6) THE VARIATIONS OF ALASKAN GLACIERS 1935-1947

by

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Since the last meeting of the International Commission of Snow and Glaciers in 1939, detailed studies have been made of the terminal portions of a number of Alaskan glaciers and a great deal of aerial photography has been undertaken for mapping purposes which provides data of great interest to the glaciologist. The general behavior of the glaciers of this part of the continent is fairly well-known, especially in the coastal areas where observations are more easily made and, therefore, more frequent. With the exception of a few glaciers whose terminal advance or recession are measured every few years, data on the behavior of the glaciers can be given only in general terms based on a comparison of photographs taken at different times, presence or absence of terminal and marginal barren zones and the characteristics of the vegetation growing near the present ice limits. It is to be regretted that prior to this year, no serious glaciologic studies have been undertaken near the firn line or in the areas of accumulation of these glaciers, so that little is known of their regimens. However, studies are now in progress designed to obtain such information during next few years.

Since the latest information on Alaskan glaciers included in the 1939 report dated mostly from observations made in 1935, this report will consider the period from that year to the present. The order to be followed in discussing the various glaciers or groups of glaciers will be in geographical order proceeding along the coast from southeast to northwest and west; then east to west along the interior ranges.

Little specific data are available on the glaciers of the Coast Range between Portland Canal and the Stikine River. However, a thinning in the terminal portions accompanied by slight recession of the termini seems to predominate.

A number of the glaciers on the west slope of the Coast Range between the Stikine and Taku Rivers have been more carefully studied. Le Conte Glacier has receded about three-quarters of a kilometer in the last two decades and the lower part of the glacier has been thinned. The small glaciers of the fiord have also shrunk appreciably. The two glaciers at the head of Muddy River have also been receding. Patterson Glacier has receded nearly one kilometer since its maximum about 1900 when it was in contact with mature forest. From 1941 to 1946 the whole lower part of the glacier thinned considerably and the terminus receded about 200-300 meters. Baird Glacier has not receded more than 100 meters from the terminal moraine formed at its recent maximum when mature trees were overturned as late as 1935, but the surface of the whole lower end of the glacier has been lowered appreciably.

The glaciers of Holkham Bay have been visited a number of times. The terminus of Dawes Glacier after remaining almost stationary from 1923 to 1941, receded about 400 meters on the south side from 1941 to 1946 with little observable change on the north side. Vertical thinning of the lower glacier's surface during this period is estimated at about 80 meters. North Dawes Glacier maintained the rapid recession which has been going on since about 1922, amounting to an additional several hundred meters from 1941 to 1946. The South Brown Glacier, being a remnant ice mass cut off from its former source of supply, has continued its slow shrinkage beneath an ever increasing mantle of ablation moraine. Brown Glacier has shrunk in volume,but its terminus has not receded appreciably in the last decade. Sumdum Glacier continued its slow recession from 1935 to 1946. Like that of Dawes Glacier, the terminus of South Sawyer Glacier, after remaining virtually stationary from 1923 to 1941, receded about 200 meters on the north side and 500-600 meters on the south. Sawyer Glacier receded about 300 meters from 1935 to 1941 and 100-150 meters more from 1941 to 1946.

The rapid recession of North Dawes, South Brown and Brown Glaciers appear to be due in large part to loss of ice spilling over from the extensive icefields to the east at the head of Dawes and South Sawyer Glaciers. This suggests that the level of this névé has been appreciably lowered, perhaps in the order of 30 to 60 meters in the last century.

The glacier at the head of Farragut River has receded about one-half kilometer

since 1929 and has suffered tremendous vertical shrinkage. Here again, the source of supply has been virtually cut off, probably due to the lowering of a névé surface, and this glacier has now become a stagnating remnant. Speel Glacier appears to have been slowly receding and shrinking in recent decades.

The glaciers of Taku Inlet afford an interesting example of varied behavior. The terminal portion of Wright Glacier has thinned appreciably since 1929 with a recession of the west side of the terminus of at least 400 meters. However, the most advanced part of the terminus is still within a few hundred meters of mature forest. Nearby summit glaciers have also shrunk noticeably in the last two decades. Talsekwe Glacier appears to have receded only a few hunderd meters in recent decades. Vertical shrinkage, however, has been considerable and the former lower tributaries from the west have all but disappeared since 1910. The terminal portion of both East and West Twin Glaciers shrank between 1941 and 1946 with East Twin showing a recession of perhaps 200 meters and West Twin experiencing virtually no change. Recession of these two glaciers has apparently been continuous since they were joined in a lobate terminus occupying the present site of Twin Glacier Lake as late as the 1890's.

Taku and Hole-in-Wall Glacier should be considered together as the latter is merely a distributary tongue of the former. Rapid advance of both has continued. Taku Glacier has advanced about 5 kilometers since 1900, much of which has been over ground previously occupied by mature trees. From 1937 to 1941, the advance varied from about 200 meters on the west side to a maximum of about 800 meters in the center. A further 400 meter advance occured from 1941 to 1946 with a corresponding thickening of 100 meters or more throughout the terminal portion. The terminus now rests in comparably shallow water or is fronted by an extensive push moraine. The terminus of Hole-in-Wall Glacier, advanced some 200-300 meters between 1941 and 1946 and reached the flats bordering the Taku Rover.

Norris Glacier, whose terminus is less than 1 ½ kilometers from the Taku has been receding slowly since a maximum about 1915 when the glacier was in contact with mature forest.

In the Lynn Canal area, Mendenhall Glacier has continued its steady recession ranging from 200 meters on the east side to 850 meters in the center between 1931 and 1945. Herbert and Eagle Glaciers have also experienced recession of several hundred meters and terminal shrinkage during the past two decades. Most of the glaciers of the Takhin and Tsirku Valleys have not experienced appreciable recession since 1910, but many show evidence of slight terminal thinning As an exception, Tsirku Glacier has experienced a net advance of some 300-400 meter since 1910. This appears to have been contributed primarily by the two lowest tributaries on the north which have noticeably increased in volume. An unnamed glacier immediately east of the Tsirku has also advanced. Garrison Glacier has been receding slowly, but its terminus is still within a few hundred meters of mature forest. Rainbow Glacier also shows evidence of slow recession. The lobate terminus of Davidson Glacier apparently receded slowly from 1931 to 1945 accompanied by some thinning of the terminal area. Other glaciers of the Lynn Canal area have not been specifically examined, but appear to have been slowly receding.

Glacier Bay, whose glaciers have experienced tremendous net recession and shrinkage amounting to a maximum of over 100 kilometers since the 18th Century, now presents a more complex picture. Recession and shrinkage has continued in all the glaciers of Muir Inlet. Muir Glacier, itself, receded about 10 ½ kilometers from 1935 to 1947 with a lowering of the ice surface at the latter position of some 300 meters. The inlet has been increased in area some 15,5 square kilometers in this 13 year period. McBride Glacier, a former tributary, became a separate glacier about 1944; Plateau Glacier receded about 3 kilometers from 1935 to 1946; while Casement and Morse Glaciers have continued their slow recession. The glacier in Adams Inlet which was about 180 meters thick and 65 square kilometers in extent in 1931, had practically disappeared by 1945 and its former tributary glaciers, Girdled and Adams, were receding up their respective valleys.

Caroll Glacier in Queen Inlet was receding and shrinking in 1935 and 1941, but in 1943 its lower portion was appreciably thickened and a minor advance apparently set in, which, however, had ended by 1946.

Rendu Glacier experienced a minor advance which culminated in 1935 or 1936 and has receded several hundred meters since that time.

In Tarr Inlet, Grand Pacific Glacier advanced about 760 meters from 1936 to 1947. The center and west side of the terminus now rest over the International

Boundary in Alaskan territory. The terminus of Margerie Glacier has remained in almost the same position since 1912,, experiencing only minor oscillations during that time. In 1946, it was in a relatively advanced position. Some of the tributary glaciers of the Grand Pacific and the small hanging glaciers in Tarr Inlet also appeared slightly forward in 1946 and 1947 relative to the previous decade.

The glaciers of Reid Inlet (also referred to in some reports as Johns Hopkins Fiord or Inlet) have exhibited rather remarkable oscillations in the past two decades. After its recession of some 11 kilometers between 1912 and 1926, John Hopkins Glacier has readvanced. From 1935 to 1941, this ranged from about 1400 meters on the west margin to about 75 meters in the middle of the terminus. From 1941 to 1946, this slow advance continued and the whole lower part of the glacier increased in volume.

Five of the hanging glaciers of the inlet show an interesting similarity of behavior, namely recession from 1935 to 1941, followed by readvance to 1947. Toyatte Glacier reached tidewater in 1935, but terminated some 250 meters above tide in 1940 and 1941. The terminus of Kashoto Glacier in 1935 was at an elevation of about 120 meters and back to about 300 meters in 1940, then down again to around 120 meters in 1941 and at tidewater in 1946 and 1947. The lower part of Gilman Glacier shrank in volume from 1935 to 1941; the terminus was reported advanced in 1945, but back to its former position in 1946. In the latter year, its volume was greater than in 1941, and about that of 1935. Clark and Tyeen Glaciers both receded from 1935 to 1941 and readvanced between 1941 and 1946.

Hoonah Glacier appears to have increased in volume in its terminal area from 1935 to 1941, followed by no appreciable net change from 1941 to 1946, but some advance from 1946 to 1947. The terminus of Topeka Glacier shows no appreciable net change form 1935 to 1947, but a hanging glacier above it, advanced between 1935 and 1940 and again from 1940 to 1941.

The terminus of Lamplugh Glacier after showing little change from 1907 to 1937, receded approximately 760 meters by 1941, then readvanced by 1943 and again by 1945, followed by recession to 1946. The latter position was 100 meters or so ahead of that in 1941.

Reid Glacier about 1500 meters from 1935 to 1941, then more slowly from 1941 to 1946. Hugh Miller Glacier seems to have experienced continuous recession from 1935 to 1946 amounting to between 900-1500 meters. Maynard and Charpentier Glaciers receded several hundred meters from 1935 to 1941 and Geikie Glacier receded some 650 meters during that interval.

The glaciers of Glacier Bay thus show behavior since 1935 which may be sumarized as follows : the glaciers of Muir Inlet, Geikie Inlet, Hugh Miller Inlet and Reid Glacier have apparently receded continuously during this time; Carroll and Rendu Glaciers have had minor advances within a pattern of net shrinkage; Grand Pacific Glacier and Johns Hopkins Glacier have had a net advance; Margerie and Lamplugh Glaciers have oscillated within limits of about 1 kilometer; and several of the hanging glaciers, both in Tarr Inlet and Reid Inlet have experienced from minor to major oscillations. In general, the period from 1935 to 1941 was one of recession in the small glaciers, and 1941 to 1946, a period of readvance. Noteworthy perhaps, is the fact that the two big glaciers which are advancing have their sources in the High Fairweather Range, whereas the glaciers have receded more or less steadily, are in lower subsidiary ranges to the east of the main range.

No detailed studies have been made of the glaciers along the west coast of the Fairweather and Brabazon Ranges between Cape Spencer and Yakutat Bay in recent years. Aerial photographs, however, indicate that the La Perouse Glacier has undergone no very great change between 1934 and 1947, though slight marginal withdrawal is evident. Its' ice is apparently still within 100-200 meters of the mature forest invaded in the advance which culminated about 1910 or 1911. A large unnamed glacier to the southwest, however, shows more terminal shrinking and recession between 1934 and 1947, but still remains within a few hundred meters of the forest.

In Lituya Bay, the Lituya and Crillon Glaciers were at their maximum positions, in contact with mature trees, in 1937, but as far as known, have not been observed since. In the Alsek Valley, aerial photographs indicate recession of the Alsek and Melbern Glaciers with large areas of their terminal portions reduced to a stagnant condition. Tho the west, in the Brabazon Range, the various westward flowing glaciers glimpsed from the air give the impression of steady, slow recession.

In Yakutat Bay,and Russell Fiord at its head,a series of ground and aerial obser-

vations were made in t946 and 1847. These reveal that Fourth Glacier has receded about 800 meters on the east, and 1600 on the west since 1909, while Hidden Glacier has receded nearly 5 kilometers since 1909 and is now about 1600 meters back of its 1905 position. Nunatak Glacier receded about 10 ½ kilometers from 1909 to 1946 accompanied by a maximum vertical shrinkage of at least 600 meters. Of this, about 1200 meters occurred between 1934 and 1938 and about 800 meters from 1938 to 1946. A former tributary on the south has receded about 1 ½ kilometers in the last decade. The terminal portion of Cascading Glacier has thinned and receded 90-120 meters since 1900, while a number of other small hanging glaciers both in Nunatak and Russel Fiords show no appreciable net change in the last three decades. In Disenchantment Bay, Variegated and Orange Glaciers have apparently experienced no appreciable net recession since 1909, but there may have been some vertical shrinkage. On the other hand, the terminus of Hubbard Glacier in 1946 was about 400 meters in advance of its position in 1910 and Turner Glacier showed slight advance and lateral expansion relative to its position in 1909.

No detailed observations of Malaspina Glacier have been made for half a century, but aerial photos suggest gradual withdrawal of its terminus and lowering of its surface. The same may be said for the Agassiz lobe. At the head of Icy Bay, the combined termini of Guyot and Tyndall Glaciers have receded nearly 24 kilometers since 1904,about 11 of which has taken place since 1913 and about 800 meters since 1934. West of Icy Bay, the termini of both Beare and White River Glaciers do not appear to have receded very rapidly in recent years.

Across the St. Elias Range on its eastern drainage, Wolf Creek Glacier in 1941 was found to be shrinking in its terminal area, but a number of its small tributaries were apparently advancing.

Bering Glacier is now receding slowly from terminal moraines formed during maximums which date about 100 years ago on the eastern and 50 years on the west. Barren zones on nunataks and along the margins also attest to gradual shrinkage of the volume of the piedmont area.

So far as known, the glaciers of the lower Copper River have not been studied in the last decade. However, aerial photographs suggest slow recession of the termini, shrinking of the terminal portions of the glaciers, and continued reduction of the stagnant ice masses remaining from earlier advances dating from perhaps a century or two ago. Sherman, Sheridan and Scott Glaciers near Cordova also appear to be shrinking slowly.

In Prince William Sound, a few specific observations are available. Valdez Glacier is apparently continuing its steady recession with an additional 30-60 meters from 1935 to 1941. Shoup Glacier's terminus remains virtually stationary, but there appears to have been some shrinkage from 1935 to 1943. Columbia Glacier which was experiencing a minor advance in 1935 had receded considerable by 1941. On the west end of the terminus, recession continued from 1941 to 1946, but on Heather Island there may have been an advance. Nevertheless, at this point the 1947 position appears to be in the order of about 300 meters back of the 1935 position, and the eastern terminus in 1947 was 100 meters or more back of its 1935 position.

Meares Glacier advanced into mature forest as much as 100-200 meters between 1935 and 1947. Yale Glacier has receded slightly on its west side and 100 to 200 meters on the east side during this interval. Harvard Glacier, however, has continued its advance with an additional 150 to 180 meters, most of which seems to have occurred since 1941. The hanging glaciers of College Fiord show behavior. The ice tongues on the southeast side draining from relatively low névés appear to be all in process of slow shrinkage and recession. The big hanging glaciers which reach tidewater on the northwest side of the inlet and have their source in high névés have behaved differently in this period. The terminus of Smith Glacier has not changed very much, although some advance may have occured, but the terminal portion of the ice stream definitely appears to be thicker. Bryn Mawr Glacier seems to have changed very little from 1935 to 1941 and then to have advanced some 450 meters by 1947 to reform a lobate terminus occupying the small inlet formerly leading from the fiord to the face of the glacier. This lobate terminus was last in existence about 1914,but this recent advance seems to have carried the ice beyond the terminal moraine dating from that time and to be more advanced than for perhaps a century or more. Vassar and Wellesley Glaciers show little change although the terminal portion of the latter may have expanded very slightly during this period.

In Harriman Fiord, no appreciable change seems to have occured in the termini of Barry, Cascade, Serpentine, Baker and Surprise Glaciers, from 1935 to 1947, but Coxe Gladier appears to have experienced a small net advance. The terminus of Cataract Glacier receded from tidewater to an elevation of 30-60 meters between 1935 and 1941 and has not undergone any significant net change since then. Harriman Glacier has continued its slow advance measurable at the west end of the terminus as about 75-90 meters. Close by, the much smaller Dirty Glacier, flowing from low névés, appears to have receded 75-90 meters during this same interval. Recession of Toboggan Glacier has been of the same order.

In Blackstone Bay, comparative photographs indicate that Marquette, Lawrence and Ripon Glaciers all show some terminal shrinkage and slight recession between 1935 and 1947, but no very rapid changes are observable on any of the glaciers.

Comparatively, few of the remaining coastal glaciers and those of the interior valleys have been observed in the last decades. Much information of record is to be had from the aerial photographs taken during the last decade, but these have not yet been correlated. There are two exceptions, however, one of which, Black Rapids Glacier, in the Alaska Range excited much interest in 1936 and 1937, when an advance of about 4.8 kilometers in 4 months was reported. Four years later, in 1941 no appreciable recession had occured ,but narrow marginal barren zones indicated that the terminal portion of the glacier was in the process of shrinking.

The second exception is the Yanert Glacier which rises also in the Alaska Range not far from the head of the Black Rapids and flows in the opposite direction. Aerial photos show that a significant advance was under way in both 1941 and 1943. However, no data on its subsequent behavior is available.

Nearly all the remaining glaciers of interior Alaska have conspicuous terminal and marginal barren zones indicating slow to rapid recession in their terminal portions in recent decades. Advancing glaciers in the interior ranges are more of an exception than along the coast. Some areas of the interior appear to be in a stage of deglaciation approaching in intensity that of the Muir Inlet basin, but observations are as yet extremely inadequate.

It is of interest that during the period 1935 to 1947, the Baird, Taku, Crillon and Lituya Glaciers of Southeastern Alaska have attained positions farther forward than at any time at least since the 18th Century and probably, longer, and that the Meares, Harvard, Harriman and possibly the Bryn Mawr in Prince William Sound have done likewise. Near these glaciers other termini have receded only within the last few decades from comparable maximum positions,and many others, though not now at maximum positions,remain within a few hundred meters of mature trees. A cursory analysis of existing aerial photographs covering almost all Alaskan glaciers, strongly suggests that the majority of glaciers which are now receding are withdrawing from terminal moraines formed during maximum advances in the 18th od 19th Centuries. Detailed studies are needed of selected representative terminal moraines to establish their approximate age. However, if they do date as suggested from the last two centuries, the present maximums being established along the coast may belong to the last phase of this period of glacial expansion which has had its counterpart in many other parts of the world.

The aerial survey of the northwest part of the continent has made it possible to ascertain the presence and extent of glaciers either not known to exist because of their small size of their position in remote unmapped areas. Data on small cirque glaciers east of the Coast Range in British Columbia and Yukon Territory is now available while the considerable glaciers of the Brooks Range in the north, the Kilbuck Mountains in western Alaska, and the Aleutian Range in the southwest are revealed in much greater detail than previously. The small and large glaciers of much of Northwestern Canada have similarly been exposed to view for the first, time in a way that makes possible a clearer understanding of their characteristics the moraine patterns and the relationship between the areas of accumulation and ablation.

The meteorological records for this period 1935 to 1946 indicate that summer temperatures were higher than normal in the areas where glaciers exist in Alaska and though total annual precipitation increased at 13 out of 14 selected stations,the amount of annual snowfall decreased on an average at 11 of these same 14 stations. Departures from the mean temperatures varied greatly in different places but in general, this period was one of relatively great summer ablation and deficient snow accumutation compared to conditions prevailing during the last few decades. The glaciers therefore, may be considered to have suffered appreciably both by greater melting,

and lessened snow supply. In other words, conditions affecting the regimen of glaciers were negative to a greater degree than previously. The general result of widespread, slow, steady recession is in accordance with the trend of the meteorological data. The advancing glaciers may be reacting to special conditions or to the fact that their sources are at higher elevations, which may be receiving a greater accumulation of snow due to a regional elevation of the zone of maximum snowfall. At present, there is insufficient data from which to determine this from direct observations. The only evidence at hand is the behavior of the termini, the meteorological records at the different stations, all of which are at elevations corresponding to the termini of the nearest glaciers or below them, and the general topographic characteristics of the glaciers themselves.

An attempt to determine whether conditions favored a relatively high or low firn line on the glaciers in the different years has been made from the records at fourteen selected meteorological stations. The factors taken into account are the temperature of the ablation season and the amount of precipitation occuring since the end of the previous ablation season. The results are given in the following table and are to be considered purely as indicating the tendency in this respect among the glaciers affected by the particular set of meteorological conditions at these stations.

Relative Position of firn line

Based on the departure from the mean of the temperatures of the ablation season and the precipitation during the preceding period from October to April.

Year	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946
Southeastern Alaska												
Ketchikan	—	HH	H	H	—	HH	HH	HH	—	H	L	—
Sitka	—	H	L	—	L	H	HH	H	—	L	L	—
Wrangell	X	HH	H	H	LL	—	HH	H	L	—	L	—
Juneau	L	H	—	—	L	H	H	H	—	H	L	—
Annex Creek	—	H	—	L	L	—	H	H	—	L	L	—
Haines	—	H	—	L	L	—	H	H	—	L	L	—
Yakutat	X	X	H	—	L	X	—	H	X	—	—	X
South Central Alaska												
Kennecott	—	H	L	H	L	H	—	—	H	—	L	HH
Valdez	X	HH	—	—	L	H	—	H	X	L	L	X
Seward	—	HH	H	X	X	—	—	H	H	—	—	H
Anchorage	—	H	—	H	—	H	—	HH	—	—	—	—
Matanuska	X	H	L	—	—	H	H	HH	H	—	L	L
Talkeetna	L	H	L	—	L	H	H	H	H	—	—	—
Central Alaska												
Fairbanks	L	—	LL	—	—	—	—	H	H	—	—	—

Key: X — No record.
— Firn line apparently near mean position.
L — Firn line relatively low compared to the mean position.
LL — Firn line very low compared to the mean position.
H — Firn line relatively high compared to the mean position.
HH — Firn line very high compared to the mean position.

Note: LL and HH represent conditions where both temperatures and precipitation favor a low or high firn line so that the combination of both factors tends to produce a very considerable departure in the position of the firn line from its mean position.