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GLACIAL LIMITS AND FLOW PATTERNS, YUKON TERRITORY, SOUTH OF 65 DEGREES NORTH LATITUDE

(Report and Map 6-1968)

O. L. Hughes, R. B. Campbell, J. E. Muller and J. O. Wheeler

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Illustration

Abstract

This report with accompanying map represents a first attempt to assemble and correlate evidence of successive advances of Cordilleran ice sheets in the interior of Yukon Territory, and of valley glaciers in adjacent mountains.

The limits of a late Wisconsin McConnell advance are marked by well-preserved moraines and other ice-marginal features. Moraines and associated features of a more extensive, early Wisconsin Reid advance are relatively subdued but distinguishable over much of the area. Widespread occurrence, beyond the Reid limit, of glacial deposits lacking distinctive geomorphic form indicates one or more advances older than and more extensive than the Reid. The limit of pre-Reid advance(s) has been defined only locally.

Flow patterns indicate that during the McConnell advance, the Cordilleran ice sheet moved as two, more or less distinct, lobes; a north- and northwest-flowing Cassiar lobe, and a northwest- and west-flowing Selwyn lobe. Valley glaciers emanating from St. Elias Mountains, and from Wernecke and eastern Ogilvie Mountains, merged with the Cassiar and Selwyn lobes, respectively, whereas valley glaciers of western Ogilvie Mountains remained independent.

GLACIAL LIMITS AND FLOW PATTERNS, YUKON TERRITORY
SOUTH OF 65 DEGREES NORTH LATITUDE

Introduction

The map together with these notes summarize present knowledge of glacial limits and flow patterns for Yukon Territory south of 65 degrees north latitude, exclusive of the extreme southeastern part and the axes of St. Elias and Selwyn Mountains. The published and unpublished maps on which the compilation is based (see index to sources on Map 5-1968) all involve photo-interpretation supported to varying degrees by ground observations. Few stratigraphic sections have been studied to support the chronologic scheme that is based mainly on comparative geomorphology, so that future work may necessitate changes in correlation from region to region or may add to the complexity of the rather simple chronologic scheme.

The great range in age of the glacial features displayed in the area is unique in Canada. In southwestern Yukon, ice fields and cirques of St. Elias Mountains support numerous large valley glaciers and uncounted smaller ones. The snouts of most of these are bordered by fresh, in part ice-cored, moraines of Neoglacial age. Well-preserved moraines found northeast of St. Elias Mountains mark the limits of an extensive late Wisconsin ice-advance; beyond these are subdued moraines produced by a more extensive (probably) early Wisconsin advance. In central Yukon comparable moraine systems mark the limits of presumed early and late Wisconsin advances of the main Cordilleran ice sheet, but beyond the subdued early Wisconsin moraines are remnants of the deposits of at least two older glaciations (Bostock, 1966). The oldest of such deposits are probably of early Pleistocene age. Similarly, moraines indicate (probably) early and late Wisconsin advances of valley glaciers in the Ogilvie Mountains, with evidence of still older glaciation(s) beyond the early Wisconsin moraines. Finally, in west-central Yukon a large unglaciated area lies beyond the limits of the most extensive advances of the Cordilleran ice sheet, and of ice emanating from St. Elias and Ogilvie Mountains.

The chronology used is based on that of Bostock (1966), who found evidence in central Yukon for four glacial advances: Nansen (oldest), Klaza, Reid, and McConnell (youngest). Moraines of Neoglacial age, closely associated with termini of modern glaciers in St. Elias Mountains, have been studied by Denton and Stuiver (1966, 1967), Borns and Goldthwait (1966), and Rutter (1968). Neoglacial limits have been delineated on the map accompanying this report.

Few glacial features remaining from the Nansen and Klaza advances can be identified on airphotos. Outside the areas studied by Bostock, much field work will be required to define in detail the limit of Pleistocene glaciation. The limit of the Nansen advance as mapped by Bostock (1966) in Carmacks map-area (see pre-Reid limit on present map) suggests that the uplands south of Nisling River in Aishihik Lake map-area must have been overridden. On the basis of reconnaissance by Hughes, much of the upland appears to lack erratics or other evidence of glaciations. The highest erratics found were at the level of, or slightly above, ice-marginal features judged from morphology to relate to the Reid advance. Therefore, for this upland, and similarly along the east end of Nisling Range, the pre-Reid limit is shown arbitrarily immediately outside (above) the Reid limit. Detailed study may show that locally the Reid was the most extensive of the advances or, alternatively, that evidence for one or more advances beyond the Reid limit has been overlooked.

Cordilleran Ice Sheet - Selwyn and Cassiar Lobes
(R.B. Campbell, O.L. Hughes, J.O. Wheeler)

During the McConnell advance, and presumably also during older advances, the main Cordilleran ice sheet in interior Yukon had two major source areas: one along Selwyn and northern Logan Mountains between 61° 30'N. and 64° 00'N., the other farther south in Cassiar Mountains, extending from about 60° 30' N. southward into British Columbia.

Ice from the more northerly source flowed mainly westward, forming what has been termed the Selwyn Lobe (Campbell, 1967). Some ice from this source flowed southward then southeastward across Liard Plain. Most of the ice from the Cassiar Mountains source flowed generally northwestward, forming the Cassiar Lobe (Wheeler, 1961). East of 132°W., ice from this source flowed northward and was deflected northeastward and eastward by the topographic barrier of Pelly Mountains and eventually joined ice from the northerly source to flow southeastward in Liard Plain. Boulder trains, grooves and striae exposed on a few ridges and summits indicate that at higher levels of the Cassiar Lobe, ice moved westward and west-northwestward across Whitehorse and Teslin map-areas. At lower levels, ice movement was influenced by topography and flow was mainly northwestward parallel with the trend of Teslin and Yukon River valleys.

Selwyn and Cassiar Lobes were separated by the topographic barrier of Pelly Mountains. Ice from the two lobes flowed into and inundated the mountains. Non-synchronous changes in the volume of flow produced surges of one lobe or the other that resulted in fluctuations of the line of demarcation between the two ice masses. Boulder trains indicate that ice tongues flowed outward from local sources that remained in Pelly Mountains some time after deglaciation began. These events, coupled with differences in the rate of thinning and retreat, created a confused record of flow directions and meltwater drainage patterns in Pelly Mountains. At the northern end of the mountains, and beyond in Glenlyon map-area, ice-margin features suggest that a northwest-plunging linear depression marked the junction of the two ice lobes. This depression possibly extended far to the southeast into Pelly Mountains.

As retreat began at the onset of the period of deglaciation, the margin of the Cassiar Lobe withdrew more rapidly than did that of the Selwyn Lobe in the region east of Carmacks. Thinning Selwyn ice then overrode small areas previously occupied by Cassiar ice.

The oldest glacial limit traceable by moraines and other ice-marginal features is that of the Reid advance (Bostock, 1966). By comparison with moraines and other features of the subsequent McConnell advance, those of the Reid are much modified and subdued.

The Reid limit, traced from southwestern Larsen Creek map-area into Aishihik Lake map-area, marks the digitate margin of the main Cordilleran ice sheet. Although the ice-marginal features are not continuously traceable, features interpreted from morphology as of Reid age, when linked together, form a limit compatible with topography and with the regional slope of the ice sheets as inferred from meltwater channels and ice-flow features. Cordilleran ice, augmented by local valley glaciers, extended as far northwest during the Reid advance as Michelle Creek in northern Larsen Creek map-area.

A stage of alpine glaciation preceded the McConnell advance in mountainous areas lying within the limits of the ice sheet. Pre-existing cirques were invaded by McConnell ice which smoothed the cirque walls and bounding spurs, and ice-marginal streams left notches in the spurs and abandoned channels in the backs of some cirques. Evidence of this early alpine glaciation is particularly apparent on the borders of the nunatak areas of Glenlyon Range. Moraines marking the McConnell limit extend from intervening spurs across distinctly troughed valleys that head in cirques or clusters of cirques. These moraines slope downward into the valleys in the upstream direction and no depositional features of the alpine glaciation are as fresh as those marking the McConnell limit. At present this pre-McConnell alpine glaciation cannot be related in time to any of the pre-McConnell ice sheet advances; it may correspond to the Reid advance.

The digitate margin of the Cordilleran ice sheet during the maximum of the McConnell advance is marked by remarkably continuous and well-preserved ice-marginal features from west-central Nash Creek map-area to central Aishihik Lake map-area. The evidence in this region indicates a single post-Reid advance although, locally, moraines indicate still-stands or minor re-advances following the McConnell maximum. However, in the valley of McIntosh Creek, north-central Aishihik Lake map-area, moraines mark an ice-marginal position between the Reid and McConnell limits as presently interpreted. The moraines are intermediate in terms of preservation between those associated with the Reid limit and those associated with the McConnell limit, and may represent a distinct post-Reid, pre-McConnell advance.

During the McConnell advance, major outlet glaciers of the Cordilleran ice sheet, augmented by ice from local sources, occupied Wind River and Hart-Beaver Valleys. The upper limits of the McConnell ice in those valleys were mainly on steep valley walls, and conspicuous moraines were developed only where the ice bulged into tributary valleys not occupied by local valley glaciers, and at the snouts of the ice tongues. To the west in Ogilvie Mountains were numerous valley glaciers comparable in size to present day glaciers of Kluane and Donjek Ranges of southwestern Yukon; many of these were too small to indicate at present map scale.

Valley glaciers of Ogilvie Mountains

(O. L. Hughes)

In contrast to the Yukon Plateau where ice of the Cordilleran sheet was continuous except for nunataks near the ice margin, ice in Ogilvie and Wernecke Mountains consisted mainly of independent valley glacier systems. In the eastern parts of these mountains the valley glaciers joined with glacier tongues that extended northwestward along Wind, Hart-Beaver and Middle Hart Valleys from the Cordilleran ice sheet.

Two advances ('intermediate' and 'last') have been inferred from sets of moraines preserved in the valleys and bordering piedmonts. One or more earlier advances are inferred from scattered glacial deposits beyond distinguishable moraines (Vernon and Hughes, 1966). Correlation of the moraine sets from valley to valley is based on comparative geomorphology, hence the possibility of erroneous correlation is greater than along the continuous (although not continuously marked) limits of the Cordilleran ice. Again on the basis of comparative geomorphology, the 'intermediate' and 'last' advances are correlated with Reid and McConnell advances, respectively of the main Cordilleran ice.

St. Elias Ice Sheets

(J.E. Muller)

In contrast to the major, windward-built, westerly flowing ice sheet of the Selwyn and Cassiar Lobes, ice flowing to leeward from the Coast and St. Elias Mountains was much less extensive. In Kluane Lake area airphoto interpretation aided by limited field observations by Muller (1967, prepared in 1963) indicated three ice limits provisionally named (in order of decreasing age and extent) Nisling, Ruby, and St. Elias. Depositional features marking the limits of the ice sheets in Ruby and Nisling Ranges are poorly preserved or lacking on steep, open hillsides, rendering the delineation of glacial limits much more difficult than in areas farther to the east. The problem is complicated by the presence of ice-marginal features of local Pleistocene ice caps and valley glaciers.

During the Nisling advance, probably correlative with the Reid, ice flowed across Shakwak Valley and covered flanking Kluane and Ruby Ranges to elevations of 5,000 to 7,000 feet. The extent of this ice across Nisling River, as shown on the present map, is well within the boundaries as originally interpreted (Muller, 1967). The rather indistinct features, mainly various high-level meltwater channels and a single, well-defined end moraine, are compatible with terminal ice tongues of this advance in several valleys in the northeastern part of Kluane Lake map-area. Further testimony of this advance is provided by the presence of high-level erratics up to 5,400 feet in elevation south of the junction of Kluane and Donjek Rivers (Muller, 1967) and, perhaps, also those at an elevation of 7,200 feet just south of Kluane Lake (Wheeler, 1963). Kluane Ranges exhibit notches and marginal channels far above the limit of the succeeding (Ruby-McConnell) advance.

The Ruby advance, tentatively correlated with the McConnell, covered essentially the same region as the Nisling but was slightly less extensive and its limit lies 500 to 1,000 feet lower. During this advance the main ice flow was from St. Elias Mountains, but the southern parts of Kluane and Ruby Ranges sustained small independent ice caps above 6,500 feet from which ice tongues flowed down valley. Valleys occupied by these tongues in Ruby Range are excellent U-troughs, but in Kluane Ranges deep canyons have been cut below the Ruby glacial floor by later fluvial erosion (see Muller, 1967; Sheep Creek on Pl. I, Burwash Creek on Pl. III). Morainal topography is locally distinct at and near the margin of this ice sheet (e.g. Muller, 1967, Pl. VII). Most of the area west of Kluane Ranges was covered by this advance to elevations of from 5,000 to 7,000 feet.

During both the Reid (Nisling) and the McConnell (Ruby) advances, ice lobes about thirty miles in width expanded into Wellesley Basin in Snag map-area and into Aishihik Valley in Aishihik Lake map-area. The 'St. Elias advance', which followed the Ruby, barely emerged into Shakwak Valley from St. Elias Mountains (Muller, 1967). Evidence for this glacial event is based on an interpretation of a system of U-troughs occupying tributary valleys of Generc, upper Donjek and Duke Rivers. The morainal deposits of Tchawsahmon Valley and possibly a morainal wall at the junction of White River and Shakwak Valley are attributed by Muller to this 'advance'. The other writers of this report prefer, on present evidence not to consider these features as indicative of a separate advance but regard them as products of a phase in the retreat of the McConnell (Ruby) ice sheet, possibly of rather long duration to allow for the establishment of the trough valleys. During this time the flow of ice from St. Elias Mountains was restricted to and channelled along major northerly and northwesterly trending valleys subparallel with bedrock trends. Locally, ice spilled over into Shakwak Valley through low passes. These major valleys were deepened substantially below the glacial floor of the previous glaciation.

Features of Deglaciation

(O.L. Hughes, R.B. Campbell, J.E. Muller, J.O. Wheeler)

Glacial lakes were formed during and following the maximum McConnell advance. Extensive glacial Lake Champagne, formed between the retreating margins of the Cassiar Lobe and ice in southern St. Elias Mountains, occupied Dezadeash Valley and valleys tributary to it to a maximum elevation of 2,800 feet (Kindle, 1953).

Lake silts more than 100 feet thick with ice-rafted, striated cobbles occur locally east of Kluane Lake and a lake level above 3,000 feet is suggested by beach terraces along the south end of Kluane Lake and on Talbot Arm. Numerous smaller lakes developed in valleys where drainage was temporarily blocked by the retreating ice margins; for example, between the Cassiar Lobe and the northeastern flank of Coast Mountains (Wheeler, 1961), and in the mountain plateau east of Aishihik Lake. In many places multiple shorelines are readily discernible on air photographs and in the field, but cannot be shown at present map scale.

Following the McConnell maximum the Cassiar Lobe retreated in a southwesterly direction (Wheeler, 1961). During deglaciation the ice level increased in general to the southeast in northwesterly trending valleys and was higher on the east side of intervening mountains than on the west side. Thus ice-marginal streams commonly flowed northwestward but overflowed westward across mountain divides, through cols, and along westerly trending valleys. A similar situation pertained to the Selwyn Lobe (Campbell, 1967), where major meltwater streams flowed west or northwest in the main valleys and minor overflow streams generally flowed westward.

Age and Correlation

(O.L. Hughes)

The Reid advance, and hence the older Klaza and Nansen advances of Bostock, are older than the normal range of radiocarbon dating. Wood in an ash layer, within organic silt lying above drift of the Reid advance (on Stewart River, 63° 30.2'N., 137° 16'W.), has been dated as more than 42,900 years old (GSC-524, Lowdon and Blake, 1968, p. 228). Thus the Reid is older than the classical Wisconsin of mid-western United States, but is not necessarily as old as Illinoian. Dates are not available for material overlying McConnell drift within the extent of the Cordilleran ice sheet, but organic silt from above presumed correlative drift in North Fork Pass in Ogilvie Mountains (64° 35'N., 135° 10'W.) was dated at 11,250± 160 years (GSC-470, Lowdon and Blake, 1968, p. 231) and from near Hart Lake (64° 35' N., 138° 17.5'W.) at 12,120± 140 years (GSC-67-2, Dyck and Fyles, 1963, p. 8).

The chronologic sequence adopted herein, based mainly on geomorphic evidence, is not yet firmly correlated with the chronology inferred by Denton and Stuiver (1967, p. 505, Fig. 7) from radiocarbon-dated stratigraphic sequences in Shakwak Valley near the south end of Kluane Lake. Denton and Stuiver's succession consists of Shakwak glaciation, Silver nonglacial interval (both occuring long before 49,000 years B.P.); Icefield glaciation beginning before 49,000 years B.P. and ending shortly before 37,700 B.P.; Boutellier nonglacial interval, beginning shortly before 37,700 B.P. and ending sometime after 30,100 B.P.; Kluane glaciation, beginning after 30,100 B.P. and lasting (in the study-area) until shortly before 12,500 B.P.; Slims nonglacial interval, beginning shortly before 12,500 B.P. and continuing to the beginning of the Neoglacial advance of Kaskawulsh glacier shortly before 2,640 B.P. (represented by thin unweathered loess in Shakwak Valley).

Denton and Stuiver's Shakwak study-area lies within the limits of the McConnell (Ruby) advance as shown on the present map, hence Kluane glaciation, inferred from the uppermost drift of that area, is correlative in a general way with the McConnell (Ruby) advance. Minimum age for deglaciation of Shakwak Valley following Kluane glaciation (12,500 B.P.) is close to minimum dates cited above for deglaciation following McConnell advance in Ogilvie Mountains.

Whereas the beginning of Kluane glaciation in Shakwak Valley is fixed by radiocarbon dating as later than 30,100 B.P., the beginning of the McConnell advance is not so fixed. Wood from the base of till referred to the McConnell advance (from Stewart River near the type locality, 63° 36' N., 135° 56' W.) is more than 35,000 years old (I (GSC) 180, Isotopes II, Trautman and Walton, 1962): wood from subjacent silt is older than 46,580 years (GSC-331, Dyck et al., 1965).

Further correlation between the chronology for Shakwak Valley and that adopted herein is highly speculative. Event for event correlation would equate Icefield glaciation with Reid advance, and Shakwak glaciation with either the Klaza or the Nansen advance of Bostock. However, Icefield glaciation ended in Shakwak valley shortly before 37,700 B.P., whereas the main Cordilleran ice sheet, following the Reid advance, had retreated eastward to within the limit of the later McConnell advance before 46,580 B.P.[1] This interpretation is supported by the radiocarbon date of more than 42,900 B.P. cited above for wood within volcanic ash near the base of organic silt that overlies Reid drift on Stewart River. Till fabric trends indicate (Denton and Stuiver, 1967, p. 497) that during Icefield glaciation ice flowed from Icefield Ranges down Slims River, bulged into Shakwak Valley and inpinged against Kluane Hills to the northeast. The pattern is markedly different to that of the general northwestward flow in the subsequent McConnell (Kluane) advance, and suggests that an independent piedmont lobe developed during a glaciation less extensive than that which followed. Moraines that might have been formed during a correlative and similarly restricted advance of the main Cordilleran ice sheet would have been overridden during the McConnell advance. A correlative of Icefield glaciation would then be lacking in the present chronologic scheme based on successive ice front positions. Moraines at McIntosh Creek, north-central Aishihik Lake map-area, could represent a small part of a moraine system, correlative with Icefield glaciation, that was not later overridden. Supporting evidence for such speculation is lacking.

In view of the above discussion, any correlation beyond that of general correlation of Kluane glaciation with McConnell advance is considered premature; correlation of older events must await further study.

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[1] Note that the age "older than 46,580 years" for sample GSC-331 is a minimum age. The sample may be several tens of thousands of years older, hence the age difference between Icefield and Reid glaciations is probably significantly greater than the difference (8,880 years) between the quoted figures.

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