAYER - VERY ROUGH ESTIMATE ONLY	S.S.	SOC.	V.
DICRANUM MUHLENBECKII	3	1	-
POLYTRICHUM COMMUNE	2	1	3
AULACOMNIUM PALUSTRE	2	-	-
CETRARIA ISLANDICA	2	+	2
CETRARIA RICHARDSONII	1	+	3

TABLE 1B - COMMUNITY GROUPING I (H-M) - STN. 122 (APPENDIX IVC)

NO. OF PLOTS	1
"PLOT NO."	122
MORAINE & AGE	NF-SL-I
PLOT SIZE (M^2.)	WHOLE SURFACE EXAMINED
EXTENT (M^2.)	5000

COMMUNITY INDIVIDUA SPECIES	S.S.	SOC.	V.
B_2 LAYER			
SALIX PLANIFOLIA	4	4	3
BETULA GLANDULOSA	3	3	3
VACCINIUM ULIGINOSUM	1	+	2
C LAYER			
CASSIOPE TETRAGONA	4	5	3
ARCTOSTAPHYLOS ALPINA RUBRA	3	3	3
CAREX PODOCARPA	3	2	3
CAREX PHYSOCARPA	3	2	3
SALIX RETICULATA	2	+	3
PETASITES FRIGIDUS	2	+	2
MERTENSIA PANICULATA	2	+	3
VALERIANA CAPITATA	2	+	3
SENECIO LUGENS	2	+	3
GEUM ROSSII	2	1	3
POLEMONIUM CAERULEUM VILLOSUM	2	+	3
POLYGONUM BISTORTA PLUMOSUM	1	+	3
PEDICULARIS LABRADORICA	1	+	3
ARTEMESIA NORVEGICA SAXATILIS	1	+	2
ARNICA LESSINGII	1	+	2
GENTIANA GLAUCA	1	+	3
EQUISETUM ARVENSE	1	+	3
RUBUS SP. (HYBRID)	1	+	2
VERONICA ALPINA VAR. UNALASCHENSIS	1	+	2
GENTIANA ALGIDA	1	1	3
LUZULA ARCUATA	1	+	3
EQUISETUM SCIRPOIDES	+	2	3
PARNASSIA KOTZEBUEI	+	+	2
LAGOTIS GLAUCA	+	+	2
ANTENNARIA MONOCEPHALA	+	1	2
CAMPANULA LASIOCARPA	+	+	2
D LAYER			
HYLOCOMIUM ALASKANUM	3	-	-
TORTULA NORVEGICA	NO DATA		
BRACHYTHACIUM SP.	NO DATA		
AULACOMNIUM PALUSTRE	NO DATA		
DRAPANOCLADUS UNCINATUS	NO DATA		
CETRARIA ISLANDICA	NO DATA		
DACTYLINA ARCTICA	NO DATA		
PELTIGERA MALACEA	NO DATA		

TABLE 1B - COMMUNITY GROUPING I (H-M) - STN. 125A (APPENDIX IVC)

NO. OF PLOTS - BROAD SURVEY IN ENTIRE GULLEY	
"PLOT NO."	NEAR 125A
MORAINE & AGE	FOXY-I
PLOT SIZE (M^2.)	PLOT NOT ESTABLISHED
EXTENT (M^2.)	6000

COMMUNITY INDIVIDUA SPECIES	* S.S.	SOC.	V.
B_2 LAYER - PROBABLY COMPLETE			
SALIX PLANIFOLIA	3	4	2
BETULA GLANDULOSA	3	5	2
SALIX BARRATTIANA	2	-	2
POTENTILLA FRUCTICOSA	2	1	3
LEDUM PALUSTRE DECUMBENS	1	+	3
VACCINIUM ULIGINOSUM	1	+	3
C LAYER - MISSED EARLY SEASON FLOWERS **			
CAREX BIGELOWII	3?	2	3
CAREX PHYSOCARPA	2	1	3
SENECIO LUGENS	2	+	3
ACONITUM DELPHINIFLORUM	2	1	3
POLEMONIUM CAERULEUM VILLOSUM	2	+	3
LUPINUS ARCTICUS	2	2	3
PETASITES FRIGIDUS	2	+	+
VALERIANA CAPITATA	1	+	3
SENECIO CONGESTUS	1	+	2
ANENOME RICHARDSONII	1	+	3
EMPETRUM NIGRUM	1	1	2
PEDICULARIS LANGSDORFII	1	+	3
MERTENSIA PANICULATA	1	+	3
SAXIFRAGA HIRCULIS	1	+	3
DRABA LONGIPES	1	+	3
DELPHINIUM GLAUCUM	1	1	3
ERIOPHORUM BRACHYANTHERUM	1	1	2
FESTUCA ALTAICA	1	1	3
POA ARCTICA	1	1	3
CALAMAGROSTIS CANADENSIS	1	1	3
TRISETUM SPICATUM	1	+	2
ARCTAGROSTIS LATIFOLIA VAR. ARUNDINACEAE	1	1	3
GEUM ROSSII	+	1	3
SALIX RETICULATA	+	+	3
VACCINIUM VITIS-IDAEA MINUS	+	1	3
POLYGONUM BISTORTA PLUMOSUM	+	+	3
LAGOTIS GLAUCA	+	+	3
PAPAVER MACOUNI	+	+	3
STELLARIA LAETA	+	+	3
ARCTOSTAPHYLOS ALPINA RUBRA	+	1	-
PARNASSIA KOTZEBUEI	+	+	2
DRYAS OCTOPETALA S.L.	+	1	2
PEDICULARIS CAPITATA	+	+	3
PRIMULA SP.	+	+	3

*S.S. VERY APPROXIMATE

STN. 125A (CONT'D) (APPENDIX IVC)

C LAYER (CONT'D)	S.S.	SOC.	V.
SAXIFRAGA HIERACIFOLIA VAR. RUFOPILOSA	+	+	3
POLYGONUM VIVIPARUM	+	+	2
GENTIANA PROPINQUA	+	+	3
SAUSSUREA VICIDA	+	+	3
ASTRAGULUS UMBELLATUS?	+	+	3
TOFIELDIA PUSILLA	+	+	2
SALIX PSEUDOPOLARIS	+	1	2
SAXIFRAGA PUNCTATA INSULARIS	+	+	2
CAREX PODOCARPA	+	1	2

D LAYER - VERY CRUDE APPROXIMATIONS FOR FORMAL COLLECTIONS WERE NOT MADE IN THIS REGION

HYLOCORNIUM ALASKANUM	3?	2	3
AULACOMNIUM POLUSTRE	1?	-	-
CETRARIA CUCULLATA)			
CLADONIA MITIS)			
CLADONIA RANGIFERINA)	PROBABLY		
CLADONIA GRACILIS)	PRESENT		

** WHERE THE SERIES SIGNIFICANCE IS MARKED WITH A + THERE STANDS A GOOD POSSIBILITY THAT THESE SHOULD BE CLASSED AS SPORADICS. MANY SPECIES WERE ALSO ON THE DRIER SLOPE OF STN. 164 OR IN THE TRANSITIONAL ZONE OF THE DRY SLOPE TO THE MOIST GULLEY BOTTOM.

TABLE IIA - ENVIRONMENTAL DATA FOR COMMUNITY GROUPING II (M) (APPENDIX IVC)

PLOT DATA			
PLOT NO.	152	111	164
MORAINE & RELATIVE AGE	FOXY-I	NF-SL-I	FOXY-I
LATITUDE (-° -' -")N	64° 37' 40"	64° 33' 50"	64° 37' 30"
LONGITUDE (-° -' -")W	138° 23' 35"	138° 16' 30"	138° 23' 50"
ELEV. (M. MSL.)	1220 10	1250 25	1215 5
PHYSIOGRAPHY			
PARENT MATERIAL (FOLK, 1965)	MUDDY GRAVEL SLOPE OF END MORAINE	MUDDY GRAVEL? SLOPE OF MORAINAL RIDGE	MUDDY GRAVEL ARCUATE LOBE- OF END MORAINE
RELIEF SHAPE - PROFILE	SLIGHTLY CONVEX	CONCAVE	CONCAVE
- CONTOUR	SLIGHTLY CONCAVE	BROADLY CONVEX	, CONCAVE
EXPOSURE OR ASPECT (-°)	360°	360 + 15°	360°
SLOPE GRADIENT (-°)	CA.20-30°	20-30°	15-20°
SLOPE ABOVE PLOT (M.)	0	CA.50	20
GEOLOGY (REFER TO TABLE I)			
DOM.REPRES. UNITS (T-K, 1966)	AS IN STN.165	AS IN STN.151*	5, MINOR 13
DOM.ROCK TYPES	CO_3BAS.,LS.,TF.	QTZT.,MONZ.,CH.	AS IN STN.165
CLIMATE			
MACROCLIMATE (KÖPPEN)	DFC OR ET	DFC OR ET	DFC OR ET
WIND EXPOSURE (A, B, C) LAYERS	-, 8, 4	-, 7, 6	-, 6, 3
SNOW DURATION (MONTHS)	CA.8½	CA.7½	CA.8½
STRATA COVERAGE (%)			
A	0	0	0
B	15	5-10	15
C	60	80	50
D	50	30	65
PLOT COVERAGE (% EXPOSED)			
BY GRAVEL AND SAND	0	0	10
BY DECAYED MATTER	0	0	0
BY WATER	0	0	0
SOIL			
TYPE (NSSC-1963)	NOT EXAMINED BUT PROBABLY AS IN STN.164	4.? *	4.21*
HUMUS THICK. (CM.)	-	-	2.5-5.0
HUMUS pH	-	-	NOT TESTED
PARENT MATERIAL	PROBABLY SLUMPED TILL	LOOSE TILL	PARTIALLY SLUMPED TILL
DRAINAGE (NSSC-1963)	-	MODERATELY WELL DRAINED	RAPIDLY DRAINED
DEPTH TO PF (CM.)	-	NOT PRESENT	NOT DETECTED
HYGROTOPE - BROOKE (1966)	MESIC	MESIC	MESIC
MAX. DEPTH LIVING ROOTS (CM.)	-	-	31
pH @ MAX. ROOTING DEPTH	-	-	NOT TESTED
OTHER		*NO SOIL PIT ANALYSIS	*CARBONATE ROCKS AND CALCIPHILIC PLANTS INSURE THIS CATEGORY

TABLE IIB - COMMUNITY GROUPING II (M) - STN. 152 (APPENDIX IVC)

NO. OF PLOTS	NIL, RANDOM SURVEY OF SLOPE
"PLOT NO."	152
MORAINE & AGE	FOXY-I
PLOT SIZE (M^2.)	PLOT NOT ESTABLISHED
EXTENT (M^2.)	17000

COMMUNITY INDIVIDUA SPECIES	S.S.	SOC.	V.
B_2 LAYER - NOT EXAMINED IN DETAIL - ROUGHLY SAME AS IN STN. 164			
BETULA GLANDULOSA	-	-	-
SALIX PLANIFOLIA	-	-	-
LEDUM PALUSTRE DECUMBENS	-	-	-
VACCINIUM ULIGINOSUM	-	-	-
C LAYER - A FEW ADDITIONAL SPECIES THAT WERE NOT FOUND AT STN. 164			
CASSIOPE TETRAGONA TETRAGONA	4	3	3
GEUM ROSSII	3	1	3
DRYAS ALASKENSIS	3	2	3
SALIX RETICULATA	3	+	3
ANENOME PARVIFLORA	2	+	3
CARDAMINE PURPUREA	2	+	3
VACCINIUM VITIS-IDAEA MINUS	2	2	3
EMPETRUM NIGRUM	2	2	2
POLYGONUM BISTORTA PLUMOSUM	2	+	3
ARCTOSTOPHYLOS ALPINE RUBRA	2	2	2
ANTENNARIA ANGUSTATA	2	1	2
TRISETUM SPICATUM	2	+	2
PARRYA NUDICAULIS VAR. INTERIOR	1	+	3
STELLARIA LAETA	1	+	3
DRYAS OCTOPETALA S.L. DRYAS CRENULATA	1	1	2
PEDICULARIS CAPITATA	1	+	3
EQUISETUM SCIRPOIDES	1	1	2
OXYRIA DIGYNA	1	+	3
SILENE ACAULIS EXSCAPA	1	2	3
ARENARIA ARCTICA	1	+	3
ARCTAGROSTIS LATIFOLIA VAR. ARUNDINACEAE?	1	1	3
ARNICA LESSINGI	1	+	3
ARTEMESIA NORVEGICA SAXATILIS	1	1	2
ANENOME NARCISSIFLORA?	1	1	3
CAREX SCIRPOIDEA	1	2	3
POA LEPTOCOMA	1	1	2
ERIGERON UNIFLORUS ERIOCEPHALUS	1	1	3
CASTILLEJA PALLIDA ELEGANS	+	+	3
TARAXACUM LYRATUM	+	+	3
SAXIFRAGA RADIATA	+	+	3
RHODIOLA INTEGRIFOLIA	+	1	2
LLYODIA SEROTINA	+	+	3
ERIGERON HUMILUS	+	+	3
PYROLA GRANDIFLORA	+	+	3
MYOSOTIS ALPESTRIS ASIATICA	+	+	3
LUPINUS ARCTICUS	+	+	3

STN. 152 (CONT'D) (APPENDIX IVC)

C-LAYER (CONT'D)	S.S.	SOC.	V.
PAPAVER MACOUNI	+	+	3
PARNOSSIA KOTZEBUEI	+	+	2
POLEMONIUM CAERULEUM VILLOSUM	+	+	3
DRABA LONGIPES	+	+	3
ASTRAGULUS UMBELLATUS	+	+	3
SALIX PSEUDOPOLARIS	+	1	2
SAXIFRAGA PUNCTATA INSULARIS	+	+	2
ANENOME RICHARDSONII	+	+	3
SENECIO LUGENS	+	+	3
D LAYER - NO FORMAL SURVEY OR COLLECTIONS			
HYLOCOMIUM ALASKANUM	CA.5	2	3
CETRARIA RICHARDSONII	1	+	3
BRACHYTHECIUM SP.	+	-	-
DREPANOCLADUS UNCINATUS	+	-	-

TABLE IIB - COMMUNITY GROUPING II (M) - STN. 111 (APPENDIX IVC)

NO. OF PLOTS	NIL - RANDOM SURVEY ONLY		
"PLOT OR QUADRAT NO."	111		
MORAINE & AGE	NF-SL-I		
PLOT SIZE (M^2.)	PLOT NOT ESTABLISHED 100 M. WIDE STRIP EXAMINED		
EXTENT (M^2.)	CA. 350,000		
COMMUNITY INDIVIDUA SPECIES	S.S.	SOC.	V.
B_1, B_2 AND A_3(?) LAYER			
BETULA GLANDULOSA	4	2	2
PICEA GLAUCA	+	+	1
C LAYER - ONLY MOST IMPORTANT SPECIES LISTED**			
CASSIOPE TETROGONA TETRAGONA	5	5	3
DRYAS OCTOPETALA S.L.	3	4	3
EMPETRUM NIGRUM	3	4	3
SALIX RETICULATA	2	+	3
PARRYA NUDICALLIS VAR. INTERIOR	2	1	3
CARDAMINE PUPUREA	2	+	3
GEUM ROSSII	2	1	3
CAREX PODOCARPA	1	1	2
UNKNOWN SPECIES	+	+	3
SALIX ARCTICA S.L.	1	2	3
ANENOME PARVIFLORA	1	+	3
ARENARIA ARCTICA	+	-	3
PEDICULARIS LANGSDORFII	+	+	2
RANUNCULUS NIVALIS?	+	+	3
POLYGONUM VIVIPARUM	+	+	3
ERIOPHORUM SP.	+	-	3
D LAYER			
HYLOCOMUIM ALASKANUM) RHYTIDIUM RUGOSUM)	7	3	3
CLADONIA MITIS? (OR CAMAUROCRAEA)	-	+	3
DACTYLINA ARCTICA	1	+	3
CETRARIA CUCULLATA?	1	+	3

** OBSERVATIONS MADE ON JULY 3RD - LATE SEASON BLOOMING SPECIES NOT LISTED

TABLE IIB - COMMUNITY GROUPING II (M) - STN. 164 (APPENDIX IVC)

NO. OF PLOT	1
PLOT OR QUADRAT NO.	164
MORAINE & AGE	FOXY-I
PLOT SIZE (M^2.)	100
EXTENT (M^2.)	6000

COMMUNITY INDIVIDUA SPECIES	S.S.	SOC.	V.
B_2 LAYER			
BETULA GLANDULOSA	4	3	3
SALIX PLANIFOLIA	3	2	3
LEDUM DECUMBENS	1	1	3
VACCINIUM ULIGINOSUM	1	+	3
SALIX RICHARDSONII	+	1	2
C LAYER			
CASSIOPE TETRAGONA TETRAGONA	4	3	3
GEUM ROSSII	3	1	3
DRYAS ALASKENSIS	3	2	3
SALIX RETICULATA	3	+	3
ANENOME PARVIFLORA	2	+	3
CARDAMINE PURPUREA	2	+	3
VACCINIUM VITIS-IDAEA MINUS	2	2	3
EMPETRUM NIGRUM	2	2	2
POLYGONUM BISTORTA PLUMOSUM	2	+	3
ARCTOSTAPHYLOS ALPINA RUBRA	2	2	2
ANTENNARIA ANGUSTATA	2	1	2
TRISETUM SPICATUM	2	+	2
PARRYA NUDICAULIS VAR. INTERIOR	1	+	3
STELLARIA LAETA	1	+	3
DRYAS OCTOPETALA s.l.	1	1	2
PEDICULARIS CAPITATA	1	+	3
EQUISETUM SCIRPOIDES	1	1	2
OXYRIA DIGYNA	1	+	3
SILENE ACAULIS VAR. EXSCAPA	1	2	3
ARENARIA ARCTICA	1	+	3
ARCTAGROSTIS LATIFOLIA VAR. ANGUSTIFOLIA	1	1	3
SENECIO ATROPURPUREUS	+	+	3
PEDICULARIS LANGSDORFII	+	+	3
LAGOTIS GLAUCA	+	+	3
LUPINUS ARCTICUS	+	1	3
PAPAVER MACOUNI	+	+	3
PARNASSIA KOTZEBUEI	+	+	2
POLEMONIUM CAERULEUM VILLOSUM	+	+	3
SAXIFRAGA HIERACIFOLIA VAR. RUFOPILOSA	+	+	3
SOLIDAGO MULTIRADIATA	+	+	3
POLYGONUM VIVIPARUM	+	+	2
DRABA LONGIPES	+	+	3
GENTIANA PROPINQUA	+	+	3
SAUSSUREA VICIDA	+	+	3
EPILOBIUM ANGUSTIFOLIUM	+	+	1
ASTRAGULUS UMBELLATUS	+	+	3
SALEX PSEUDOPOLARIS	+	1	2
SAXIFRAGA PUNCTATA INSULARIS	+	+	2

STN. 164 (CONT'D) (APPENDIX IVC)

C LAYER (CONT'D)	S.S.	SOC.	V.
CAREX PODOCARPA	+	1	2
FESTUCA ALTAICA	+	1	2
POA ARCTICA	+	1	2
ANENOME RICHARDSONII	+	+	3
SENECIO LUGENS	+	+	3
D LAYER			
HYLOCOMIUM ALASKANUM	6	2	3
CLADONIA RANGIFERINA	3	2	2
AULACOMNIUM PALUSTRE	2	-	-
CLADONIA GRACILIS	2	1	2
CETRARIA CUCULLATA	1	+	2
CLADONIA MITIS	1	1	2
DACTYLINA ARCTICA	1	+	3
CLADONIA ALPESTRIS	+	1	2

**ALL SPECIES OF VERY SMALL DOMINANCE COULD BE CONSIDERED AS SPORADICS AND AS A PORTION OF THE NEIGHBOURING MOIST GULLEY TYPE OF HABITAT (STN. 125A). THE BOUNDARY BETWEEN THE DRY SLOPE AND THE MOIST GULLEY IS VERY GRADATIONAL.

TABLE IIIA - ENVIRONMENTAL DATA FOR COMMUNITY IIID (H-M) (APPENDIX IVC)

PLOT DATA				
PLOT OR QUADRAT NO.	306 ***	304	223A	217
MORAINE & RELATIVE AGE	OGILVIE-III	OGILVIE-III	CHAP.LAKE-II	CHAP.LAKE-II
LATITUDE (-° -' -")	64° 56' 00"	64° 56' 00"	64° 53' 10"	64° 53' 10"
LONGITUDE (-° -' -")	138° 18' 30"	138° 19' 00"	138° 17' 40"	138° 17' 40"
ELEV (M.MSL.)	1090-1140	1145±5	965±5	960±5
PHYSIOGRAPHY				
PARENT MATERIAL	MUDDY GRAVEL	MUDDY GRAVEL*	GRAN.MUDDY SAND	-
LAND FORM	SOLIFLUCTION LOBES ON SLOPE	RIDGE CREST	CREST OF END MORAINE	MARSH FLAT
RELIEF SHAPE - PROFILE	SLIGHTLY CONCAVE	SLIGHTLY UNDULATORY	STRAIGHT	UNDULATORY-FLAT
- CONTOUR	SLIGHTLY CONCAVE	SINUOIDAL-STRAIGHT	STRAIGHT	STRAIGHT
EXPOSURE OR ASPECT (_°)	CA.125°	270°	FLAT	FLAT
SLOPE GRADIENT (_°)	CA.10°	2°	± NIL	± NIL
SLOPE DISTANCE ABOVE PLOT (M.)	CA.200	CA.50	NIL	NOT APPLICABLE
GEOLOGY (REFER TO TABLE I:)				
DOM.REPRES. UNITS (T-K,1966)	13, 1, 5, 7*	13, 1, 5, 7?	1, 13, 7	NOT RELEVANT
DOM.ROCK TYPES	QTZT., CO_3BAS., STST.	QTZT., CO_3BAS., STST.	QTZT., CO_3SS., STST.	PEAT
CLIMATE				
MACROCLIMATE (KÖPPEN)	DFC OR ET	DFC OR ET	DFC OR ET	DFC OR ET
WIND EXPOSURE (A,B,C) LAYERS	-, 9, 6	-, 9, 6	-, 7, 6	-, 7, 3
SNOW DURATION (MONTHS)	CA.8 MONTHS	8½	8	8
STRATA COVERAGE (%)				
A	CA.5	-	-	-
B	CA.20	CA.30	15	20
C	CA.80	CA.60	50	40
D	CA.30	CA.60	80	CA.25
PLOT COVERAGE (% EXPOSED)				
BY GRAVEL AND SAND	CA.5	0	-	-
BY DECAYED DEBRIS	CA.0	CA.0	-	10
BY WATER	CA.5	0	± 10	30-50
SOIL				
TYPE (NSSC-1963)	6.2 -/7 OR 7.2**	5.1 -/8	5.1 -/8 OR *6.21	7.12
HUMUS THICK. (CM.)	± 30	7.5	5.0	> 51
HUMUS pH	PROBABLY NEUTRAL	NOT TESTED	CA.8.0	NOT TESTED
PARENT MATERIAL	CONVOLUTED TILL AND EOLIAN SILT	TILL	EOLIAN OR COLLUVIAL SAND ON LOOSE TILL	PEAT
DRAINAGE (NSSC-1963)	POORLY TO V.POORLY DRAINED	POORLY DRAINED	POORLY DRAINED	POORLY DRAINED
DEPTH TO PF	? PROBABLY 30-50	> 90 NOT DETECTED	NOT DETECTED	60
HYGROTOPE - BROOKE (1966)	MESIC TO HYDRIC	HYGRIC	HYGRIC	HYDRIC *
MAX. DEPTH OF LIVING ROOTS (CM.)	-	CA.50	NOT RECORDED	CA.10
pH @ MAX.ROOTING DEPTH	SLIGHTLY BASIC(?)	NOT TESTED	> 7.0 < 8.0	NOT TESTED
OTHER				

***NOT A FORMAL PLOT

*FROM RESULTS OF NEARBY STN.304

**SOIL PIT NOT ESTABLISHED.

*TOP 50 CM. OF PROFILE COULD BE EOLIAN SILT.

* DUE TO VAGUE COLOUR STRAT. IN C-HORIZON.

* WITH MESIC PEAT HUMMOCKS.

TABLE IIIB - COMMUNITY GROUPING IIID - (H-M) - STN. 306 (APPENDIX IVC)

NO. OF PLOTS OR QUADRATS	0 - CASUAL OBSERVATIONS ONLY
"PLOT NO."	306*
MORAINE & RELATIVE AGE	OGILVIE - III
PLOT SIZE (M^2.)	NOT ESTABLISHED - RECONNAISSANCE SURVEY ONLY
EXTENT (M^2.)	CA. 450,000

COMMUNITY INDIVIDUA SPECIES	S.S.	SOC.	V.
A_2 OR A_3 LAYER			
PICEA GLAUCA	2	+	2
B LAYER			
BETULA GLANDULOSA	4	+	2
SALIX PLANIFOLIA	4	3	2
SALIX GLAUCA VAR. ACUTIFOLIA	4	3	2
LEDUM PALUSTRE DECUMBENS	2	+	3
RHODODENDRUM LAPPONICUM	2	+	2
VACCINIUM ULIGINOSUM	1	1	3
C LAYER			
CAREX BIGELOWII	6	2	2
ERIOPHORUM BRACTYANTHERUM?	3	2	2
CASSIOPE TETRAGONA TETRAGONA	3	2	2
DRYAS INTEGRIFOLIA	2	2	2
SALIX RETICULATA	2	+	2
PEDICULARIS LABRADORICA	2	+	2
VACCINIUM VITIS IDAEA MINUS	1	2	3
ARCTOSTOPHYLOS ALPINA RUBRA	1	2	3
SAUSSUREA ANGUSTIFOLIA	1	+	3
POLYGONUM VIVIPARUM	1	+	2
PEDICULARIS LANGSDORFII	1	+	3
VALERIANA CAPITATA	1	+	3
SAXIFRAGA HIRCULIS	1	+	3
EQUISTETUM SCIRPOIDES	1	+	2
RUMEX ARCTICUS	1	+	3
SENECIO LUGENS	1	+	3
GENTIANA PROPINQUA	1	+	3
LAGOTIS GLAUCA	1	+	3
MELANDRIUM APETULUM	1	1	3
TOFIELDIA PUSILLA	1	1	3
ACONITUM DELPHINIFLORUM	1	+	3
ASTRAGULUS OR OXYTROPIS SP. (NO BLOOMS)	1	1	2
ERIOPHORUM ANGUSTIFOLIUM	1	+	3
HEDYSARUM MACKENZII	+	1	2
PARNASSIA PALUSTRIS	+	1	3
ANDROMEDA POLIOFOLIA	+	1	2

D LAYER - NOT EXAMINED OR COLLECTED

* THIS VERY ROUGH CHART REPRESENTS ONLY A VERY APPROXIMATE ECOLOGICAL SITUATION ON THE UPPER REACHES OF THE SLOPE WHERE SLUMPING IS ONLY OF MINOR CONSEQUENCE.

TABLE IIIB - COMMUNITY GROUPING IIID - (H-M) - STN. 304 (APPENDIX IVC)

NO. OF PLOTS	1		
PLOT OR QUADRAT NO.	304 **		
MORAINE & RELATIVE AGE	OGILVIE - III		
PLOT SIZE (M^2.)	NO FORMAL PLOT - RANDOM SURVEY		
EXTENT (M^2.)	CA. 500,000		
COMMUNITY INDIVIDUA SPECIES	S.S.	SOC.	V.
B_2 LAYER			
BETULA GLANDULOSA	4	4	2
SALIX PLANIFOLIA	4	3	2
SALIX GLAUCA VAR. (IDENT. NOT CONFIRMED)	4	3	2
LEDUM PALUSTRE DECUMBENS	2	+	3
RHODODENDRON LAPPONICUM	2	+	2
VACCINIUM ULIGINOSUM	1	1	3
PICEA GLAUCA	+	+	2
C LAYER			
CAREX BIGELOWII (IDENT. NOT CONFIRMED)	6	2	2
ERIOPHORUM BRACHYANTHERUM (UNCONFIRMED)	2	2	2
ERIOPHORUM CHAMISSONIS (OR E. SCHEUCHZERI OR MOD. E. BRACHYANTHERUM)	1	+	2
SALIX RETICULATA	2	+	2
VACCINIUM VITIS-IDAEA MINUS	2	2	3
ARCTOSTAPHYLOS APINA RUBRA	2	2	1
DRYAS INTEGREFOLIA AND D. OTOPETALA S.L.	2	2	2
ANDROMEDA POLIOFOLIA	1	1	2
SAUSSUREA AUGUSTIFOLIA	1	+	3
POLYGONUM VIVIPARUM	1	+	2
PEDICULARIS SUDETICA? (OR P. LANGSDORFII?)	1	+	2
VALERIANA CAPITATA	1	+	3
SAXIFRAGA HIRCULIS	1	1	3
EQUISETUM SCIRPOIDES (IDENT. NOT CONFIRMED)	1	1	2
RUBUS SP. (HYBRID)	+	1	3
SENECIO LUGENS	+	+	3
GENTIANA PROPINQUA	+	+	3
LAGOTIS GLAUCA	+	+	3
CASSIOPE TETRAGONA TETRAGONA	+	2	3
MELANDRIUM APETULUM (OR M. FURCATA= LYCHNIS AFFINIS)	+	1	2
TOFIELDIA PUSILLA	+	+	2
D LAYER - VERY APPROXIMATE, SAMPLES DAMAGED			
HYLOCOMIUM ALASKANUM	6	2	3
CLADONIA RANGIFERINA	3	2	2
PELTIGERA APHTOSA	1	1	2
CETRARIA CUCULLATA (IDENT. NOT CONFIRMED)	1	+	2
AULACOMNIUM PALUSTRE	+	-	-

** AREA VISITED ONCE ONLY; LATE IN THE SEASON

TABLE IIIB - COMMUNITY GROUPING IIID - STN. 223A (APPENDIX IVC)

NO. OF PLOTS	½ OF 1
PLOT OR QUADRAT NO.	223A (HYGRIC STAND)
MORAINE AND RELATIVE AGE	CHAP.LAKE-II
PLOT SIZE (M^2.)	CA. 35
EXTENT (M^2.)	CA. 3500

COMMUNITY INDIVIDUA SPECIES	S.S.	SOC.	V.
B LAYER			
BETULA GLANDULOSA	3	3	2
RHODODENDRON LAPPONICUM	3	2	2
SALIX PLANIFOLIA	3	3	2
LEDUM PALUSTRE DECUMBENS	2	+	3
POTENTILLA FRUCTICOSA	1	+	3
SALIX GLAUCA VAR. ACUTIFOLIA	1	+	2
C LAYER			
CAREX BIGELOWII	2	2	3
PEDICULARIS LANGSDORFII	2	+	3
VACCINIUM VITIS-IDAEA MINUS	2	1	3
TOFIELDIA PUSILLA	2	+	3
ARCTOSTOPHYLAS ALPINA RUBRA	2	2	2
SALIX RETICULATA	2	+	2
EMPETRUM NIGRUM	2	2	3
ERIOPHORUM BRACHYANTHERUM	1	1	3
PEDICULARIS SUDETICA	1	+	2
PEDICULARIS LABRADORICA	1	+	3
SAUSSUREA ANGUSTIFOLIUM	1	+	3
CAREX PHYSOCARPA?	1	1	2
OXYCOCCUS MICROCARPUS	1	1	2
SAXIFRAGA HIRCULIS	1	+	3
POLYGONUM VIVIPARUM	1	+	2
EQUISETUM SCIRPOIDES	1	1	1
VALERIANA CAPITATA	1	+	3
POLEMONIUM CAERULEUM VILLOSUM	1	+	3
GENTIANA PROPINQUA	+	+	2
ARCTAGROSTIS LATIFOLIA VAR. ARUNDINACEAE?	-	-	-
ANDROMEDA POLIOFOLIA	1	1	2
SAXIFRAGA HIERACIFOLIA VAR. RUFOPILOSA	1	+	3
LUPINUS ARCTICUS	+	1	3
D LAYER *			
RHYTIDIUM RUGOSUM	1	1	=
POLYTRICHUM COMMUNE	2	=	=
TOMENTHYPNUM NITENS	2?	=	=
AULACOMNIUM TURGIDUM	2?	=	=
BRACHYTHECIUM SP.	2?	=	=
DICRANUM MUHLENBECKII?	2?	=	=
DICRANUM BERGERI?	2?	=	=
SPAGHNUM CAPILLACEUM	3	-	-
CLADONIA MITIS	1	1	2

* NOT CAREFULLY CHECKED IN THE FIELD

TABLE IIIB - COMMUNITY GROUPING IIID - (H-M) - STN. 217 (APPENDIX IVC)

NO. OF PLOTS	1		
PLOT OR QUADRAT NO.	217		
MORAINE & AGE	CHAP. LAKE-II		
PLOT SIZE (M^2.)	700		
EXTENT (M^2.)	17,000		
COMMUNITY INDIVIDUA SPECIES	S.S.	SOC.	V.
B_2 LAYER			
BETULA GLANDULOSA	4	2	2
SALIX PLANIFOLIA	3	3	2
VACCINIUM ULIGINOSUM ***	1	+	2
LEDUM PALUSTRE DECUMBENS	1	+	2
RHODODENDRON LAPPONICUM ***	1	+	2
POTENTILLA FRUCTICOSA	+	+	3
C LAYER			
CAREX BIGELOWII	6	2	2
ANDROMEDA POLIOFOLIA **	3	1	2
EMPETRUM NIGRUM ***	2	1	3
TOFIELDIA PUSILLA **	2	+	2
SALIX RETICULATA	2	+	2
VACCINIUM VITIS-IDAEA MINUS	2	1	3
RUBUS CHAEMAEROUS	1	+	2
PEDICULARIS LANGSDORFII**	1	+	2
TRIGLOCHIN MARITIMA **	1	+	2
ARCTOSTAPHYLOS ALPINA RUBRA ***	1	2	1
OXYCOCCUS MICROCARPUS **	1	+	2
STELLARIA LAETA ***	1	+	2
POLYGONUM VIVIPARUM	1	+	2
SALIX PSEUDOPOLARIS	1	2	2
SAXIFRAGRA HIRCULIS	1	1	3
CAREX SCIRPOIDEA? ***	1	+	1
ERIOPHORUM BRACHYANTHERUM **	1	1	3
ERIOPHORUM ANGUSTIFOLIUM **	+	+	3
ERIOPHORUM SCHEUCHZERI? ** (OR MODIFIED E. BRACHYANTHERUM)	+	+	2
PINQUICULA VILLOSA? (POSSIBLY P. VULGARIS)	+	+	2
D LAYER - NOT ADEQUATELY STUDIED FOR S.S. ANALYSIS WHILE IN THE FIELD			
BRYOPHYTES - UNDIFFERENTIATED OF: DICRANIUM MUHLENBECKII? AULACOMNIUM TURIGIDUM DICRANIUM ELONGATUM?**	5	4	2
CETRARIA CUCULLATA ***	2	+	2
CLADONIA GRACILIS ** *	2	1	2
CLADONIA MITIS ***	2	1	2
OCHROLECHIA UPSALIENSIS **	1	1	3

STN. 217 (CONT'D) (APPENDIX IVC)

SPORADICS		S.S.	SOC.	V.
PICEA GLAUCA	B LAYER	+	+	1

NOTE: BOG NEAR STN. 223A & B NOT STUDIED IN DETAIL, BUT THE FOLLOWING WERE OBSERVED IN ADDITION TO THE ABOVE:

C LAYER			
SAUSSUREA ANGUSTIFOLIUM ***	+	+	3
CAREX PHYSOCARPA	1	2	3
LYCOPODIUM SELAGO VAR. APPRESSUM	1	2	3
B_2 LAYER			
SALIX GLAUCA VAR. ACUTIFOLIA***	1	-	2

NOTE: THOSE SPECIES OCCURRING IN THE TURFY, PEATY AND DRIER HUMMOCKS IN THE BOG ARE MARKED BY A TRIPLE ASTERISK; THOSE THAT OCCUR ONLY IN THE WATER ARE MARKED BY A DOUBLE ASTERISK; AND NON-ASTERISK DESIGNATED SPECIES OCCUR IN THE INTERVENING TRANSITION ZONES.

TABLE IVA - ENVIRONMENTAL DATA FOR COMMUNITY IIIC (H) (APPENDIX IVC)

PLOT DATA					
PLOT NO.	216	222	218	144	214
MORAINE & RELATIVE AGE	CHAP.LAKE-II	CHAP.LAKE-II	CHAP.LAKE-II	NF-NL-I	CHAP-LAKE-II
LATITUDE (-° -' -")N	64° 55' 05"	65° 50' 50"	64° 51' 45"	64° 37' 05"	64° 50' 30"
LONGITUDE (-° -' -")W	138° 17' 40"	138° 19' 40"	138° 18' 15"	138° 20' 40"	138° 20' 30"
ELEV. (M.MSL.)	965±5	1010±5	985±5	1310	1005±5
PHYSIOGRAPHY					
PARENT MATERIAL (FOLK, 1965)	SLIGHTLY GRAN.MUD	MUD	MUD	SLIGHTLY GRAN.MUD	MUD
LAND FORM	SLOPE OF LOBE OF END MORAINE	ERLAT TOP OF MORAINAL RIDGE CREST	SLOPE OF MORAINAL RIDGE	SLOPE OF END MORAINE LOOP	SLOPE OF MORAINAL RIDGE
RELIEF SHAPE = PROFILE	SLIGHTLY CONCAVE	STRAIGHT	SLIGHTLY CONCAVE	STRAIGHT	STRAIGHT
- CONTOUR	SLIGHTLY CONCAVE	DOMAL	SLIGHTLY CONCAVE	STRAIGHT	STRAIGHT
EXPOSURE OR ASPECT (_°)	325°	FLAT	060°	180°	180°
SLOPE GRADIENT (_°)	± 6°	0°	5°	7°	8°
SLOPE ABOVE PLOT (M.)	50	0	40	200	50
GEOLOGY (REFER TO TABLE I)					
DOM.REPRES. UNITS	AS IN STN.223 *	AS IN STN.220	13, 1, 5, 7, 18 *	13, 1, 7, 5 *	13, 1, 5, 7, 18*
DOM.ROCK TYPES	AS IN STN.223	AS IN STN.220	QTZT., CO_3SS., BAS., STST., GR.	QTZT., CH., ARG., CO_3BAS.	QTZT., CO_3SS., STST., CO_3BAS., GR.
CLIMATE					
MACROCLIMATE (KÖPPEN)	DFC OR ET	DFC OR ET	DFC OR ET	DFC OR ET	DFC OR ET
WIND EXPOSURE (A, B, C) LAYERS	-, 8, 6	-, 9, 7	-, 8, 6	-, 8, 4	-, 7, 4
SNOW DURATION (MONTHS)	8	7½	8	7	7½
STRATA COVERAGE (%)					
A	-	-	-	-	-
B	20	15	30	20	40
C	80	60	60	90	40
D	20	60	30	30	60
PLOT COVERAGE (% EXPOSED)					
BY GRAVEL AND SAND	0	5	0	0	0
BY DECAYED DEBRIS	0	5	0	0	0
BY WATER	0	0	0	0	0
SOIL					
TYPE (NSSC-1963)	7.2 OR 5.1 -/7	6.2 -/7 OR 5.1 -/7 **	7.2 OR 5.1 -/7	7.21? OR 5.1 -/7	5.1 -/7 **
HUMUS THICK (CM.)	30	7.5	38 **	36	10
HUMUS pH	7.5	CA.6.2	6.2	NOT TESTED	NOT TESTED
PARENT MATERIAL	CONVOLUTED EOLIAN SILT AND GLACIAL TILL	EOLIAN SILT	CONVOLUTED EOLIAN SILT	CONVOLUTED EOLIAN SILT	CONVOLUTED EOLIAN SILT
DRAINAGE (NSSC-1963)	IMPERFECT TO POORLY DRAINED	POORLY DRAINED	IMPERFECT TO POORLY DRAINED	POORLY DRAINED	POORLY DRAINED
DEPTH TO PF CM.	40	40	0	15	52
HYGROTOPE - BROOKE (1966)	HYGRIC	HYGRIC	HYGRIC	HYDRIC **	HYGRIC
MAX.DEPTH LIVING ROOTS (CM.)	50	40	0	15 CM.	10 CM.
pH @ MAX.ROOTING DEPTH	8.0	7.0	6.5		NOT TESTED
OTHER	* 223 IS SUFFICIENTLY CLOSE AND ON SAME MORAINAL LOBE TO WARRANT THIS ANALOGY	** THE Ah HORIZON DESIGNATION IS VERY WEAK AND NEEDS CHEMICAL ANALYSIS IN ORDER TO VERIFY THE GLEYSOLIC CLASSIFICATION	* USING NEARBY STN. 220 RESULTS FOR TILL **TEMP 4.4°C THICKNESS DEMANDS 7.2 CLASSIFICATION	NIGGERHEAD TERRAIN *STN.148 RESULTS **IN THIS SENSE - THE SOILS ARE SATURATED BUT ALSO FROZEN MOST OF THE YEAR	*FROM TILL SAMPLE AT STN.220 **POSSIBLY DUE TO CONVOLUTIONS THIS WOULD BE CLOSER TO A 6.2 -/7

TABLE IVB - COMMUNITY GROUPING IIIC (H) - STN. 216 (APPENDIX IVC)

NO. OF PLOTS	1
PLOT OR QUADRAT NO.	216
PLOT SIZE (M^2.)	100
EXTENT (M^2.)	30,000

COMMUNITY INDIVIDUA SPECIES	S.S.	SOC.	V.
B_2 LAYER			
SALIX GLAUCA VAR. ACUTIFOLIA	4	5	2
BETULA GLANDULOSA	3	4	2
SALIX PLANIFOLIA	2	4	2
VACCINIUM ULIGINOSUM	2	+	3
RHODODENDRON LAPPONICUM	2	+	3
LEDUM PALUSTRE DECUMBENS	1	+	2
C LAYER			
CAREX BIGELOWII	5	2	2
DRYAS INTEGRIFOLIA	3	2	3
PEDICULARIS LANGSDORFII? (OR P. LANATA?)	2	+	3
VACCINUM VITIS-IDAEA MINUS	2	1	3
ARCTAGROSTIS LATIFOLIA VAR. ARUNDINACEA	2	4	3
ERIOPHORUM BRACHYANTHERUM	1	1	2
SALIX RETICULATA	1	+	3
STELLARIA LAETA	1	1	3
ARCTOSTAPHYLOS ALPINA RUBRA	1	1	3
PEDICULARIS LABRADORICA	1	+	3
PETASITES FRIGIDUS	1	+	0
SAUSSUREA ANGUSTIFOLIA	1	+	3
SAXIFRAGA HIRCULIS	1	1	3
EMPETRUM NIGRUM	+	1	3
PARRYA NUDICAULIS VAR. INTERIOR	+	+	3
LAGOTIS GLAUCA	+	+	3
SENECIO ATROPURPUREUS?	+	+	2
ERIOPHORUM CHAMISSONIS	+	+	2
PYROLA GRANDIFLORA	+	+	3
SAXIFRAGA HIERACIFOLIA VAR. RUFOPILOSA	+	+	3
ASTRAGULUS UMBELLATUS?	+	+	3
EQUISETUM VARIEGATUM	+	1	2
POLYGONUM VIVIPARUM	+	+	2
TOFIELDIA PUSILLA	+	+	2
D LAYER			
HYLOCOMIUM ALASKANUM)	5	1	3
RHYTIDIUM RUGOSUM)			
AULACOMNIUM ACUMINATUM	1	-	-
AULACOMNIUM TURGIDUM	1	-	-
BRACHYTHECIUM SP.	1	-	-
PTILIDIUM CILIARE	1	-	-
DREPANOCLADUS UNCINATUS	1	-	-
CLADONIA AMAUROCRAEA	1	2	2
CETRARIA CUCULLATA *	1	1	1

STN. 216 (CONT'D) (APPENDIX IVC)

SPORADICS

POLENTILLA FRUCTICOSA	B_2 LAYER	+	+	3
VALERIANA CAPITATA	C LAYER	+	+	3
POLYGONUM BISTORTA	C LAYER	+	+	3

* IDENTIFICATION NOT CONFIRMED BY DR. G. OTTO

TABLE IVB - COMMUNITY GROUPING IIIC (H) - STN. 222 (APPENDIX IVC)

NO. OF PLOTS	1
PLOT OR QUADRAT NO.	222
PLOT SIZE (M^2.)	100
EXTENT (M^2.)	24,000

COMMUNITY INDIVIDUA SPECIES	S.S.	SOC.	V.
B_2 LAYER			
SALIX GLAUCA VAR. ACUTIFOLIA	4	4	2
BETULA GLANDULOSA (VAR. GLANDULOSA)	3	5	2
SALIX PLANIFOLIA	3	4	2
RHODODENDRON LAPPONICUM	3	+	2
LEDUM PALUSTRE DECUMBENS	2	+	3
VACCINIUM ULIGINOSUM	1	+	3
C LAYER			
CAREX BIGELOWII	5	2	2
DRYAS INTEGRIFOLIA	3	2	2
ARCTOSTAPHYLOS ALPINA RUBRA	2	2	3
PEDICULARIS LABRADORICA	2	+	3
VACCINIUM VITIS-IDAEA MINUS	2	1	3
EMPETRUM NIGRUM	2	1	3
PEDICULARIS LANGSDORFII	1	+	3
ERIOPHORUM BRACHYANTHERUM ERIOPHORUM SCHEUCHZERI (OR MOD. E. BRACHYANTHERUM)	1	1	2
PARRYA NUDICAULIS VAR INTERIOR	1	+	3
EQUISETUM SCIRPOIDES	1	1	2
EQUISETUM VARIEGATUM	1	1	2
STELLARIA CRASSIFOLIA?	1	-	2
SAUSSUREA ANGUSTIFOLIA	1	+	3
EPILOBIUM ANGUSTIFOLIA	1	1	3
VALERIANA CAPITATA	1	+	3
POLYGONUM VIVIPARUM	1	+	2
ARCTAGROSTIS LATIFOLIA VAR. ARUNDINACEAE	1	1	3
FESTUCA ALTAICA	1	1	3
SAXIFRAGA HIERACIFOLIA VAR. RUFOPILOSA	+	+	3
PEDICULARIS CAPITATA	+	+	3
PYROLA GRANDIFLORA	+	+	3
SAXIFRAGA PUNCTATA INSULARIS	+	+	3
D LAYER - S.S. WAS NOT ACCURATELY ESTABLISHED IN THE FIELD			
RHYTIDIUM RUGOSUM	4	2	3
CLADONIA MITIS	2	2	3
CLADONIA RANGIFERINA	2	2	3
POLYTRICHUM JUNIPERINUM	2	1	3
CLADONIA UNICIALIS	1	1	2
PELTIGERA APHTOSA	1	+	3
CETRARIA CUCULLATA *	1	+	3
CETRARIA ISLANDICA *	1	+	3
CLADONIA ALPESTRIS *	1	1	3
AULACOMNIUM TIRGIDIUM	+	-	-

*IDENTIFICATIONS NOT CONFIRMED BY DR. G. OTTO

TABLE IVB - COMMUNITY GROUPING - IIIC (H) - STN. 218 (APPENDIX IVC)

NO. OF PLOTS	1
PLOT OR QUADRAT NO.	218
PLOT SIZE (M^2.)	100
EXTENT (M^2.)	9000

COMMUNITY INDIVIDUA SPECIES	S.S.	SOC.	V.
B_2 LAYER			
BETULA GLANDULOSA	4	5	2
SALIX PLANIFOLIA	3	3	2
SALIX GLAUCA VAR. ACUTIFOLIA	3	3	2
LEDUM PALUSTRE DECUMBENS	1	+	3
VACCINIUM ULIGINOSUM	+	+	3
C LAYER			
CAREX BIGELOWII	7	5	2
EMPETRUM NIGRUM	4	1	3
VACCINIUM VITIS-IDAEA MINUS	4	2	3
ARCTOSTOPHYLOS ALPINA RUBRA	3	2	3
PEDICULARIS LANGSDORFII	3	+	3
PEDICULARIS LABRADORICA	2	+	3
STELLARIS LAETA	1	+	3
SALIX RETICULATA	1	+	2
DRYAS INTEGRIFOLIA	1	1	2
PYROLA GRANDIFLORA	1	+	3
SAUSSUREA ANGUSTIFOLIA	1	+	3
PETASITES FRIGIDUS	1	+	0
SENECIO ATROPURPUREUS	+	+	3
POLYGONUM BISTORTA	+	+	3
ERIOPHORUM BRACHYANTHERUM ? AND ERIOPHORUM SCHEUCHZERI (OR MOD. E. BRACHYANTHERUM)	+	1	2
ARENARIA ARCTICA	+	+	2
EQUISETUM SCIRPOIDES	+	1	2
ARCTAGROSTIS LATIFOLIA VAR. ARUNDINACEAE	+	1	2
RUBUS CHAMAEMORUS	+	+	0
MELANDRIUM APETALUM	+	1	3
D LAYER - S.S. NOT ACCURATELY ESTIMATED			
HYLOCOMNIUM ALASKANUM	5	2	3
CLADONIA AMAUROCRAEA	3	2	3
CLADONIA RANGIFERINA	2	1	2
CLADONIA GRACILIS	2	1	3
PELTIGERA APHTOSA	1	1	2
SPAGHNUM SP.**) TOMENTHYPNUM NITENS**) AULACOMNIUM TURGIDUM**) BRACHYTHECIUM SP.**) POHLIA NUTANS?**) PLEUROZIUM SCHREBERI**) DICRANUM ELONGATUM?**)	CA. 4	-	CA. 2
CETRARIA CUCULLATA*	+	+	2

STN. 218 (CON'TD) (APPENDIX IVC)

		s.s.soc.	v.
SPORADICS			
LUPINUS ARCTICUS	C LAYER	+ 1	3

* IDENTIFICATION NOT CONFIRMED BY DR. G. OTTO
** INDIVIDUAL NUMERICAL ANALYSIS OMMITTED.

TABLE IVB - COMMUNITY GROUPING IIIC (H) - STN. 144 (APPENDIX IVC)

NO. OF PLOTS	1
PLOT OR QUADRAT NO.	144
MORAINE & AGE	NF-NL-I
PLOT SIZE (M^2.)	100
EXTENT (M^2.)	150,000

COMMUNITY INDIVIDUA SPECIES	S.S.	SOC.	V.
B_2 LAYER			
BETULA GLANDULOSA	4	4	1
SALIX PLANIFOLIA	4	3	2
LEDUM PALUSTRE DECUMBENS	2	+	2
RHODODENDRON LAPPONICUM	+	+	2
C LAYER			
CAREX BIGELOWII	9	2	3
ERIOPHORUM BRACHYANTHERUM	2	1	3
EMPETRUM NIGRUM	2	1	3
VACCINIUM VITIS-IDAEA	2	1	3
STELLARIA LAETA	1	+	2
PEDICULARIS LABRADORICA	1	+	3
PEDICULARIS LANGSDORFII	+	+	3
POLYGONUM BISTORTA PLUMOSUM	+	+	3
PETASITES FRIGIDUS	1	+	0
SENECIO ATROPURPUREUS	+	+	3
VALERIANA CAPITATA	+	+	3
POLEMONIUM CAERULEUM VILLOSUM	+	+	3
SALIX RETICULATA	+	+	3
D LAYER - NOTE LICHEN COLLECTIONS NOT INCLUDED AS DAMAGED BEYOND RECOGNITION IN TRANSPORT			
SPAGHNUM CAPILLACEUM?	2	1	3
DICRANUM MUHLENBECKII	2	-	-
SPORADICS			
DRABA? SP. C LAYER	+	+	3

TABLE IVB - COMMUNITY GROUPING IIIC (H) - STN. 214 (APPENDIX IVC)

NO. OF PLOTS	1		
PLOT OR QUADRAT NO.	214		
PLOT SIZE (M^2.)	100		
EXTENT (M^2.)	22,000		
COMMUNITY INDIVIDUA SPECIES	S.S.	SOC.	V.
B_2 LAYER			
BETULA GLANDULOSA	4	4	2
SALIX PLANIFOLIA	4	5	2
SALIX GLAUCA VAR. ACUTIFOLIA	3	5	2
LEDUM PALUSTRE DECUMBENS	1	+	3
C LAYER			
CAREX BIGELOWII	6	2	2
VACCINIUM VITIS-IDAEA	2	1	3
EMPETRUM NIGRUM	2	1	3
PEDICULARIS LABRADORICA	2	+	3
SAUSSUREA ANGUSTIFOLIA	2	+	3
PETASITES FRIGIDUS	2	+	0
PEDICULARIS LANGSDORFII	1	+	3
STELLARIS LAETA	1	+	3
PYROLA GRANDIFLORA	1	+	3
ARCTOSTAPHYLOS ALPINA RUBRA	1	2	3
SENECIO ATROPURPUREUS	+	+	3
DRYAS INTEGRIFOLIA	+	1	2
POLYGONUM BISTORTA	+	+	3
ERIOPHORUM BRACHYANTHERUM	+	1	2
SAXIFRAGA HIERACIFOLIA VAR. RUFOPILOSA	+	+	3
RUBUS CHAMAEROMORUS	+	+	0
POLYGONUM VIVIPARUM	+	+	2
D LAYER - VERY APPROXIMATE SURVEY			
HYLOCOMIUM ALASKANUM)	7	4	3
RHYTIDIUM RUGOSUM)			
AULACOMNIUM TURGIDUM)	>+	-	-
SPHENOLOBUS MINATUS)			
DICRANUM ELONGATUM)			
CETRARIA CUCULLATA	2	+	3
CLADONIA RANGIFERINA	2	2	3
CLADONIA MITIS?	2	-	-
CETRARIA RICHARDSONII	1	+	3
SPORADICS			
PICEA GLAUCA A_3 & B_1 LAYER	+	+	2
EPILOBIUM ANGUSTIFOLIUM (IN FRESH RAW SOIL MARK) C LAYER	+	1	3

TABLE VA - ENVIRONMENTAL DATA FOR COMMUNITY IIIB (M-H) (APPENDIX IVC)

PLOT DATA				
PLOT NO.	223B	221	213	165
MORAINE & RELATIVE AGE	CHAP.LAKE-II	CHAP.LAKE-II	CHAP.LAKE-II	FOXY-I
LATITUDE (-° -' -")N	64° 53' 10"	64° 51' 25"	64° 51' 25"	64° 37' 30"
LONGITUDE (-° -' -")W	138° 17' 40"	138° 18' 30"	138° 18' 30"	138° 24' 00"
ELEV. (M.MSL.)	965 S	990 S	980 S	1220 S
PHYSIOGRAPHY				
PARENT MATERIAL (FOLK, 1965)	SLIGHTLY GRANULAR MUDDY SAND	MUDDY SANDY GRAVEL	MUD	GRAVELLY MUD
LANDFORM	CREST OF END MORAINE	DISTURBED SLOPE OF MORAINE CREST	SLOPE OF MORAINE CREST	END MORAINE LOBE
RELIEF SHAPE = PROFILE	STRAIGHT	STRAIGHT	STRAIGHT	STRAIGHT
- CONTOUR	STRAIGHT	SLIGHTLY CONVEX	STRAIGHT	STRAIGHT
EXPOSURE OR ASPECT (-°)	FLAT	270°	270°	090° ± 10°
SLOPE GRADIENT (-°)	NIL	9°	9°	26°
SLOPE ABOVE PLOT (M.)	NIL	40	40	100
GEOLOGY (TABLE I')				
DOM.REPRES. UNITS (T-K, 1966)	1, 13, 7	13, 1, 5, 7, 18 *	USE STN.220 RESULTS	5, MINOR 13
DOM.ROCK TYPES	QTZT., CO_3Ss., STST.	QTZT., CO_3Ss., STST., CO_3BAS., GR.	USE STN.220 RESULTS	CO_3BAS., Ls., TF.
CLIMATE				
MACROCLIMATE (KÖPPEN)	DFC OR ET	DFC OR ET	DFC OR ET	DFC OR ET
WIND EXPOSURE (A, B, C) LAYERS	-, 7, 6	-, 6, 4	-, 6, 4	-, 8, 5
SNOW DURATION (MONTHS)	8	8	8	8
STRATA COVERAGE (%)				
A	0	0	0	0
B	15	30	30	20
C	50	70	70	30
D	80	40	40	90
PLOT COVERAGE (% EXPOSED)				
BY GRAVEL AND SAND	0	5	0	0
BY DECAYED MATTER	0	0	0	0
BY WATER	0	0	0	0
SOIL				
TYPE (NSSC-1963)	5.1-/8 OR *	6.21, OR 5.1-/8	5.1 -/7 *	5.1 -/8
HUMUS THICK (CM.)	5	5	10	20.5
HUMUS pH	CA.8.0	6.0	NOT TESTED	NOT TESTED
PARENT MATERIAL	EOLIAN OR COL-LUVIAL SAND OVER LOOSE TILL	LOOSE TILL	CONVULUTED EOLIAN SILT	INDURATED TILL
DRAINAGE (NSSC-1963)	POORLY DRAINED	WELL DRAINED	POORLY DRAINED	POORLY TO V.POORLY DRAINED
DEPTH TO PF OR IMPERMEABLE LAYER-(CM.)	NOT DETECTED	NOT DETECTED	76	(?) NOT LOCATED*
HYGROTOPE - BROOKE (L966)	MESIC	MESIC	HYGRIC	HYGRIC
MAX. DEPTH ROOTS (CM.)	NOT RECORDED	CA.20	23	NOT RECORDED
pH @ MAX.ROOTING DEPTH	7.0 8.0	8.0	NOT TESTED	NOT TESTED
OTHER	*DUE TO VAGUE COLOR STRAT. IN C HOR. A 6.21 IS A POSSIBILITY.	* NEARBY STN.220 RESULTS ARE BEING USED., PROBABLE SLUMP AREA.	*IN NON-SLUMP AREA AT STN. 221.	* PF PROBABLY NOT SO FAR BENEATH SURFACE

TABLE VB - COMMUNITY GROUPING IIIB (M-H) - STN. 223B (APPENDIX IVC)

NO. OF PLOTS OR QUADRATS	½ OF 1 **
PLOT NO.	223B (MESIC STAND)
MORAINE & AGE	CHAP. LAKE-II
PLOT SIZE (M^2.)	CA. 65
EXTENT (M^2.)	CA. 3000

COMMUNITY INDIVIDUA SPECIES	S.S.	SOC.	V.
B_2 LAYER			
BETULA GLANDULOSA	3	3	2
RHODODENDRON LAPPONICUM	3	2	2
SALIX PLANIFOLIA	3	3	2
LEDUM PALUSTRE DECUMBENS	2	+	3
VACCINIUM ULIGINOSUM	1	+	2
C LAYER			
CAREX BIGELOWII	2	2	2
PEDICULARIS LANGSDORFII	2	+	3
VACCINIUM VITIS-IDAEA MINUS	2	1	3
DRYAS INTEGRIFOLIA	2	2	2
ARCTOSTAPHYLOS ALPINA RUBRA	2	2	2
SALIX RETICULATA	2	+	2
EMPETRUM NIGRUM	2	2	3
SENECIO ATROPURPUREUS?	1	+	2
PARRYA NUDICAULIS	1	+	3
PEDICULARIS LABRADORICA	1	+	3
POLYGONUM VIVIPARUM	1	+	2
GENTIANA PROPINQUA	+	+	2
ARCTAGROSTIS LATIFOLIA VAR. ARUNDINACEAE?	1	1	3
D LAYER - NOT CHECKED CAREFULLY IN THE FIELD			
RHYTIDIUM RUGOSUM	3	2	2
CLADONIA MITIS	1	1	2
PLEUROZIUM SCHREBERI?	1	-	-
CETRARIA CUCULLATA *	1	+	2
ALECTORIA NIGRICANS? *	1	+	2
CETRARIA ISLANDICA? *	1	+	2
CLADONIA GRACILIS? *	1	1	2
SPORADIC			
PICEA GLAUCA B_1 LAYER	+	+	2

* IDENTIFICATIONS LACK CONFIRMATION BY DR. G. OTTO

** STN. 223 WAS DIVIDED INTO A & B SECTORS DUE TO A DISTINCT MOISTURE BOUNDARY FOUND SUBSEQUENTLY IN THE QUADRAT.

TABLE VB - COMMUNITY GROUPING IIIB (M-H) - STN. 221 (APPENDIX IVC)

NO. OF PLOTS	1		
PLOT OR QUADRAT NO.	221		
PLOT SIZE (M^2.)	100		
EXTENT (M^2.)	AT LEAST 2500		
COMMUNITY INDIVIDUA SPECIES	S.S.	SOC.	V.
B_2 LAYER			
PICEA GLAUCA	+	+	2
B_1 LAYER			
PICEA GLAUCA	+	+	1
B_2 LAYER			
SALIX GLAUCA (IDENT. UNCONFIRMED)	4	3	2
BETULA GLANDULOSA	4	4	2
RHODODENDRON LAPPONICUM	3	+	3
LEDUM PALUSTRE DECUMBENS	2	+	3
VACCINIUM ULIGINOSUM	1	+	3
SHEPHERDIA CANADENESIS	1	+	2
C LAYER			
DRYAS INTEGRIFOLIA	3	2	2
GENTIANA PROPINQUA	3	+	3
PARRYA NUDICAULIS	2	+	3
EMPETRUM NIGRUM	2	1	3
ARCTOSTAPHYLOS ALPINA RUBRA	2	2	3
TOFIELDIA PUSILLA	2	+	2
CAREX BIGELOWII	2	2	2
DRYAS OCTOPETALA s.l.	1	1	2
PEDICULARIS LANGSDORFII	1	+	3
POLYGONUM BISTORTA	1	+	3
VACCINIUM VITIS-IDAEA MINUS	1	1	3
SAUSSUREA ANGUSTIFOLIA	1	+	3
ANENOME PARVIFLORA	1	+	3
EPILOBIUM ANGUSTIFOLIUM	1	+	3
VALERIANA CAPITATA	1	+	3
PETASITES FRIGIDUS	1	+	0
FESTUCA ALTAICA	1	1	3
ARCTAGROSTIS LATIFOLIA VAR. ARUNDINACEAE	1	1	3
PEDICULARIS CAPITATA	+	+	2
SENECIO ATROPURPUREUS? (NOT CONFIRMED)	+	+	3
SALIX RETICULATA	PRESENT?		
D LAYER S.S. NOT STUDIED IN DETAIL IN FIELD			
HYLOCOMIUM ALASKANUM) RHYTIDIUM RUGOSUM)	4	2	3
CLADONIA UNCIALIS	2	1	2
CLADONIA MITIS	2	1	2
CLADONIA ALPESTRIS	2	1	2

STN. 221 (CONT'D) (APPENDIX IVC)

D LAYER (CONT'D) S.S. NOT STUDIED IN DETAIL IN FIELD	S.S.	SOC.	V.
DICRANUM MUHLENBECKII			
SPENOLOBUS MINATUS			2
AULACOMNIUM ACCUMINATUM	3	1	OR
TOMENTHYONUM NITENS			3
AULACOMNIUM PALUSTRE			
DICRANIUM BERGERI			
CETRARIA RICHARDSONII	1	+	3

* POSSIBLY 20,000 M^2.

TABLE VB - COMMUNITY GROUPING IIIB (M-H) - STN. 165 (APPENDIX IVC)

NO. OF PLOTS	1
PLOT OR QUADRAT NO.	165
MORAINE & AGE	FOXY-I
PLOT SIZE (M^2.)	100
EXTENT (M^2.)	35,000

COMMUNITY INDIVIDUA SPECIES	s.s.	soc.	v.
B_2 LAYER			
SALIX PLANIFOLIA	4	4	2
BETULA GLANDULOSA	3	3	1
SALIX GLAUCA	3	2	2
LEDUM PALUSTRE DECUMBENS	3	+	2
VACCINIUM ULIGINOSUM	2	+	2
SALIX BARRATTIANA?	1	+	2
POTENTILLA FRUCTICOSA	+	+	3
C LAYER			
SALIX RETICULATA	3	+	3
VACCINIUM VITIS-IDAEA MINUS	3	1	3
PEDICULARIS LANGSDORFII	2	+	3
GENTIANA PROPINQUA	2	+	3
TOFIELDIA PUSILLA	1	+	2
PYROLA GRANDIFLORA	1	+	3
ERIOPHORUM CHAMISSONIS	1	+	2
LAGOTIS GLAUCA	1	+	3
DRYAS OCTOPETALA S.L.	1	1	2
DRYAS INTEGRIFOLIA	1	1	2
EQUISETUM SCIRPOIDES	1	1	2
STELLARIA LAETA	1	+	3
PEDICULARIS LABRADORICA	1	+	3
POLYGONUM BISTORTA PLUMOSUM	1	+	3
PETASITES FRIGIDUS	1	+	+
EMPETRUM NIGRUM	1	1	2
POLYGONUM VIVIPARUM	1	+	2
ARCTOSTAPHYLOS ALPINA RUBRA	1	1	1
CAREX PHYSOCARPA	1	1	3
LUPINUS ARCTICUS	+	1	3
SENECIO ATROPURPUREUS	+	+	2
ANENOME DRUMMONDI?	+	1	2
D LAYER - VERY ROUGH APPROXIMATIONS			
HYLOCOMIUM ALASKANUM	4	2	3
CLADONIA GRACILIS	3	2	2
CLADONIA AMAUROCRAEA	3	2	2
DICRANUM MUHLENBECKII?	2	=	=
DREPANOCLADUS SP.	1	=	=
TOMENTHYPNUM NITENS	1	=	=
SPHENOLOBUS MINATUS	1	-	-

TABLE VIA - ENVIRONMENTAL DATA FOR COMMUNITY IIIA (M-H) (APPENDIX IVC)

PLOT DATA				
PLOT NO.	220	141	143	148
MORAINE & RELATIVE AGE	CHAP.LAKE-II	NF-NL-I	NF-NL-I	NF-NL-I
LATITUDE (-° -' -")N	64° 51' 25"	64° 36' 30"	63° 37' 05"	63° 37' 05"
LONGITUDE (-° -' -")W	138° 18' 30"	138° 20' 00"	138° 20' 40"	138° 20' 40"
ELEV. (M.MSL.)	990±5	1190±5	1185±5	1185±5
PHYSIOGRAPHY				
PARENT MATERIAL (FOLK, 1965)	MUD OVER A MUDDY SANDY GRAVEL	SLIGHTLY GRANULAR MUD	MUDDY SANDY GRAVEL* AND GRAVELLY MUD	GRAVELLY MUD
LAND FORM	FLAT MORAINE CREST	SLOPE OF END MORAINE	CREST OF ARCUATE END MORAINE	CREST OF ARCUATE END MORAINE
RELIEF SHAPE = PROFILE	STRAIGHT	STRAIGHT	FLAT	FLAT
- CONTOUR	STRAIGHT	STRAIGHT	± STRAIGHT	± STRAIGHT
EXPOSURE OR ASPECT (-°)	0-FLAT	345°	FLAT	FLAT
SLOPE GRADIENT (-°)	0	5°	NIL	NIL
SLOPE ABOVE PLOT (M.)	0	80	0	0
GEOLOGY (REFER TO TABLE I)				
DOM.REPRES. UNITS (T-K-1966)	13, 1, 5, 7, 18	13, 1, 7, 5*	13, 1, 7, 5	13, 1, 7, 5
DOM.ROCK TYPES	QTZT., CO_3SS., STST., CO_3BAS., GR.	QTZT., CHR., ARG., CO_3BAS.	QTZT., CH., ARG., CO_3BAS.	QTZT., CH., ARG., CO_3BAS.
CLIMATE				
MACROCLIMATE (KÖPPEN)	DFC OR ET	DFC OR ET	DFC OR ET	DFC OR ET
WIND EXPOSURE (A, B, C) LAYERS	-, 8, 5	-, 8, 4	-, 10, 8	-, 10, 8
SNOW DURATION (MONTHS)	CA.8	CA.7½	CA.7½	CA.7½
STRATA COVERAGE (%)				
A	0	0	0	0
B	40	50	15	15
C	40	90	30	30
O	60	30	90	90
PLOT COVERAGE (% EXPOSED)				
BY GRAVEL AND SAND	0	0	5	5
BY DECAYED DEBRIS	0	0	0	0
BY WATER	0	0	0	0
SOIL				
TYPE (NSSC-1963)	6.1 -/7 *	5.1 -/7	5.1 -/8 & 4.31*	6.21 **
HUMUS THICK. (CM.)	5-10	7.5	5.0	5.0
HUMUS pH	6.5	NOT TESTED	4.5	NOT TESTED
PARENT MATERIAL - GENETIC DESC.	CONVOLUTED EOLIAN SILT AND TILL (?)	CONVOLUTED EOLIAN SILT	ABLATION TILL * AND INDURATED TILL	INDURATED TILL
DRAINAGE (NSSC-1963)	POORLY DRAINED	POORLY DRAINED	MOD. DRAINED *	POORLY DRAINED
DEPTH TO PF	43; NOT DETECTED	58	NOT DETECTED	NOT DETECTED
HYGROTOPE - BROOKE (1966)	± HYGRIC	HYDRIC **	MESIC	HYGRIC
MAX. DEPTH LIVING ROOFTS (CM.)	NOT RECORDED	0-CONFINED TO LF HORIZON	NOT RECORDED	NOT RECORDED
pH @ MAX. ROOTING DEPTH	CA. 7.0-8.0	-	CA.6.0	NOT TESTED
OTHER	*2 PROFILES EXAMINED; TILL OR II LAYER IN ONE ONLY.	**IN THIS SENSE THE SOILS ARE SATURATED BUT THIS IS PF.	* SPLIT PROFILE A THIN LAYER OF DIRTY GRAVEL FADES OUT.	** PROFILE TENDS TO SHOW AN INDISTINCT B-HORIZON.

TABLE VIB - COMMUNITY GROUPING - IIIA (M-H) - STN.220 (APPENDIX IVC)

No. OF PLOTS	1
PLOT OR QUADRAT No.	220
MORAINE AND AGE	CHAP.LAKE-II
PLOT SIZE (M^2.)	100
EXTENT (M^2.)	CA.12,000

COMMUNITY INDIVIDUA SPECIES	S.S.	SOC.	V.
B_2 LAYER			
BETULA GLANDULOSA (VAR. SIBIRICA)	5	5	2
SALIX GLAUCA VAR. ACUTIFOLIA	4	4	2
SALIX PLANIFOLIA	4	4	2
LEDUM PALUSTRE DECUMBENS	2	+	2
C LAYER			
CAREX BIGELOWII	4	2	3
VACCINIUM VITIS-IDAEA MINUS	3	1	3
PEDICULARIS LABRADORICA	2	+	3
POLYGONUM BISTORTA PLUMOSUM	1	+	3
PETASITES FRIGIDUS	1	+	2
STELLARIA LAETA	1	+	3
ERIOPHORUM CHAMISSONIS	1	+	2
SAUSSUREA ANGUSTIFOLIA	1	+	3
ARCTOSTAPHYLOS ALPINA RUBRA	1	2	1
PYROLA GRANDIFLORA	+	+	3
D LAYER - NOT ACCURATELY CHECKED FOR S.S.			
SPHAEROPHORUS (STEREOCAULON) TOMENTOSUM	4	2	3
CLADONIA AMAUROCRAEA	3	2	3
POLYTRICHUM JUNIPERINUM	3	2	2
CETRARIA CUCULLATA	2	+	3
DICRANUM SP.	2	-	-
PELTIGERA APHTOSA? (NOT CONFIRMED)	+	+	1

TABLE VIB - COMMUNITY GROUPING - IIIA (M-H) - STN. 141 (APPENDIX IVC)

NO. OF PLOTS	1
PLOT OR QUADRAT NO.	141
MORAINE & AGE	NF-NL-I
PLOT SIZE (M^2.)	100
EXTENT (M^2.)	130,000

COMMUNITY INDIVIDUA SPECIES		S.S.	SOC.	V.
B_2 LAYER				
BETULA GLANDULOSA		6	4	2
SALIX PLANIFOLIA		5	4	2
LEDUM PALUSTRE DECUMBENS		3	+	3
C LAYER				
CAREX BIGELOWII		8	2	3
ERIOPHORUM BRACHYANTHERUM		2	1	3
EMPETRUM NIGRUM		2	2	3
VACCINUM VITIS-IDAEA MINUS		2	1	3
STELLARIA LAETA AND S. CILIATOSEPALA		2	+	2
RUBUS CHAMAERMORUS		1	+	1
POLYGONUM BISTORTA PLUMOSUM		1	+	3
PETASITES FRIGIDUS		1	+	1
CALAMAGROSTIS CANADENSIS		1	1	3
SAUSSUREA VICIDA YUKONENSIS		+	+	3
D LAYER				
HYLOCOMIUM ALASKANUM		4	1	3
CLADONIA MITIS		3	1	3
CLADONIA AMAUROCRAEA		2	+	3
SPHAGNUM CAPILLACEUM?		2	1	3
SPORADICS *				
POTENTILLA FRUCTICOSA	B_2 LAYER	+	+	3
PEDICULARIS LABRADORICA	C LAYER	+	+	3
SENECIO LUGENS	C LAYER	+	+	3
SAXIFRAGA HIRCULIS	C LAYER	+	+	3
MERTENSIA PANICULATA	C LAYER	+	+	3

* NEAR EDGE OF SLOPE, AND ON ADJACENT PEATY SOILS ON GRAVEL

TABLE VIB - COMMUNITY GROUPING - IIIA (M-H) - STN. 143 (APPENDIX IVC)

NO. OF PLOTS	1 ONLY
PLOT OR QUADRAT NO.	143
MORAINE & AGE	NF-NL-I
PLOT SIZE (M^2.)	100
EXTENT (M^2.)	60,000

COMMUNITY INDIVIDUA SPECIES	S.S.	SOC.	V.
B_2 LAYER			
SALIX PLANIFOLIA	4	4	2
BETULA GLANDULOSA	3	5	2
LEDUM PALUSTRE DECUMBENS	2	1	2
RHODODENDRON LAPPONICUM	1	+	2
C LAYER			
CAREX BIGELOWII	7	2	2
VACCINIUM VITIS-IDAEA MINUS	3	1	3
ERIOPHORUM BRACHYANTHERUM	2	1	3
EMPETRUM NIGRUM	2	2	3
PETASITES FRIGIDUS	2	1	+
ARENARIA ARCTICA	1	+	2
ARCTOSTAPHYLOS ALPINA RUBRA	1	1	+
SALIX RETICULATA	1	+	2
POLYGONUM BISTORTA PLUMOSUM	1	+	2
POLYGONUM VIVIPARUM	1	+	1
STELLARIA LAETA	1	+	2
DRYAS OCTOPETALA S.L.	+	1	2
D LAYER			
RHYTIDIUM RUGOSUM	3	2	3
AULACOMNIUM TURGIDUM	2	=	=
PLEUROZIUM SCHREBERI	2	=	=
PTILIDIUM CILIARE	2	-	-
CLADONIA AMAUROCRAEA	2	1	3
CLADONIA MITIS	2	1	2
CETRARIA CUCULLATA	2	+	3
CLADONIA ALPESTRIS?	1	1	3
POLYTRICHUM SP. (COMMUNE?)	+	1	1

TABLE VIIA - ENVIRONMENTAL DATA FOR COMMUNITY II (X) (APPENDIX IVC)

PLOT DATA		
PLOT NO.	219	212
MORAINE & RELATIVE AGE	CHAP.LAKE-II	CHAP.LAKE-II
LATITUDE (-° -' -")N	64° 51' 50"	64° 55' 05"
LONGITUDE (-° -' -")W	138° 18' 30"	138° 17' 45"
ELEV. (M. MSL.)	1005±5	970±5
PHYSIOGRAPHY		
PARENT MATERIAL (FOLK, 1965)	MUDDY SANDY GRAVEL	GRAVEL
LAND FORM	KNOB ON MORAINE CREST	KNOB ON MORAINE CREST
RELIEF SHAPE - PROFILE	CONVEX	CONVEX
- CONTOUR	CONVEX	STRAIGHT
EXPOSURE OR ASPECT (-°)	360°	270°
SLOPE GRADIENT (-°)	SLIGHT	5°
SLOPE ABOVE PLOT (M.)	0	1-2
GEOLOGY (REFER TO TABLE II)	SEE STN.220**	SEE STN.223 **
DOM.REPRES. UNITS (T-K, 1966)	13, 1, 5	13, 1, 7
DOM.ROCK TYPES	QTZT.,BAS.,	QTZT.,STST.
CLIMATE		
MACROCLIMATE (KÖPPEN)	DFC OR ET	DFC OR ET
WIND EXPOSURE (A, B, C) LAYERS	-, 10, 9	-, 8, 7
SNOW DURATION (MONTHS)	8	8
STRATA COVERAGE (%)		
A	0	0
B	45	15
C	30	15
D	80	85
PLOT COVERAGE (% EXPOSED)		
BY GRAVEL AND SAND	10	10
BY DECAYED DEBRIS	0	0
BY WATER	0	0
SOIL		
TYPE (NSSC-1963)	4.21	4.21(?)
HUMUS THICK (CM.)	2.5	2.5-5.0
HUMUS pH	NOT DETERM.	4.5
PARENT MATERIAL	ABLATION TILL	ABLATION TILL
DRAINAGE (NSSC-1963)	RAPIDLY DRAINED	RAPIDLY DRAINED
DEPTH TO PF (CM.)	NOT DETECT.	NOT DETECT.
HYGROTOPE - BROOKE (1966)	DRY	DRY
MAX. DEPTH ROOTS (CM.)	23	10
pH @ MAX. ROOTING DEPTH	6.5	6.5
OTHER	** PEBBLE COUNTS FROM THE INDICATED NEARBY TILL SAMPLES WERE USED	** BASED ON PEBBLE COUNT IN NEARBY TILL LOCALE

TABLE VIIB - COMMUNITY GROUPING II (X) - STN. 219 (APPENDIX IVC)

NO. OF PLOTS	1
PLOT OR QUADRAT NO.	219
MORAINE & RELATIVE AGE	CHAP.LAKE-II
PLOT SIZE ($M.^2$)	100
EXTENT ($M.^2$)	3500

COMMUNITY INDIVIDUA SPECIES		s.s.	soc.	v.
B_2 LAYER				
BETULA GLANDULOSA		7	5	2
SALIX GLAUCA		3	2	1
VACCINIUM ULIGINOSUM		1	+	2
LEDUM PALUSTRE DECUMBENS		1	+	2
C LAYER				
VACCUMUM VITIS-IDAEA MINUS		5	1	3
STELLARIA LONGIPES s.l.		3	1	3
FESTUCA ALTAICA		2	1	1
EMPETRUM NIGRUM		2	1	2
ARCTOSTAPHYLOS ALPINA RUBRA		2	2	3
SALIX ARCTICA s.l.		1	1	2
ASTRAGULUS ALPINUS		1	1	2
PEDICULARIS LABRADORICA		1	+	3
PANYA NUDICAULIS		1	1	3
ARNICA LOUISEANA FRIGIDA		+	+	1
PEDICULARIS LANGSDORFII		+	+	1
LINNAEA BOREALIS		+	+	1
D.LAYER				
RHYTIDIUM RUGOSUM		5	1	2
STEREOCAULON (SPHAEROPHORUS) TOMENTOSUM?		3	1	2
DICRANIUM MUHLENBECKII		3	1	2
CLADONIA ALPESTRIS		3	1	2
CLADONIA UNCINALIS		2	1	2
CETRARIA CUCULLATA		2	1	2
ALECTORIA NIGRICANS		2	1	2
SPORADICS				
PICEA GLAUCA	B LAYER	+	+	1
RHODODENDRON LAPPONICUM	C LAYER	+	+	2
DRYAS INTEGRIFOLIA	C LAYER	+	2	2

TABLE VIIB - COMMUNITY GROUPING II (X) - STN. 212 (APPENDIX IVC)

NO. OF PLOTS		1	
PLOT OR QUADRAT NO.		212	
PLOT SIZE (M^2.)		100	
EXTENT (M^2.)		6000	
COMMUNITY INDIVIDUA SPECIES		S.S.	SOC. V.
B_2 LAYER			
BETULA GLANDULOSA		4	5 2
SALIX GLAUCA		3	2 1
LEDUM PALUSTRE DECUMBENS		2	1 2
VACCINIUM ULIGINOSUM		1	+ 2
SALIX PLANIFOLIA		+	1 2
C LAYER			
VACCINIUM VITIS-IDAEA MINUS		4	1 3
FESTUCA ALTAICA		3	3 2
EMPETRUM NIGRUM		2	1 3
DRYAS INTEGRIFOLIA		1?	1 -
DRYAS OCTOPETALA S.L.		1?	1 -
ARCTOSTAPHYLOS ALPINA RUBRA		1	1 3
PARRYA NUDICAULIS VAR. INTERIOR		1	1 3
PEDICULARIS LABRADORICA		1	+ 3
LUZULA MULTIFLORA		1	1 3
CASSIOPE TETRAGONA		+	1 +
D LAYER			
CLADONIA ALPESTRIS		5	5 3
RHYTIDIUM RUGOSUM		4	3 3
CETRARIA ISLANDICA*	)		
CLADONIA GRACILIS*	)	3	1 2
CLADONIA MITIS	)		
CETRARIA CUCULLATA*		3	1 2
ALECTORIA NIGRICANS*		2	+ 2
SPORADICS			- -
SALIX ATHABASCENSIS	B_2 LAYER	+	- -
SAUSSUREA AUGUSTIFOLIA	C LAYER	+	+ 2
PETASITES FRIGIDUS	C LAYER	+	+ +
MELANDRIUM APETULUM	C LAYER	+	1 1

* THESE SPECIES HAVE NOT BEEN CONFIRMED BY DR. G. OTTO

TABLE VIIIA - ENVIRONMENTAL DATA FOR COMMUNITY I (X)

(APPENDIX IVC)

PLOT DATA					
PLOT NO.	302	166	139	140	142
MORAINE & RELATIVE AGE	OGILVIE-III	FOXY-I	NF-SL-I	NF-NL-I	NF-NL-I
LATITUDE (-° -' -")N	64° 56' 00"	64° 37' 30"	64° 33' 40"	64° 36' 30"	64° 37' 00"
LONGITUDE (-° -' -")W	138° 19' 00"	138° 23' 30"	138° 15' 50"	138° 20' 00"	138° 20' 30"
ELEV. (M.MSL.)	1145±5	1230±5	ca.1280	1190±5	1190±5
PHYSIOGRAPHY					
PARENT MATERIAL (FOLK, 1965)	MUDDY SANDY GRAVEL	TWO: FINE SAND, AND MUDDY SANDY GRAVEL	MUDDY SANDY GRAVEL	MUDDY SANDY GRAVEL	MUDDY SANDY GRAVEL
LAND FORM	CONVEX KNOLL	CONVEX KNOLL ON MORAINAL RIDGE	CONVEX KNOLL	KNOB TOP OF MORAINAL RIDGE	KNOB ON CREST OF MORAINAL RIDGE
RELIEF SHAPE = PROFILE	BROADLY CONVEX	BROADLY CONVEX	BROADLY CONVEX	CONVEX	CONVEX
- CONTOUR	BROADLY CONVEX	CONVEX	BROADLY CONVEX	CONVEX	CONVEX
EXPOSURE OR ASPECT (-°)	ALL DIRECTIONS	FLAT	FLAT	135°	FLAT TO 135°
SLOPE GRADIENT (-°)	SLIGHT	0	0	SLIGHT	0-5°
SLOPE ABOVE PLOT (M.)	0	0	0	5	0
GEOLOGY (REFER TO TABLE I')					
DOM.REPRES. UNITS (T-K, 1966)	13, 1, 7, 5 **	5	1, 18, 13, 7**	13, 1, 7, 5 *	13, 1, 7, 5 *
DOM.ROCK TYPES	QTZT., STST., BAS.	CO_3BAS., LS.	QTZT., MONZ., CH.	QTZT., CH., CO_3BAS., ARG.	QTZT., CH., ARG., CO_3BAS.
CLIMATE					
MACROCLIMATE (KÖPPEN)	DFC OR ET	DFC OR ET	DFC OR ET	DFC OR ET	DFC OR ET
WIND EXPOSURE (A, B, C) LAYERS	-, 9, 5	-, 8, 4	-, 9, 8	-, 8, 7	-, 10, 9
SNOW DURATION (MONTHS)	8(?)	8	7½	7½-8	ca.7½
STRATA COVERAGE (%)					
A	0	0	0	0	0
B	60	80	20	25	25
C	60	30	ca.50	25	30
D	90	95	ca.50	50	40
PLOT COVERAGE (% EXPOSED)					
BY GRAVEL AND SAND	10	5	20	20	25
BY DECAYED DEBRIS	0	0	0	0	0
BY WATER	0	0	0	0	0
SOIL					
TYPE (NSSC-1963)	3.2(?) *	5.11/4.21**	4.21(?)	4.21	4.21
HUMUS THICK (CM.)	5.0	5	2.5	2.5	5.0
HUMUS pH	NOT TESTED	NOT TESTED	NOT TESTED	NOT TAKEN	NOT TAKEN
PARENT MATERIAL	ABLATION TILL	EOLIAN SAND OVER ABLATION TILL	ABLATION TILL	ABLATION TILL	ABLATION TILL
DRAINAGE (NSSC-1963)	RAPIDLY DRAINED	WELL DRAINED	RAPIDLY DRAINED	RAPIDLY DRAINED	RAPIDLY DRAINED
DEPTH TO PF	NOT DETECT.	NOT DETECT.	NOT DETECT.	NOT DETECT.	NOT DETECT.
HYGROTOPE - BROOKE (1966)	DRY	MODERATELY DRY	DRY	DRY	DRY
MAX. DEPTH ROOTS (CM.)	18	17.5	23	NOT RECORDED	12.5
pH @ MAX. ROOTING DEPTH	NOT TESTED	NOT TESTED	NOT TESTED	6.0-6.5	NOT TESTED
OTHER	**FROM TILL PEBBLE ANALYSIS STN.304 *PROVIDED THE Bf HOR. IS NOT OF EOLIAN ORIGIN	**BURIED SOIL PROFILE DUE TO POST-GLACIAL EOLIAN CYCLE	**STN.151 DATA; IN TILL	*FROM STN.148 DATA; IN TILL	*STN.148 DATA; IN TILL

TABLE VIIIB - COMMUNITY GROUPING I (X) - STNS. 302 AND 139 (APPENDIX IVC)

NO. OF PLOTS	1			1		
PLOT NO.	302			139		
MORAINE & RELATIVE AGE	OGILVIE III			NF-SL-I		
PLOT SIZE (M^2.)	WHOLE SURFACE EXAM.			WHOLE SURFACE EXAM.		
EXTENT (M^2.)	3500			1200		
COMMUNITY INDIVIDUA SPECIES *	S.S.	SOC.	V.	S.S.	SOC.	V.
B_2 LAYER						
BETULA GLANDULOSA	6	3	2	5	5	2
SALIX PLANIFOLIA	4	2	2	3	2	2
LEDUM PALUSTRE DECUMBENS	2	1	2	1	+	2
VACCINIUM ULIGINOSUM	2	+	2	1	+	2
RHODODENDRON LAPPONICUM	1	+	2	-	-	-
C LAYER						
VACCINIUM VITIS-IDAEA	5	2	3	1	1	2
DRYAS OCTOPETALA S.L.	5	2	2	3	2	2
EMPETRUM NIGRUM	5	2	3	1	1	2
SALIX RETICULATA	1	+	2	2	+	2
ARCTOSTAPHYLOS ALPINA RUBRA	=	=	=	3	2	2
POTENTILLA LEDEBOURIANA	=	=	=	2	1	2
TRISETUM SPECATUM	=	=	=	1	1	2
SALIX ARCTICA S.L.	=	=	=	1	1	2
CALAMAGROSTIS CANADENSIS	=	=	=	1	1	2
CAMPANULA LASIOCARPA	-	-	-	+	+	2
EPILOBIUM ANGUSTIFOLIUM	+	+	1	-	-	-
D LAYER						
RHYTIDIUM RUGOSUM	5	2	3	=	=	=
CLADONIA RANGIFERINA	2	1	2	=	=	=
CLADONIA GRACILIS	2	1	2	=	=	=
ABIETINELLA ABIETINA	1	1	+	-	-	-
HYLOCOMIUM ALASKENUM	=	=	=	PRESENT **		
ALECTORIA NIGRICANS	=	=	=	1	+	2
ALECTORIA OCHROLEUCA	=	=	=	1	+	2
PLEUROZIUM SCHREBERI	=	=	=	PRESENT **		
CETRARIA NIVALIS	=	=	=	PRESENT **		
POLYTRICHUM PILIFERUM	-	-	-	+	-	-

*BASED ON ONE BRIEF VISIT - HENCE, VERY ROUGH APPROXIMATIONS; 302 WAS A LATE SEASON VISIT.

**NUMERICAL DATA NOT ESTIMATED IN THE FIELD; PHOTOGRAPHS NOT AVAILABLE FOR INSPECTION.

TABLE VIIIB - COMMUNITY GROUPING I (X) - STN. 166 (APPENDIX IVC)

NO. OF PLOTS	1
PLOT OR QUADRAT NO.	166
MORAINE & RELATIVE AGE	FOXY-I
PLOT SIZE (M^2.)	100
EXTENT (M^2.)	15,000

COMMUNITY INDIVIDUA SPECIES	S.S.	SOC.	V.
B_2 LAYER			
BETULA GLANDULOSA (30 CM. HIGH)	7	6	1
SALIX PLANIFOLIA	6	4	2
SALIX BARRATTIANA?	2	2	2
POTENTILLA FRUTICOSA	1	2	3
LEDUM PALUSTRE DECUMBENS	1	+	3
VACCINIUM ULIGINOSUM	1	+	2
RHODODENDRON LAPPONICUM	1	+	2
C LAYER			
LUPINUS ARCTICUS	3	2	3
DRYAS OCTOPETALA S.L.	3	2	3
VACCINIUM VITIS-IDAEA MINUS	3	2	3
STELLARIA LAETA	2	1	3
EMPETRUM NIGRUM	2	2	3
ARCTOSTAPHYLOS ALPINA RUBRA	2	2	3
EPILOBIUM AUGUSTIFOLIUM	1	+	+
POLYGONUM VIVIPARUM	+	+	1
GRAMINAE (FESTUCA SP.?)	+	+	1
POLEMONIUM CAERULEUM VILLOSUM	+	+	3
POLYGONUM BISTORTA PLUMOSUM	+	+	3
GENTIANA PROPINQUA	+	+	2
D LAYER			
HYLOCOMIUM ALASKANUM	6	2	3
RHYTIDIUM RUGOSUM	6	2	3
STEREOCAULON (SPHAEROPHORUS) TOMENTOSUM	4	2	3
CLADONIA RANGIFERINA	4	1	3
CLADONIA UNCINALIS	2	1	3
POLYTRICHUM JUNIPERINUM	2	2	3
DICRANUM MUHLENBECKII	2	-	-
AULACOMNIUM TURGIDUM	2	-	-
ABIETINELLA ABIETINA	2	-	-
CLADONIA PYXIDATA	+	1	1

TABLE VIIIB - COMMUNITY GROUPING I (X) - STN. 140 (APPENDIX IVC)

No. OF PLOTS	1
PLOT OR QUADRAT No.	140
MORAINE & AGE	NF-NL-I
PLOT SIZE (M^2.)	100
EXTENT (M^2.)	36,000

COMMUNITY INDIVIDUA SPECIES		s.s.	soc.	v.
B_2 LAYER				
BETULA GLANDULOSA		5	6	2
SALIX PLANIFOLIA		3	2	2
C LAYER				
POTENTILLA LEDEBOURIANA		4	2	2
SILENE ACAULIS VAR. EXSCAPA		2	2	3
VACCINIUM VITIS-IDAEA MINUS		2	1	3
ARCTAGROSTIC LATIFOLIA VAR. ANGUSTIFOLIA		2	1	3
CALAMAGROSTIS CANADENSIS		2	1	3
SALIX ARCTICA S.L.		1	2	1
EMPETRUM NIGRUM		1	2	2
ARCTOSTAPHYLOS ALPINA RUBRA		1	2	2
STELLARIA CILIATOSEPALA		1	+	3
DRYAS OCTOPETALA S.L.		1	2	2
EPILOBIUM ANGUSTIFOLIUM		+	+	+
CAMPANULA LASIOCARPA		+	+	2
D LAYER				
SPHAERPHORUS (STEREOCAULON) TOMENTOSUM		3	2	3
HYLOCORMIUM ALASKANUM		3	2	2
ALECTORIA NIGRICANS		2	+	2
ALECTORIA OCHROLEUCA		2	+	2
BUELLIA SP. C.F. MORIOPSIS		+	1	2
POLYTRICHUM PILIFERUM)		2	1	2
POLYTRICHUM COMMUNE)				
RHIZOCARPON SP.		1	1	2
SPORADICS				
SALIX ARCTICA VAR. TORULOSA	C LAYER	+	2	2
POLYGONUM BISTORTA PLUMOSUM	C LAYER	+	+	3

TABLE VIIIB - COMMUNITY GROUPING I (X) - STN. 142 (APPENDIX IVC)

NO. OF PLOTS	1
PLOT OR QUADRAT NO.	142
MORAINE & AGE	NF-NL-I
PLOT SIZE (M^2.)	100
EXTENT (M^2.)	12,000

COMMUNITY INDIVIDUA SPECIES	S.S.	SOC.	V.
B_2 LAYER			
BETULA GLANDULOSA	4	6	2
SALIX PLANIFOLIA	2	4	1
LEDUM PALUSTRE DECUMBENS	1	+	2
VACCINIUM ULIGNOSUM	1	+	2
C LAYER			
POTENTILLA LEDEBOURIANA	3	2	2
VACCINIUM VITIS-IDAEA MINUS	3	2	3
FESTUCA ALTAICA	3	3	2
TRISETUM SPICATUM	2	1	1
SALIX ARCTICA S.L.	1	2	2
SILENE ACAULIS VAR. EXSCAPA	1	2	3
STELLARIA LAETA	1	+	3
ANENOME NARCISSIFLORA?	+	1	2
LEDUM DECUMBENS PALUSTRE	+	1	2
ARNICA LOUISEANA FRIGIDA	+	+	3
ANENOME MULTICEPS?	+	+	2
CAMPANULA LASIOCARPA	+	+	3
POLYGONUM BISTORTA	+	+	3
D LAYER			
SPHAEROPHORUS (STEREOCAULON) TOMENTOSUM	4	5	3
CLADONIA MITIS	2	2	3
CLADONIA RANGIFERINA	2	2	3
CETRARIA NIVALIS	2	1	3
RHYTIDIUM RUGOSUM	1	1	3
SPHAEROPHORUS (STEREOCAULON) FRAGILIS	1	1	3
DICRANIUM MUHLENBECKII	1	1	-
ALECTORIA NIGRICANS	1	+	3
ALECTORIA OCHROLEUCA	1	+	3
POLYTRICHUM JUNIPERINUM	1	1	1
BUELLIA SP. CF. MORIOPSIS	+	1	2
RHIZOCARPON SP.	1	+	-

TABLE IXA - ENVIRONMENTAL DATA FOR COMMUNITY O-COMPLEX (APPENDIX IVC)

PLOT DATA				
PLOT NO.	138	151	135	84
MORAINE & RELATIVE AGE	NF-SL-I	NF-SL-I	NF-SL-I	AUG 17TH-I
LATITUDE (-° -' -")N	64° 34' 00"	64° 33' 30"	64° 34' 0"	64° 28' 10"
LONGITUDE (-° -' -")W	138° 15' 20"	138° 15' 30"	138° 15' 30"	138° 11' 00"
ELEV. (M.MSL.)	1310	1310±15	1280	1050±
PHYSIOGRAPHY				
PARENT MATERIAL (FOLK, 1965)	MUDDY SANDY GRAVEL	MUDDY SANDY GRAVEL	NO ANALYSIS	MUDDY SANDY GRAVEL
LAND FORM	TERMINAL MORAINE ARCUATE RIDGE CREST	RIDGE CREST OF TERMINAL MORAINE	MINOR LOBE OF TERMINAL MORAINE	MAIN LOBE CREST TERMINAL OF MORAINE
RELIEF SHAPE - PROFILE	BROADLY CONVEX	BROADLY CONVEX	BROADLY CONVEX	BROADLY CONVEX
- CONTOUR	STRAIGHT ±	SIGMOID ±	SLIGHTLY CONVEX	BROADLY CONVEX
EXPOSURE ASPECT (-°)	FLAT	FLAT	240°	270° ±
SLOPE GRADIENT (-°)	NIL	NIL	12-13°	0-10°
SLOPE ABOVE PLOT (M.)	0	0	150	100
GEOLOGY (REFER TO TABLE I)				
DOM.REPRES. UNITS (T-K, 1966)	13, 1, 7, 15(?)	1, 18, 13, 7	13, 13B, 1, 7, 11	13, 16, 13A, 13B
DOM.ROCK TYPES	QTZT.,CH.,ARG., STST.	QTZT.,MONZ.,CH.	QTZT.,CH.	QTZT.,GAB.
CLIMATE				
MACROCLIMATE (KÖPPEN)	DFC OR ET	DFC OR ET	DFC OR ET	DFC OR ET
WIND EXPOSURE (A, B, C) LAYERS	-, 9, 6	-, 9, 7	-, 5, 1	-, 5, 2
SNOW DURATION (MONTHS)	7½	7½	9	8-9
STRATA COVERAGE (%)				
A	0	0	0	0
B	75	55	75	40-50
C	30	20	10	50
D	90	90	95	90
PLOT COVERAGE (% EXPOSED)				
BY GRAVEL AND SAND	5	10	0	10
BY DECAYED DEBRIS	0	0	0	0
BY WATER	0	0	0	0
SOIL				
TYPE (NSSC-1963)	4.31	4.31(?)	4.32	4.32
HUMUS THICK (CM.)	5.0	5.0	5.0	2.5
HUMUS pH	NOT TESTED	NOT TESTED	NOT TESTED	NOT TESTED
PARENT MATERIAL	INDURATED TILL	INDURATED TILL	INDURATED TILL	LOOSE TILL
DRAINAGE (NSSC-1963)	WELL DRAINED	MOD.WELL DRAINED	WELL DRAINED	WELL DRAINED
DEPTH TO PF (CM.)	NOT DETECTED	NOT DETECTED	NOT DETECTED	NOT DETECTED
HYGROTOPE - BROOKE (1966)	MESIC	MESIC	MOD.DRY	MOD.DRY
MAX.DEPTH LIVING ROOTS (CM.)	NOT RECORDED	NOT RECORDED	NOT RECORDED	22.5
pH @ MAX.ROOTING DEPTH	NOT TESTED	NOT TESTED	6.0	-
OTHER	DISCONTINUOUS ELUVIATION IN THE AH HORIZON IN THE SOIL PROFILE.	NO AH HORIZON IN THE SOIL PROFILE.	-	-

TABLE IXB - COMMUNITY GROUPING O (X-M) COMPLEX - STN. 138 (APPENDIX IVC)

NO. OF PLOTS	1		
PLOT OR QUADRAT NO.	138		
MORAINE & RELATIVE AGE	NF-SL-I		
PLOT SIZE (M^2.)	100		
EXTENT (M^2.)	30,000		
COMMUNITY INDIVIDUA SPECIES	S.S.	SOC.	V.
B_2 LAYER			
BETULA GLANDULOSA	8	6	2
SALIX PLANIFOLIA	4	3	2
SALIX GLAUCA S.L.	2	2	2
LEDUM PALUSTRE DECUMBENS	2	+	3
VACCINIUM ULIGINOSUM	1	+	3
C LAYER			
VACCINIUM VITIS-IDAEA MINUS	3	2	3
ARCTOSTAPHYLOS ALPINA RUBRA	3	3	3
STELLARIA LAETA	2	1	3
EMPETRUM NIGRUM	1	2	3
PEDICULARIS LABRADORICA	1	+	3
SALIX ARCTICA S.L.	1	2	-
EPILOBIUM AUGUSTIFOLIUM	1	+	+
CAREX PHYSOCARPA	1	1	2
TRISETUM SPICATUM	1	+	2
CALAMAGROSTIS CANADENSIS	1	1	2
SALIX PSEUDOPOLARIS	+	1	2
D LAYER			
HYLOCOMIUM ALASKANUM	6	2	3
POLYTRICHUM JUNIPERINUM	3	2	3
CLADONIA ALPESTRIS	3	-	3
CLADONIA GRACILIS	3	-	3
CLADONIA RANGIFERINA?	3	-	3
PLEUROZIUM SCHREBERI	3	-	-
AULACOMNIUM TURGIDUM	2	-	-

TABLE IXB - COMMUNITY GROUPING O (X-M) COMPLEX - STN. 151 (APPENDIX IVC)

NO. OF PLOTS	1
PLOT OR QUADRAT NO.	151
MORAINE	NF-SL-I
PLOT SIZE (M^2.)	100
EXTENT (M^2.)	60,000

COMMUNITY INDIVIDUA SPECIES		S.S.	SOC.	V.
B_2 LAYER				
BETULA GLANDULOSA		7	5	2
SALIX PLANIFOLIA		3	3	2
LEDUM PALUSTRE DECUMBENS		2	+	3
SALIX GLAUCA S.L.		2	2	2
C LAYER				
VACCINIUM VILIS-IDAEA MINUS		3	2	3
EMPETRUM NIGRUM		2	2	3
ANENOME NARCISSIFLORA INTERIOR		2	1	2
DRYAS OCTOPETALA S.L.		1	2	2
PETASITES FRIGIDUS		1	+	+
GRAMINAE (TRISETUM?)		1	+	+
SALIX ARCTICA VAR. TORULOSA		1	2	1
CAREX SP. (PHYSOCARPA?-SPECIMENS LOST)		1	1	1
STELLARIA LAETA		1	+	3
PEDICULARIS LABRADORICA		1	+	3
POLYGONUM BISTORTA		1	+	3
POLYGONUM VIVIPARUM		1	+	2
ARNICA LOUISEANA?		+	1	2
ANTENNARIA COMPACTA		+	1	1
D LAYER				
RHYTIDIUM RUGOSUM		6	4	3
STEREOCAULON (SPHAEROPHORUS) TOMENTOSUM		5	2	2
CLADONIA GRACILIS		4	2	2
SPHAEROPHORUS FRAGILIS		3	2	2
CETRARIA RICHARDSONII		3	+	3
CETRARIA CUCULLATA		2	+	2
CETRARIA NIVALIS		2	+	2
ALECTORIA OCHROLEUCA		1	+	2
ALECTORIA NIGRICANS		1	+	2
SPORADIC				
PICEA GLAUCA	B_1 LAYER	+	+	0

TABLE IXB - COMMUNITY GROUPING O (X-M) COMPLEX - STN. 135 (APPENDIX IVC)

NO. OF PLOTS	1
PLOT OR QUADRAT NO.	135
MORAINE & RELATIVE AGE	NF-SL-I
PLOT SIZE (M^2.)	100
EXTENT (M^2.)	30,000

COMMUNITY INDIVIDUA SPECIES		s.s.	soc.	v.
B_2 LAYER				
BETULA GLANDULOSA		8	4	2
SALIX PLANIFOLIA		1	2	2
C LAYER				
EMPETRUM NIGRUM		2	1	3
VACCINIUM VITIS-IDAEA MINUS		2	+	3
STELLARIA LAETA		+	+	3
ANTENNARIA MONOCEPHALA		+	1	2
D LAYER				
RHYTIDIUM RUGOSUM **	)			
HYLOCOMIUM ALASKANUM**	)			
PLEUROZIUM SCHREBERI**	)			
POLYTRICHUM COMMUNE	)	10	10	3
SPHENOLOBUS MINUTUS	)			
DICRANUM ELONGATUM	)			
CLADONIA GRACILIS		3	2	3
CLADONIA MITIS		3	2	3
CLADONIA RANGIFERINA		2	1	3
CLADONIA DEFORMIS		1	1	3
CETRARIA RICHARDSONII		+	+	3
SPORADICS				
RANUNCULUS NIVALIS?	C LAYER	+	+	3

** PRESENT IN ABOUT EQUAL PROPORTIONS

TABLE IXB - COMMUNITY GROUPING O (X-M) COMPLEX - STN. 84 (APPENDIX IVC)

No. OF PLOTS	1
PLOT No.	84
MORAINE & RELATIVE AGE	AUGUST 17TH-1
PLOT SIZE (M^2.)	NORTH ONE HALF OF MORAINE
EXTENT (M^2.)	CA.58,000

COMMUNITY INDIVIDUA SPECIES	SUB-LAYER	S.S.	SOC.	V.
B LAYER				
SALIX GLAUCA X INTERGRADES	B_1	2	5	2
PICEA GLAUCA	B_1	1	+	1
ALNUS CRISPA	B_1	1	+	1
POPULUS TREMULOIDES	B_1	+	+	1
BETULA OCCIDENTALIS	B_1	+	+	1
BETULA GLANDULOSA	B_2	7	5	2
SALIX GLAUCA X INTERGRADES	B_2	3	5	2
LEDUM DECUMBENS	B_2	2	3	3
VACCINIUM ULIGINOSUM	B_2	1	3	3
ROSA ACICULARIS	B_2	+	+	3
C LAYER				
VACCINIUM VITIS-IDAEA MINUS		5	4	3
ARCTOSTAPHYLOS ALPINA RUBRA		5	5	3
EMPETRUM NIGRUM		4	3	3
STELLARIA CILIATOSEPALA		3	+	3
LUPINUS ARCTICUS		2	2	3
ANENOME NARCISSIFLORA?		2	2	2
SAXIFRAGATRICUSPIDATA		1	2	3
EPILOBIUM AUGUSTIFOLIUM		1	+	2
PEDICULARIS FLAMMEA		+	+	2
CAMPANULA LASIOCARPA		+	+	2
D LAYER				
CLADONIA RANGIFERINA		4	4	3
CLADONIA MITIS		4	4	3
CLADONIA GRACILIS		4	4	3
STEREOCAULON (SPHAEROPHORUS) TOMENTOSUM		4	4	3
RHYTIDIUM RUGOSUM		3	3	-
POLYTRICHUM JUNIPERINUM		3	2	3
CETRARIA CUCULLATA		2	2	3
CETRARIA ISLANDICA		2	1	2
ALECTORIA NIGRICANS		1	+	2
THAMNOLIA VERMICULARIS		+	+	2
PELTIGERA? APHTHOSA?		+	1	-

APPENDIX IVD

TAXONOMIC PROBLEMS

All vascular plants were identified in the Herbarium of the Botany Department at the University of British Columbia during the summer of 1965. Sufficient boreal, arctic and cordilleran alpine species are in these collections for study and comparative purposes. Despite these facilities and the recent publication of applicable regional botanical textbooks certain taxonomic problems arose over some of the Ogilvie Mountains' flora. The taxonomic difficulties are summarized in the short paragraphs to follow and are arranged alphabetically according to genus.

Genus Achillea

According to Wiggins and Thomas (1962) the distinctions between A. borealis Bong and A. lanulosa Nutt. are poor unless cytological approaches are utilized. Anderson's (1959) key employs height of involcries as a criteria, but this did not hold for known specimens in the Herbarium. However, Wiggins and Thomas' colour of phyllary margins did work with the Herbarium specimens, whereby brown were typical of A. borealis and lighter to straw colour were characteristic for A. lanulosa. The specimens in the Ogilvie collections would fit the former.

Genus Betula

Identification of the varieties of Betula glandulosa on the basis of leaf breadth to length is one diagnostic character used by Wiggins and Thomas. It was found to be a variable feature in our specimens. Measurements were borderline; or worse, measurements varied enough from leaf to leaf occurring on the same stem so as to permit classification to both variety glandulosa and to variety sibirica. Such characters as pubescence, toothed leaf margins, and cuneate versus uniform leave shapes were also of identical variability on the same branch of the shrub. Viereck (1966) notes the same problems in the species and varietal determinations of the dwarf birch. It would appear that the arctic-alpine forms of this genus are due for a thorough revision based on a sound statistical basis; a circumpolar approach will have to be employed.

Genus Carex

Porsild (1957) claims that Carex Bigelowii Torr. is a species of the Amphi-Atlantic phytogeographic province and claims that its western counterpart, Carex lugens Holm differs by an absence of runners, narrower leaves and flatter leaves. Wiggins and Thomas (1962) do not recognize a C. Bigelowii from the north slope of the Brooks Range, but Anderson (1959) lists the species as circumboreal and differentiates it from Carex lugens on an aphyllopodic-phyllopodic runner relationship. Yukon specimens of C. Bigelowii identified by Dr. H.M. Raup exist in the U.B.C. Herbarium collections. Our specimens show the following:

Species:	characters from Anderson, Porsild etc.			
C. lugens	densely caespitose	leaves 1-2.5 mm. wide	leaves revolute	spike linear
C.Bigelowii	stoloniferous	leaves 2-8 mm. wide	leaves flat	spike oblong
Ogilvie spec.	both	usually 3 mm. wide	flat	± linear
C. lugens	perigynia not concealed by scales		phyllopodic	runners absent
C. Bigelowii	perigynia concealed by scales		aphyllopodic	long runners present
Ogilvie spec.	perigynia concealed		aphyllopodic	short runners present

From the foregoing it is obvious that our specimens compare more readily to C. Bigelowii, and despite possible authoritative objections Mr. E.W. Easthame would prefer to leave it at this classification until future revision of the sub-genus.

Genus Castilleja

According to Wiggins and Thomas (1962) and Anderson (1959) the subspecies elegans and caudata of the species C. pallida Spreng are differentiated on the following: height of plant (usually shorter for elegans), lobed leaves (not or barely so in elegans), and colour of bracts (purplish for elegans, yellow for caudata). Our specimens display purplish yellow

bracts, a height of 25 cm., and barely lobate tips in a few of the leaves; they have white villous hairs in the inflorescence - typical of subsp. elegans.

Genus Draba[1]

According to Porsild (1951) and subsequent authorities the species Draba longipes has a white or more rarely a pale yellow corolla. Our specimens are sulphurous yellow; otherwise the anatomical comparison was identical to most published descriptions.

Genus Rubus

Porsild (1951) differentiates Rubus arcticus L. from Rubus alaskensis Bailey from Rubus acaulis Michx. on a combination of many characteristics. Save one locality to be mentioned our specimens show a range of 8-11 characteristics of R. arcticus, 8-9 for R. alaskensis, and 7-12 for R. acaulis to be in common with one another. This must be the closest fit to a triple hybrid ever found in nature. At one roadside locale a specimen matches R. arcticus L. in every detail save the perianth; 6 to 7 sepals and 7 petals in what should be a 5 merous floral assemblage were noted.

Genus Rumex

Rumex arcticus Trautv. has leaf dimensions no greater than 10 cm. x 4 cm. according to Porsild (1957). Ours are 17 cm. x 35 mm. According to Anderson (1959) R. arcticus has capsules measuring 4 mm. in length, R. occidentalis Wats are 5 mm., and R. fenestratus Green are 7 mm. Wiggins and Thomas lists the formermost with 5 mm. capsules. Our specimens have 4 mm. long capsules, but their whole leaf is of the crispy and wavy character typical of R. fenestratus and R. occidentalis; R. arcticus are supposedly crisped only on the margins. It appears that our specimens may justify the lumping of the species in this group.

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[1] Unfortunately, the writer determined the Draba species without the knowledge that Porsild (1964) had identified Draba sibirica collected from the slopes of "Dall Sheet Mountain". The species is apparently quite variable in the region for Hultén (1966) described a new species, Draba ogilviensis, from the same area. Porsild (1967) has synonymized this new species description with D. sibirica by comparing a large variable series of specimens taken throughout the summer of 1966 about the pass area. Hence, the writers collections probably belong to this species as well - the remarks concerning D. longipes should therefore be ignored.

Genus Salix (pseudopolaris vs. arcticus)

In many instances the writer had no trouble distinguishing S. pseudopolaris Flod from S. arcticus s.l. by the use of descriptions in Raup's (1959) diagnosis. However, specimens on a common boundary to Stns. 122-139 are a very good intergrade as shown by the following:

Character	Salix arctica	S. pseudopolaris	Our specimens
leaves	2 cm. length	2 cm. length	2.5 cm.
peduncles	glabrate?	pilose	pilose
capsules	pedicellate	not pedicellate	usually pedicellate
style length	1.2-1.3 mm.	0.5-0.8 mm.	1.3 mm.
stipules	subulate	not apparent	subulate
leaves	glabrate	sparingly villous	sparingly villous
catkin length	3-8 mm.	5-10 mm.	10 mm.
peticles	glabrous	villous	villous
petiole length	5-15 mm.	1-2 mm.	3-4 mm.
scales	1.5-2.5 mm.	1.6-2.0 mm.	ca. 2.0 mm.

The specimens are listed as a hybrid, for both species were collected in this general vicinity.

Genus Salix (pulchra vs planifolia)

Hultén (1941-1950), Wiggins and Thomas (1962), and Porsild (1957) claim that S. pulchra Cham. is typical of the western Cordillera and of the arctic while S. planifolia is shown by the lattermost author to be confined to the eastern portion of boreal North America with only a slight overlapping into the eastern-most Yukon Territory. Raup (1959) has identified both from the Yukon, and basing our identifications on leaf lustre (dull in S. pulchra) and stipule persistence (not so in S. planifolia) ours are

predominately Salix planifolia. Are the Ogilvies a zone of mixing of two "races" of what should be one species?

Genus Salix (glauca vs. arbusculoides and Bebbiana)

At Stn. 84 specimens of willows are with hair lengths on the capsules much too long to be S. glauca. They are not S. alaxensis (Anderss.) Cov. for their styles are much too short. However, these two characteristics are typical of S. arbusculoides (Anderss.) and S. Bebbiana Sarg. However, agreement for such characters as pedicel length, leaf pubescence, colour of bract hairs, twig colour and twig pubescence is an even split. The pedicels, the bract hair colours, some twig colours and some twig pubescence is that of S. arbusculoides while the remainder are those of S. Bebbiana as described by Raup (1959).

Genus Saussurea

Some specimens of Saussurea collected from isolated localities on the north lobe of the North Fork Moraine demonstrated characteristics of both S. angustifolia (Willd) D.C. and S. vicida var. yukonensis (Porsild) Hultén. Characters typical of the former are: the glabrous stem, the 30 cm. length, the lack of multicellular hairs, and the differing lengths of bracts - those of the latter are: the leaves exceeding the inflorescence in height, the involute leaves, the haphazard rather than an imbricate bract arrangement, the congested infloresence, and the outer bracts slightly shorter than the next row of inner ones. Otherwise the specimens fit both descriptions. Originally, Porsild described the variety yukonensis as a variety of S. angustifolia, but Hultén (1941-1950) moved it to species S. vicida known from the Bering Sea region on what appears to be inadequate basis. Our specimens confer that Porsild was indeed more correct, but alternately suggest that S. vicida and S. angustifolia are not really valid species distinctions - a development that Polunin (1959) suggests in his text. Our specimens do not fit descriptions of S. monticola (heads too congested), S. remotiflora (long pedicils-to-heads wanting), S. alpina (our leaves are too narrow and lack dentation), S. densa (outer bracts of ours are too short) nor S. americana (our leaves much too narrow and not denticulate, and too few rows of bracts).

On the slope of the North Klondike valley below "Edge Peak" a specimen of Saussurea sp. was collected with a solitary head (S. vicida is at least 3 and S. angustifolia is at least 2 headed). The plants are a scant 10 cm. high and have 4 to 5 rows of poorly imbricated phyllaries that show a progressively outward shortening of the rows. The writer was unable to locate any similar descriptions in the literature; the specimens await further study at the U.B.C. Herbarium.

Genus Senecio

Senecio alaskanus Hultén (= S. yukonesis Porsild) specimens from Stn. 136A do not compare with Herbarium specimens too well, but our specimens appear to fit the published descriptions.

Other Genera

As to be expected the writer, like previous floral investigators to the Yukon, experienced trouble with the Dryas, Stellaria, Antennaria and Taraxacum genera. The former most are notorious hybridizers in the Yukon and one wonders if the Porsild (1947) treatment of this group is of useful consequences - apparently Polunin (1959) does not think so. The other genera have similar problems and it will be useful to all concerned to utilize Polunin (1959) terminology until collections from the Alaska, Yukon and Siberia are extensive enough to permit expert re-evaluation of their true specific makeups.

GEOLOGICAL SURVEY OF CANADA
DEPARTMENT OF MINES AND TECHNICAL SURVEYS

116B and 116C (East half)

Coloured Supplement to Figure 4

Note:- Legend below is not the same as that used for thesis maps.

LEGEND

CENOZOIC

PLEISTOCENE AND RECENT

3 — *FLUVIATILE DEPOSITS: silt, sand, and gravel*
3a, *silt, sand, and gravel of terraces*
3b, *silt, sand, and gravel of modern flood plains*
3c, *silt, sand, and gravel of alluvial fans*
3d, *silt, clay of fluvial or glaciolacustine orgin, with thermokarst depressions*

2 — *GLACIO-FLUVIAL DEPOSITS: sand, gravel, minor silt*
2a, *terrace and pitted-terrace, kame terrace and outwash delta deposits (see also pit and delta symbols)*
2b, *hummocky or ridged deposits*
2c, *esker complex deposits*

1 — *GLACIAL DEPOSITS: till, minor sand, and gravel*
1a, *terminal and recessional moraine deposits*
1b, *ground moraine*
1c, *dead ice deposits (with hummocky or knob-and-kettle form)*

Geological boundary (approximate, gradational)
Glacial striae
Drumlin or drumlinoid ridge
Direction of ice flow – last glaciation
– intermediate glaciation
Cirques-containing active ice in last glaciation
-containing active ice in intermediate or older glaciation, but not in last glaciation
End or terminal moraines – last glaciation
– intermediate glaciation
– age uncertain
Limit of glaciation (inferred but not marked by end moraine) – last glaciation
– intermediate glaciation
Lateral moraines (locally including minor kame terraces)
Eskers and prominent ridges in esker complexes
Debris-covered glaciers
Rock glaciers (tongue-shaped, spatulate, lobate)
Erratic
Lateral and sub-lateral meltwater channels (arrow shows direction of flow)
Major meltwater discharge channels (arrow shows direction of flow)
Incised channels of modern streams
Erosional scarp
Land or rock slide
Pingo
Patterned ground
Pits or kettles
Delta
Palsa

Geology by P. Vernon and O. L. Hughes, 1961

To accompany G. S. C. Bulletin 136 by Peter Vernon and O. L. Hughes

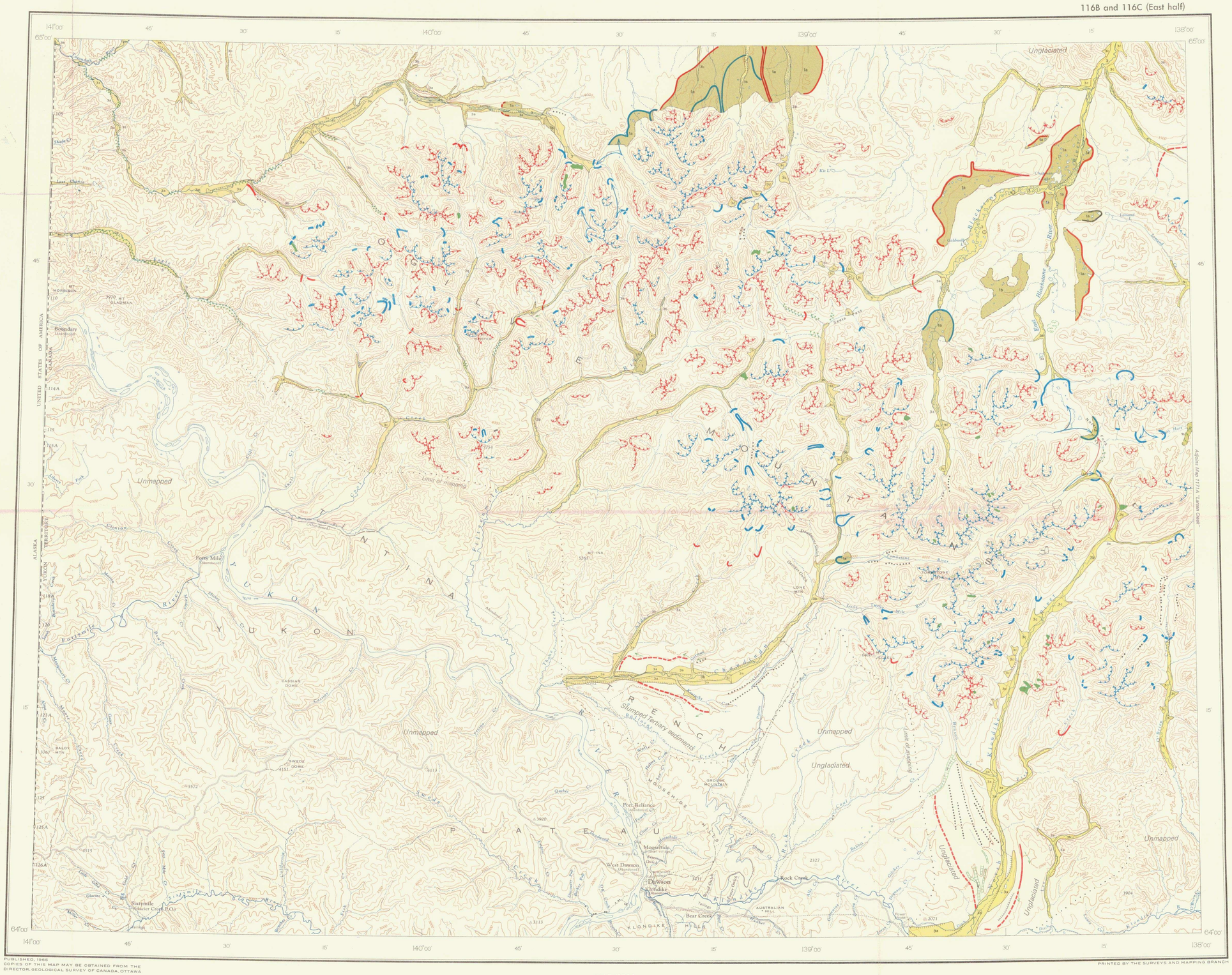
Geological cartography by the Geological Survey of Canada, 1964

Road, all weather
Other roads
Cart track
Trail
Power transmission line
Horizontal control point
International boundary
Stream ice and intermittent stream
Marsh
Contours (interval 500 feet)

Base-map compiled and drawn by the Surveys and Mapping Branch, 1958

Mean magnetic declination, 33° 23' East decreasing 3.8' annually. Readings vary from 31° 46' in the S W corner to 35° 00' in the N E corner of the map-area

INDEX MAP



PUBLISHED, 1965
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MAP 1170A

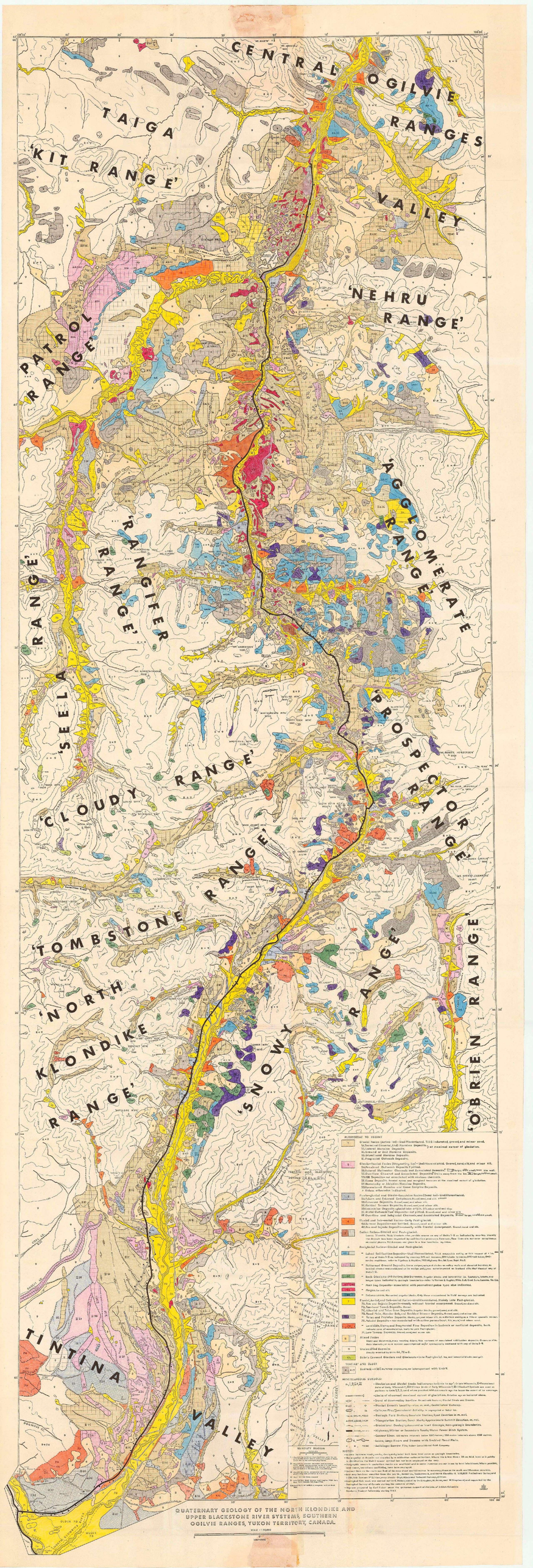
SURFICIAL GEOLOGY

DAWSON

YUKON TERRITORY

Scale 1:253,440
1 inch to 4 miles

Miles 4 0 4 8 12 Miles
Kilometres 6 0 6 12 18 Kilometres


CENTRAL OGILVIE RANGES
TAIGA
'KIT RANGE'
VALLEY
'NEHRU RANGE'
PATROL RANGE'
'AGGLOMERATE RANGE'
'RANGIFER RANGE'
'SEELA RANGE'
PROSPECTOR RANGE
'CLOUDY RANGE'
'TOMBSTONE RANGE'
'NORTH KLONDIKE RANGE'
'SNOWY RANGE'
'O'BRIEN RANGE
TINTINA VALLEY
PLEISTOCENE TO RECENT
TERTIARY AND OLDER
MISCELLANEOUS SYMBOLS
NOTES:
QUATERNARY GEOLOGY OF THE NORTH KLONDIKE AND UPPER BLACKSTONE RIVER SYSTEMS, SOUTHERN OGILVIE RANGES, YUKON TERRITORY, CANADA.