Glaciological and Geological Investigations on the 1965 Mount Kennedy, Yukon, Expedition

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Glaciological and Geological Investigations on the 1965 Mount Kennedy, Yukon, Expedition

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Grant No. 485: For scientific studies in connection with the 1965 mapping of the Mount Kennedy-Hubbard massif, in Canada's St. Elias Mountains. See account by Bradford Washburn (1971) of the mapping operations of the expedition.

During the course of the 1965 expedition to the Mount Kennedy-Hubbard massif in the central St. Elias District, Yukon (fig. 1), sponsored by the National Geographic Society in cooperation with a number of other scientific agencies[1] (Washburn, 1971; Miller and Chrzanowski, 1968), certain glaciological and geological studies were conducted as adjuncts to the expedition's basic survey and mapping mission. As the area involved was largely in an unexplored region of the Yukon, this activity resulted in specific observations not previously obtained on the glaciers and bedrock ridges in this sector of the St. Elias Mountains, as well as in some reconnaissance information that should serve as a useful basis for comparison with more comprehensive future research. Some of the data obtained are of value also in connection with the National Geographic Society's long-term Alaskan Glacier Commemorative Project, carried out between 1965 and 1970 in adjoining districts of Alaska, the Yukon, and northern British Columbia (Miller, 1965, 1969).

The glaciological team engaged in the high-altitude research on Mount Kennedy itself, and on the upper Hubbard and Lowell Glaciers, included Maynard M. Miller and Tyler Kittredge, of the Glaciological and Arctic Sciences Institute, Michigan State University; Wayne M. Smith, M.D., Barry W. Prather, and Hans Lehmann, M.D., of the Foundation for Glacier and Environmental Research, Seattle, Washington; and Ronald McLaughlin,

[1]Including the Boston Museum of Science, the University of New Brunswick, Michigan State University, the U. S. Coast and Geodetic Survey, the Canadian Geodetic Survey, and the Foundation for Glacier and Environmental Research, Seattle, Washington.

of the Department of Game, Government of Canada. Adjunct investigations in July and September 1965 of the area below the névé-line on the Lowell and Dusty Glaciers and on several rock glaciers in the southern Kluane range, were carried out by two teams consisting of Dr. M. M.

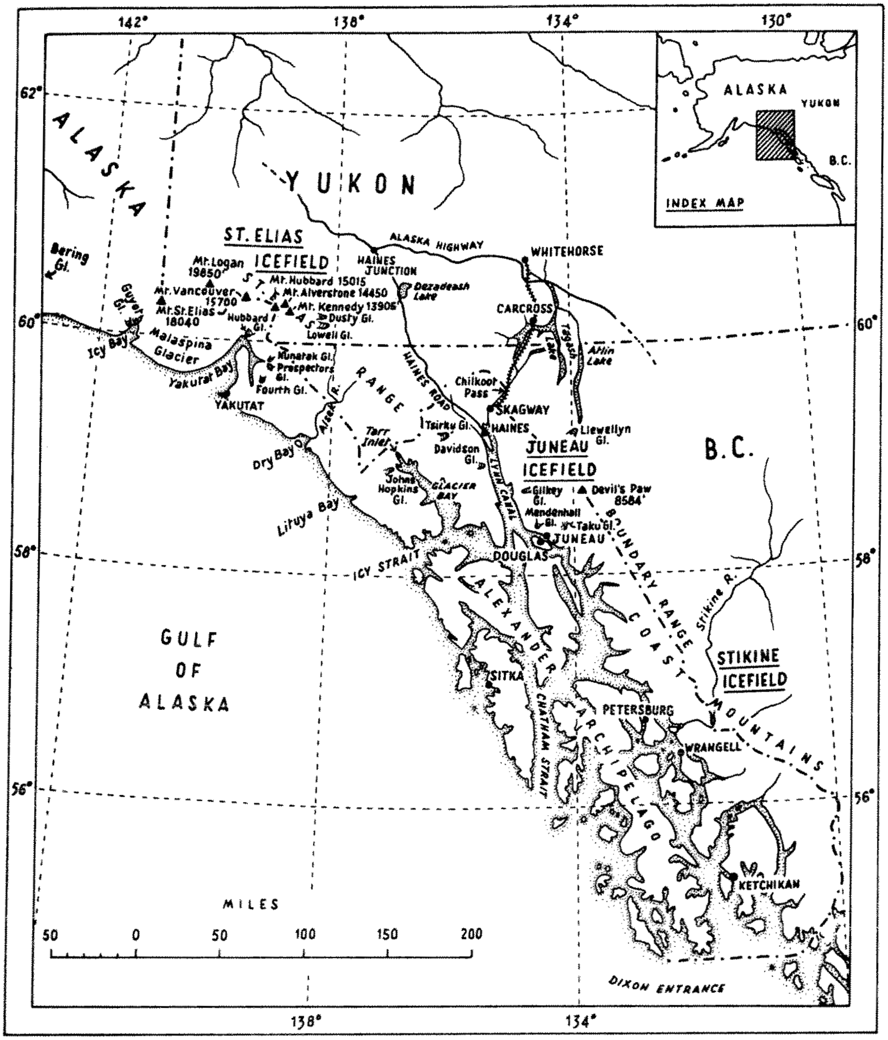


FIG. 1. Map of southeastern Alaska denoting main icefield areas in the St. Elias and Alaska-Canada Boundary Ranges.

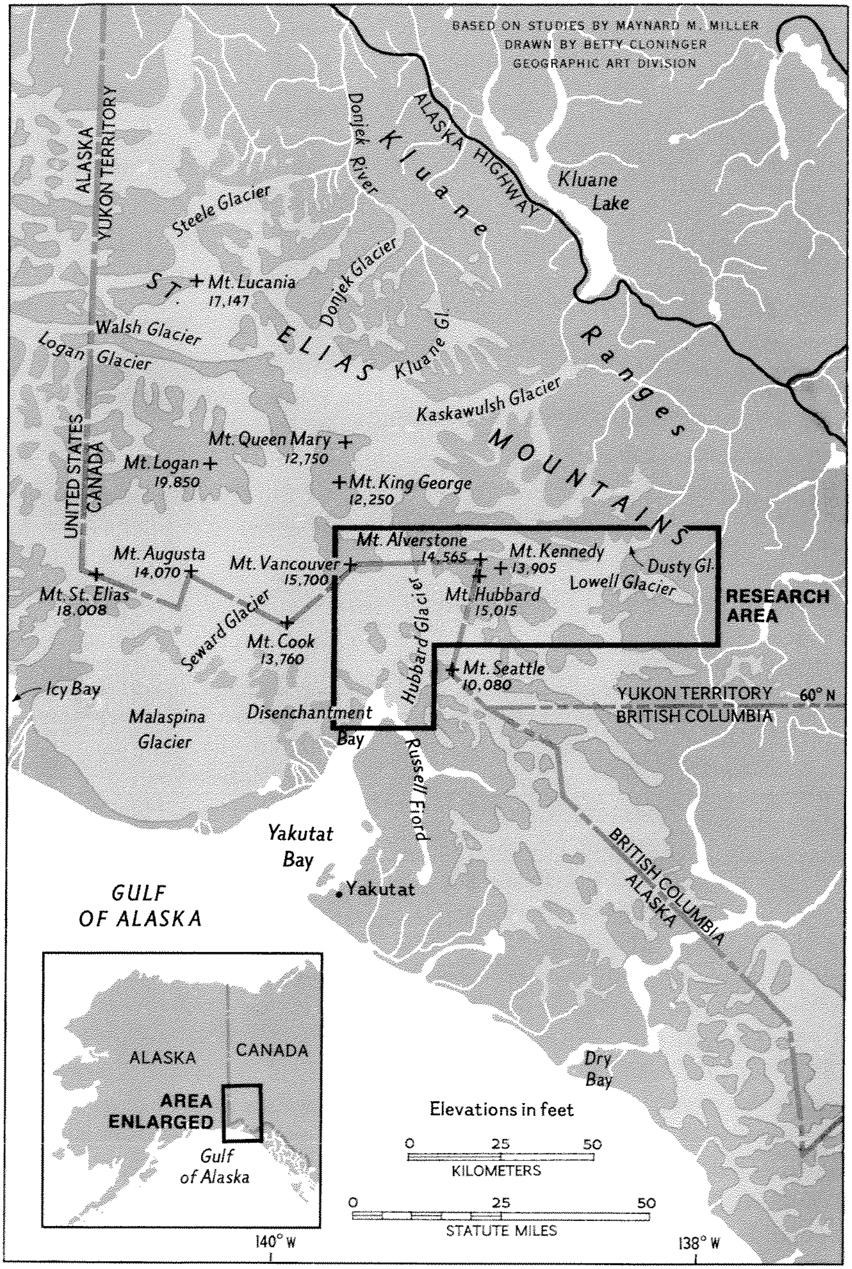


FIG. 2. Map of the Alaska-Yukon region showing the Mounts Kennedy-Hubbard-Alverstone field research area, 1965.

Miller, J. H. Anderson, J. Backe, R. Carlson, C. P. Egan, D. M. Potter, Dr. A. Pearson, S. Hulse, D. Field, and P. Lucier. In addition, excellent help was given in the regional glacier and rock-glacier photography by H. B. Washburn, D. Lietzke, and C. Knight. Particularly helpful in air logistics were Jim Lipinski, Doug Green, and Bill Granley, of Klondike Helicopter Services (Whitehorse); Roy Hepworth, of Falconbridge Mining Company; and Lloyd Ryder and Ron Connelley of the Yukon Flying Service (Whitehorse).

The research program resulted in information generally summarized in this report. Pertinent field data, analyses, and interpretations of glaciological character are incorporated in a more detailed report on the longer-term project. The 1965 information is supplemented by additional observations of glaciomorphological and periglacial nature made between 1966 and 1969, some mention of which is made later in this report with respect to the Dusty Glacier and the Alsek River areas, lying immediately east of Mount Kennedy (fig. 2).

Meteorological Records

General meteorological observations were made at Camp 2, at the 8,000-foot level on upper Cathedral Glacier (fig. 3) over the period March 15-25. Unfortunately, a 30-day Ryan recording thermograph, installed at this site, was buried by blizzard snows and lost. Continuous meteorological records, however, were obtained on a 3-hourly synoptic basis at Camp 1 (base camp) at 4,800 feet on the southwest arm of the Lowell Glacier over the 56-day period, April 5 to May 30, 1965, on which latter date the research party evacuated these camps. Recording-thermograph and maximum-minimum temperature data were subsequently obtained on several check visits to read thermometers and change charts on instruments left at base camp. From these records fairly continuous climatological information was obtained for the 6-month period April-September 1965.

An unusual 16-day record of meteorological data was obtained at Camp 3 (13,400 feet), near the summit of Mount Kennedy, during the last half of May, with simultaneous records taken at Camp 1. Comparison of these data provides a significant vertical profile of late-spring atmospheric conditions over the heart of the St. Elias Mountains. In a subsequent report these will be compared with simultaneous Canadian and American records at government weather stations in Whitehorse, Haines Junction, and Yakutat and as far south as Gustavus in Glacier Bay.

Weather data at the field stations include continuous records of ambient temperature, maximum and minimum temperature, humidity, precipitation, wind direction and velocity, barometric pressure, cloud cover,

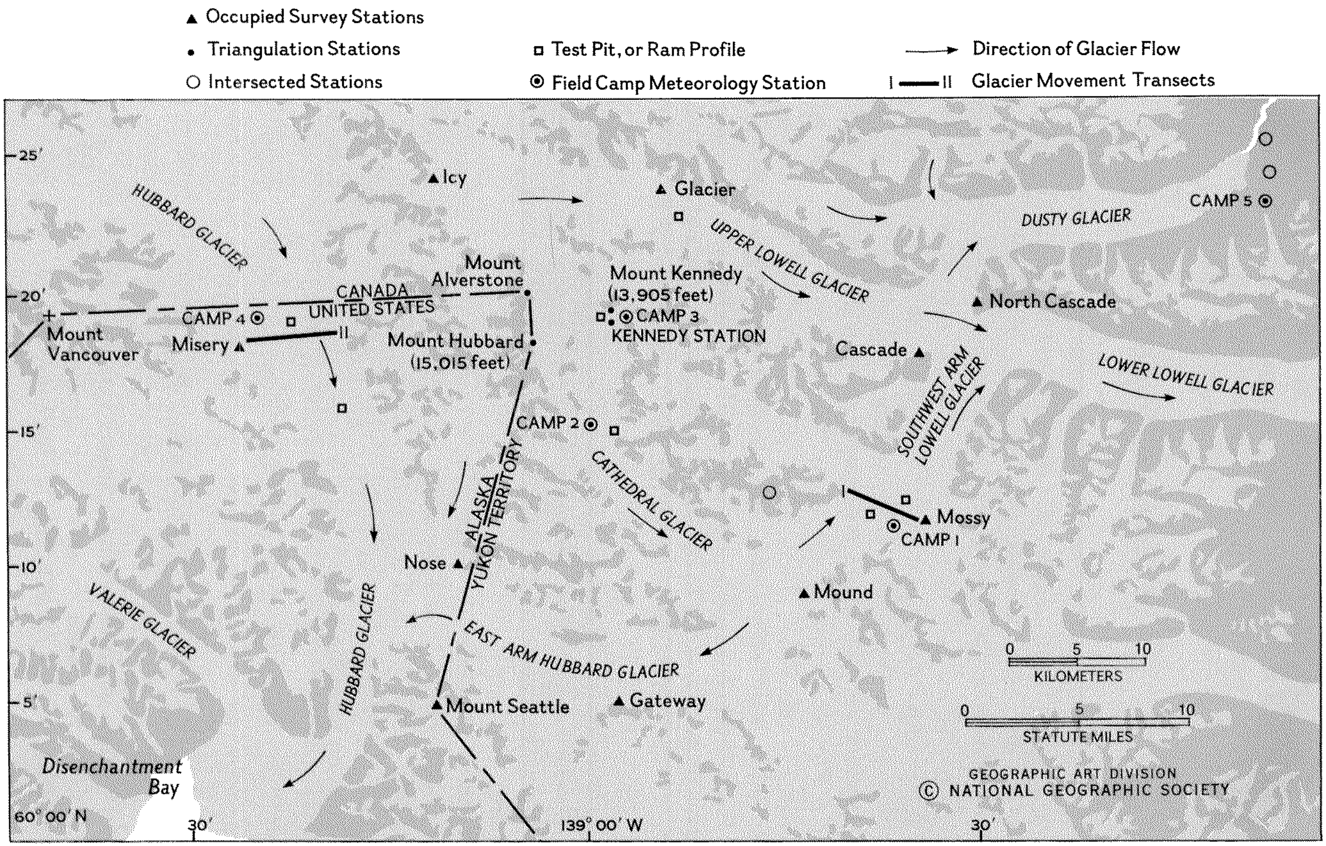


FIG. 3. Glaciological and geological research sites, Mount Kennedy area, 1965.

ceiling and visibility, duration of sunshine, and total sky and solar radiation in langleys. Allied with these are gross accumulation and ablation measurements at Camp 1 and at selected sites on two main glacier movement transects described later with respect to the Lowell and Hubbard Glaciers (fig. 3).

Glaciothermal Studies

Daily englacial thermal conditions were measured on a thermistor cable installed to a depth of 30 feet at Camp 1 early in April. The thermistor spacing was at 5-foot intervals, thus providing significant information on the amelioration of the winter cold wave at the 4,800-foot level on the Lowell Glacier. These data are useful for comparison with records obtained at the 6,000-foot level on the Seward Glacier, west of Mount Kennedy, by an Arctic Institute expedition in the summer of 1948 and with subsequent Arctic Institute records obtained in more recent years at the Icefield Ranges Research Project station of the upper Kaskawalsh Glacier, 100 miles to the north (Wood, 1969). They may also be correlated with the weather records from the Kaskawalsh camp obtained during this same spring of 1965. Further comparisons will be made with englacial and surface temperature measurements on the Taku Glacier of the Juneau Icefield (fig. 1) at comparable 4,000- 7,000-foot levels in the 1950's and through the 1960's (see Miller, 1965, 1969). The glaciothermal data, only partially integrated to date with the meterological records at Camp 1, suggest the geophysical character of the Lowell Glacier to be essentially Temperate at low elevations and in a sub-Temperate glaciothermal state at elevations above approximately 6,000 feet.

Englacial temperatures were also measured in the ice cave at the 13,400-foot level on Mount Kennedy. Here, during May, the ice remained persistently at $-10°$ C. at a depth of 3 meters. The glacier at this height may thus be considered as sub-Polar, whereas at Camp 2 (8,000 feet) it is deemed to be trending toward a sub-Temperate character. On the summit of Mount Hubbard (ca. 15,000 feet) the conditions are extrapolated as geophysically Polar in character, that is, with englacial temperatures remaining persistently well below freezing even during the summer months.

Test Pits and Snow Profiles

A sequence of snow profiles obtained on walls of test pits at Camp 1 was obtained at 2-week intervals for comparison with similar data on other glaciers in the Alaska-Canada Boundary Ranges. The main test pit was dug in mid-April to a depth of 20 feet. This site was flown over and photographed in mid to late September in 1965, 1966, and 1969. On each occasion the firn pack at the 4,800-foot level had ablated out, revealing a negative mass budget regime below this level.

Snow profiles were also taken by Rammesonde. These included profiles at the middle stake of the main movement transect on the Southwest Arm of the Lowell Glacier and at survey Station Glacier (5,000 feet) on the North Arm of the Lowell Glacier; as well as on the main cross transect at 5,500 feet east of Station Misery and Camp 4 on the upper Hubbard Glacier (fig. 3).

Glacier Movement Stake Surveys

Across-glacier movement transects were surveyed on two lines of flagged stakes (14 feet high). The first was extended across the Southwest Arm, Lowell Glacier, northward toward Mount Kennedy from Station Mossy (fig. 3). The second line of 11 flagged stakes was set on a line eastward across the upper Hubbard Glacier from Station Misery and Camp 4. These transects are denoted as Movement Profile I (Southwest Arm, Lowell Glacier, mean transect elevation 4,800 feet) and Movement Profile II (main upper Hubbard Glacier, mean transect elevation, 5,500 feet). The first and second surveys on Profile I were taken in April and May and repeated on July 15. The initial surveys on Profile II were taken in mid-May and repeated late in May and again on July 15, thus providing two to three months of record for the computation of daily movement velocities and directions. Velocities of upward of 6 to 10 feet per day in the center of the Hubbard Glacier at this elevation are indicated by preliminary calculations.

Geological Observations

During the course of the mapping and survey program, rock samples were collected at or near each of the main triangulation stations, including Mossy, Gateway, Nose, Misery, Icy, Cascade, and North Cascade (fig. 3). In each case the lithologies were predominantly metamorphic, with various degrees of metamorphism in limestone, slate, and pelites. Samples were obtained also from bedrock outcrops at the northern end of Movement Profile I and from both the western and eastern ends of Movement Profile II. Additionally, samples of granodiorite were collected at Station Kennedy (13,400 feet, see fig. 4), the main high-elevation survey site on the Mount Kennedy summit plateau.

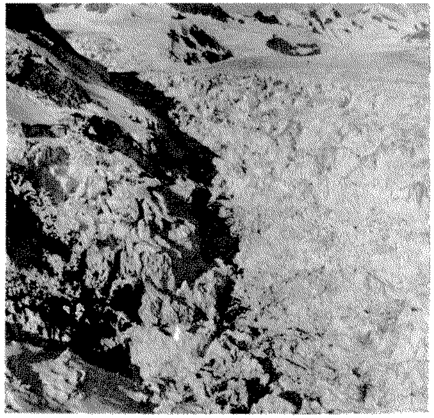




FIG. 4 *(left)*. Paul Swift of U. S. Coast and Geodetic Survey beside T-3 theodolite using signal mirror at Station Kennedy, elevation 13,400 feet. Station benchmark drilled into granodiorite outcropping. Photo by M. M. Miller, May 1965.

FIG. 5 *(center)*. Marginal shear zone and increased crevassing on upper Dusty Glacier at about 6,000 feet elevation. View toward northwest in September 1965. Photo by M. M. Miller.

FIG. 6 *(right)*. Main upper névé zone of Dusty Glacier at 8,000 feet showing marked increase in crevasses as of mid-September 1965. Photo by M. M. Miller.

A large number of ground and aerial photographs of the complex geology exposed on all flanks of Mount Kennedy and Hubbard were obtained for future reference. In general, the area is characterized by intensely warped and folded fault-block structures (basin and range morphology), with the higher ridges comprised of granitized and migmatized units, laced with pegmatite, aplite, and dolerite intrusions. The depression areas of course are flooded with ice. The bedrock sequence where it is visible grades from dominantly migmatic units in the overturned and highly folded and irregularly granitized rocks of the highland (fig. 5) to the lower-grade metamorphics and more gentle structures exposed more fully on the eastern and western flanks of the St. Elias Mountains. Bedrock which outcrops in the Nunatak ranges or central massifs of these mountains is extremely complex and difficult to map because of the high elevation and precipitousness of the terrain as well as the excessive ice cover.

The main western wall of Mount Hubbard is a fault scarp, with upward of 10,000 feet of bedrock exposure. This fault zone parallels the main Hubbard Glacier trench and extends southwest toward Mount Seattle (11,000 feet), the east flank of which also represents a fault scarp as, indeed, does the east wall of Mount Vancouver (15,700 feet). This suggests that the main Hubbard Glacier here flows in a graben depression. Certainly, the region is one of active present tectonic activity. Eventually resurveys of the key control points of the Mount Kennedy map should be made in the next several hundred years, as they may reveal notable changes in vertical and horizontal position. The now-established precise elevation of the brass bench mark that we imbedded in granite at the first-order second-rank control station near the summit of Mount Kennedy thus can have added long-term scientific significance.

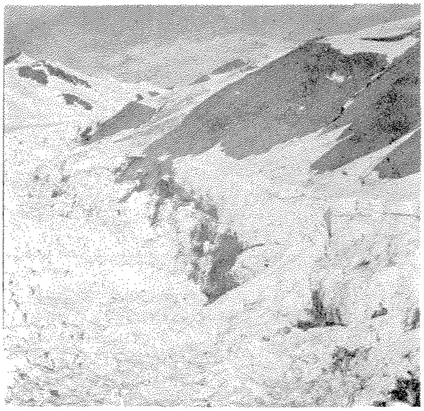
Main Lowell Glacier-Dusty Glacier Geomorphological Survey and Deformation Studies

A series of aerial flights along the valleys of the Dusty and Lowell Glaciers, not only in 1965 but each summer through 1969, has revealed remarkable marginal shearing, especially on the main Dusty Glacier where the ruptured zones extended to the top of the upper névé basin. The pulverized and highly twisted appearance of this glacier's surface which we photographed in 1965 was comparable to that reported subsequently on other surging Alaskan glaciers.

During April and May 1965, and again later (see below), our aerial reconnaissance flights over the Dusty Glacier, from its terminus to its source area a few miles east of Mount Kennedy, revealed for the first time that a major surge, with attendant increase in crevassing, had been in force for some months throughout the length of the glacier (figs. 5,6). The margins of the upper half of the glacier, especially the main northwest sector, were seen to be undergoing an accentuated surging condition, being severely sheared and manifesting a maximum Block-Schollen or plug flow characteristic. Included with this was an association of tumbled ice blocks, seracs, pinnacles, and large detached segments left hanging on valley walls (figs. 7,8). This was comparable to those photographed in 1966 during our air surveys of the surging Steele Glacier some miles to the north. In 1965 the Dusty Glacier terminus too was advancing vigorously and at the time forming a large terminal push moraine. The structural and geomorphic effects of this surge, and evidences for earlier surges of several tributary glaciers in this system, were documented in the June, July, and September 1965 aerial photographs (e.g., see fig. 9). Because of the small névé areas involved in each sector of this glacier system (fig. 6), the effects are suggested to have some relationship to the Alaskan coastal earthquakes of 1958 or 1964, indeed possibly both. Furthermore, the aerial photography performed in September each year since 1965 has proved that a rather abrupt slowdown was under way by mid-1966, with a complete cessation of surge effects by 1968 and a strong down-wasting under way by 1969.

During September 1965 a field camp (Camp 5) was set up at the Dusty Glacier terminus close to the valley train and where four photosurvey stations were established (fig. 10). Here a study was carried out to determine any unique characteristics of surge moraines for comparison with several distinct and arcuate down-valley moraines of earlier vintage, as well as with associated proglacial features. The multiple moraine sequence outside of the 1965 surge limit includes the following: (1) A fresh-appearing and unweathered push moraine with lateral segments quite distinct along the north wall of the valley, and less conspicuous on the south flank (willow discs suggest pre-1945); (2) an older, poorly developed, and relatively thin moraine line, with trimline correlates on the valley flanks (spruce ring discs reveal this moraine probably established at or before 1925); (3) a double moraine, well developed (dubbed the Bear Moraine) and with trimline correlates on the north valley flank—dendrochronologic evidence suggests as established at or before 1895. Some isolated evidences were also found of older moraine remnants and ice limits (possibly pre-Neoglacial), but these are difficult to fit into any connected pattern (Miller, Egan, and Hulse, 1968).

A large number of spruce discs were taken, as well as tree-ring cores in the vicinity of the terminus (fig. 11). These give some clues to the recent trends in regional climate. In this regard there was very slow tree growth



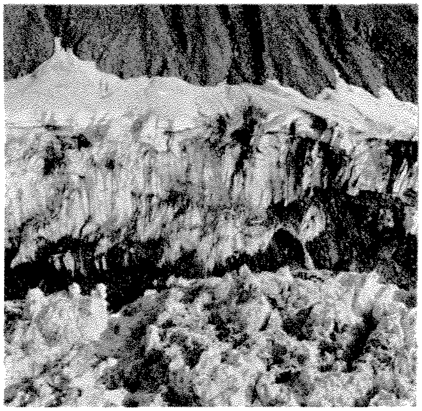


FIG. 7 *(left)*. Northeastern edge of upper Dusty Glacier at 7,000 feet showing lowering of main glacier surface in consequence of surge. Note remnant rim of ice still clinging to valley wall. September 1965.

FIG. 8 *(right)*. Detached northern margin of middle Dusty Glacier at 4,500-foot level in mid-September 1965, showing same effect illustrated in figure 7. Photos by M. M. Miller.

in this valley until 1923 or so, with a slight increase in growth up to about 1935. Subsequent growth to the early 1960's was rapid, implying some increased wetness in this area over the previous 30 years. These relationships may be significant in understanding recent trends in the regional glacier pattern.

Aerial photography that was repeated on this terminus in September 1966, and further photographs from the air and on the ground in the autumn of 1967 and 1968 and from the air in September 1969, have much aided our interpretations. The convexly oversteepened ice cliffs observed at the terminus and lower lateral areas in September 1965 (fig. 10) by September 1966 had become concave in cross profile and considerably thinned, indicating marked slowing down of the surge effects at the terminus in this intervening year. The terminal surge had completely petered out by October 1968 and was nowhere in evidence even in the upper reaches of the glacier by late September 1969. In contrast, on September 24, 1969, the Lowell Glacier's terminal zone was photographed and found to have developed all characteristics the Dusty Glacier terminus had displayed in 1965. In fact, its chaotic and broken surface was in full flood and crowding well forward across the Alsek River, threatening to create an ice dam and impound a lake upstream, a situation which trimline and strandline evi-

FIG. 9. Oblique view looking west up lower Dusty Glacier showing pronounced surge effects with attendant deformation of medial moraines and new crevassing. Photo by M. M. Miller, September 1965.

dences show had previously taken place in the mid-18th century. The surge effect is a delayed response in this much longer and larger glacier, which is fed by a tributary adjacent to the upper Dusty Glacier. This is significant because the main surge on the Lowell Glacier has affected only that portion nourished by the upper Lowell Glacier lying north and west of Station Cascade (fig. 3). It is this area that is contiguous with the upper Dusty Glacier. Thus the causal factor is presumably the same that affected the Dusty Glacier terminus in the mid-1960's. In 1969 a further condition of significance was photographed from the air on the Southwest Arm of the Lowell Glacier in the area of Camp 1 (fig. 3). This was a notable increase in crevassing compared to conditions found there in 1965.

The contrast is heightened by the observed 1965 to 1968 condition of the terminus of the Lowell Glacier, which had till then continued slow down-wastage and retreat, at least since the 1920's.

Investigation of Rock Glaciers in the Dezadeash Sector of the Kluane Ranges, East of Mount Kennedy

A number of rock glaciers occur in easterly-facing valleys of the Kluane Ranges, which flank the main Saint Elias Mountains west of the Haines Road in southwestern Yukon Territory. A 1965 reconnaissance of a dozen of these by air, and of two on the ground (fig. 12), followed by further

FIG. 10. View northeast and down valley across advancing terminus of Dusty Glacier in mid-September 1965, showing effects of catastrophic surge as ice shears forward and overrides valley train deposits. Older moraine limits visible at edge of dark outwash in middle distance. Photo by M. M. Miller.

FIG. 11. J. H. Anderson extracting spruce cores with increment borer for dendrochronology study of recent climatic conditions near Dusty Glacier terminus. Photo by M. M. Miller, September 1965.

observations in each summer through 1970, have yielded information that underscores their potential in interpretation of Holocene climatic variations in this region (i.e., since 10,000 B.P.).

Ground studies have been focused on two well-developed prototype rock glaciers in this sequence, respectively 1 and 4 miles north of Beloud Post on Dezadeash Lake (lat. 60°27′N., long. 137°5′W.). On the first, along its longitudinal axis, there are four or five discrete morphogenic segments. In an up-valley direction from the terminus, each segment is of successively younger age. A striking pattern of arcuate wave-banding characterizes the oldest segment in the terminal zone of each (fig. 13). In plan view, this is not unlike arched wave-banding (wave-ogives) in alpine glaciers.

Two dominant and relatively quiescent morphogenetic zones occur in the lower half of these glaciers (Miller and Anderson, 1968). A more recently active thrust zone is observed in the provenance sector, allied with modern glacial rubble at the head of each valley. The sequence is represented by (1) a terminal (oldest) zone of stabilized and weathered felsitic and arenaceous rubble, the individual rocks being rather blocky and rectilinear in form; (2) an intermediate (younger) zone of much less weathered "felsites," partially stabilized and with mixed metasedimentary clastics; (3) an upper (youngest) zone of unweathered, actively moving, friable rubble; and (4) an associated recent to subrecent terminal moraine and protalus embankments (in some of the valleys with glacial ground moraine). In

FIG. 12. Terminal zone of rock glacier 1 mile north of Beloud Post in the Dezadeash area east of Mount Kennedy showing angular nature of rock fragments and crevassing. Photo by M. M. Miller, September 1965.

several instances, the rock glaciers grade upward into V-form valleys, with the fifth zone (5) represented by existing glaciers and associated Neoglacial morainic material at their head. The upper three zones continue to be contaminated by mixing of mass wastage material derived from the higher valley walls.

The terminal zones are bulbous and flanked by afforested deposits of older glacial till. The glaciers vary in length from 2 to 5 miles and are one-quarter to one-half mile wide. The slope gradient of the southernmost prototype (i.e., on the top surface of the lowermost zone) has a mean of 10°.

Material on the flanking slopes lies at the lowest angle of repose (30° to 33°). The intermediate zone has a mean gradient of 15° in the top surface, with the flanking slopes at a maximum angle of repose (35° to 38°). Flanking slopes of the highest zone in many places are actively sliding at gradients above the angle of repose. The surface of each zone exhibits not only the wave-banding phenomena but also evidences of discontinuous faultlike displacements and crevassing (fig. 12) suggesting the possibility of an ice core.

The following main mass wastage processes are operative in the activated higher zones and in the recent past have been operative in the more stabilized lower zones: (a) primary talus-creep and rolling sliding mass movements on oversteepened margins; (b) subsidence and settling-slumping deformation on the main low-gradient benches, accentuated by removal of footings through the sliding processes dominant on the flanks; and (c) over-all mass creep, probably with periodic variations in longitudinal stress imposed by overriding of the higher zones and which may relate to development of the wavelike bulges.

The coarseness and platy fragmental character of the rubble (fig. 12) apparently play a role in the over-all process. It suggests minimum effects from annual variations in interstitial ice, although spotty areas of permafrost are known in this sector of the Alaska-Yukon. (For example, permafrost was found at a depth of 50 feet in a recently driven well at Cortino's Lodge above and adjacent to Dezadeash Lake). The absence of fines in this rubble is attributed to removal by percolating water and to some extent by wind. Such fluvial and aeolian processes are known to be particularly effective in adjoining valleys of the St. Elias Mountains. It may be pertinent that an abnormally shallow sector of Dezadeash Lake lies immediately below this rock glacier, suggesting a significant outwash and deposition of fines.

Processes (a), (b), and (c) are considered to affect zones (2) and (3). Process (c) is the only one affecting zone (1), with, in fact, such activity now practically nil. In another century this lower zone will likely become covered with the encroaching forests of aspen, which characterize the flanking till-slopes in this dry, subcontinental climate.

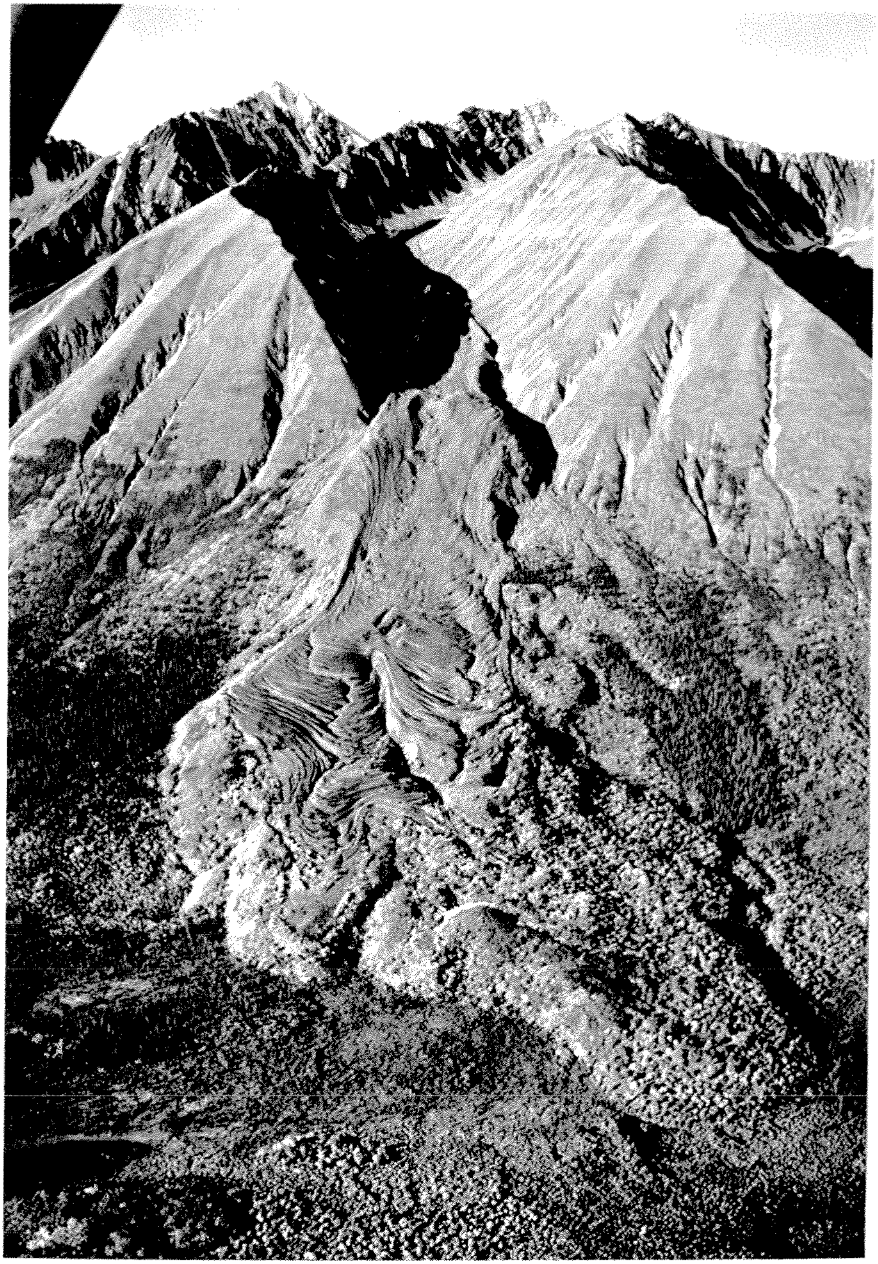


FIG. 13. Aerial view of Dezadeash rock glacier 4 miles north of Beloud Post. Note truncation of late Pleistocene lateral moraines normal to rock-glacier axis near timberline. Photo by M. M. Miller, September 1965.

Although there is a notably fragmental character to the rubble a few rounded boulders occur in the intermediate zones and at higher levels, suggesting some fluvioglacial effects out of the upper basins. In the active provenance zone mixed frost-shatter and glacial action appear to characterize the originating process. The dominant platy character of most fragments, however, is considered to be a primary factor in accentuating the creep process.

The rock glaciers truncate late Pleistocene main-valley lateral moraines in this region (fig. 13). Also a well-developed lichen flora occurs on the lower two morphogenetic segments. All evidence indicates that these unique mass wastage features are periglacial in character and have been in the process of continuous development since mid-Thermal Maximum time. Provisionally zone (1) is ascribed to waning glacial conditions just prior to the Thermal Maximum and hence of early Holocene time; zone (2) to the development of waxing Neoglacial conditions following the Thermal Maximum; and zones (3), (4), and (5) to less severe later Neoglacial environmental (climatic) fluctuations. There are many open questions, however, and field studies are being continued. In these, movement survey stakes, phototheodolite mapping techniques, soil science, and botanical quadrat and lichenometric and dendrochronological approaches are being invoked.

Regional Aerial Glacier Surveys in the Mount Kennedy Area

In the late summers of 1965, 1966, 1967, 1968, and 1969 a number of aerial photographs were obtained to aid in evaluation of the regime of other glaciers in this interior region. The area of concern extends northward to Mount Lucania and southward to the bordering ranges of the Alsek River. The photographs provide a regional picture of the situation in a way not possible from the ground. It is of interest that in the mid to late 1960's apparently only the Dusty, Lowell, and Steele Glaciers have experienced major surges on the interior flanks of the St. Elias Mountains, although the Butler, Turner, Variegated, Walsh and several other glaciers on the maritime flanks of these mountains exhibited strong surge effects during the early to mid-1960's. This aspect of the study has been reported in more detail elsewhere (Miller, 1965, 1971).

REFERENCES

MILLER, MAYNARD M.

1965. The Alaskan Glacier Commemorative Project. Proc. 16th Alaska Sci. Conf., AAAS, pp. 107-108.

1969. The Alaskan Glacier Commemorative Project, Phase I. Nat. Geogr. Soc. Res. Rpts., 1964 Projects, pp. 135-152, illus.

1971. The Alaskan Glacier Commemorative Project, Phase II. Nat. Geogr. Soc. Res. Rpts., 1965 Projects, pp. 181-194, illus.

MILLER, MAYNARD M., and ANDERSON, J. H.

1968. Rock glaciers of the Dezadeash District, St. Elias Mountains, Yukon Territory, Canada. Proc. 19th Alaska Sci. Conf., AAAS, pp. 45-56.

MILLER, MAYNARD M., and CHRZANOWSKI, ADAM

1968. A joint U.S.-Canadian memorial project—The Mount Kennedy map, St. Elias Mountains, Alaska-Yukon. *In* "Science in the North," abstracts of papers presented at the 19th Alaska Science Conference, Whitehorse, Y.T., August 1968, Abstract no. 3, 1 p.

MILLER, MAYNARD M.; EGAN, CHRISTOPHER P.; and HULSE, S.

1968. 1965-69 studies of surge activity and moraine patterns on the Dusty Glacier, St. Elias Mountains, Yukon Territory. Proc. 19th Alaska Sci. Conf., AAAS, pp. 47-48.

WASHBURN, BRADFORD

1971. The mapping of Mount Hubbard and Mount Kennedy, 1965. Nat. Geogr. Soc. Res. Rpts., 1965 Projects, pp. 249-277, illus.

WOOD, WALTER A.

1969. The Alaska-Yukon Icefield Ranges Research Project, 1964, 1965, and 1966. Nat. Geogr. Soc. Res. Rpts., 1964 Projects, pp. 257-261.

MAYNARD M. MILLER