The Alaskan Glacier Commemorative Project, Phase II

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Grant Nos. 526, 548: In support of the second year (1965) of a continuing program to study changes in glaciers along the southern Alaskan coast since the National Geographic Society's Tarr and Martin studies early in the century, with special attention to the problem of periodic fluctuations and the causal factors involved.

As outlined in three recent papers (Miller, 1965, 1967, 1969), the National Geographic Society has supported a regional glacier study in south and southeastern coastal Alaska beginning with the first field season of concentrated research in 1964. The purpose is to interpret significant changes in the glaciers of this region for comparison with the comprehensive studies of the National Geographic Society's expeditions of 1909-1913 as carried out by Ralph S. Tarr and Lawrence Martin (1914). A newer impetus has been given by the effects of the catastrophic earthquake that shook this coast on Good Friday, 1964 (Miller and Potter, 1965). The area of concern is broadly delineated by the map, figure 1. The routes of the 1964 and 1965 surveys are shown in figure 2.

The two prime sectors where efforts were concentrated in this Phase II of the regional study were as follows: (a) A control locality in the Alaska-Northern British Columbia Boundary Range, including the Juneau Icefield and the Taku and Atlin Districts (fig. 3), and (b) a set of four localities within the tectonically sensitive zone affected by the severe earthquakes of 1899, 1908, 1958, and 1964. These latter areas visited in 1965 are Glacier Bay; the Fairweather Range, west of Juneau; the Yakutat Bay-Icy Bay region reached from Yakutat, Alaska; the Alsek River-Mount Kennedy region, reached from Whitehorse and Haines Junction, Yukon Territory; and the Copper River region and the Chugach Range, reached from Cordova and Valdez, Alaska. Brief comments are made on the work accomplished in each sector.

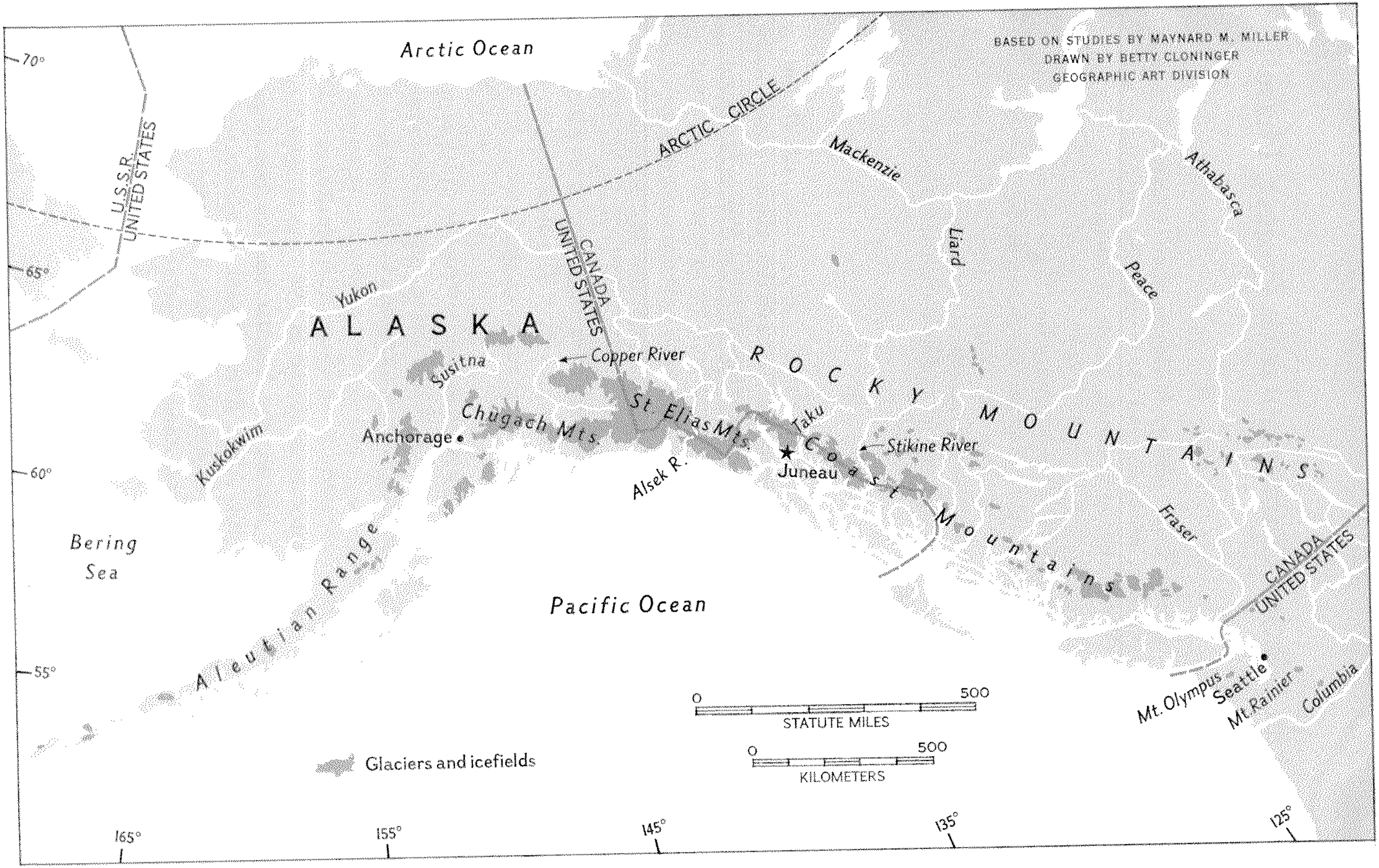


FIG. 1. General map of Alaska and the North Pacific Coast Ranges showing main centers of present glaciation.

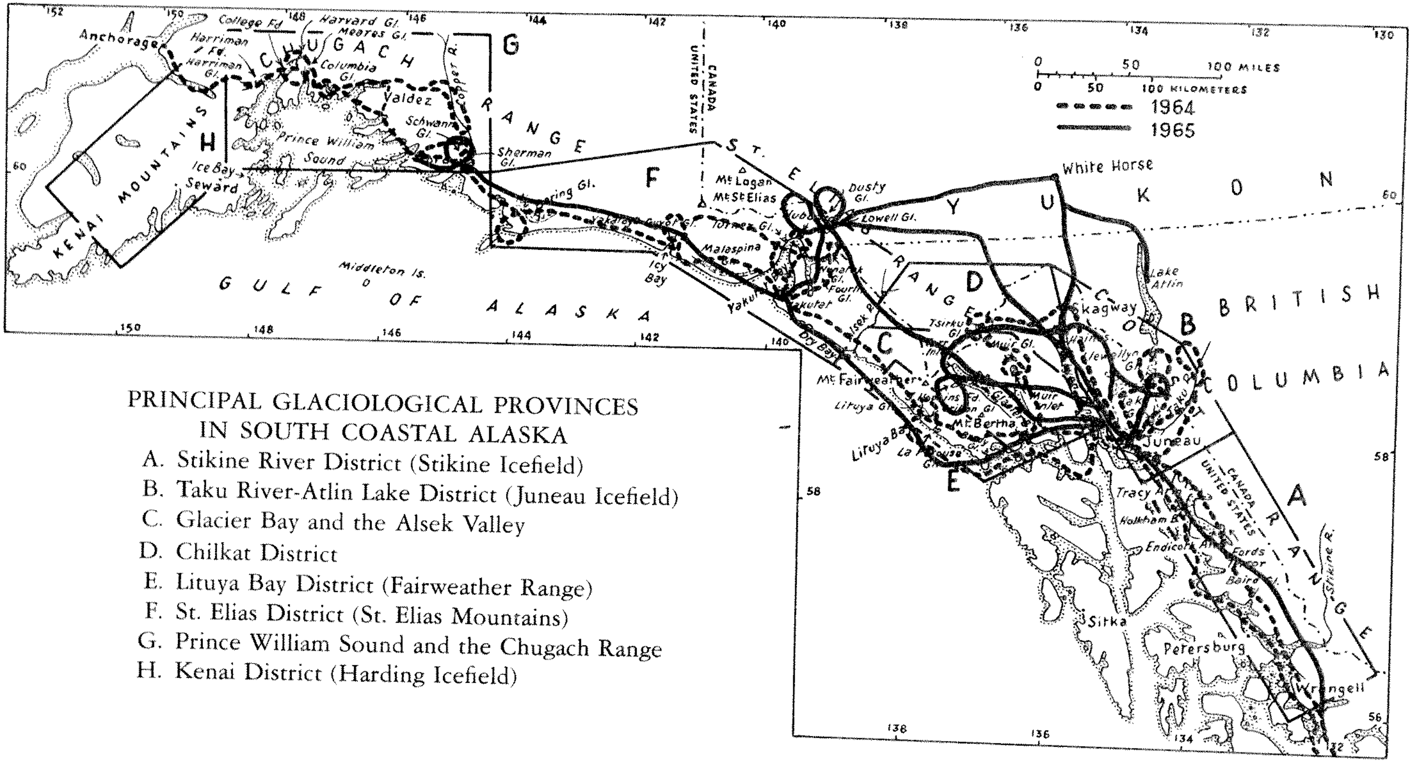


FIG. 2. Map showing route of National Geographic Society Alaskan Coastal Glacier regional survey during summers of 1964 and 1965.

Northern Boundary Range

An extensive photogrammetric and glacier-movement survey was conducted on the Juneau Icefield (fig. 3) in 1965, using phototheodolite methods. The primary surveying efforts were put forth by Dr. Gottfried Konecny (1966), Dr. Adam Chrzanowski, and Gerhard Gloss, all of the Division of Surveying Engineering, University of New Brunswick, Canada, assisted by Adnan Al-Naqash and Thomas Herbert, from the Geology Department, Michigan State University. These surveys, using P-30 phototheodolites, covered the terminal and lower glacier areas of the Mendenhall, Lemon, Ptarmigan, Thomas, Norris, Taku, and Hole-in-Wall Glaciers, with preliminary surveys and photo-station records obtained on the upper Taku, Vaughan Lewis, and Gilkey Glaciers in the Berner's Trench (fig. 4, *right)* and on the East and West Twin Glaciers, etc. Aerial surveys were also carried out on all main glaciers peripheral to the Juneau Icefield between the Talsekwe Trench near Tulsequah on the east and upper Lynn Canal near Skagway on the northwest, including the Antler (fig. 4, *left* and *center*), Meade, Davison, and other key glaciers.

Continuing measurements of regime trends on the Juneau Icefield névé were also conducted on the upper Norris, Taku, Llewellyn, Vaughan Lewis, and Lemon Glaciers. The summer's ablation measurements continued to indicate that at successively higher elevations lower rates of ablation and correspondingly shorter annual melting seasons pertain. At representative stations on the icefield, a strongly positive regime trend was again observed with a general lowering of the névé-line, yet still with relatively greater amounts of retained accumulation on the higher névés.

Through the work of C. P. Egan (1965) and others of our research team, this is seen as a temperature-dependent function, rather than via direct control through elevation. Analyses of regional precipitation and temperature trends during the past quarter of a century from nearby coastal stations show a high correlation coefficient, thus attaching further regional significance to the névé records from this climatologically sensitive glacier system.

Structural and deformation studies were also conducted on the Gilkey and Vaughan Lewis Glaciers by T. F. Kittredge (1967) and others. A unique contribution to the study of wave-ogives was made by theodolite movement stake surveys (Gloss et al., 1965; also see fig. 5) and the careful plane table mapping of wave bulges below the icefall of the Vaughan Lewis Glacier. From this a topographic map was constructed for comparison with the 1964 surveys. By superposition of these maps, the annual nature of the wave bulges was elucidated—a fact of considerable importance in the analysis of climatological causal factors in the pulsation of glaciers. To clarify the

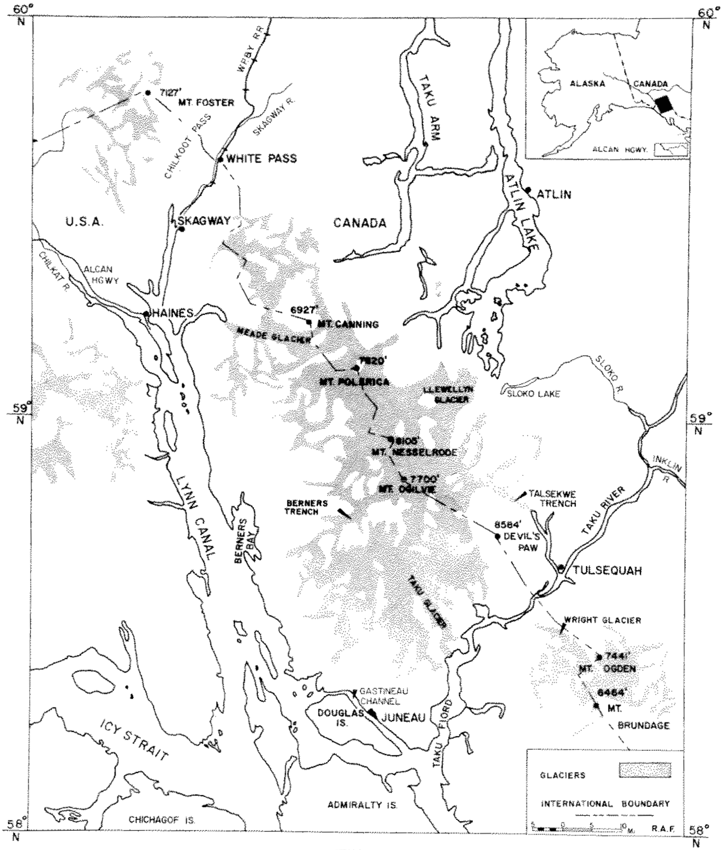


FIG. 3. Map of Northern Boundary Range, Alaska-British Columbia, showing areas of Juneau Icefield in the Taku and Atlin Districts.

relationships, ablation on crests and troughs of successive wave bulges was recorded, vertical strain diamonds were set up and measured in crevasses, and crystal axis orientation studies of core samples were made to gain insight into the mode and rate of flow deformation in the compressive flow zone below the Vaughan Lewis Icefall.

In an additional effort to clarify the role of climate in glacier change, glaciohydrological studies were initiated by Dr. James Bugh (1965) and A. E. Helmers on the Lemon Glacier near Juneau. The hydrological and glaciological record shows that this glacier has been gradually diminishing in size over the past four decades but that the trend is reversing itself. Also this year computed ablation, derived from the theoretical predicting equation for the early ablation season, based on the physiography of the Lemon Glacier and the positive degree days, agreed within 7 percent of the observed 1965 stakes. Previous assessments have indicated that each budget year for the 1953-58 period showed a deficit, except in 1954-55 when a surplus was registered. In 1964-65, however, the position of the seasonal névé-line (traced by terrestrial photogrammetry) and the pit stratigraphy indicated a large surplus budget. Additionally, crevasse studies on the Lemon Creek Glacier revealed a surplus for the 1963-64 accumulation season and apparently a very large surplus for the 1962-63 accumulation season. The interval 1959-62 tended toward equilibrium conditions on this glacier.

One rather significant result of the 1965 studies came from a detailed geobotanical investigation by Dr. Roland Beschel (1965), of Queens University, Canada, on what proved to be a 16th-century moraine on the Bucher Glacier east of Lynn Canal. Two main moraines were dated. Crustose lichens growing on the outer (older) moraine provisionally indicate a growth period of 300 to 350 years. Slightly larger lichens were found to be present outside of this moraine. A dendrochronological date was obtained from the lowest of several trunk discs sawed from a large mountain hemlock *(Tsuga mertensiana)* growing on the crest of the outermost moraine. A disc from near the base of this tree contained approximately 330 rings, not counting a rotten central core some 30 centimeters in diameter. Allowing time for establishment of the seedling, and growth to the disc height, the date of formation of this moraine is considered to be near or slightly prior to A.D. 1600. This is the earliest certain dating of Little Ice Age moraines (see later discussion) in southeastern Alaska to date.

Fairweather Range

Aerial photographic surveys and some ground observations were made in Glacier Bay, the Fairweather Range, Lituya Bay, and the Tsirku-Tahkin River valleys west of Haines, Alaska. Substantial evidence was found of strong marginal shearing accompanied by surging in small glaciers east of Queen Inlet, north of Tarr Inlet, and at least on one main high-level glacier on the north wall of Johns Hopkins Fiord. It was not clear whether these could be climatic in cause or represent effects of the 1964 earthquake, with its epicenter some hundreds of miles to the northwest, or a delayed effect of the 1958 earthquake, which had its epicenter only a scant 20 miles to the west in Lituya Bay.

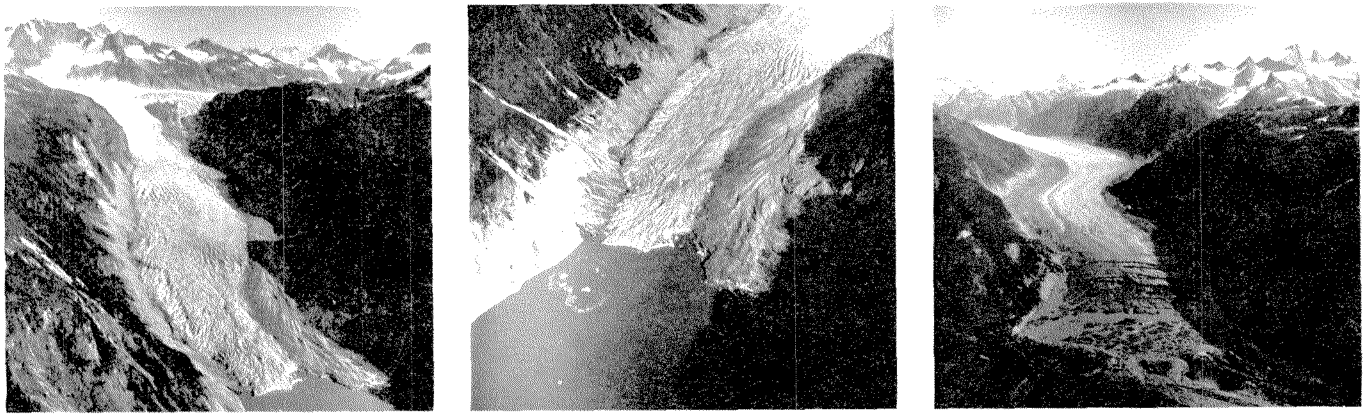


FIG. 4. *Left* and *center,* Oblique aerial views of the Antler Glacier. *Right,* View of Gilkey Glacier. Both glaciers are slowly downwasting and retreating. They are typical mountain-valley glaciers in the vicinity of Berner's Trench east of Lynn Canal, Taku District, Northern Boundary Range. Photos by M. M. Miller, September 1965.

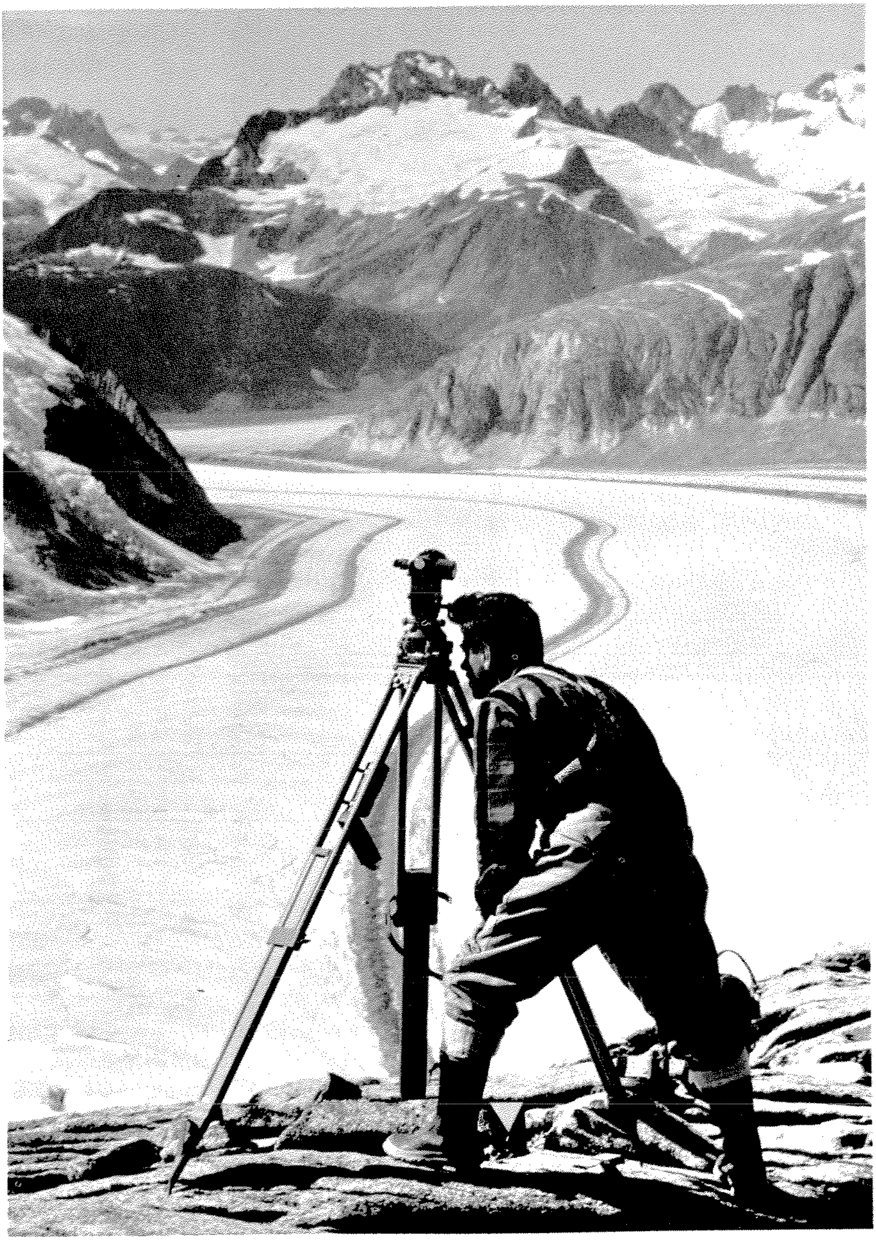


FIG. 5. Prof. Gerhard Gloss of the University of New Brunswick at theodolite survey station in Gilkey Canyon. Vaughan Lewis and upper Gilkey Glaciers separated by curving medial moraine in middle distance. National Geographic Society photo.

St. Elias Mountains

Further aerial and ground surveys in the Alsek-Dusty-Upper Lowell Glacier area revealed additional surge effects, as given in the 1965 Mount Kennedy expedition glaciological report (Miller, 1971). Surge effects were still visible on Turner and Variegated Glaciers as filmed in 1964 (Miller, 1969). The 1965 positions of Icy Bay glaciers and those in the Copper River Valley were also photographed, although very severe storms in September precluded fully effective results. A week was also spent on the ground in the Mount Kennedy area, mapping the Dusty Glacier surges and studying the age relationship of older moraines in the Dusty Glacier valley. Investigations were also carried out in the Dezadeash region of the east St. Elias District, including reconnaissance of a series of unique rock glaciers.

Chugach Range

Two weeks were spent making a phototheodolite and tellurometer survey of the Sherman Glacier near Cordova and its huge avalanche precipitated by the 1964 Alaska earthquake (figs. 6, 7). The field party engaged in this survey was comprised of Dr. Maynard M. Miller, Prof. Peter Wilson of the University of New Brunswick, D. M. Potter, Ken Blurton, J. A. Miller, and S. Hulse. In this, extensive use was made of helicopter logistic support. Severe weather curtailed all further field work in the Chugach Range for 1965 in the last week of September.

Alaskan Little Ice Age Pattern

The sequence of 1965 air photographs and ground observations, added to those of 1964, permits a summary of the fluctuational pattern of Alaskan coastal glaciers covering the period of the last several hundred years. The results are presented in figure 8. These curves represent late Neoglacial fluctations, otherwise referred to as the Alaskan Little Ice Age. The diagram shows the regional pattern of glacier behavior for southeastern Alaska because it represents the four main categories of present terminal regime among about 200 glaciers on which regional data have been acquired (Miller, 1970). It is significant that none of the glaciers noted in this diagram have been materially affected by earthquake-avalanching, and none has significantly experienced the sudden type of surging recently observed on the Turner, Dusty, Steele, or other such glaciers in the St. Elias Mountains, or indeed that seen in the Johns Hopkins Inlet sector of the Fairweather Range in 1965.

To interpret this figure, further explanation must be given. Technically the Little Ice Age refers to the latest widespread phase of climatological

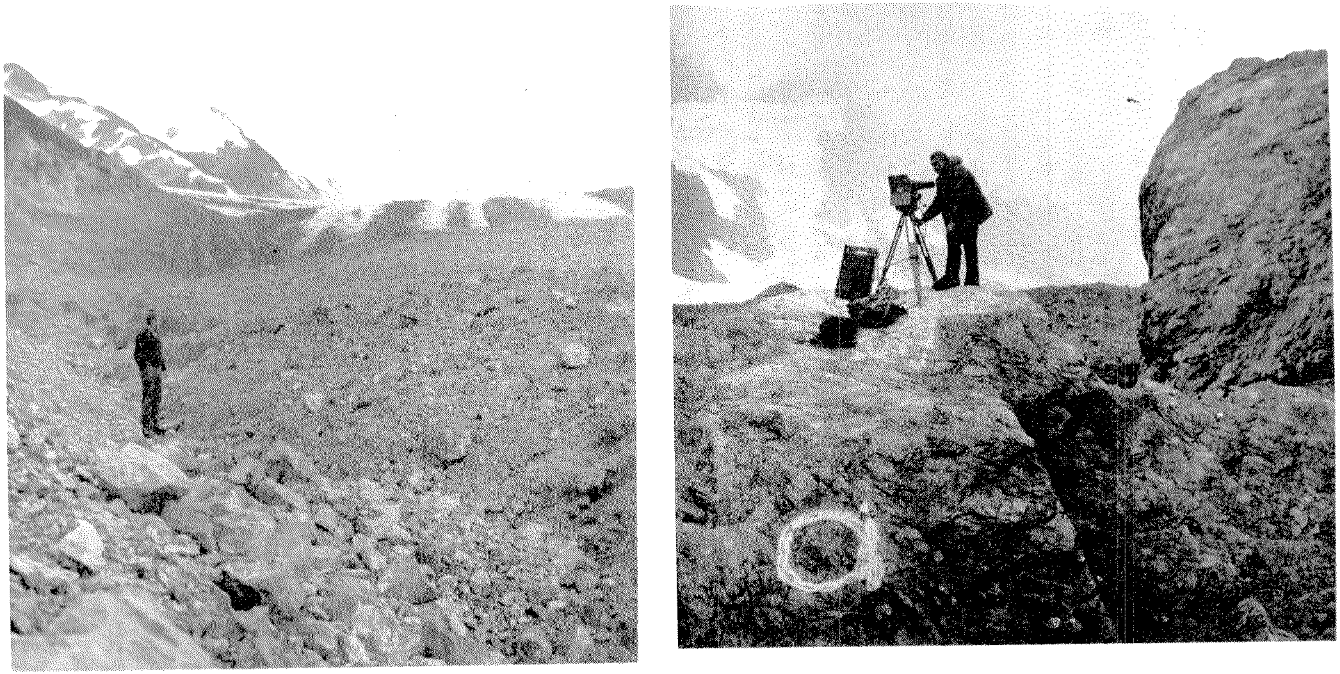
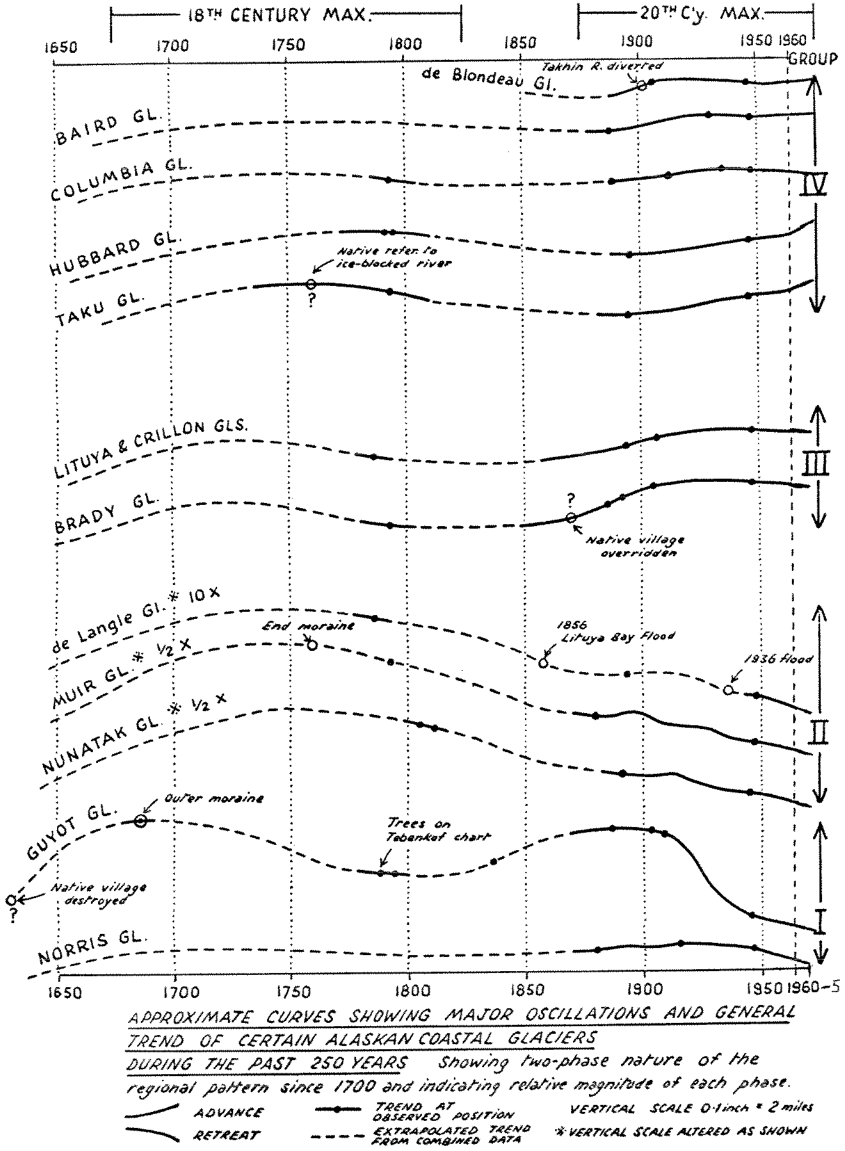


FIG. 6. *Left,* Close view of eastern edge of Sherman Glacier rock-debris slide covering glacier, 5 miles above its terminus. *Right,* Tellurometer-survey station on Sherman Glacier slide. Boulders weigh up to 30 tons. Photos by M. M. Miller, September 1965.

FIG. 7. Panorama of catastrophic rock-debris slide on Sherman Glacier in the Eastern Chugach Range as viewed from National Geographic Society research campsite on eastern side of glacier in September 1965. The earthquake avalanche detritus in the slide covers an area of at least 10 square miles. Photo by M. M. Miller.



APPROXIMATE CURVES SHOWING MAJOR OSCILLATIONS AND GENERAL TREND OF CERTAIN ALASKAN COASTAL GLACIERS DURING THE PAST 250 YEARS Showing two-phase nature of the regional pattern since 1700 and indicating relative magnitude of each phase.

FIG. 8

reglaciation, beginning about five centuries ago in the latter quarter of the Neoglacial Age. This figure shows that despite seeming differences in terminal regime at any one time, when one views the pattern over several centuries the Little Ice Age fluctuations are all double-phased in nature. This also reflects what we know as a world-wide growth of Temperate glaciers reaching their culmination in the early to mid-18th century and again in the late-19th to early- to mid-20th centuries. The Alaska coastal Little Ice Age pattern depicted here is in special detail, as it reveals that at any one time the terminal regime of glaciers in adjoining areas may be quite out of phase. Thus, one glacier may experience strong advance while another is simultaneously in strong retreat. We see that the latest advances on a small percentage of high-level trunk glaciers (such as the Hubbard and Taku) have continued into the 20th century, in spite of a general diminution of ice cover around the periphery of some of the lower Alaskan icefields (e.g., as reflected by the downwasting of the Guyot and Norris Glaciers over the past half-century).

Teleconnection and the Problem of Surging Glaciers

Recent fluctuations in Scandinavia and Patagonia are quite similar to the Alaskan Little Ice Age pattern. The teleconnectional similarity is shown by the existence in all three regions of upward of a dozen recessional moraines over the past 200 years. Such evidence supports the global nature of the regime changes, and hence the probability of climatological cause. This also reveals the acute sensitivity of Alaskan coastal glaciers as historians of secular climatic change. How the patterns of terminal behavior produced by surging glaciers of the kind described in the Dusty Glacier valley and elsewhere fit into this picture is yet little understood. They appear to be anomalous and the causal factors may be complex. In this, earthquake avalanche effects may be only one of several factors, even though the surging glaciers first reported by Tarr and Martin (1914) in Yakutat Bay, Alaska, between 1910 and 1913, were attributed by them solely to that cause. The probability of other explanations for this spectacular, though seemingly selective phenomenon, and the need to clarify this aspect in the light of major climatic influences on nonsurging glaciers will continue to prompt vigorous investigation.

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