DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

BULLETIN 526

COASTAL GLACIERS
OF
PRINCE WILLIAM SOUND AND KENAI PENINSULA
ALASKA

BY

U. S. GRANT AND D. F. HIGGINS

WASHINGTON
GOVERNMENT PRINTING OFFICE
1913

CONTENTS.

	Page.
Introduction	7
Scope of this report	7
Earlier explorations	8
Maps of the glaciers	9
Photographs of the glaciers	10
Glaciers of Prince William Sound	11
Port Valdez	11
General features	11
Valdez Glacier	12
Shoup Glacier	15
Columbia Glacier	18
Unakwik Inlet	25
General features	25
Meares Glacier	25
Port Wells	26
General features	26
College Fiord	27
General features	27
Yale Glacier	27
Harvard Glacier	29
Smith Glacier	30
Bryn Mawr Glacier	31
Vassar Glacier	31
Wellesley Glacier	32
Harriman Fiord	33
General features	33
Barry Glacier	34
Serpentine Glacier	35
Baker Glacier	35
Surprise Glacier	36
Cataract Glacier	36
Harriman Glacier	37
Dirty Glacier	37
Toboggan Glacier	38
Passage Canal	40
Blackstone Bay	41
General features	41
Tebenkof Glacier	42
Blackstone Glacier	43
Port Nellie Juan	45
General features	45
Ultramarine Glacier	45
Nellie Juan Glacier	46
Falling Glacier	46
Taylor Glacier	46

	Page.
Glaciers of Prince William Sound—Continued.	
Icy Bay	47
General features	47
Princeton Glacier	49
Chenega Glacier	49
Tiger Glacier	50
Bainbridge Glacier	50
Glaciers of the southern shore of Kenai Peninsula	52
Cape Puget to Cape Resurrection	52
Puget Glacier	52
Excelsior Glacier	53
Ellsworth Glacier	53
Resurrection Bay	54
Thumb Cove glaciers	54
Godwin Glacier	55
Bear Glacier	56
Aialik Bay	57
General features	57
Aialik Glacier	58
Pederson Glacier	58
Holgate Glacier	59
Northwestern Glacier	60
Two Arm Bay	61
Nuka Bay	62
General features	62
McCarty Glacier	62
Split Glacier	64
Yalik Glacier	65
Petrof Glacier	66
Port Dick	67
Kachemak Bay	68
Summary	68
Index	73

Page.

PLATE XXX. *A*, Ice front, push moraine, and dead trees at north side of front of Bainbridge Glacier; *B*, Puget Glacier.......... 51
XXXI. *A*, Ellsworth Glacier; *B*, East part of front of Bear Glacier...... 56
XXXII. *A*, West part of front of Bear Glacier; *B*, North part of front of Aialik Glacier.......... 57
XXXIII. Map of upper part of Aialik Bay.......... 58
XXXIV. *A*, South part of front of Aialik Glacier; *B*, North part of front of Pederson Glacier.......... 58
XXXV. *A*, Holgate Glacier; *B*, Northwestern Glacier.......... 59
XXXVI. Front of Northwestern Glacier: *A*, East part; *B*, West part..... 60
XXXVII. Front of McCarty Glacier: *A*, East part; *B*, Central part....... 62
XXXVIII. *A*, West side of McCarty Glacier; *B*, Split Glacier.......... 63
XXXIX. *A*, East part of front of Yalik Glacier; *B*, East part of front of Petrof Glacier.......... 66
XL. *A*, West part of front of Petrof Glacier; *B*, Small ridges in front of Petrof Glacier.......... 67

FIGURE 1. Map of Valdez and vicinity.......... 11
2. Map of Shoup Bay and Shoup Glacier, Port Valdez.......... 16
3. Map of Meares Glacier and head of Unakwik Inlet.......... 26
4. Map of northern part of College Fiord, Port Wells.......... 28
5. Map of Blackstone Bay.......... 43
6. Map of Icy Bay.......... 48
7. Map of front part of Bainbridge Glacier.......... 51
8. Sketch map of Puget Glacier and head of Puget Bay.......... 53
9. Sketch map of Ellsworth Glacier and head of Day Harbor.......... 53
10. Sketch map of Thumb Cove glaciers, Resurrection Bay.......... 55
11. Map of front part of Bear Glacier.......... 56
12. Sketch map of front part of Northwestern Glacier.......... 61
13. Map of front part of McCarty Glacier.......... 63
14. Diagrammatic cross section of west side of McCarty Glacier....... 63
15. Map of front part of Split Glacier.......... 64
16. Diagrammatic cross section of front edge of Split Glacier.......... 65
17. Sketch map of front part of Yalik Glacier.......... 65
18. Sketch map of front part of Petrof Glacier.......... 66

ILLUSTRATIONS.

		Page.
PLATE I.	Reconnaissance map of Prince William Sound	In pocket.
II.	Reconnaissance map of the southern part of Kenai Peninsula	In pocket.
III.	*A*, Valdez Glacier from the southwest; *B*, Delta of Valdez Glacier and Lowe River	12
IV.	*A*, Center of front of Valdez Glacier; *B*, West edge of front of Valdez Glacier	13
V.	*A*, North part of front of Shoup Glacier; *B*, South part of front of Shoup Glacier	16
VI.	Map of Columbia Bay and front of Columbia Glacier	18
VII.	West part of front of Columbia Glacier: *A*, June 27, 1899; *B*, June 24, 1909	18
VIII.	Edge of Columbia Glacier: *A*, June 26, 1899; *B*, July 10, 1905	18
IX.	Edge of Columbia Glacier: *A*, July 15, 1908; *B*, June 24, 1909	19
X.	*A*, Columbia Glacier invading forest; *B*, Push moraine at front of Columbia Glacier	20
XI.	*A*, West part of front of Columbia Glacier; *B*, East part of front of Columbia Glacier, bare zone, and overturned forest	22
XII.	*A*, East part of front of Columbia Glacier, terminal moraine, and remnant of forest; *B*, Meares Glacier, Unakwik Inlet	23
XIII.	*A*, East part of front of Yale Glacier; *B*, Center and west part of front of Yale Glacier	28
XIV.	*A*, West part of front of Harvard Glacier; *B*, East part of front of Harvard Glacier	30
XV.	*A*, Harvard Glacier; *B*, Bryn Mawr Glacier	30
XVI.	*A*, West side of College Fiord; *B*, Bryn Mawr Glacier from end of College Point	31
XVII.	Map of Harriman Fiord, Port Wells	34
XVIII.	Panorama of west side of Harriman Fiord	34
XIX.	East part of front of Barry Glacier: *A*, August 20, 1905; *B*, June 29, 1909	34
XX.	Center and west part of Barry Glacier: *A*, August 20, 1905; *B*, June 29, 1909	35
XXI.	*A*, Baker Glacier; *B*, Surprise Glacier	36
XXII.	*A*, Cataract Glacier; *B*, East part of front of Harriman Glacier	37
XXIII.	*A*, Toboggan Glacier; *B*, West part of front of Tebenkof Glacier	38
XXIV.	*A*, East part of front of Tebenkof Glacier; *B*; Split Glacier	42
XXV.	Map of Port Nellie Juan	46
XXVI.	*A*, Front of Nellie Juan Glacier; *B*, West side of Nellie Juan Glacier	46
XXVII.	*A*, Chenega and Princeton glaciers; *B*, Tiger Glacier	48
XXVIII.	Front of Chenega Glacier: *A*, North part; *B*, South part	49
XXIX.	*A*, Front of Bainbridge Glacier; *B*, South part of front of Bainbridge Glacier	50

COASTAL GLACIERS OF PRINCE WILLIAM SOUND AND KENAI PENINSULA, ALASKA.

By U. S. Grant and D. F. Higgins.

INTRODUCTION.

SCOPE OF THIS REPORT.

During the summer of 1905 the senior author and Sidney Paige were engaged in a study of the ore deposits and the general geology of Prince William Sound. This work was continued in 1908 for a few weeks by both the present authors, who in 1909 extended it to the southern part of Kenai Peninsula. In these three field seasons the whole shore line of Prince William Sound (except that of some of the islands) and of Kenai Peninsula from Portage Bay to Seldovia Bay of Cook Inlet was examined. In the course of this work all the tidewater glaciers and many others near tidewater were seen and some notes, photographs, and maps were made of all the tidewater glaciers and of many of the others. This work was hurriedly done and was secondary to the study of the bedrock geology and the ore deposits; nevertheless it is thought worth while to put on record the information thus obtained regarding the glaciers, for it will afford a basis for future study of the fluctuations of these ice streams.

This paper, then, is not expected to make many additions to the large amount of scientific material concerning the problems of glaciers and glaciation that is already available, but it is intended to supply some definite information regarding the present positions of the fronts of the glaciers and the more evident facts of their fluctuations. Moreover, it is hoped that this publication may attract attention to some of the most magnificent American scenery that is now accessible to the tourist and nature lover. Except the Columbia Glacier, the glaciers of Port Wells, and possibly one or two others, the ice streams here considered had not been figured nor described before this study was undertaken.

In the first season of field work, in 1905, information concerning the Valdez, Shoup, Columbia, and Meares glaciers and some of the glaciers of Port Wells was obtained. In 1908 the Valdez, Shoup, Columbia, and Barry glaciers were again visited, and the glaciers of Port Nellie Juan, Icy Bay, and Port Bainbridge were mapped. The small glaciers above Thumb Cove of Resurrection Bay also were visited and sketched. In 1909 all the tidewater glaciers of the northern shore of Prince William Sound from Port Valdez westward to and including Blackstone Bay and all the glaciers of the southern shore of Kenai Peninsula discussed in this report, except those at the head of Thumb Cove of Resurrection Bay, were visited and mapped.

Since beginning this work the authors have prepared small-scale maps on which the positions of the fronts of a number of these glaciers are shown.[1] Most of these maps, however, are drawn on too small a scale to show in much detail the positions of these glacial fronts. Brief descriptions of some of the more important glaciers discussed in this report have been published recently.[2]

EARLIER EXPLORATIONS.

The earliest explorers of Prince William Sound and Kenai Peninsula gave little information concerning the glaciers; in fact, glaciers as such were not known to them. Cook[3] in 1778 and especially Vancouver[4] in 1794 explored much of the above district, and some of their maps and descriptions show that certain of the bays or fiords were ended by vertical walls of ice, from which blocks fell into the sea.

Dall[5] visited Kachemak Bay of Cook Inlet in 1880, in 1892, and in 1895, and studied especially the Grewingk Glacier. The results of his mapping of this glacier were incorporated in charts of the United States Coast and Geodetic Survey.

The more recent explorations of this district by geologists of the United States Geological Survey were begun by Mendenhall[6] and Schrader[7] in 1898, but the varied interests of their expeditions allowed little attention to be paid to the glaciers.

In 1899 the Harriman Alaska Expedition visited Prince William Sound and described the Columbia Glacier and the glaciers of Port Wells. These descriptions were written by Gilbert[8] and form the chief published source of information concerning the glaciers of

[1] Bull. U. S. Geol. Survey No. 284, 1906, p. 79; No. 379, 1909, Pl. IV, and p. 100; No. 442, 1910, Pl. III; No. 443, 1910, Pl. II.

[2] Grant, U. S., and Higgins, D. F., Glaciers of Prince William Sound and the southern part of the Kenai Peninsula, Alaska: Bull. Am. Geog. Soc., vol. 42, 1910, pp. 721–738; vol. 43, 1911, pp. 321–338, 401–417, 721–737.

[3] Cook, James, A voyage to the Pacific Ocean undertaken by the command of His Majesty for making discoveries in the northern hemisphere, etc., in 1776–1780, 3 vols., London, 1784.

[4] Vancouver, George, Voyage of discovery to the North Pacific Ocean, etc., in 1790–1795, 3 vols., London, 1798.

[5] Dall, W. H., Bull. Philos. Soc., Washington, vol. 6, 1884, pp. 33–36; Bull. U. S. Geol. Survey No. 84, 1892; Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, p. 789.

[6] Mendenhall, W. C., A reconnaissance from Resurrection Bay to the Tanana River, Alaska, in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 265–340.

[7] Schrader, F. C., A reconnaissance of a part of Prince William Sound and the Copper River district, Alaska, in 1898: Idem, pp. 341–423.

[8] Gilbert, G. K., Glaciers and glaciation: Alaska, vol. 3, Harriman Alaska Expedition, 1904.

Prince William Sound. No attempt has been made to duplicate these excellent descriptions in the present paper.

In 1904 Davidson [1] published a list, accompanied by notes and maps, of the coastal glaciers of Alaska. Brooks,[2] in his description of Alaskan geography and geology, has made mention of the glaciers of this district; Reid [3] has contributed some notes on the variations of Alaskan glaciers; and Tarr and Martin [4] studied the Valdez, Shoup, and Columbia glaciers in 1909.

MAPS OF THE GLACIERS.

Most of the older maps of Prince William Sound and Kenai Peninsula are on a scale so small and are so generalized that they furnish very little information concerning the actual positions of glacial fronts at the dates on which the maps were made. They are thus of little aid in determining historic positions of the fronts of the glaciers and could not furnish a basis for a study of glacial fluctuations unless the fluctuations amounted to several miles—a maximum not reached in historic times by the glaciers under discussion. Cook mapped Prince William Sound and Kenai Peninsula in 1778, but his map is on a very small scale. Vancouver's maps of 1794 and Tebenkof's of 1852, the latter following closely those of Vancouver, furnished the basis for most of the maps of this district up to the end of the nineteenth century. Recently the work of the United States Coast and Geodetic Survey has given accurate delineations of parts of Prince William Sound and Kenai Peninsula, but very considerable portions of the coast line have not yet been mapped by this organization. Unfortunately for our purposes, the fronts of only two tidewater glaciers, the Shoup of Port Valdez and the Bear of Resurrection Bay, have been thus mapped. The maps of the Columbia Glacier and of the glaciers of Port Wells published by the Harriman Alaska Expedition [5] were the first to show details of these glaciers. The United States Geological Survey has issued maps showing in some detail the positions of the fronts of some of the glaciers of Prince William Sound, especially those of the Shoup and Valdez glaciers.[6]

Thus at the beginning of the present study of the glaciers of Prince William Sound and Kenai Peninsula there was available detailed information concerning only the Valdez, Shoup, Columbia, and

[1] Davidson, George, The glaciers of Alaska that are shown on Russian charts or mentioned in older narratives: Trans. and Proc. Geog. Soc. Pacific, 2d ser., vol. 3, 1904, pp. 1–98, 11 maps.

[2] Brooks, A. H., The geography and geology of Alaska: Prof. Paper U. S. Geol. Survey No. 45, 1906; especially pp. 244–245 and Pl. XXII.

[3] Reid, H. F., The variations of glaciers: Jour. Geology, vol. 14, 1906, pp. 402–410; vol. 17, 1909, pp. 667–671.

[4] Tarr, R. S., and Martin, Lawrence, The National Geographic Society's Alaskan expedition of 1909: Nat. Geog. Mag., vol. 21, 1910, pp. 1–54.

[5] Gilbert, G. K., Glaciers and glaciation: Alaska, vol. 3, Harriman Alaska Expedition, 1904, Pls. XI and XIII.

[6] Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, map No. 20; The geology and mineral resources of a portion of the Copper River district, Alaska; Special publication, 1901, pl. 2.

Bear glaciers and some of the glaciers of Port Wells, and this information extended back only a few years.

In the present report Plates I and II (in pocket) show the general distribution of the glaciers of Prince William Sound and the southern part of Kenai Peninsula. More detailed information concerning these glaciers is given in a number of the other plates and figures. These maps were, with minor exceptions, made by the junior author. Some of the maps are merely sketches indicating the general relations of the glaciers to the shore line; others are more carefully made. An idea of the accuracy of these maps can be gained from noting the closeness and number of the positions that were occupied or intersected in making the maps. In this work the information obtained by the authors was usually controlled by graphic triangulation with the "baby" plane table from base lines or United States Coast and Geodetic Survey triangulation stations. The base lines were determined by the log of the boat, and in the expansions these approximately correct values were assumed to be the true values. The control was supplemented by occasional boat and foot traverses. The sketching was done from the stations and from the boat between stations. A few minor changes were made in the office from photographs.

PHOTOGRAPHS OF THE GLACIERS.

In any study of the positions of glacier fronts dated photographs are of prime importance, for they furnish accurate records and can be obtained when there is not time for detailed observations. If the photographs are taken from easily recognized stations which can be occupied in later years their value is still greater. In the present study of the glaciers of Prince William Sound and Kenai Peninsula many photographs were taken from stations shown on the several detailed maps accompanying this report. These and other photographs will be of so great value in the study of future fluctuations of these ice streams that it has been thought wise to list, under the description of each glacier (or general area), all the photographs showing that glacier or area in the collections preserved in the office of the United States Geological Survey at Washington. In these lists the following abbreviations have been used:

G: Photographs taken by U. S. Grant and D. F. Higgins, 1908-9
Gi: Photographs taken by G. K. Gilbert, 1899.
M: Photographs taken by W. C. Mendenhall, 1898.
P: Photographs taken by Sidney Paige, 1905.
Sc: Photographs taken by F. C. Schrader, 1898.
Sp: Photographs taken by A. C. Spencer, 1900.

In addition to the photographs noted above, the following have been accessible to the writers: (1) Photographs taken by C. Hart Merriam and E. S. Curtis for the Harriman Alaska Expedition, 1899;

(2) photographs taken by W. E. Carlin for the George W. Perkins party, 1909; (3) photographs taken by R. S. Tarr and Lawrence Martin for the National Geographic Society expedition, 1909; (4) photographs taken by P. S. Hunt and G. G. Cantwell, of Valdez.

GLACIERS OF PRINCE WILLIAM SOUND.

PORT VALDEZ.

GENERAL FEATURES.

Port Valdez is the extreme northeastern fiord of Prince William Sound. The main portion of the fiord trends east and west and is about 14 miles long and 3 miles wide. Its axis is essentially parallel

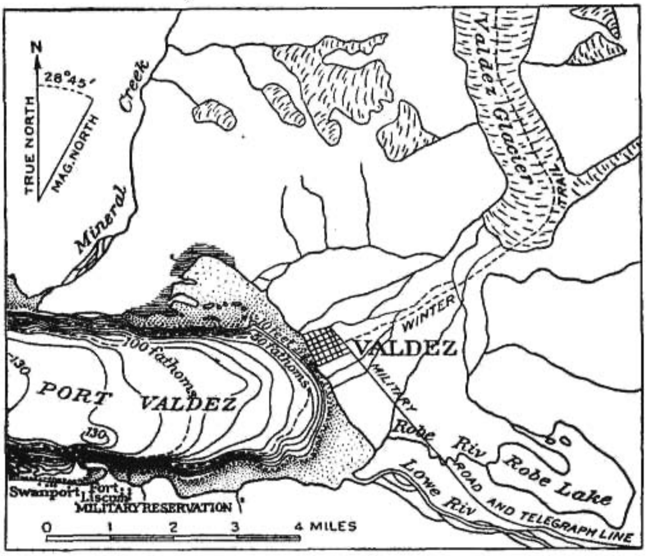


FIGURE 1.—Map of Valdez and vicinity. From maps of the United States Geological Survey and Coast and Geodetic Survey. Submarine contour interval, 10 fathoms.

with the strike of the country rocks. At its western end this portion bends abruptly to the south-southwest, narrows to a width of a mile, and cuts almost directly across the strike of the rocks. The depression in which Port Valdez lies extends northwestward in the Shoup Glacier valley, northeastward in the Valdez Glacier valley, and eastward in the valley of Lowe River. Except for these valleys, each of which is much smaller than the port itself, Port Valdez is hemmed in by steep mountains, those on the west and north being extremely steep and rising to heights of 4,000 to 5,400 feet. The mountains on the south side are 3,000 to 4,600 feet in height.

The main portion of Port Valdez is a wide, flat-bottomed trough averaging about 800 feet in depth and reaching in one place a depth of 858 feet below sea level. The sides of this trough below sea level are uniformly steep, having a customary slope of 24°, but in one place this slope is over 51° for a vertical distance of 756 feet. (See figs. 1 and 2.) The eastern end of Port Valdez is being rapidly filled with material brought down by Lowe River and by streams from the Corbin and Valdez glaciers, most of this material coming from the latter glacier. The advancing delta thus produced has a steep submarine front, its slope being nearly 12°. The subaerial portion of the delta extends east along Lowe River, also northeast, 4 miles, to the Valdez Glacier, rising in this distance probably 250 feet. It seems quite probable that slumping is taking place occasionally along the seaward edge of the delta. On February 14, 1908, an earthquake of considerable magnitude visited this district and broke in several places both the Seattle-Valdez and the Valdez-Seward cables, which run east and west through Port Valdez. Accompanying the earthquake there seems to have been a slumping of the delta front which buried sections of the cables. The cause of the earthquake is not known, but it is thought to have been minor faulting, for one of the cables was broken in deep water on the flat bottom of the fiord 11 miles from Valdez. The slumping of the delta front at this time was therefore probably a result rather than a cause of the earthquake.

On Port Valdez there is one tidal glacier, the Shoup. The Valdez Glacier reaches within 4 miles of the port and the lower end of the Corbin Glacier lies 7 miles east of Valdez. The Valdez Glacier receives smaller ice streams from the east, but its main snow field lies on the northwest. The Shoup Glacier and probably part of the Columbia Glacier come from the same snow field. There are a few small glaciers high up in the mountains about the ends of the main portion of Port Valdez, the most noticeable of which are one (unnamed) a mile or more east of the front of the Valdez Glacier, and one 3 miles southeast of Shoup Bay, called the Annin Glacier.[1]

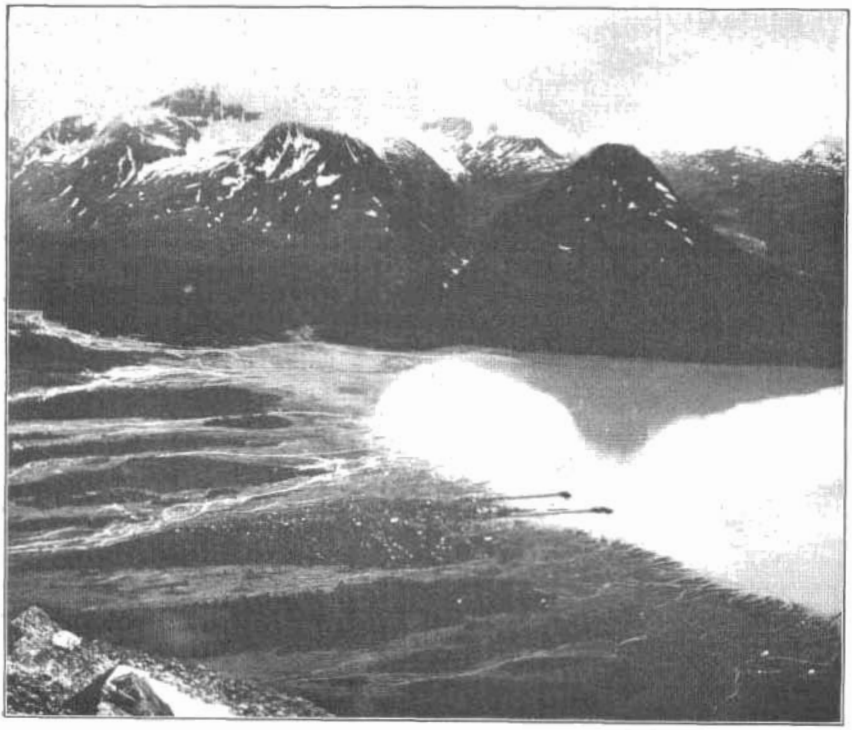
VALDEZ GLACIER.

The Valdez Glacier (fig. 1) is situated about 4 miles northeast of the town of Valdez and is well known as one of the glacial highways of Alaska. During the spring and summer of 1898 and the early part of 1899 this glacier was used as a roadway by the host of gold seekers passing northward from Valdez into the Copper River and Yukon basins. The construction in 1899 of the military telegraph line and trail, followed in later years by the development of the trail into a wagon road, from Valdez northward over Thompson Pass into the Copper River basin has taken away the necessity for traveling

[1] Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, maps Nos. 20 and 21.

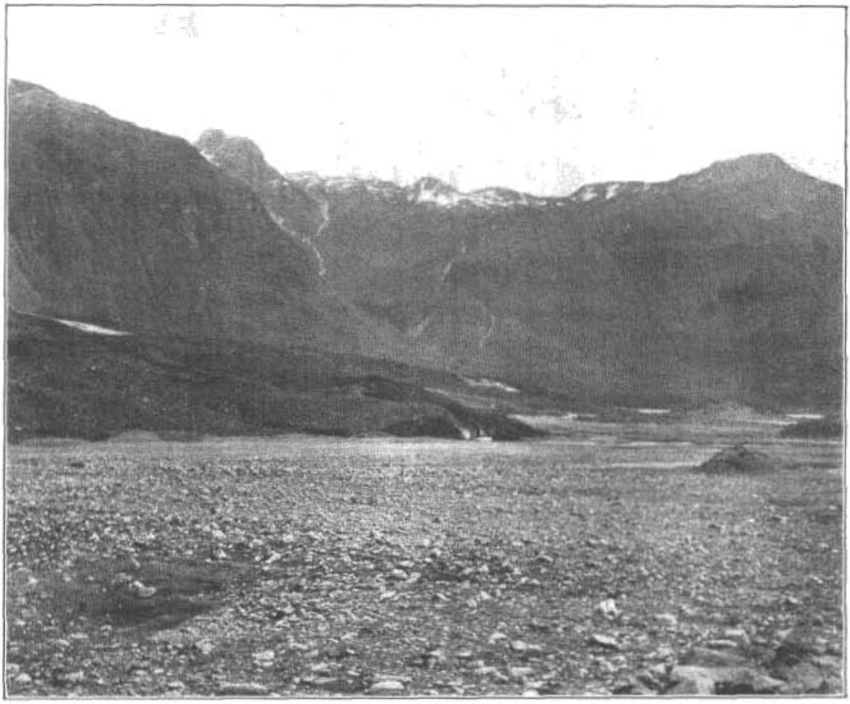
A. VALDEZ GLACIER FROM THE SOUTHWEST.

Distance about 1½ miles. July 11, 1908. Photograph G 1.



B. DELTA OF VALDEZ GLACIER AND LOWE RIVER.

Photographed by Cantwell.



A. CENTER OF FRONT OF VALDEZ GLACIER.
Looking southeast. July, 1905. Photograph P 711.

B. WEST EDGE OF FRONT OF VALDEZ GLACIER.
July, 1905. Photograph P 711a.

over the Valdez Glacier. The front of the glacier is covered with débris, has a low slope, and is easy of ascent, although in 1898 within the first 500 feet of rise there were three marked benches, each about 100 feet high, over which passage was difficult. The glacier itself and the method of traveling over it have been interestingly described by Schrader.[1]

A hasty visit was made to the west side of the front of the Valdez Glacier in July, 1905, and another on July 11, 1908. At these times a few notes and photographs showing the position of the edge of the ice were taken, but no map of the glacier was made.

The front of the glacier is covered with débris (Pls. III, *A*, and IV, *A*), and toward its center an area thus covered runs back from the front of the ice and may form part of a medial moraine, though this point was not determined. The front deploys slightly on the plain of outwash material, and it is commonly reported that the ice reaches out under this plain for a considerable distance, even to the sea, but the evidence presented for this extension of the ice is far from conclusive. The outwash plain is broad, contains many reticulated stream channels, and reaches to the sea. (See Pl. III, *B*.) These streams vary much in position and in volume. The front of the glacier is so fully exposed to the sun that a few consecutive bright summer days cause extensive melting and a consequent flooding of the streams. Such an occurrence in the summer of 1905 carried away a few small buildings from the eastern edge of Valdez, but the town is now protected from encroachments of this character by a strong cordon of piles connected by heavy planks.

Photographs of the front of the Valdez Glacier, taken in July, 1905, are shown in Plate IV. The mound from which these were taken was destroyed by an advance of the ice at some time before July, 1908, and while the glacier was extended a moraine 10 to 30 feet high and 25 to 125 feet wide was deposited 250 to 300 feet in advance of the position of the front of the ice in 1905. This moraine is a quarter of a mile in length, and its western end is about the same distance from the western rock wall of the valley. In July, 1908, the front of the glacier at the western side was about 100 feet in advance of its position in 1905, and the central part of the front was apparently a short distance less advanced than in 1905. In August, 1909, the Valdez Glacier was visited by Tarr and Martin, whose photographs show that the central and western parts were a little less advanced than they were in 1908, and that the extreme western edge was slightly less advanced than in 1905. Photographs of the glacier, taken from a distance by A. C. Spencer in June, 1900, show that the position of the glacial front on that date was not materially different from its

[1] Schrader, F. C., A reconnaissance of a part of Prince William Sound and the Copper River district, Alaska, in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 350-356, 365-366, 381-382.

positions in 1905, 1908, and 1909. There is no forest near the front of the ice, hence the present time seems to be in general a period of retreat for this glacier. The cover of low vegetation and the small extent of the bare zone on the western wall of the valley indicate that there has been no marked advance of the ice beyond its positions of 1905 and 1909 since the opening of the twentieth century.

Reid gives the following information concerning the Valdez Glacier:[1]

> Dr. L. S. Camicia has been keeping a record since 1901 of the position of the Valdez Glacier, Prince William Sound, Alaska. A stone monument was made on the moraine in front of the glacier and the distance to the ice determined. He found the following variations, measurements having been made in June of each year: 1901–2, a retreat of 39 feet; 1902–1904, 165 feet; 1904–5, 138 feet. The next observation was made in October, 1908; as the monument had been destroyed, he estimated its position as well as he could, and found a retreat since the last observation of 244 feet, making a total retreat from 1901 to 1908 of 586 feet.

Evidently the same advance of the ice (occurring between July, 1905, and July, 1908) that destroyed the above-mentioned monument also destroyed the mound from which our observations were made in July, 1905. The destruction of these points of reference makes it impossible to determine accurately the position of the ice front in 1908 with reference to its position three years earlier. Moreover, the fluctuation of one part of the ice front differs from that of other parts, and as our observations and those of Dr. Camicia may not have had reference to the same point in the glacier's front, it is not surprising that the two estimates of retreat from 1905 to 1908 are not in full agreement. Our estimates are based on a hurried examination of the locality in 1908 and on a study of photographs of the glacial front, some taken then and some three years before.

The maps showing the Valdez Glacier indicate that a feeder comes down the first valley on the east and joins the main stream. Our photographs show, however, that this smaller glacier ends before joining the larger stream and that another glacier comes in from the south and nearly or quite joins the small glacier just mentioned.

Photographs of Valdez Glacier.

Sc 51. Front of glacier from the west edge of the glacier, 600 feet above sea level. The low dark point in the center is the one referred to under (1) in No. G 2 below. 1898.

Sc 52 to 55. Views on glacier, back from the front. 1898.

Sc 56. Front of glacier from west edge of the glacier, looking S. 25° W. 1898.

Sc 57. Source of river at front of glacier. 1898.

Sc 59. Center of front of glacier, looking N. 50° E. 1898.

Sc 62 to 72. Views on glacier, back from the front. 1898.

Sc 194. Distant view of glacier. October 22, 1898.

Sc 195. Distant view of glacier. 1898.

Sp 7. General view of front of glacier from the southwest. June 15, 1900.

---

[1] Reid, H. F., The variation of glaciers: Jour. Geology, vol. 17, 1909, p. 670.

Sp 11. General view of front of glacier from the south. June 24, 1900.

P 708. Débris-covered front of glacier and outwash plain, taken from the glacier and looking toward Valdez. July, 1905.

P 709. Crevasse near front of glacier. July, 1905.

P 710. Valdez Glacier (in foreground) and smaller glaciers on east side of the Valdez (in background). July, 1905.

P 711. (Here reproduced as Plate IV, *A*.) Center of front of glacier, looking southeast. July, 1905.

P 711a. (Here reproduced as Plate IV, *B*.) Western edge of front of glacier. July, 1905.

P 734. Outwash plain, extreme eastern edge cf glacier, and small hanging glacier. September 9, 1905.

G 1. General view of front of glacier from a distance of about 1½ miles. July 11, 1908.

G 2. Center of front of glacier, looking S. 67° E. From the position from which this photograph was taken bearings are as follows: (1) S. 4° W. to outer end of rock ridge that extends into the valley for about half a mile from its east side; (2) S. 66° E. to talus slope on small stream east of glacier—this talus slope is shown just to the left of the center of this photograph and in the center of Plate IV, *A;* (3) S. 51° W. to outer end of rock ridge that extends into the valley for a few rods from its west side. This photograph was taken from very nearly the same position as Nos. P 711 and P 711a. From the position above described the nearest point of the ice was 530 feet distant in a direction N. 48° E., on July 11, 1908.

G 3. Western edge of front of glacier, looking N. 22° W. from same position as last. July 11, 1908.

G 4. Western edge of front of glacier, looking N. 14° E. from top of a nearly circular mound, 12 feet high, 40 feet in north-south diameter and 30 feet in east-west diameter of base. This mound is about one-fourth of a mile from the west side of the valley, and is the first prominent mound seen on approaching the glacier from the southwest. From this position bearings are as follows: (1) S. 3° E. to point (1) under No. G 2; (2) S. 73° E. to point (2) under No. G 2; (3) S. 67° W. to point (3) under No. G 2. July 11, 1908. This same position was occupied by Tarr and Martin in August, 1909.

G 5. Center of front of glacier, looking S. 72° E. from same position as No. G 4. July 11, 1908.

G 6. Detail of front of glacier, looking up first valley on east of glacier. July 11, 1908.

G 9. Eastern front of glacier from southeast end of eastern dock at Valdez. July 12, 1908.

SHOUP GLACIER.

Shoup Glacier reaches tidewater at the head of Shoup Bay, which connects with the northwestern corner of the main portion of Port Valdez. On maps published in 1900 [1] this is called the Canyon Creek Glacier, but on the United States Coast and Geodetic Survey charts 8521 and 8519, published, respectively, in 1902 and 1906, it is called the Shoup Glacier, by which name it is now commonly known at Valdez and Fort Liscum. This glacier is of economic importance in that it furnishes ice for Valdez and Fort Liscum, the detached bergs being lifted upon barges and taken to these towns.

Shoup Glacier was visited and photographed on July 4, 1905, July 13, 1908, and June 16, 1909, and its front was mapped on the

[1] Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, maps Nos. 19, 20, 21. Report on Public Resolution No. 25, Fifty-fifth Congress, 3d session, map 7.

last date. (See Pl. V and fig. 2.) The record of the position of the front of the glacier before 1905 is confusing. The first three of the maps made in 1898 (published in 1900 and noted above) show the ice front as reaching tidewater close behind the spit at the mouth of Shoup Bay, whereas the other map indicates that the glacier ends on a flat a mile from tidewater. These maps, however, are reconnaissance maps, and probably the position of the front of the glacier was

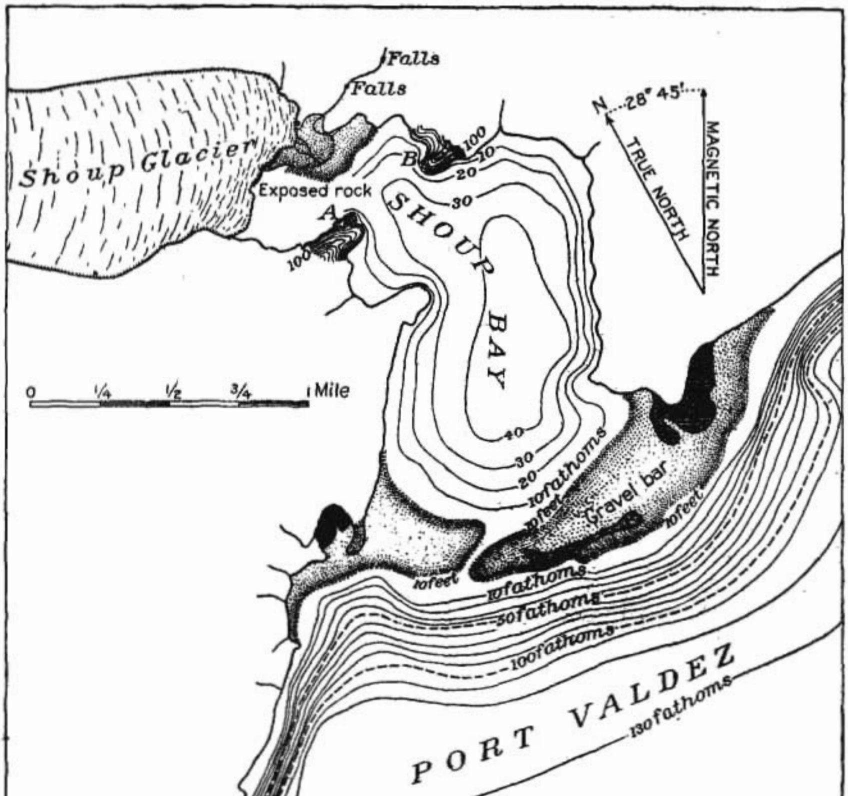
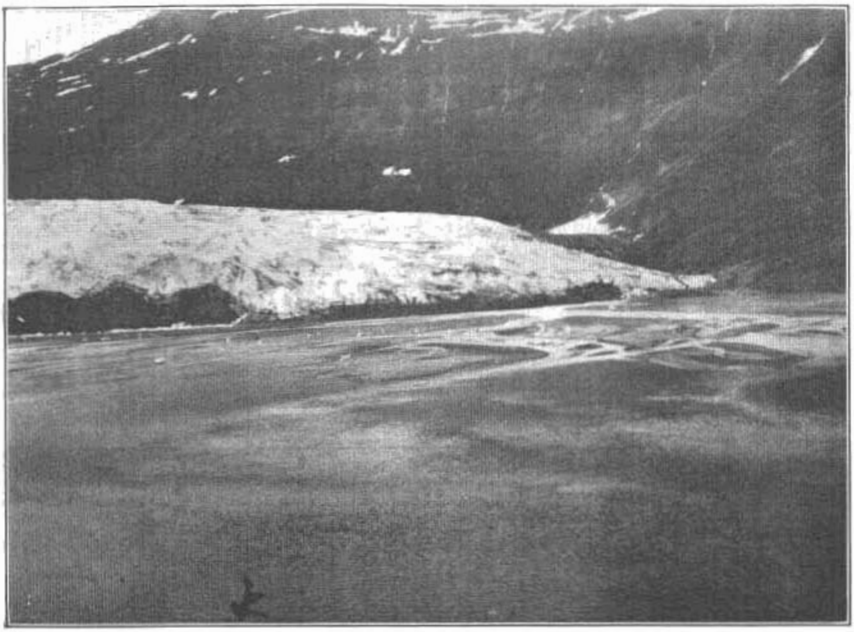


FIGURE 2.—Map of Shoup Bay and Shoup Glacier, Port Valdez, July 16, 1909. Data south of point marked A from Coast and Geodetic Survey chart No. 8521; base line A-B assumed 0.34 mile; contour interval on land, 20 feet; submarine contour interval, 10 fathoms. Occupied points indicated by circles, intersected points by crosses.

not carefully located in the field. The growth of vegetation about the head of Shoup Bay shows that the glacier has not advanced more than a few rods beyond its present position for the last 15 years and very likely not for 50 years. The Coast Survey charts 8521 and 8519 show a distance between points A and B (fig. 2)[1] and the front of the ice one-third greater than that shown on our map. This difference may be

[1] Point A is the top of a small, round glaciated rock knob about 60 feet above sea level, on the south point of the entrance to the inner port of Shoup Bay. Point B is the middle one of three rocky projections on the north point of the entrance to the inner part of Shoup Bay. It is about 30 feet above sea level.



A. NORTH PART OF FRONT OF SHOUP GLACIER.

From point A, figure 2. July 13, 1908. Photograph G 10.

B. SOUTH PART OF FRONT OF SHOUP GLACIER.

From Point A, figure 2. July 13, 1908. Photograph G 12.

due to inaccuracies in our sketch or to the fact that the detailed work of the Coast Survey was not carried clear to the front of the glacier; or it may possibly, but not probably, be due to the glacier front standing farther back in 1900 and 1901, the years in which the field work for the Coast Survey charts was probably done. However, two men who obtained ice from the glacier in those years state that the ice was then in advance of its present position and that the ledges (visible in 1905, 1908, and 1909, and shown on the left of Pl. V, *A*, and the right of Pl. V, *B*) near the center of the ice front were not then visible. An advance of 50 feet would cover these ledges. They are shown just emerging from the ice in a photograph (Sc 61) taken by F. C. Schrader in 1898.

Photographs taken from point A, figure 2, on each of our three visits, as well as those taken by Tarr and Martin in August, 1909, show practically no fluctuation in the position of the northern half of the front of the glacier and slight variations in the position of the southern half. In July, 1908, the ice near the southern edge of the front was a little (estimated from photographs at 100 feet) in advance of its position on the other dates, and in July, 1905, the same portion was a little farther back than on the other dates. In July, 1905, a small push moraine, rising 20 feet above high tide, stood at the front of the ice 100 yards north of the southern end of the front. At later dates this moraine was not present.

Vegetation extends within a few yards of the ice, hence there is only a very narrow bare zone bordering the ice, in places practically none. This vegetation is 5 to 15 feet high and is mainly alders, at least out as far as points A and B, and the glacier front is now close to its maximum extension in the last 15 and probably in the last 50 years. The shores of the bay lack the usual forest, and most of the trees present are less than 3 inches in diameter. Though the trees are not large, it seems very improbable that the glacier has extended to the entrance of Shoup Bay within the last 100 years. The mouth of the bay is nearly closed by a morainic deposit, behind which is a considerable depression and in front of which is a steep slope to the flat bottom of Port Valdez. (See fig. 2.) Shoup Bay is, therefore, a hanging valley on the side of Port Valdez, the floor of the bay being more than 500 feet above the bottom of the port. The general postglacial submergence of this part of the Alaskan coast has embraced the drowning of the main glacial trough (Port Valdez) and the hanging valley (Shoup Bay) on its side. (See submarine contour lines on figs. 1 and 2.)

Photographs of Shoup Glacier.

Sc 33. Distant view of glacier, looking N. 40° W. 1898.

Sc 61. Front of glacier, looking N. 45° W. from point on south 300 feet above sea level. This point is probably about one-fourth mile southwest of point A in figure 2. 1898.

Sc 197. Distant view of glacier, looking north-northwest. October 26, 1898.

P 662. Detail of front of glacier from point near south end of front. July 4, 1905.

P 663. From same point as No. P 662. Nos. P 662 and 663 form a panorama.

P 664. From same point as No. P 662.

P 665. North part of front of glacier, from point A, figure 2. July 4, 1905.

P 666. Center of front of glacier, from point A.

P 667. South part of front of glacier, from point A. Nos. P 665 to 667 form a panorama.

P 705. South part of front of glacier. July 4, 1905.

P 706. A nearer view of the same. July 4, 1905.

P 707. A still nearer view of part of the same, showing push moraine. July 4, 1905.

G 10. Here reproduced as Plate V, *A*. North part of front of glacier, from point A, figure 2. Point A is the top of a small round glaciated rock knob about 60 feet above sea level, on the south point of the entrance to the inner part of Shoup Bay. July 13, 1908.

G 11. Center of front of glacier, from point A.

G 12. Here reproduced as Plate V, *B*. South part of front of glacier, from point A. Nos. G 10 to 12 form a panorama.

G 73. North part of front of glacier, from point B, figure 2. Point B is the middle one of the three rocky projections on the north point of the entrance to the inner part of Shoup Bay. The station was about 30 feet above sea level. June 16, 1909.

G 74. South part of front of glacier, from point B. Nos. G 73 and 74 form a panorama.

G 75. North part of front of glacier, from point A, figure 2. June 16, 1909.

G 76. Center of front of glacier, from point A.

G 77. South part of front of glacier, from point A. June 16, 1909. Nos. G 75 to 77 form a panorama. This point was occupied by Tarr and Martin in August, 1909.

COLUMBIA GLACIER.

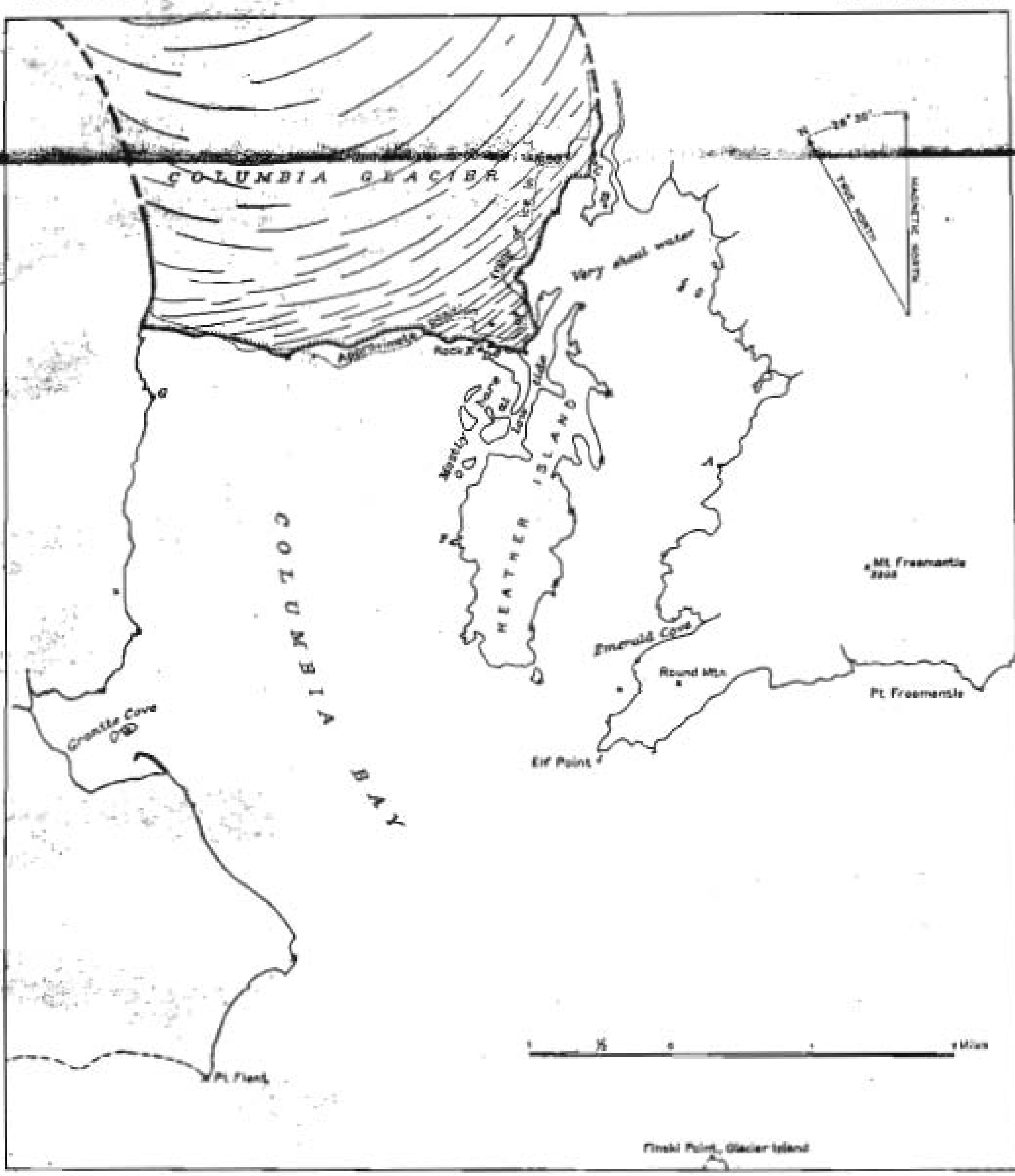
The Columbia Glacier is situated at the head of Columbia (or Glacier) Bay, 15 miles northeast of the town of Ellamar. Davidson indicates that this has also been called the Freemantle Glacier.[1] The name Columbia was applied by the Harriman Alaska Expedition (1899) and is now in common use. Gilbert[2] has described the Columbia Glacier in detail, and it is not necessary to duplicate his descriptions. Some additional information, mostly concerning the fluctuations of the glacier, will be given below. Other facts connected with this glacier have been noted by Tarr and Martin.[3]

We visited the Columbia Glacier on July 10, 1905, July 15, 1908, and June 24, 1909. On the two earlier dates a few notes and photographs were taken, and on the last date the bay and the front of the glacier were mapped and a series of photographs was obtained. Our chief observations have to do with the fluctuations of the glacial front that have taken place since the study of the glacier by Gilbert in 1899. Data concerning the position of the front of the ice are given on the accompanying map (Pl. VI), on which is also indicated approximately the position of the glacial front in 1899 as

[1] Davidson, George, The glaciers of Alaska that are shown on Russian charts or mentioned in older narratives: Trans. and Proc. Geog. Soc. Pacific, 2d ser., vol. 3, 1904, p. 33.

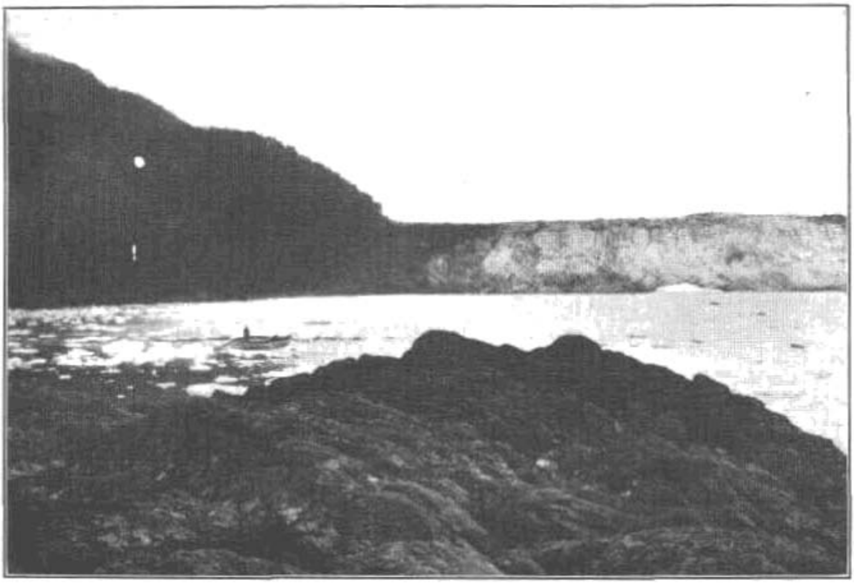
[2] Gilbert, G. K., Glaciers and glaciation: Alaska, vol. 3, Harriman Alaska Expedition, 1904, pp. 71-82.

[3] Tarr, R. S., and Martin, Lawrence, The National Geographic Society's Alaskan Expedition of 1909: Nat. Geog. Mag., vol. 21, 1910, pp. 1-54.



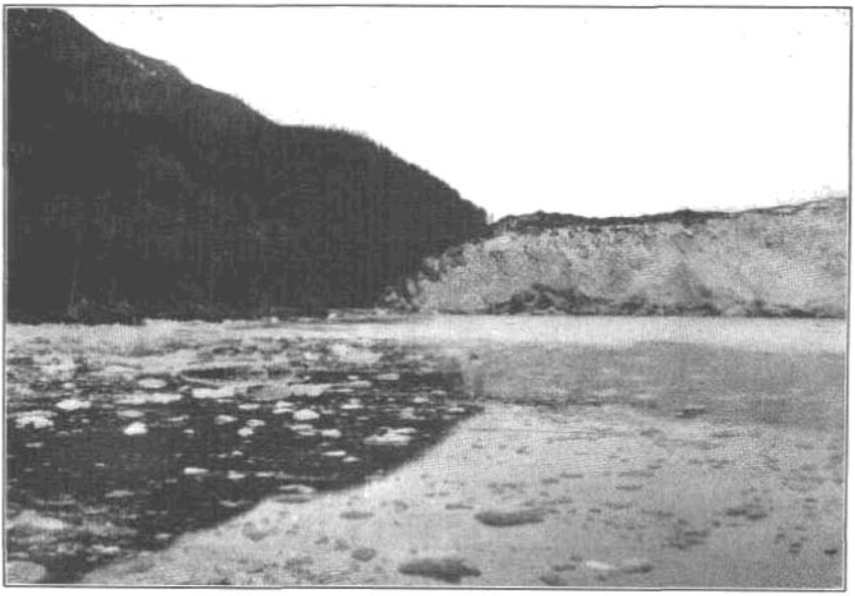
MAP OF COLUMBIA BAY AND FRONT OF COLUMBIA GLACIER.

June 23 and 24, 1909. Base line from Point Freemantle to Finski Point assumed 3.8 miles from Coast and Geodetic Survey chart No. 8519. Occupied points indicated by circles, intersected points by crosses.



A. JUNE 27, 1899.

Photographed by Gilbert. Photograph Gl 355.

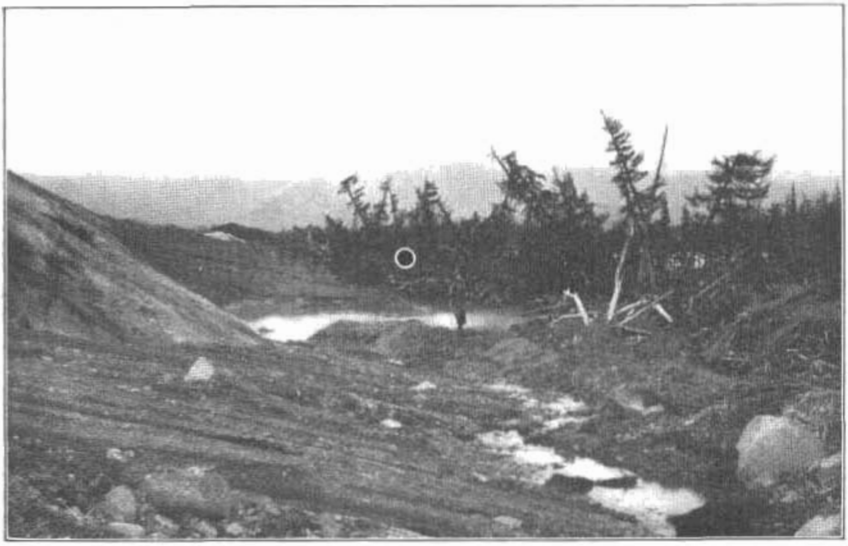


B. JUNE 24, 1909.

Photograph G 91.

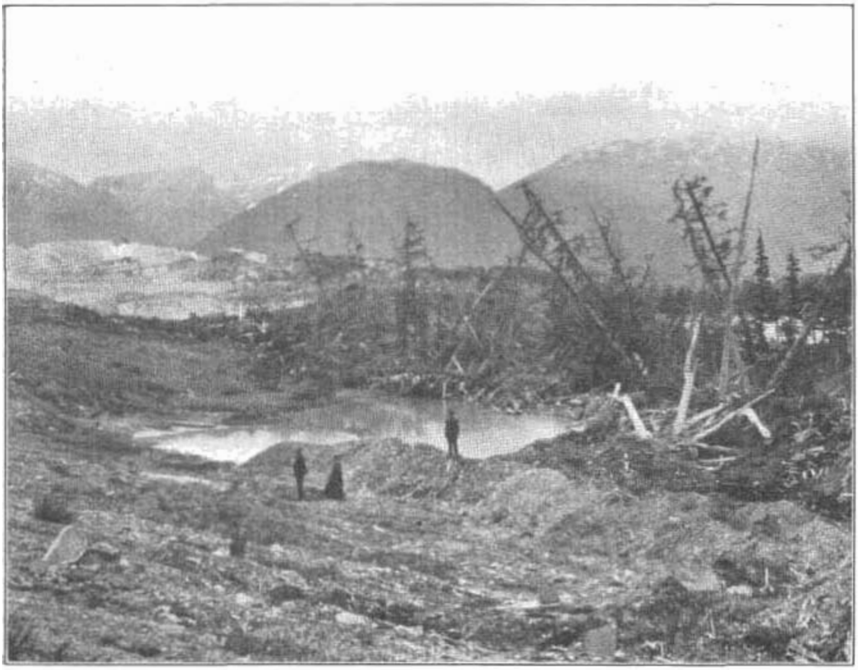
WEST PART OF FRONT OF COLUMBIA GLACIER.

From point G, Pl. VI.



A. JUNE 26, 1899.

The ice front rests at the north (left) edge of the pond. Photograph Gi 354.

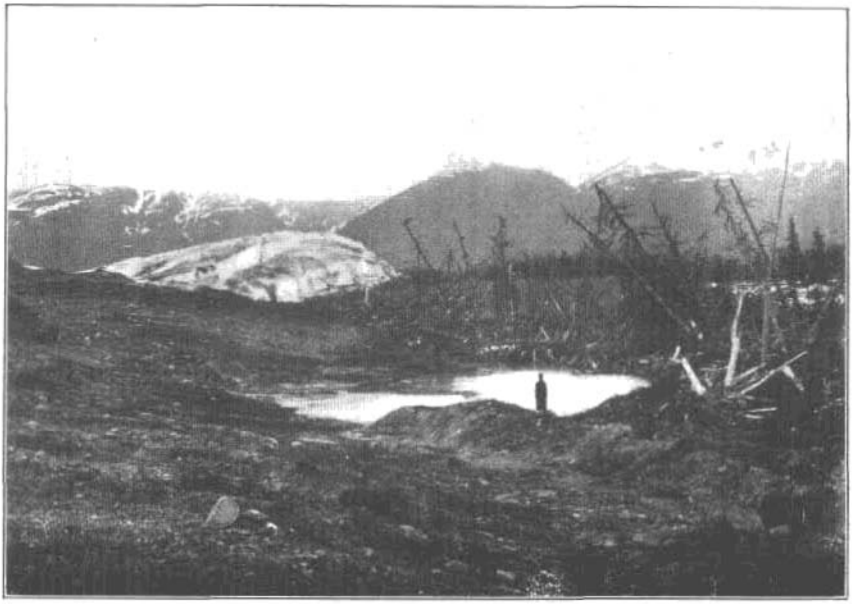


B. JULY 10, 1905.

Photograph P 673.

EDGE OF COLUMBIA GLACIER.

Shows fluted moraine and forest overturned by ice.



A. JULY 15, 1908.

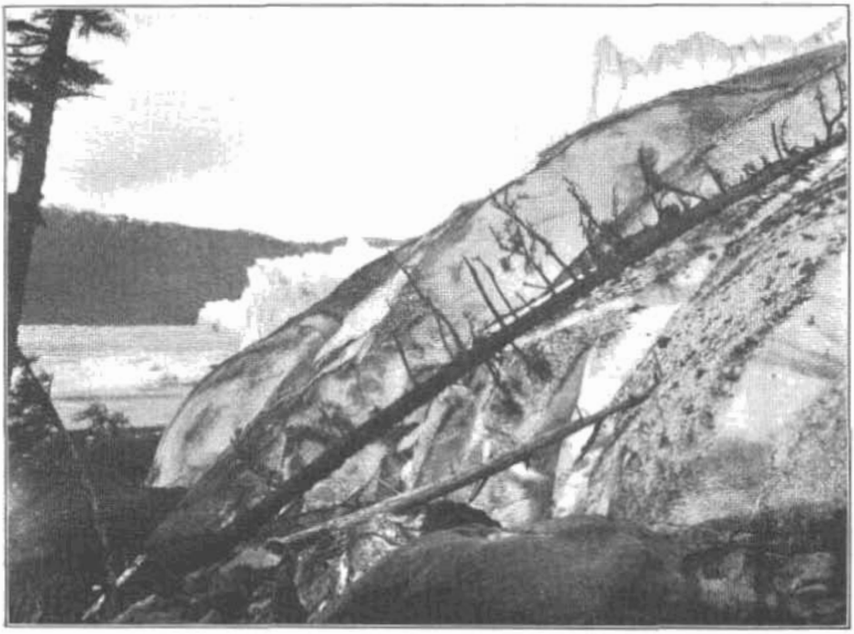
Photograph G 17.

B. JUNE 24, 1909.

Photograph G 85.

EDGE OF COLUMBIA GLACIER.

Same locality as that shown in Plate VIII.



A. COLUMBIA GLACIER INVADING FOREST.

West shore of island on which the glacier rests. June 24, 1909. Photograph G 87.

B. PUSH MORAINE AT FRONT OF COLUMBIA GLACIER.

West shore of island on which the glacier rests. June 24, 1909. Photograph G 183.

that the former maximum advance of the ice was three or four years rather than 15 or more years ago.

In the advance of the ice in 1909 into the previously disturbed forest some trees were pushed forward bodily without being overturned, although the inclination of some was changed. One tree had been moved ahead of the ice 100 feet by June 24, 1909, and even farther by August 23 of the same year, but was still nearly upright. This is the tall, limbless, barkless, nearly upright tree near the right of Plate IX, *B*. The same tree in a different position can be recognized in the other photographs of this locality (Pls. VIII, *A* and *B*, and IX, *A*). Such movement without overthrow of trees could be readily accomplished, when the ground was frozen, by the glacier pushing forward the frozen layer of soil, but in the case just described part of the movement took place in July and August, when the ground was not frozen.

On the western edge of the island on which the glacier rests the ice was also advancing on June 24, 1909. At the highest tide line the front of the ice had then just reached the limit of its farthest previous advance since the advent of the present forest and was again attacking the trees that had been killed or disturbed in that advance, estimated to have taken place in 1894. (See Pl. X, *A*.) The lowest tree resting on the ice shown in this illustration is visible at the extreme left of a photograph (G 19) taken on July 15, 1908, when the ice was 200 feet (estimated) north of this tree. On the beach at this place in 1909 a push moraine 25 feet high (Pl. X, *B*), composed of beach materials, bordered the ice and was in places actually being advanced by it. As this push moraine rested on land covered by the highest tides, it had probably been formed only a few weeks.

An ascent of the glacier was made near the western side of this island in June, 1909, and barometer readings checked on sea level showed that the height of the tidal ice cliff west of the island was at least 400 feet. In 1899 it was estimated to be 300 feet.

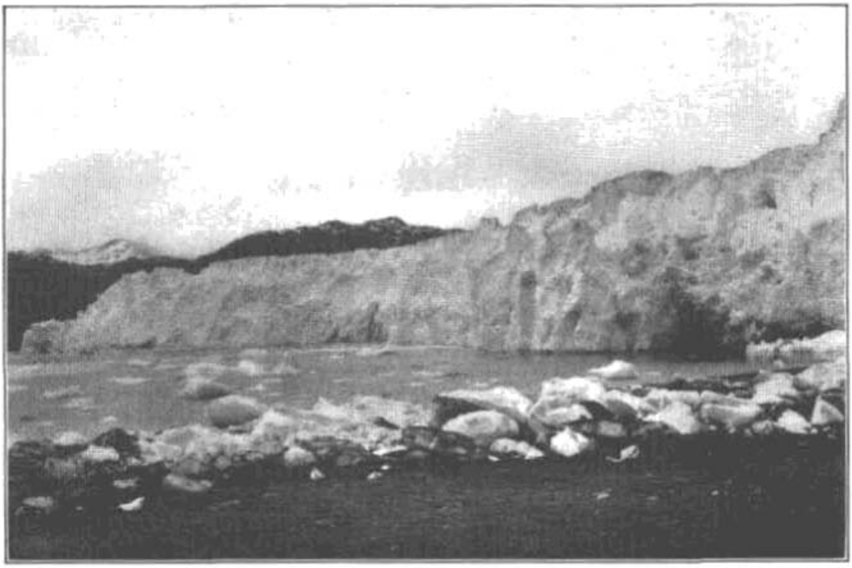
The eastern part of the island consists of a terminal moraine, which is not covered with bushes or trees and is of recent construction, probably dating from 1894. This moraine was being added to at the times of our visits in 1908 and 1909. In the earlier year examples of both push and terminal moraines were seen in process of formation. The former were in places being added to directly by deposits from the melting of the ice that was constructing them, and the latter showed, on a small scale, fine examples of knob and kettle topography in the making. In 1909 flows of mud were coming down from the melting edge of the ice and were reaching tidewater, where they aided in silting the tide flats just west of the north end of Heather Island.

In the moraine here described were many fragments of shells of pelecypods and gastropods, apparently of recent species. It is improbable that these forms live in the cold milky waters adjacent to the melting ice, and the presence of their remains in the recently deposited drift would indicate that the ice front was in geologically recent time considerably farther north than at present. The head of the north end of the eastern part of Columbia Bay is shallow, and it is suggested that a retreat of the ice front of not more than a mile might have exposed ground above tidewater, so that the drainage from the eastern part of the glacier would be diverted westward, leaving the eastern part of Columbia Bay free or nearly free of glacial waters, thus establishing conditions favorable to molluscan life at this point.

The wide tongue of ice that rests on the small island near the north end of Heather Island was pushing forward rapidly in June, 1909, and Tarr and Martin report farther advances in August of the same year. We have not sufficient information to determine definitely how far this tongue has advanced in recent years, but Gilbert's map [1] and our impressions gained by a hurried visit in 1908 would indicate that the extreme southern part of this ice tongue in 1909 was 700 feet in advance of its position 10 years before. The reason for the extreme advance at this point is probably to be found not so much in the fact that this portion of the glacier is moving more rapidly than the rest of the ice stream as in the fact that the front, both east and west of this tongue, is attacked by warm ocean water and waves, which cause breaking down of the ice front as well as more rapid melting than on the land. The part of the glacier west of this island, where the water is probably deep, doubtless has a considerably higher rate of movement than the part east of the island where the water is very shallow. The projection of the tongue of ice above mentioned beyond the general front of the glacier was very noticeable in 1909 and is shown by photographs taken 10 years earlier, though it does not appear so prominently on the map made in 1899. The approximate location of the front of this tongue in both these years is shown on the map forming Plate VI.

At the northeastern corner of Columbia Bay (northeast of point C, shown in Pl. VI) there was in 1909 a well-defined bare zone 50 to 200 feet wide between the ice front and the forest which had been attacked by an earlier advance of the glacier. (See Pl. XI, *B.*) The ice was advancing on this bare zone in 1909. It was probably at this point that Gilbert estimated, from spruce trees which had grown since the forest was destroyed, that this catastrophe occurred not later than 1892. South of point C there is a small stretch of beau-

[1] Alaska, vol. 3, Harriman Alaska Expedition, Pl. XI.



A. WEST PART OF FRONT OF COLUMBIA GLACIER.

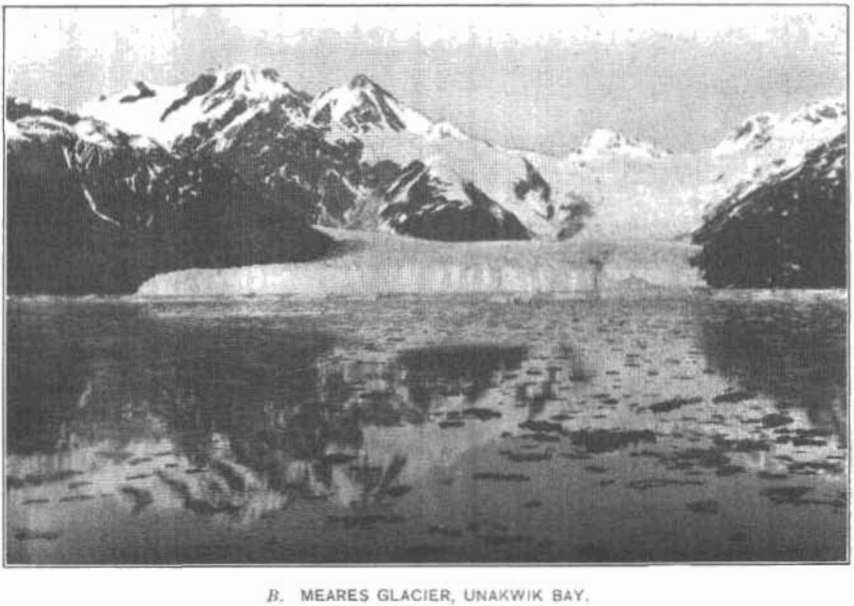
From point E, Plate VI. June 24, 1909. Photograph G 88.

B. EAST PART OF FRONT OF COLUMBIA GLACIER, BARE ZONE, AND OVERTURNED FOREST.

From point C, Plate VI. June 24, 1909. Photograph G 83.

A. EAST PART OF FRONT OF COLUMBIA GLACIER, TERMINAL MORAINE, AND REMNANT OF FOREST.

From point B, Plate VI. June 24, 1909. Photograph G 82.



B. MEARES GLACIER, UNAKWIK BAY.

From point C, figure 3. June 26, 1909. Photograph G 96.

tiful and typically morainic country (Pl. XII, *A*), which is now well grassed over and which carries small scattered spruces and some thin tundra soil. These spruces range in size up to 6 inches in diameter, the largest being perhaps 15 or 20 years of age. South and southeast of this morainic area are remnants of a forest, which was partly destroyed by the ice when the outer portion of this moraine was formed (Pl. XII, *A*), that is, at the earliest advance recorded since the advent of the present forest—probably 50 years ago and possibly longer.

Photographs of Columbia Glacier.

Gi 337. Distant view of glacier from point near east side of entrance to Columbia Bay. June 25, 1899.

Gi 338. Western part of glacier from point near center of entrance to Columbia Bay. June 25, 1899.

Gi 339. Center of glacier. June 25, 1899.

Gi 340-344. Panorama of glacier from hill east of glacier. June 26, 1899.

Gi 345. Front of glacier from the east. June 26, 1899.

Gi 346. Surface of glacier. June 26, 1899.

Gi 346a. Surface of glacier. June 26, 1899.

Gi 347. Surface of broad moraine on glacier. June 26, 1899.

Gi 348 and 349. Forest overturned by recent advance of glacier. June 26, 1899.

Gi 350 and 351. Southeast front of glacier. June 26, 1899.

Gi 352 and 353. Fluted moraine at front of glacier from a position probably a few yards northwest of point D, Plate VI. June 26, 1899.

Gi 354. Here reproduced as Plate VIII, *A*. Fluted moraine, forest overturned by ice, and edge of glacier, from point D, Plate VI. See under P 673. June 26, 1899.

Gi 355. Here reproduced as Plate VII, *A*. West end of front of glacier from point G, Plate VI. See under G 90. June 27, 1899.

Gi 356. Push moraine on western shore of Columbia Bay. June 27, 1899.

Gi 357 and 358. Panorama of western part of front of glacier from western shore of Columbia Bay. June 27, 1899

Gi 359. Front of glacier from western shore of Columbia Bay. June 27, 1899.

Gi 360. Front of glacier from hill on western shore of Columbia Bay. June 27, 1899.

P 671 and 672. Front of glacier, from position near point E, Plate VI. July 10, 1905.

P 673 and 674. No. 673 is here reproduced as Plate VIII, *B*. Panorama of fluted moraine, forest overturned by ice, and front of glacier from point D, Plate VI. Point D is on the northern part of the small island on which the front of the glacier rests. This position was overridden by the ice in August, 1909. July 10, 1905. From the same position photographs have been taken as follows: Gi 354, June 26, 1899; G 17 and 18, July 15, 1908; G 85 and 86, June 24, 1909.

G 15. Front of glacier from position one-half mile northeast of point D, Plate VI. July 15, 1908.

G 16. Ice overriding moraine from position about one-fourth mile northeast of point D, Plate VI. July 15, 1908.

G 17 and 18. No. 17 is here reproduced as Plate IX, *A*. Panorama of fluted moraine, forest overturned by ice, and front of glacier from point D, Plate VI. See under P 673. July 15, 1908.

G 19. Front of glacier and push moraine from a position a few rods west of point D, Plate VI. July 15, 1908.

G 20 and 21. Morainic topography in process of formation from position about one-fourth mile northeast of point D, Plate VI. July 15, 1908.

G 80 and 81. Panorama of front of glacier from point A, Plate VI. Point A is a rocky point on the east shore of Columbia Bay 1¼ miles north of Emerald Cove. June 24, 1909.

G 82. Here reproduced as Plate XII, *A*. Front of glacier and old moraine from point B, Plate VI. Point B is on the summit of a beautifully developed moraine at the north edge of the undisturbed forest west of the mouth of the stream which enters Columbia Bay at its northeast corner. June 24, 1909.

G 83. Here reproduced as Plate XI, *B*. Front of glacier and overturned forest, from point C, Plate VI. Point C is close to the edge of the ice and 0.3 mile north of point B. June 24, 1909.

G 84. Front of glacier and mud flows from position about one-half mile east of point D, Plate VI. June 24, 1909.

G 85 and 86. No. 85 is here reproduced as Plate IX, *B*. Forest overturned by ice and edge of glacier, from point D, Plate VI. June 24, 1909. See under P 673.

G 87. Here reproduced as Plate X, *A*. Front of glacier from position a few rods west of point D, Plate VI. June 24, 1909. The lowest (dead) tree in this photograph is seen at the extreme left of G 19.

G 88. Here reproduced as Plate XI, *A*. Front of glacier from point E, Plate VI. Point E is the top of a ledge of coarse-grained graywacke on the beach on the west side of the island on which the glacier rests. This ledge is not entirely covered by ordinary high tide. June 24, 1909. Photograph G 184 was taken from this same point.

G 89. Front of glacier, looking N. 51° W. (magnetic) from point F, Plate VI. Point F is a prominent exposure of massive graywacke on the end of a point projecting from the west side of Heather Island, about a mile from the south end of this island. June 24, 1909.

G 90 and 91. Here reproduced as Plate VII, *B*. West part of front of glacier from point G. Point G is on the end of a rocky point on the west side of Columbia Bay. The actual position from which the photograph was taken is covered at high tide. June 24, 1909. Photograph Gi 355 was taken from this same position on June 27, 1899.

G 92. Front of glacier from point near north shore of Glacier Island. June 25, 1909.

G 174. Front of glacier from position 1,000 feet south of point C, Plate VI. June 24, 1909.

G 175. Front of glacier from station on moraine about three-fourths of a mile southwest of point B. June 24, 1909.

G 176. Front of glacier from station about one-fourth of a mile east of Point D. June 24, 1909.

G 177. Surface of glacier from station on glacier about one-eighth of a mile north of point D. June 24, 1909.

G 178. Front of glacier from same station as G 177. June 24, 1909.

G 179. Crevasse in glacier from same station as G 177. June 24, 1909.

G 180. Surface of glacier from same station as G 177. June 24, 1909.

G 181. Front of glacier and push moraine from a position a few rods west of point D. June 24, 1909.

G 182. Front of glacier and overturned forest from a position a few rods west of point D. June 24, 1909.

G 183. Here reproduced as Plate X, *B*. Front of glacier and push moraine from a position a few rods west of point D. June 24, 1909.

G 184. Front of glacier from point E. See under G 88. June 24, 1909.

G 185. Front of glacier from a position about one-eighth of a mile southeast of point E, Plate VI. June 24, 1909.

G 186 to 189. Icebergs from glacier. June 24, 1909.

G 191. Front of glacier from near north shore of Glacier Island. June 25, 1909.

UNAKWIK INLET.

GENERAL FEATURES.

Unakwik Inlet is 16 miles west of Glacier Bay and extends northward from the main body of Prince William Sound for 22 miles (estimated). The bay is from 1 to 3 miles wide and does not appear to be very deep; at any rate there are shallows in places due to morainic accumulations. One of the most noticeable of these is in the vicinity of Jonah Bay. The northern part of Unakwik Inlet is, however, fiord-like and is probably deep. On the west side, about Jonah Bay, are a few small glaciers high up in the mountains. Three of these are on the flanks of the most prominent mountain on the west side of Unakwik Bay. We named this Unakwik Peak. From its western side descend the Amherst and Crescent glaciers of Port Wells. East of Unakwik Inlet the Pedro Glacier lies back in the mountains, and its waters reach tidewater through Miners Lake and Miners River. Four miles north of the mouth of this river is a small, narrow, beautiful, cascading ice stream, named Brilliant Glacier. Ranney Glacier is a prominent feature of the upper part of Unakwik Inlet. This glacier does not reach tidewater, but a stream (Ranney Creek) from the glacier enters the northwest side of the bay half a mile west of the front of Unakwik Glacier.

MEARES GLACIER.

The Meares Glacier is situated at the head of Unakwik Inlet. We have named it after one of the early (1786) explorers of Prince William Sound, Capt. John Meares. Little definite information concerning this glacier is available aside from the sketch and photographs here noted. Fidalgo (1790) and probably also Vancouver (1794) visited this bay, found the upper part blocked by ice, and noted the noise made by the fall of ice from the glacier front. The maps of that time are too inaccurate to give definite information concerning the position of the front of the glacier. On August 25, 1905, we made a hurried visit to the head of Unakwik Inlet, but made no map of the glacial front and took no photographs because our supply of films was exhausted. On June 26, 1909, we again visited the bay and mapped (fig. 3) and photographed (Pl. XII, *B*) the front of the glacier.

The Meares Glacier, although not so large as others, is one of the most beautiful ice streams of Prince William Sound. The end of the glacier is about 0.8 of a mile wide and forms a vertical wall of pure ice which we estimated to be 300 feet high. It is actively discharging. The glacier is formed by two ice streams, which descend from lofty mountains. The northern stream is the larger, and from the junction of the two a small medial moraine extends westward to the end of the glacier, keeping well toward its southern side.

In 1905, as viewed from the distance of a mile, the bushes and trees seemed to be close to the ice, and no bare zone (or at most a very narrow one) was visible between the ice and the forest. In 1909 the front of the glacier appeared to be a little in advance of its position of four years before. On the south side of the glacier near the front was a brown zone, estimated to be 200 feet wide, which appeared to be dead vegetation rather than bare rock, and on the northern edge of this brown zone, at the southern edge of the glacier, were a few small trees. There is a sparse forest close to the glacier containing trees 10 inches (estimated) in diameter. The ice is now, therefore, at its maximum advance within the last 100 years and quite probably at the maximum within two or three times that period.

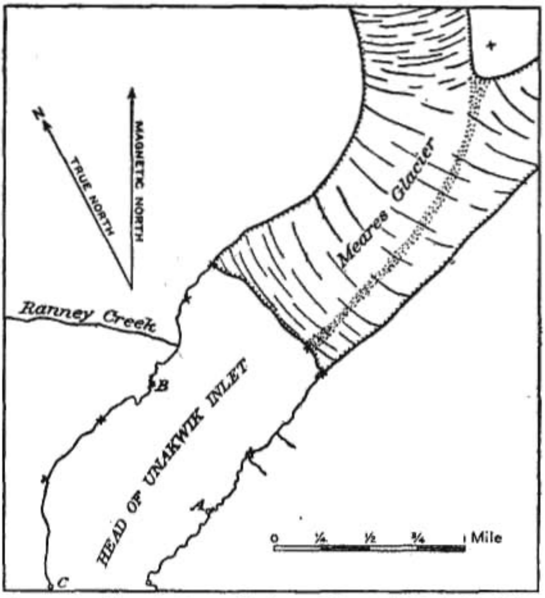


FIGURE 3.—Map of Meares Glacier and head of Unakwik Inlet June 26, 1909. Scale is approximate. Occupied points indicated by circles, intersected points by crosses.

Photographs of Unakwik Inlet and Meares Glacier.

G 93. Brilliant Glacier, east side of Unakwik Inlet. June 26, 1909.

G 94. North part of front of Meares Glacier from point A, figure 3. Point A is on a small flat-topped rock point, the first of the two most prominent points on the south shore between the bend near the head of Unakwik Inlet and the glacier. It is about half a mile from the point at the bend of the inlet. June 26, 1909.

G 95. South part of front of Meares Glacier from point B, figure 3. Point B is on a small rocky projection on the north shore of the head of Unakwik Inlet, situated about 300 yards west of the gravel fan at the mouth of Ranney Creek. The small point next west of B is covered with alders. June 26, 1909.

G 96. Here reproduced as Plate XII, *B*. Meares Glacier from point C, figure 3. Point C is a small rocky point directly opposite the prominent point on the east side of Unakwik Inlet at the bend near its head. Just back (west) of point C rises a very steep mountain side. June 26, 1909.

PORT WELLS.

GENERAL FEATURES.

Port Wells, with its two large arms, College and Harriman fiords, forms the extreme northwestern part of Prince William Sound. The valley in which Port Wells lies is very extensive, reaching from the front of the Harvard Glacier south-southwest through Cochrane Bay to the head of Port Nellie Juan, a distance of 56 miles at sea level. The same straight depression is continued for an unknown distance both north-northeast and south-southwest of the points named. (See Pl. I, in pocket.)

The glaciers of Port Wells were seen in part by Mendenhall in 1898 and were studied by the Harriman Alaska Expedition in 1899. We made a hurried visit to Port Wells in August, 1905, and took a few notes and photographs. On August 11, 1908, we visited the Barry Glacier. From June 28 to July 2, 1909, we were in Port Wells and at this time mapped the port and its glaciers (Pls. I and XVII and fig. 4) and obtained a few photographs. Port Wells and its glaciers form a very inviting field and would well repay careful study.

West of Port Wells are extensive unexplored ice fields, from which numerous glaciers emerge. Many of these glaciers reach sea level. There are also numerous smaller ice streams, each of which comes from a névé area of its own, so that the glacier and the névé are practically one. The southernmost ice field of Port Wells is that about the head of Harriman Fiord, which feeds the northeastward-moving Harriman Glacier. The same ice field apparently furnishes material to the Bettles Glacier, flowing to the east, and to the Pigot and Billings glaciers, which flow southward. It is probable that ice from the same field moves westward into the drainage basin of Turnagain Arm of Cook Inlet.

COLLEGE FIORD.

GENERAL FEATURES.

The glaciers of College Fiord (fig. 4) have been described by Gilbert.[1] Additional data, most of them concerning the largest three glaciers, the Yale, the Harvard, and the Bryn Mawr, are here given.

Along the west side of College Fiord is a lofty mountain range; the prominent peak at the south end of this range is named Mount Emerson, after Prof. B. K. Emerson, who was a member of the Harriman Alaska Expedition of 1899. Within a short distance north of this peak the mountain range carries several glaciers that hang high above the fiord, and beyond these are others which descend to sea level and have been named, from south to north, the Wellesley, Vassar, Bryn Mawr, and Smith glaciers. North of the latter group is the Baltimore Glacier, which does not reach sea level (Pl. XIV, *A*).

YALE GLACIER.

The first description of the Yale Glacier was written by Mendenhall[2] in 1898. In 1899 the glacier was visited by the Harriman

[1] Gilbert, G. K., Alaska, vol. 3, Harriman Alaska Expedition, 1904, pp. 81-89, 175-176.

[2] Mendenhall, W. C., A reconnaissance from Resurrection Bay to the Tanana River, Alaska, in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 273, 325.

Alaska Expedition and described by Gilbert.[1] In 1905 the senior author of this report made a hasty visit to the east arm of College Fiord and noted that the only evidence of either recent retreat or advance of the ice front was a very narrow bare zone on the east side of the glacier front.

Notes and photographs by both Mendenhall and Gilbert, compared with observations made in 1909, show that there has been no marked

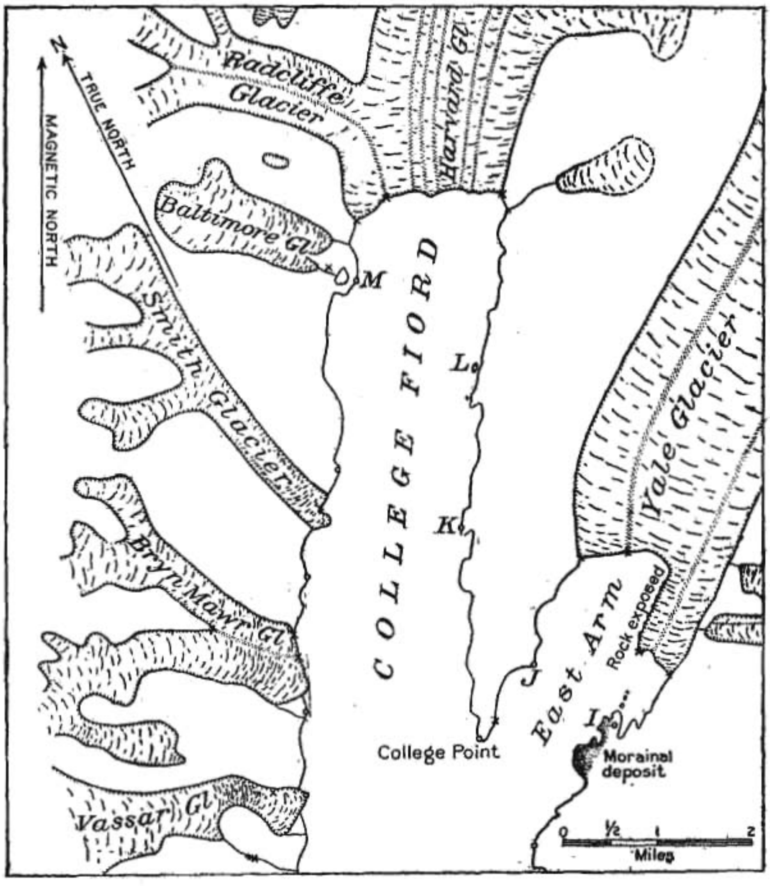
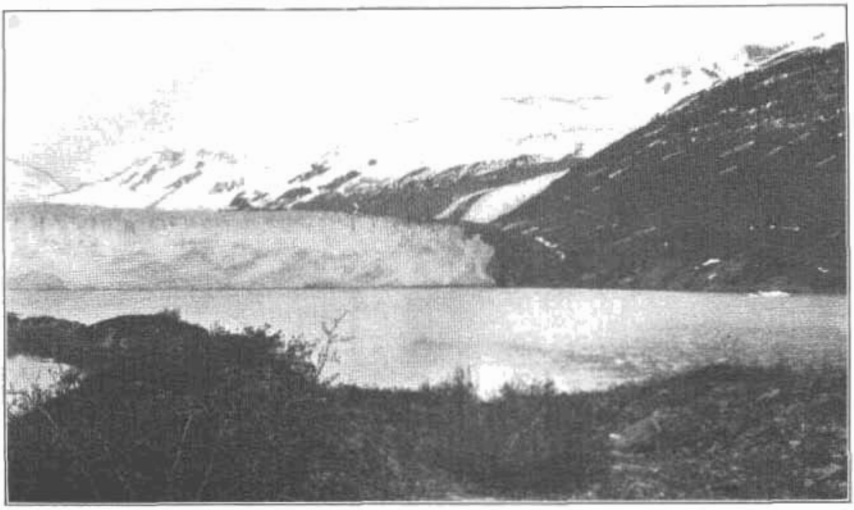


FIGURE 4.—Map of northern part of College Fiord, Port Wells, June 30, 1909. Occupied points indicated by circles, intersected points by crosses.

advance at the edges of the ice front since 1898, but that the eastern side of the glacier has advanced slightly. Gilbert says:

> The trough in which it [the glacier] lies is forested along the water edge on both sides for the greater part of the distance from the main fiord to the glacier, but barren in the immediate vicinity of the glacier. There are straggling trees high on the valley wall at the end of the glacier, but they do not come down close to the ice.

[1] Harriman Alaska Expedition, vol. 3, 1904, p. 83.



A. EAST PART OF FRONT OF YALE GLACIER.

From point I, figure 4. July 1, 1909. Photograph G 202.

B. CENTER AND WEST PART OF FRONT OF YALE GLACIER.

From point I, figure 4. July 1, 1909. Photograph G 203.

This was the condition of the surroundings at the time of our visit in 1909, except that there was a very narrow bare zone on each side of the glacier. On the east side the ice was separated from grass and alders by only a few rods of rock débris. Possibly these narrow bare areas are due to no more than the rapid melting away of the ice in the summer. Although the sides of the fiord are barren of trees, they are clothed with a tangle of salmonberry bushes and alders up to the line where the scattered timber begins. This line is very distinct on each side of the fiord (Pl. XIII, *A*, right side). It is practically horizontal at an elevation of 900 feet (estimated) and probably marks the lateral margin of the great ice stream which once occupied the entire fiord.

The published maps show the front of the glacier as approximately straight, but intersections on the front in 1909 showed that the east part of the glacier projects beyond the west part. The former portion is held in place by a hard ledge of rock extending about parallel with the axis of the glacier. Plate XIII, *B*, shows this feature of the front as well as portions of the rock projecting from under the ice cliff. This ledge shows distinctly in a photograph made by Curtis in 1899. The tiny islands in the foreground of Plate XIII, *B*, are gull rookeries and belong to the same hard rock layers. The station from which this view was taken is on a glaciated knob of the same resistant formation. Careful examination of the Harriman expedition photograph shows that the ice front was then probably much as it is now. The irregular shape may have been overlooked in a rather cursory survey, for we have noticed that in a perspective view ice fronts are very deceptive and that a seemingly straight wall of ice shows marked irregularities when more closely examined.

The west side of the glacier is probably resting on a surface above high tide, as noted by Gilbert. In fact, at two places small portions of such a surface may be seen, though an advance of a few yards would cover them. On the extreme west a small morainal deposit is being made.

The presence of a mature alder thicket close to the ice front indicates that the glacier is now very near its maximum advance in a period of perhaps 50 or more years. The gravelly point a mile below the glacier on the east side of the fiord is probably the remains of an older terminal (recessional) moraine. This moraine, however, is later than the time of greater ice extension indicated by the lower limit of the spruce forest about 900 feet above sea level.

HARVARD GLACIER.

The Harvard Glacier is the trunk glacier of College Fiord and is the largest and most impressive of that inlet. The glacier has several feeders and six distinct medial moraines, as well as other less distinct drift accumulations on its surface. The frontal cliff is estimated to be 350 feet high, and at the times of our visits was discharging abundantly, the water down as far as College Point carrying much ice. Waves generated by the fall of icebergs and the strong currents in front of the glacier make it impracticable to approach near the glacial front in a small boat. Reports are current that native seal hunters in bidarkas have been drawn under the glacier by northward flowing currents. At the time of our visit in 1909 there were marked northward-flowing currents on both sides of the fiord near its upper end.

The Harvard Glacier was visited by the Harriman Alaska Expedition in 1899.[1] We saw and photographed the glacier at a distance in 1905 and from a nearer point in 1909 (Pls. XIV, *A* and *B*, and XV, *A*).

Gilbert's description calls attention to the relation of the Harvard Glacier to its southernmost feeder on the west, the Radcliffe Glacier, and notes that the two barely coalesced in 1899, and that the medial moraine bounding the feeder extended without curvature to the frontal cliff. A photograph taken in 1905 shows that practically the same conditions prevailed at that date. In 1909, however, this medial moraine was distinctly curved (as Gilbert predicted it would be should the glaciers advance), and it followed the general axis of the trunk stream for half a mile before reaching tidewater. (Pls. XIV, *A*, and XV, *A*.) Thus the position of the west part of the front of the Harvard Glacier was approximately the same in 1899 and 1905, but there was an advance prior to July 1, 1909, at which time the ice front is estimated to have been half a mile farther south than on the earlier dates.

Gilbert reports, from a study of photographs, that in 1899 the eastern part of the front of the Harvard Glacier was 1,000 to 2,000 feet north of the apex of an alluvial fan made by a stream from a small hanging glacier. A photograph taken 10 years later (Pl. XIV, *B*), compared with his statements and photograph,[2] indicates that in 1909 the eastern part of the glacial front had advanced beyond its position in 1899 by a distance roughly estimated at a quarter of a mile.

SMITH GLACIER.

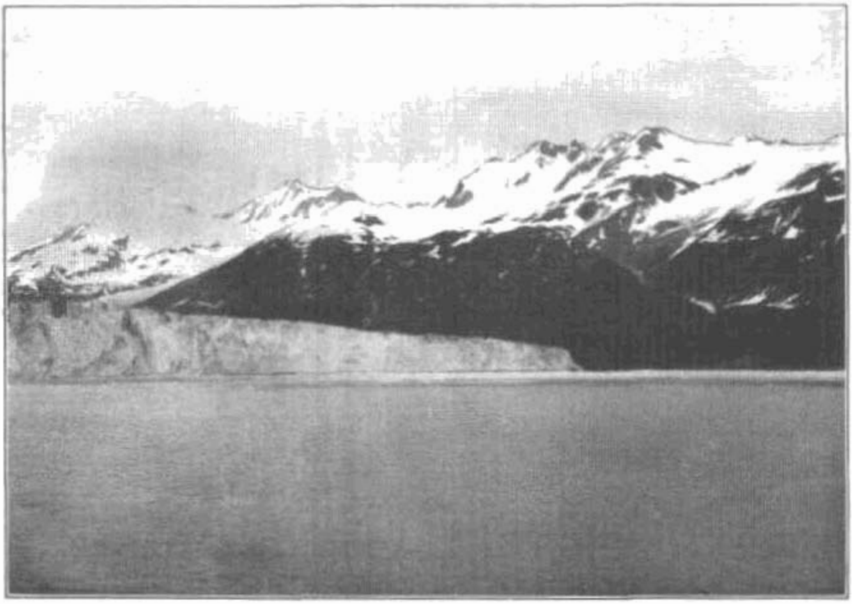
The Smith, which is the first tidewater glacier south of the Harvard, has not been studied in detail. This glacier is shown in photographs made in 1899 and 1909, but these were taken at some distance and were not intended primarily to show this glacier. A comparison of these photographs and of maps of College Fiord made in the abovementioned years indicates that the front of the glacier, especially

[1] Alaska, vol. 3, Harriman Alaska Expedition, 1904, pp. 84-86, 89.

[2] Idem, vol. 1, 1901, plate facing p. 72.

A. WEST PART OF FRONT OF HARVARD GLACIER.

From point L, figure 4. The glacier on the left, not reaching tidewater, is the Baltimore, and the large ice stream joining the Harvard Glacier is the Radcliffe. July 1, 1909. Photograph G 208.

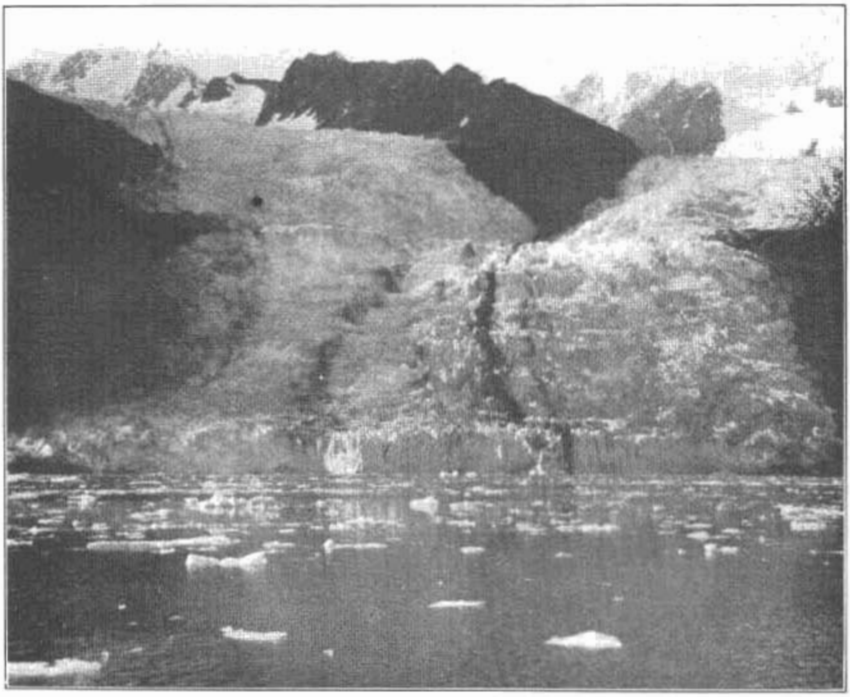


B. EAST PART OF FRONT OF HARVARD GLACIER.

From point M, figure 4. July 1, 1909. Photograph G 109.

A. HARVARD GLACIER.

From point K, figure 4. The glacier on the left is the Radcliffe. July 1, 1909. Photograph G 207.

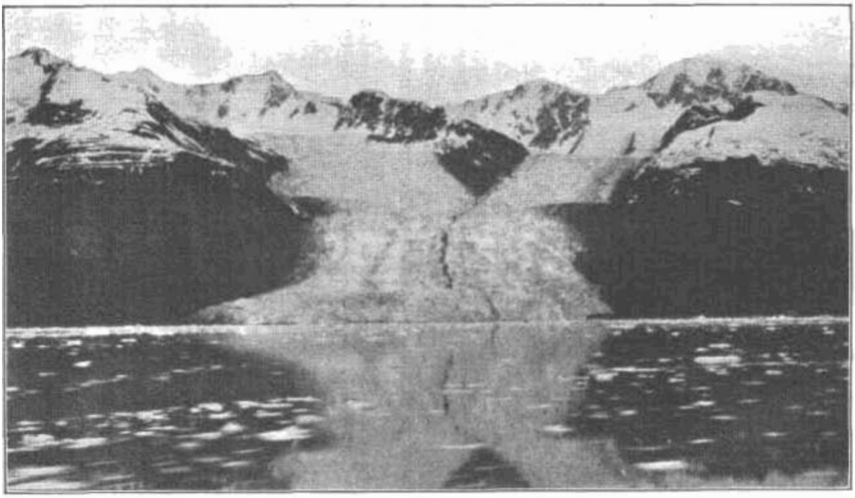


B. BRYN MAWR GLACIER.

August 21, 1905. Photograph P 692.

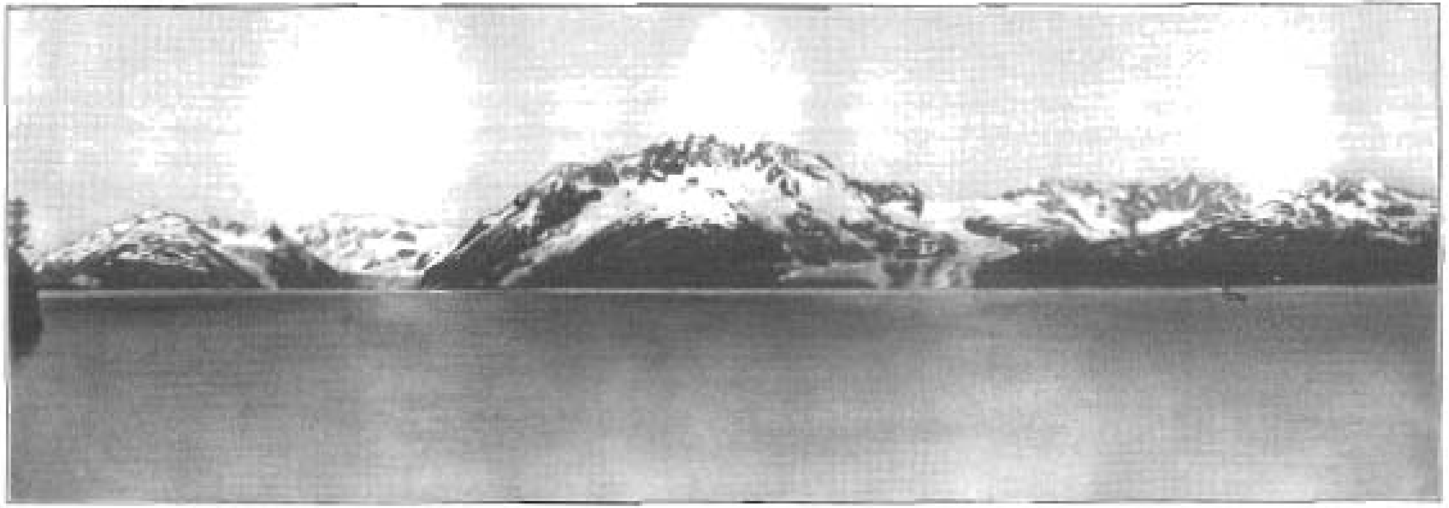
A. WEST SIDE OF COLLEGE FIORD.

From point L, figure 4. July 1, 1909. Bryn Mawr Glacier in center, Smith Glacier on right. Photograph G 210.



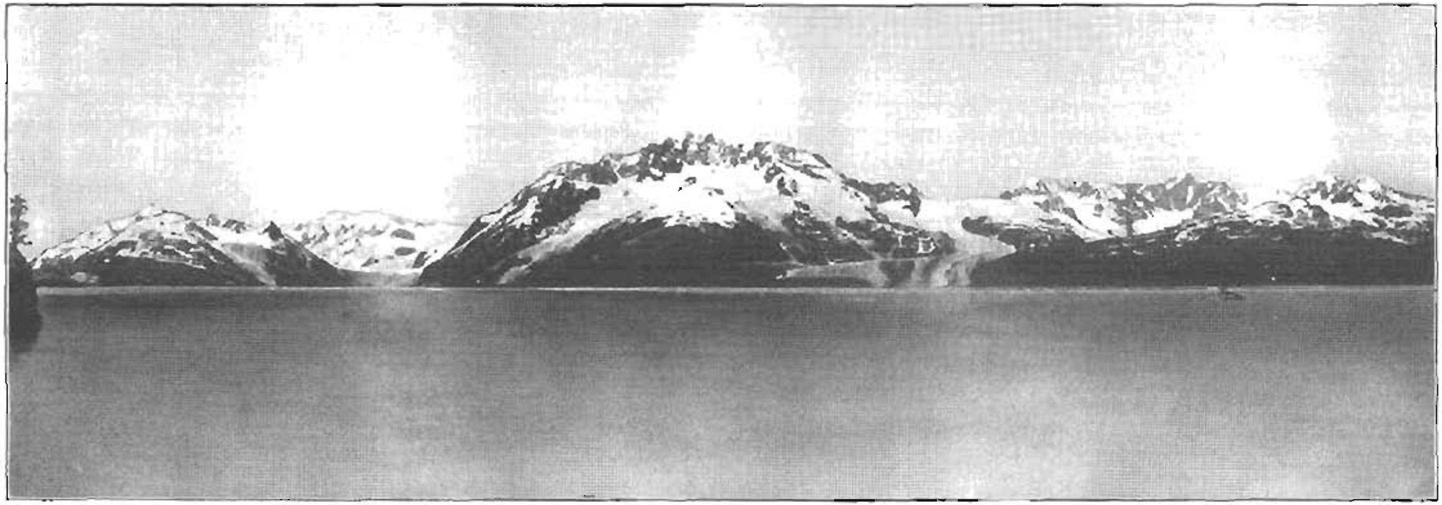
B. BRYN MAWR GLACIER.

From end of College Point. July 1, 1909. Photograph G 206.



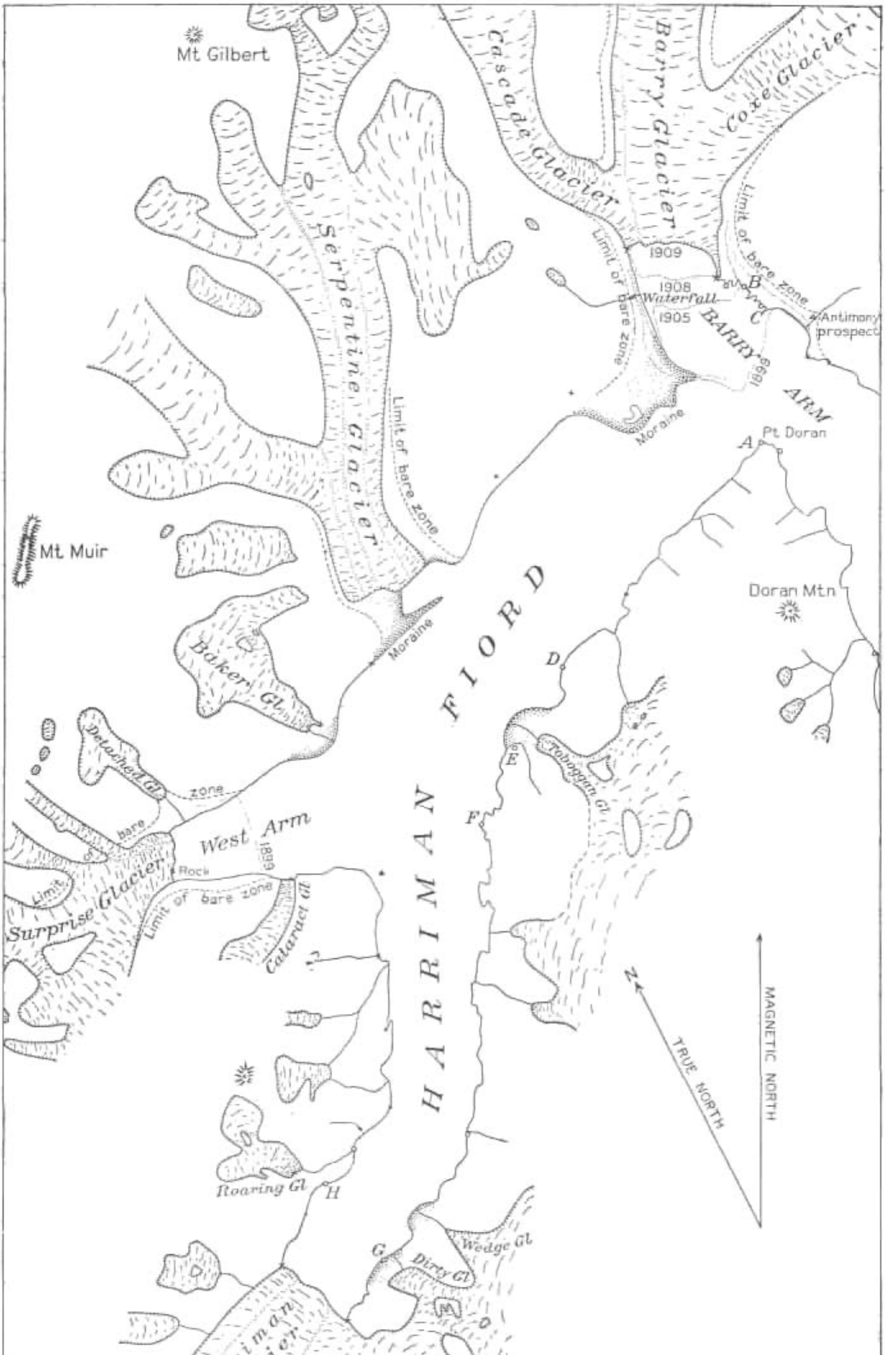
PANORAMA OF WEST SIDE OF HARRIMAN FIORD.

From point 5, Plate XVII. From right to left the glaciers are the Serpentine, Baker, Detached, Surprise, and Cataract. The highest peak in the center is Mount Muir, and the peak above and just to the left of the boat is Mount Gilbert. These peaks are approximately 10,000 feet above sea level. The front of the Serpentine Glacier is 2½ miles from the observer and the Surprise 5½ miles. June 29, 1909. Photographs G 193 to G 196.



PANORAMA OF WEST SIDE OF HARRIMAN FIORD.

From point D, Plate XVII. From right to left the glaciers are the Serpentine, Baker, Detached, Surprise, and Cataract. The highest peak in the center is Mount Muir, and the peak above and just to the left of the boat is Mount Gilbert. These peaks are approximately 10,000 feet above sea level. The front of the Serpentine Glacier is 2½ miles from the observer and the Surprise 5½ miles. June 29, 1909. Photographs G 193 to G 196.



MAP OF HARRIMAN FIORD, PORT WELLS.

June 29 and 30, 1909. Occupied points indicated by circles, intersected points by crosses.

Our photographs taken in 1905 were few, and in 1908 time permitted only a hurried view of the Barry Glacier. In 1909 a little more time was spent in Harriman Fiord, but very much less than the locality deserves. Sufficient data are at hand, however, to show that the Barry and Surprise glaciers have retreated markedly in the past 10 years and that the Serpentine, Cataract, Harriman, and Toboggan glaciers have shown much less change in that time.

BARRY GLACIER.

The Barry Glacier is in some ways the most interesting on Harriman Fiord, and the record of its fluctuations is more complete than that of any other on Port Wells. In 1899 the front of the glacier was well out into the waters of Harriman Fiord, and 10 years later this glacier showed a much greater retreat than any other that we have studied. This glacier has been called the Washington,[1] but the name Barry was proposed earlier and is now in common use.

From 1899 to 1909 the Barry Glacier retreated approximately 2.1 miles, measured along the axis of the glacier. (See Pl. XVII.) From 1899 to 1905 the retreat was 1.2 miles; from 1905 to 1908, 0.4 mile; and from August 11, 1908, to June 29, 1909, 0.5 mile. In 1899 a long point of ice extended forward from the eastern part of the glacial front; in 1905 there was a similar projection from the western part, and in 1909 a shorter point extended forward from the eastern part. The two earlier points of ice were probably in the main unmelted stagnant portions of the glacier resting mostly above tide level, but the 1909 projection was part of the moving glacier.

Along both sides of the Barry Glacier an extensive bare zone lies between the ice and a mature spruce forest (Pls. XIX and XX). Near the antimony prospect southeast of the glacier there are fragments of trees in the drift, and near the southern limit of the bare zone at this locality are a number of fallen trunks. The limit of this bare zone indicates the maximum advance of the ice since the growth of the present forest. The ice probably stood near this point of maximum advance for a considerable period, during which were deposited the morainic accumulations on the west side of the bay on which the glacier is situated. No means of ascertaining definitely the date of the end of this maximum advance are available, but the condition of the forest above the bare zone and the vegetation on the morainic deposits just mentioned would indicate that such a maximum occurred 25 or more years ago. The glacier had retreated from this farthest advanced position when it was first studied, in 1899. Still more advanced positions probably have not been occupied by the ice front for several centuries.

In 1905 and 1908 the frontal cliff of the glacier was estimated to be 250 feet high, but in 1909 the cliff appeared to have not more

[1] Gannett, Henry, Nat. Geog. Mag., vol. 10, 1899, p. 510.

G 208 and 209. No. 208 is here reproduced as Plate XIV, *A*. Panorama of Harvard Glacier from point L, figure 4. July 1, 1909. Point L is on a small rock island on the east side of College Fiord, about 3½ miles south of the Harvard Glacier. The island is very bushy on the extreme top, and the station occupied is on the west side of the island at nearly as great an elevation.

G 210. Here reproduced as Plate XVI, *A*. West side of College Fiord from point L, figure 4. Smith Glacier on right. July 1, 1909.

G 211. Harvard Glacier from boat opposite Bryn Mawr Glacier. July 1, 1909.

G 212. Bryn Mawr Glacier. July 1, 1909.

HARRIMAN FIORD.

GENERAL FEATURES.

The first recorded visit to Harriman Fiord was made by the Harriman Alaska Expedition in 1899, and the main glaciers were named by the members of that expedition. Prior to that date the Barry Glacier, lying at the sharp bend in the fiord, was the only one that had been recorded, and earlier explorers evidently had assumed that this ice stream filled the whole end of this arm of Port Wells (Pl. XVII). That this glacier, however, has not extended across the fiord for a long series of years is shown by the vegetation, including a sparse forest that comes down nearly to the water's edge opposite the glacier and by well-authenticated reports that native seal hunters had repeatedly gone past the front of the Barry Glacier and into the inner part of the fiord. To the Harriman expedition is due the credit of bringing to public knowledge this magnificent fiord, hemmed in by lofty mountains whose sides and valleys carry many glaciers. Five of these ice streams reach tidewater.

Among the localities in Alaska that derive scenic interest from glaciers three stand out prominently—Glacier Bay, the Yakutat-Disenchantment Bay region, and Harriman Fiord. The panorama of mountain, ice, snow, and water that unfolds itself from points along the southeastern shore of Harriman Fiord has few equals anywhere else in the world.

The most striking peaks about the fiord are Mount Gilbert on the north and a four-peaked summit, Mount Muir, on the west of the Serpentine Glacier. (See Pl. XVIII.) Rough estimates of their altitudes made by vertical angles gave results approximating 10,000 feet for each. These peaks are named after Grove Karl Gilbert, a geologist on the United States Geological Survey, and John Muir, the veteran naturalist, who were both among the first scientists to see Harriman Fiord.

The records of the fluctuations of the glaciers along Harriman Fiord are unfortunately fragmentary. Gilbert's descriptions are derived mainly from a study of photographs and from accounts by others.[1]

[1] Op. cit., vol. 3, pp. 89-97.

close examination. The south part of the front of this glacier was in 1909 as far advanced as it had been in recent years, whereas the north part of the front has very recently been 200 feet farther east. We made no measurements or photographs of this glacier in 1905, but our impression is that in 1909 its front projected farther into College Fiord than it did four years before. Gannett's map of 1899 does not show this glacier projecting east of the coast line, as it did 10 years later (fig. 4). The 1899 map, however, is drawn on a very small scale, and is evidently a sketch map, so that this detail may have been omitted. Still it is very probable that the Vassar Glacier did advance between 1905 and 1909, as did the Bryn Mawr and Harvard glaciers and probably the Smith Glacier. The advance of the Vassar Glacier since 1899, and most probably since 1905, is thought to be about 500 feet.

WELLESLEY GLACIER.

The Wellesley Glacier carries considerable débris on its north side near its front. There is a bare morainic zone along both sides of the front of this glacier, and willows 10 feet high are scattered over this morainic area. Herbaceous vegetation comes practically to the edge of the ice. It is estimated that the ice front in 1909 stood as far forward as it had at any time in the last five years and that the morainic area carrying the willows represents an advance of 15 or more years ago. No further details concerning the Wellesley Glacier are available.

Photographs of glaciers of College Fiord.

P 692. Here reproduced as Plate XV, *B*. Bryn Mawr Glacier. August 21, 1905.

P 693. Harvard Glacier. August 21, 1905.

G 109. Here reproduced as Plate XIV, *B*. East part of front of Harvard Glacier, from point M, figure 4. July 1, 1909. Point M is on the eastern edge of the rocky point in front of the Baltimore Glacier and is about 40 feet above sea level.

G 110. West end of front of Harvard Glacier; Baltimore Glacier at left. July 1, 1909.

G 111. Side view of Bryn Mawr Glacier. July 1, 1909.

G 201. West side of College Fiord from bay northwest of Amherst Glacier. June 30, 1909.

G 202 and 203. Here reproduced as Plates XIII, *A* and *B*. Panorama of front of Yale Glacier from point I, figure 4. July 1, 1909. Point I is on a small round rock knob and 30 or 40 feet above sea level. This is one of a series of knobs formed by a hard rock layer whose northeastward prolongation is marked by small islands. A cairn 3 feet high in an open space marks point I.

G 204 and 205. Panorama of east part of front of Yale Glacier from point J, figure 4. July 1, 1909. Point J is on a smooth, rounded rock point, the most prominent one between College Point and the north end of the front of the Yale Glacier. The station is a few feet from the water's edge on a rock strongly marked by glacial grooving.

G 206. Here reproduced as Plate XVI, *B*. Bryn Mawr Glacier from end of College Point. July 1, 1909.

G 207. Here reproduced as Plate XV, *A*. Harvard Glacier from point K, figure 4. July 1, 1909. Point K is a rocky point on the east side of College Fiord, directly opposite the Smith Glacier.

the southern half of the front, was more advanced in 1909 than it was 10 years earlier. The amount of this advance can not be accurately estimated from the data at hand, but the part of the front projecting beyond the shore line (see fig. 4) probably was not present in 1899. This advance is perhaps as much as 600 feet, and judging from the advances recorded in the adjacent glaciers (Harvard and Bryn Mawr) it has probably taken place since 1905.

BRYN MAWR GLACIER.

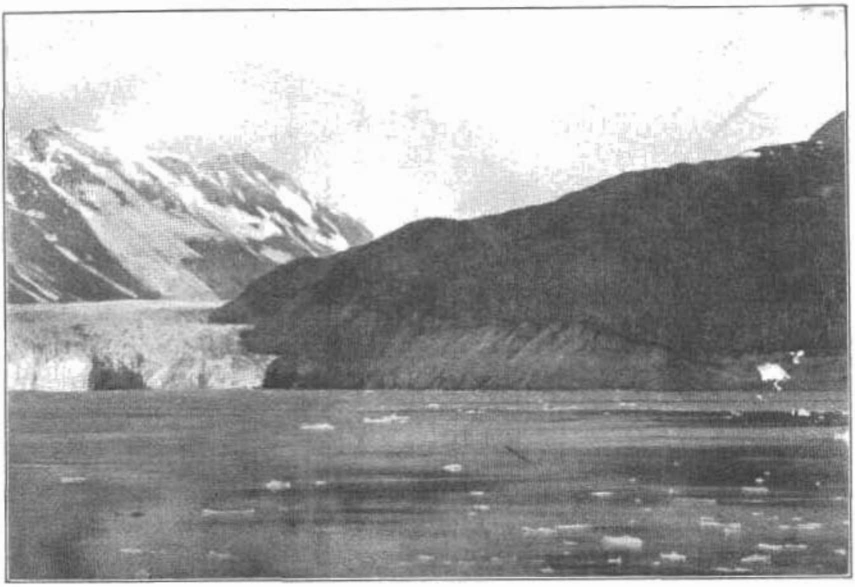
The Bryn Mawr Glacier is the largest and the most attractive of those on the west side of College Fiord. It is a veritable ice cascade and gives a vivid impression of a rushing torrent to one who views the glacier from a point directly in front and not far distant. (Pl. XV, *B*.) The glacier is formed by two trunk streams, which unite about a mile back from tidewater. The two streams flow in a deep valley of fairly gentle slope, but just before joining they plunge over a steep slope. Below this junction the glacier has a gentle gradient for about half a mile; then it is brought by another and still more tumultuous fall nearly to tidewater, before reaching which it again receives a flattened profile on the floor of College Fiord. These ice cascades are shown in Plate XV, *B*, and Plate XVI, *B*, and the profile of the lower part of the glacier is shown in Plate XVI, *A*. Below the crest of the upper fall the glacier lies in a very shallow trough. The crests of these ice falls are thought to represent the approximate upper limits of the trunk glacier of College Fiord at two earlier stages in its history; the Bryn Mawr Glacier of to-day occupies a hanging valley on the side of this fiord. Similar characters are shown by other glaciers of College Fiord, and their significance has been noted by Gilbert.[1]

A comparison of the photographs taken in 1899 [2] with those taken in 1909 indicates that the glacier was farther advanced at the latter date, and that its front (especially the southern half of the front) deployed more widely on the shallow bottom of College Fiord. A photograph taken in 1905 (Pl. XV, *B*) and the impression gained from a brief study four years later indicate that the glacier was less advanced at the earlier date, when it was at approximately the same position as in 1899. The amount of the advance shown in the photographs taken in 1909 can not be estimated closely from the data at hand, but it is probably as much as 500 feet.

VASSAR GLACIER.

The front of the Vassar Glacier is about 200 feet high and is covered with débris to such an extent that the underlying ice is seen only by

[1] Op. cit., vol. 1, pp. 86–88, 175–176. [2] See idem, vol. 2, p. 276, and vol. 3, frontispiece.



A. AUGUST 20, 1905.

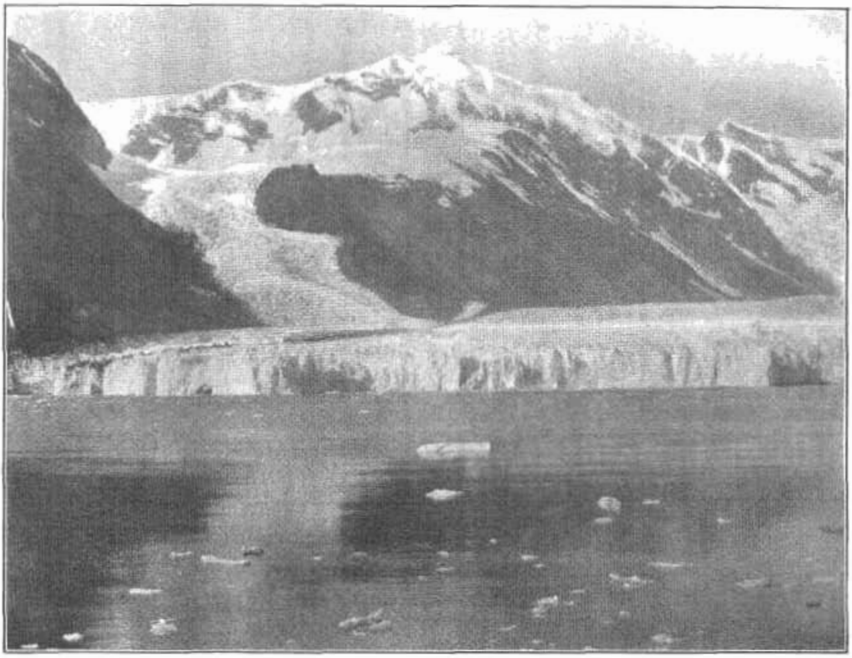
Photograph P 686.

B. JUNE 29, 1909.

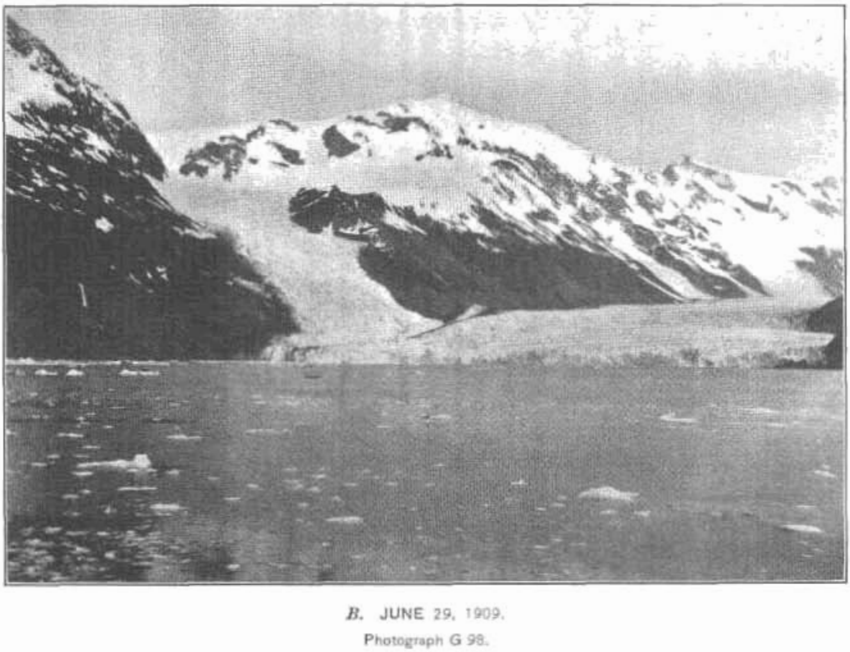
Photograph G 99.

EAST PART OF FRONT OF BARRY GLACIER.

From point A, Plate XVII.



A. AUGUST 20, 1905.
Photograph P 685.



B. JUNE 29, 1909.
Photograph G 98.

CENTER AND WEST PART OF FRONT OF BARRY GLACIER.

From point A, Plate XVII. The waterfall at the left in *B* is just visible at the extreme left in *A*.

than half this height. The photographs of Plate XIX, taken in 1905 and 1909 from the same point, show considerable change in the ice front, especially in the altitude of the surface of the first feeder on the right, where it joins the main stream. The height of the bare zone on the east side near the present glacial front has been estimated as 400 feet above the ice of to-day. The thickness of the ice stream at its maximum recorded extent, therefore, was here 400 feet greater than at present. The front is now about 2.5 miles back of this maximum advance.

The position of the west part of the ice front in 1909 with reference to the first feeder (Cascade Glacier) and the noticeable waterfall from the hanging valley near the north end of the forested zone (Pl. XX, *B*) will assist in recording the amount of future fluctuation of this glacier.

SERPENTINE GLACIER.

The Serpentine Glacier is the first to reach tidewater west of the Barry Glacier. A considerable bare zone along the sides of the Serpentine Glacier and morainic accumulations in front of the glacier are evidences of an advance in comparatively recent years, but prior to 1899. The bare zone on the side is underlain by a distinct lateral moraine deposited at the time of this advance.

Our information concerning a still more recent retreat of the ice front consists in a few photographs taken in 1899, 1905, and 1909. The ice cliff in 1899 [1] was probably higher and extended farther along tidewater than in 1909 (Pl. XVIII), and the eastern side of the glacier was more advanced at the earlier date. Photographs taken from a definite locality (point A, Pl. XVII) in 1905 and 1909 show that in the former year the west part of the front was more advanced than in 1909.

The Serpentine Glacier, then, had an advance a few years before 1899; in 1905 the position of the front of the ice was approximately the same as in 1899; and in 1909 the ice front was farther back than at either of the other dates. The retreat from 1905 to 1909 was perhaps a quarter of a mile, and from the advance before 1899 to the present time the glacier has retreated approximately half a mile on its center and eastern side and three-quarters of a mile on its western side. These distances are to be regarded only as estimates, for we did not study the front of this glacier close at hand, and most of our information comes from photographs.

BAKER GLACIER.

The Baker Glacier is named after Dr. Marcus Baker, editor of the Geographic dictionary of Alaska.[2] The névé and the ice stream of this glacier are practically one, and nearly the whole glacier is shown

---

[1] Alaska, vol. 1, Harriman Alaska Expedition, 1901, plate opposite p. 124; vol. 3, 1904, fig. 50.

[2] Bull. U. S. Geol. Survey No. 187, 1902; No. 299, 1906.

in Plate XXI, *A*. The surface of the Baker Glacier has a steep slope (shown in partial profile in Pl. XVIII), but near the sea the ice stream breaks over an almost vertical cliff, from which the ice falls and then accumulates near tidewater. A small tongue of the glacier, however, passes over this cliff and joins the ice below. These features can be seen in Plate XXI, *A*, which shows the conditions existing in 1909. In 1905 there was no ice at the base of the cliff, the small tongue of the glacier came downward only a short distance from the top of the cliff, and the ice front above the cliff was not so high nor so prominent as in 1909. The photographs taken in 1899 to which we have access show that the conditions existing then were very similar to those in 1909, but no front view of the glacier at the earlier date is available.

The Baker Glacier, therefore, shows a retreat between 1899 and 1905, but in 1909 the ice had advanced to, and probably beyond, its position of 10 years previous. Data are not at hand to measure the amount of this retreat and advance, but the distance is probably only a few hundred feet.

SURPRISE GLACIER.

The Surprise Glacier reaches tidewater in a vertical cliff at the head of the west arm of Harriman Fiord. Along both sides of the glacier is a bare zone, which extends forward nearly to the Cataract Glacier. Gannett's map of Port Wells [1] shows the front of the Surprise Glacier practically at the point where the Cataract Glacier reaches tidewater. Photographs taken that year, however, show that the two glaciers were separated by a distance estimated to be a quarter of a mile. In 1909 the front of the Surprise Glacier was much farther (estimated at 1.1 miles) back than in 1899. How much of this retreat had taken place since 1905 is not clear, for our photograph of that year is indistinct; but it is certain that a considerable part of the retreat had occurred by 1905. A rock ledge, divided into two parts, projected from the front of the glacier near its south side in 1909. (See Pl. XXI, *B*.) Evidently this ledge would be covered by a slight advance of the ice; at least, so it appeared from our nearest point of observation to the Surprise Glacier, opposite the front of the Cataract Glacier. It is our recollection that no such ledge was visible in 1905.

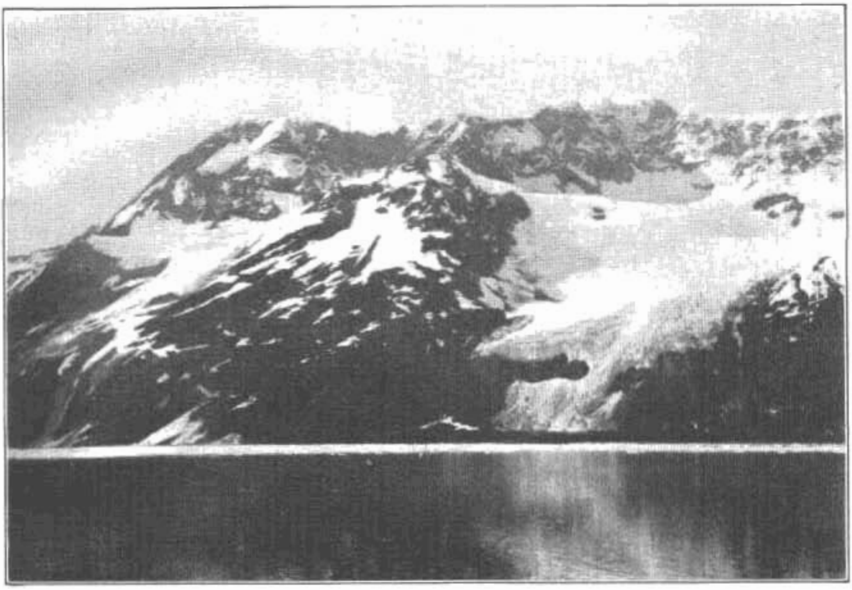
The maximum advance of the Surprise Glacier in recent years is indicated by the bare zone; by 1899 the glacier had retreated about a tenth of a mile. This retreat was being continued in 1905, and in 1909 the glacier had retreated 1.1 miles from its position in 1899.

CATARACT GLACIER.

The Cataract is a small glacier descending a steep valley and reaching tidewater on the south side of the west arm of Harri-

---

[1] Alaska, vol. 3, Harriman Alaska Expedition, 1904, Pl. XIII.

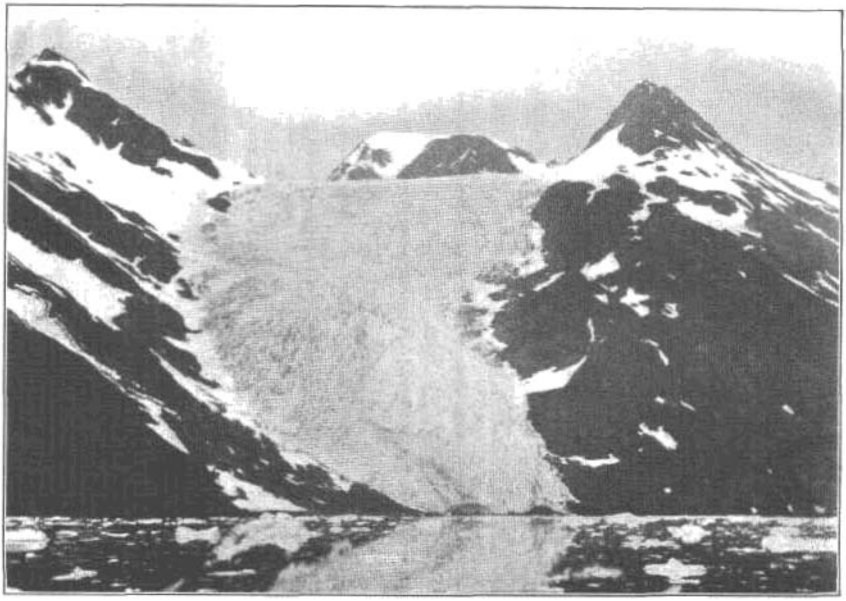


A. BAKER GLACIER.

From point F, Plate XVII. Detached Glacier on left. June 29, 1909. Photograph G 105.

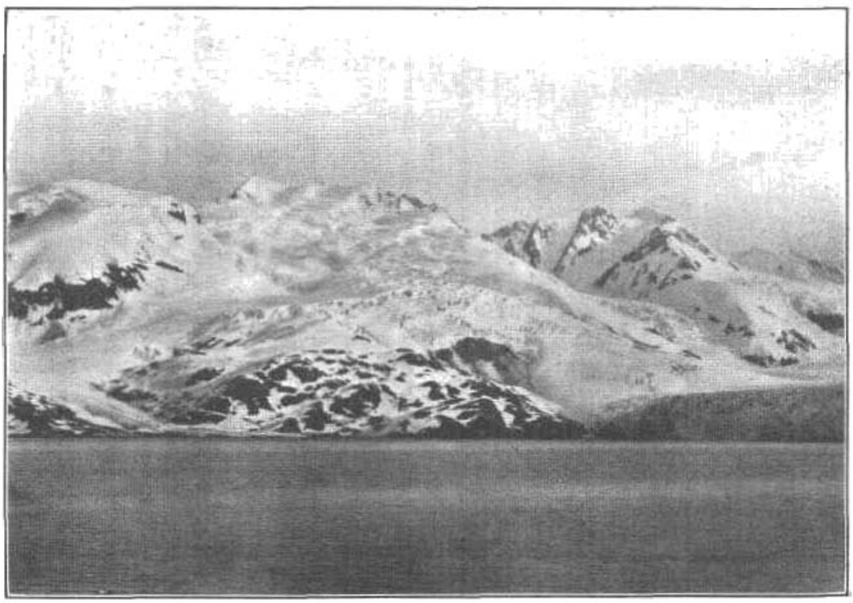
B. SURPRISE GLACIER.

From point F, Plate XVII. Detached Glacier on right. June 29, 1909. Photograph G 104.



A. CATARACT GLACIER.

June 30, 1909. Photograph G 107.



B. EAST PART OF FRONT OF HARRIMAN GLACIER.

From point H, Plate XVII. Dirty Glacier on left. June 29, 1909. Photograph G 106.

man Fiord. A comparison of Gannett's map of 1899 [1] with our map (Pl. XVII) does not show any noticeable change in the position of the front of the glacier in the last 10 years. We have no photographs of this glacier taken before 1909, but those taken in that year (Pls. XVIII and XXII, *A*) will be of service in determining future advance or retreat. The latter view shows a narrow bare zone along the west side of the glacier, but the extent to which the shrubs have encroached upon this zone indicates that the ice stream has not in recent years (perhaps 25 years) been much larger than at present.

HARRIMAN GLACIER.

The Harriman is the trunk glacier of Harriman Fiord and comes to the water's edge at the southwest end of the fiord. The frontal cliff is estimated to be 300 feet high. The glacier has several feeders and comes from an extensive snow field from which emerge only a few peaks that are not permanently snow covered.

Photographs of the eastern part of the front of the Harriman Glacier, taken from point H, Plate XVII, in 1905 and in 1909 (Pl. XXII, *B*), show that this side of the glacier retreated approximately 700 feet between these dates. A comparison of an 1899 photograph [2] with our 1905 view indicates that between 1899 and 1905 the east side of the glacier retreated about half the above distance. As the two photographs were not taken from the same point this estimate of the retreat between 1899 and 1905 is only approximate. A careful examination of the western part of the ice front in 1909 from the position of a photograph taken in 1899 [3] showed no noticeable difference in the position of the glacier. In 1899 a considerable embayment existed in the eastern third of the front of this glacier, but this feature was not present in 1905 and 1909.

On the east side of Harriman Fiord scattered spruce trees extend southward to and just beyond the front of the Wedge Glacier, but do not reach so far south on the west side of the fiord. The absence of trees nearer the front of the Harriman Glacier seems to be due, as suggested by Gilbert,[4] not to the glacier's having recently covered this area, but more likely to conditions unfavorable to forest growth. Though the glacier front may have advanced 2 miles farther north within the last century, it probably has not done so. In fact it is not likely that an extension of more than this distance has taken place within two or more centuries.

DIRTY GLACIER.

Dirty Glacier is a small ice stream reaching nearly to tidewater, three-fourths of a mile northeast of the east end of the front of Harri-

[1] Loc. cit.
[2] Idem, Pl. XV, upper figure.
[3] Idem, Pl. XV, lower figure.
[4] Idem, p. 96.

man Glacier. The smaller glacier comes from part of the extensive snow field that covers this end of the valley of Harriman Fiord. That portion of the Dirty Glacier which comes from the southwest lies in a shallow valley which is full, and in a few places more than full, of ice. This glacier has a medial moraine, which becomes more pronounced near the end and covers much of the glacier with dark débris, whence the name Dirty Glacier. In 1905 this glacier was a little more advanced than in 1909, and its tributary valley above mentioned overflowed more at the earlier date.

TOBOGGAN GLACIER.

The Toboggan Glacier is a small ice stream coming from a rather extensive snow field that lies in the northern part of the peninsula separating Harriman Fiord from the lower part of Port Wells. This glacier has a marked bare zone along its sides, and its end deploys on a flat not far above sea level (Pl. XXIII, *A*). We visited this glacier on August 21, 1905, and on June 29, 1909. At the earlier date a small cairn was built on the outer or north end of the first projecting rock ridge on the right side of the valley going up, and the following bearings were taken: (1) To the extreme right end of front of glacier, S. 45° E.; (2) to the center or most advanced part of front of glacier, S. 63° E.; (3) to the extreme left end of front of glacier, S. 87° E. In 1909 bearing (1) was S. 55° E. and bearing (3) was S. 81° 30′ E. In 1905 the center or most advanced part of the front—(2) above—was 723 feet (by pacing) from the cairn. Just at the extreme front of the ice at this time was a low rock ridge crossing the valley. In 1909 the most advanced part of the glacier was 252 feet farther back than in 1905. However, in 1909 a freshly deposited low moraine on the northern half of the plain in front of the glacier indicates that the ice some time between 1905 and 1909 had been about 400 feet in advance of its position in the earlier year. The map of 1899 [1] shows that the glacier did not reach tidewater at that time, but the absence of vegetation on the bare zone at the side of the glacier and on the flat in front of it in 1905 (Pl. XXIII, *A*) shows that the ice front has occupied an advanced position, reaching practically to tidewater, at a very recent date, possibly, but not probably, later than 1899.

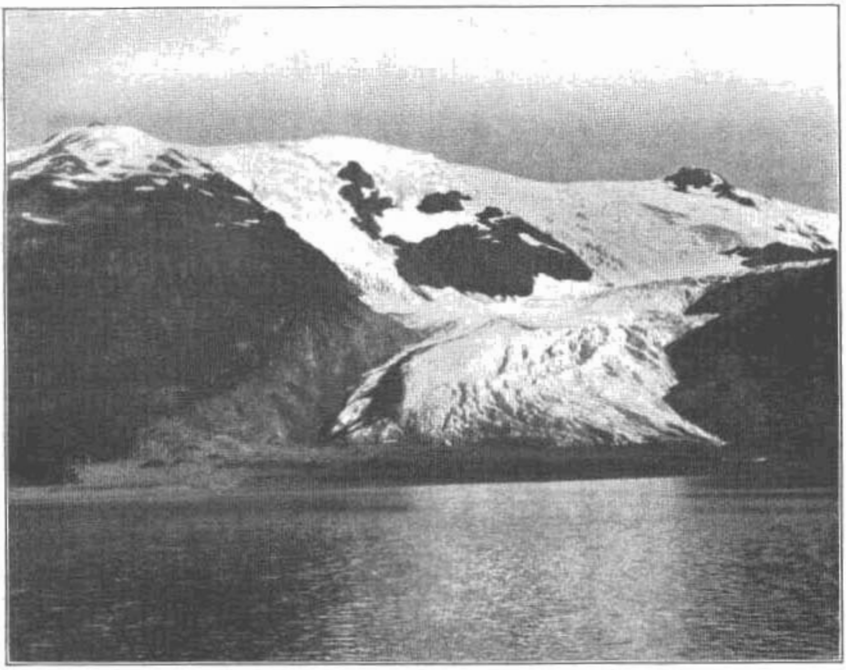
Photographs of glaciers of Harriman Fiord.

P 683. Distant view of Barry Glacier. August 20, 1905.

P. 684 and 685. No. 685 is here reproduced as Plate XX, *A*. Front of Barry Glacier from point A, Plate XVII. August 20, 1905. Point A is about 80 feet above sea level, on a mossy bench 50 to 100 feet wide, on the most northerly part of Point Doran. From this station the ground drops very steeply to tidewater. From the same position the following photographs have been taken: P 686 and 687, G 98–100, G 108.

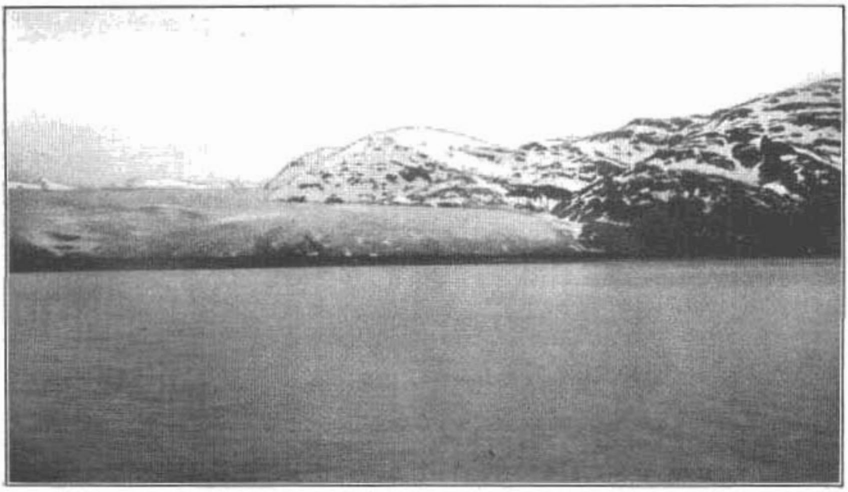
---

[1] Alaska, vol. 3, Harriman Alaska Expedition, 1904, Pl. XIII.



A. TOBOGGAN GLACIER.

August 20, 1905. Photograph P 731.



B. WEST PART OF FRONT OF TEBENKOF GLACIER.

From point A, figure 5. July 5, 1909. Photograph G 113.

P 686. Here reproduced as Plate XIX, *A*. East side of front of Barry Glacier from point A, Plate XVII. August 20, 1905.

P 687. Serpentine, Baker, and Surprise glaciers from point A, Plate XVII. August 20, 1905.

P 688. Distant view of Harriman Glacier. August 20, 1905.

P 689. South side of front of Harriman Glacier and south side of front of Dirty Glacier from point H, Plate XVII. August 20, 1905. Point H is the top of a dark-colored conglomerate bowlder about 12 feet high, standing at high-tide line on the west side of Harriman Fiord on the southern part of the fan from the Roaring Glacier. This bowlder is plainly visible from a boat coasting along the shore. From the same position the following photographs have been taken. P 690 and 691; G 106, G 199 and 200.

P 690 and 691. Front of Harriman Glacier from point H, Plate XVII. August 20, 1905.

P 731. Here reproduced as Plate XXIII, *A*. Toboggan Glacier. August 20, 1905.

P 732. Hanging Glacier (probably the Roaring Glacier). August 20, 1905.

P 733. Baker Glacier. August 20, 1905.

G 60. East part of front of Barry Glacier. August 11, 1908.

G 61. West part of front of Barry Glacier. August 11, 1908.

G 72. West part of front of Barry Glacier. August 11, 1908.

G 97. Mountains north and west of Harriman Fiord from Esther Passage. June 28, 1909. The highest dark peak in center of right half of photograph is Mount Gilbert; Mount Muir is on the left. See G 192.

G 98. Here reproduced as Plate XX, *B*. West side of Barry Glacier from point A, Plate XVII. June 29, 1909. See under P 684.

G 99. Here reproduced as Plate XIX, *B*. East side of Barry Glacier from point A, Plate XVII. June 29, 1909. See under P 684.

G 100. Serpentine, Baker, and Surprise glaciers from point A, Plate XVII. June 29, 1909. See under P 684.

G 101. West side of Barry Glacier, from point C, Plate XVII. June 29, 1909. Point C is about 60 feet above sea level on the second rock point north of the long gravel beach on the east side of the bay on which the glacier is situated. This point is composed chiefly of hard slate, much smoothed and rounded by recent glaciation.

G 102. General view of Barry Glacier. June 29, 1909.

G 103. Serpentine Glacier from point D, Plate XVII. June 29, 1909. Point D is about 60 feet above sea level on a small bench, on a fairly steep mossy slope, on the southeast side of Harriman Fiord, 1 mile northeast of the front of the Toboggan Glacier. Photographs G 193–196 also were taken from this station.

G 104. Here reproduced as Plate XXI, *B*. Surprise Glacier from point F, Plate XVII. June 29, 1909. Point F is about 100 feet above sea level, on a mossy bench a mile southwest of the gravel fan in front of the Toboggan Glacier. Behind (southeast of) this station is a small depression opening to the southwest, and northwest of the station the land descends steeply to the sea. Photographs G 197 and 198 also were taken from this station.

G 105. Here reproduced as Plate XXI, *A*. Baker Glacier from point F, Plate XVII. June 29, 1909.

G 106. Here reproduced as Plate XXII, *B*. East side of front of Harriman Glacier from point H, Plate XVII; Dirty Glacier at left. June 29, 1909. See under P 689.

G 107. Here reproduced as Plate XXII, *A*. Cataract Glacier. June 30, 1909.

G 108. West side of Barry Glacier from point A, Plate XVII. June 30, 1909. See under P 684.

G 192. Mountains west of Harriman Fiord, from Esther Passage; Mount Muir in central background. June 28, 1909. See G 97.

G 193 to 196. Here reproduced as Plate XVIII. Panorama showing Cataract, Surprise, Baker, and Serpentine glaciers from point D, Plate XVII. June 29, 1909. See under G 103.

G 197 and 198. Panorama of Serpentine and Baker glaciers, from point F, Plate XVII. June 29, 1909. See under G 104.

G 199 and 200. Panorama of Harriman Glacier, from point H, Plate XVII; Dirty Glacier on left. June 29, 1909. See under P 689.

PASSAGE CANAL.

There are no glaciers that reach tidewater on Passage Canal, although several approach the canal from the north, west, and southwest. The Seth and Billings glaciers descend southward from the same general ice field that feeds the Harriman Glacier and end about a mile from the north shore of Passage Canal. Northwest of the upper part of the canal are at least three small glaciers draining into this body of water. The most important ice stream near the canal is the Portage Glacier, described below.

A hasty visit was made by our party to the head of Passage Canal (Portage Bay) on July 3, 1909. The eastern end of Portage Glacier was too far distant from the shore and too much hidden by a low, bare rocky point in the gravel-filled valley to permit careful observations. It is probable that no large part of the glacier debouches on the east side of the divide between Passage Canal and Turnagain Arm, for no large glacial stream enters the head of the canal. A trail over this glacier was much used for travel between Prince William Sound and Cook Inlet before the Seward-Sunrise trail was opened.

In 1898 Mendenhall visited the head of this bay and made the following interesting observations:[1]

> The isthmus which connects Kenai Peninsula with the mainland is only about 12 or 13 miles broad from tidewater to tidewater and probably stands but little above sea level, but for 5 miles of this distance it is buried under a glacier, which flows from the high mountains of the peninsula to the south. This glacier at its highest point is about 1,000 feet above tide, and can be crossed in a few hours from the open waters of Portage Bay by prospectors or others who desire to reach Sunrise City or the headwaters of Cook Inlet before this body of water is open to navigation in the spring. For more than 100 years it has been used as a route, first by the Russian and Indian traders, and later by miners, who usually cross it without difficulty in the winter or early spring. In the summer the crevasses open, and it is but rarely used, especially since at that season the all-water route is so much easier and cheaper.
>
> * * * * * * *
>
> Portage Bay receives several glacial tributaries. Southwest of Point Pigot, which separates this bay from Port Wells, is the mouth of Blackstone Bay, which receives Blackstone Glacier from the south. Both the bay and glacier are named for a miner who lost his life there a few years ago.
>
> Three glaciers approach sea level at the head of Portage Bay. One of these is Portage Glacier, whose foot is about a mile back from the beach. Its outlet is toward

[1] Mendenhall, W. C., A reconnaissance from Resurrection Bay to the Tanana River, Alaska, in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 273, 325, 326.

Turnagain Arm, and it probably has never discharged into Prince William Sound. A second glacier spills over the mountain rim 2,000 feet above tide in an ice cataract on the southeast side of the bay. The third and smallest, now rapidly retreating, flows down from the mountains to the northwest, and has until very recently reached across the belt of gravel delta which separates the foot of the mountain slope from the head of the bay, but has now dwindled until the portion reaching the gravel plain is small and composed wholly of white ice.

This little glacier illustrates very well the rapidity of the ice retreat and shows us the processes whose results only remain in portions of the New England landscape. One quarter of a mile out from its present terminus is a hillock 220 feet high and half a mile long, with its longer axis parallel with the glacier front. It is now separated from this latter by an open valley paved with bowlders. At first sight this elevation was supposed to be a simple terminal moraine, but upon examination it proved to consist mostly of ice deeply covered with angular débris, which is also disseminated through it. This remnant of the glacier seems to stand near a position which the ice front occupied long enough to become covered by a sufficiently thick mantle of protective débris, so that melting was not so rapid as in the less well-protected part of the glacier just back of the front. The separation from the glacier was probably facilitated by the exit of the subglacial stream through a tunnel back of the protecting mantle. The combined melting from above and below soon removed this neck, leaving the former front isolated as it stands to-day. Since its isolation it has been shrinking each summer and now occupies less than half of its original area. Around its seaward side is a belt of rough ground of slight relief covered with angular and unsorted material, which has been let down into position by the melting of the ice front. The outer rim of this zone is somewhat higher than the inner portion, giving it the form of a shallow amphitheater facing the remnant of the glacier. The stability of the position of maximum advance for a short time due to the balance between flow and melting at the front accounts for the slightly greater accumulation there and the building of the low rubble wall.

These recent glacial details of topography are the more striking since they are built upon a smooth water-laid deposit of relatively fine material. This delta is of the type which usually forms before glaciers in these fiords and gives about the only level areas to be found near sea level in a region of sharp topographic forms. At its outer margin, a short distance seaward from low-tide level, the delta slopes abruptly to the profound depths so often found in these inlets.

BLACKSTONE BAY.

GENERAL FEATURES.

The early maps of the shore line between Point Culross and Passage Canal were inaccurate, probably because they were made by explorers who had not followed closely the intricacies of the shore line. Blackstone Bay, except its head, was fairly well shown on these maps, but Cochrane Bay was poorly delineated, and Culross Passage was not shown at all. Vancouver's map (1794) of this district and Tebenkof's (1849) have formed the basis for other and later maps. Applegate's map of 1887 [1] adds some detail and is the first map to which we have access that indicates the Tebenkof Glacier. Culross Passage, behind Point Culross, was reported by the United States Geological

[1] Davidson, George, The glaciers of Alaska that are shown on Russian charts or mentioned in older narratives: Trans. and Proc. Geog. Soc. Pacific, 2d ser., vol. 3, 1904, map 11.

Survey reconnaissance of 1905 and indicated on chart No. 8502 of the United States Coast and Geodetic Survey in 1907. A more detailed map of this district has now been published.[1] (See also Pl. I and fig. 5 of the present report.)

On the maps of Vancouver and Tebenkof, "ice and snow," which undoubtedly refers to a glacier discharging into the sea, are shown at the head of Cochrane Bay, and the accompanying description[2] indicates the same fact. There was evidently a mistake in locating this glacier. It should be shown at the head of the next bay west (Blackstone Bay), for there is no evidence that in historic time a glacier occupied the head of Cochrane Bay. The land at the head of this bay is comparatively low, and extends south-southwest to Port Nellie Juan. The glacier seen by Vancouver was evidently the Blackstone Glacier, which reaches tidewater at the head of Blackstone Bay.

Our information concerning the glaciers of Blackstone Bay was gained by a hurried reconnaissance on July 5, 1909. No definite information concerning the positions of the fronts of these glaciers at an earlier date is extant.

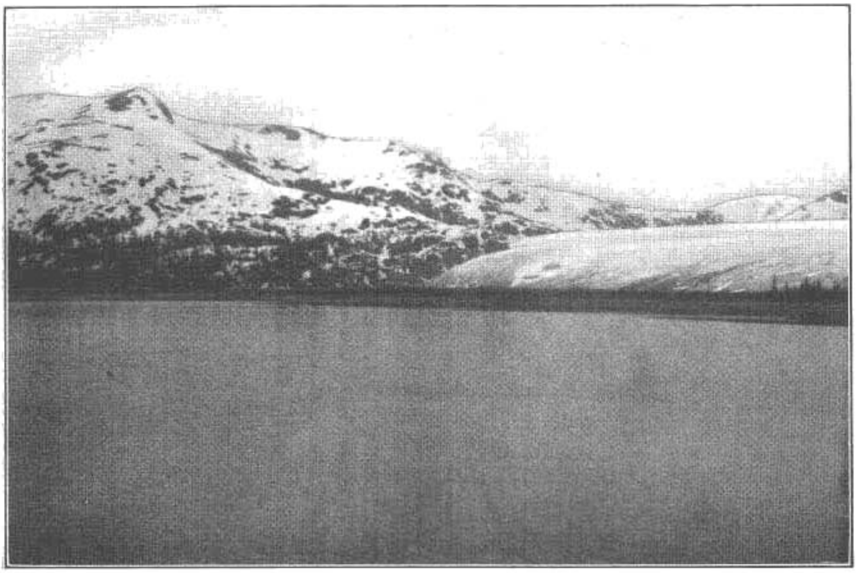
TEBENKOF GLACIER.

The front of the Tebenkof Glacier comes within about a mile and a quarter of the shore of a small bay on the south side of the entrance to Blackstone Bay and is named after Capt. M. D. Tebenkof, governor of Russian America from 1845 to 1850. This glacier is an ice stream 1½ to 2 miles wide, which flows northward in a valley parallel to Blackstone Bay. The ice field of this glacier is continuous with that of the Blackstone Glacier. The Tebenkof Glacier has a comparatively low slope, and its front lies on a flat of glacial débris. This flat in places is covered with a forest, which would indicate that the glacier had not reached tidewater in the last century and probably not in a considerably longer period. Along each part of the front of the glacier is a bare zone, estimated to be 500 feet wide, which has apparently been covered by a recent advance of the ice. The date of this advance, which probably destroyed part of the forest at the west edge of the glacier, is uncertain, but the absence of vegetation on the bare zone indicates that it probably took place within the last 10 or 15 years. The front of the glacier was not visited, so nothing is known of the distance between the present front and this recent advanced position, which represents the maximum advance since the growth of the present forest. The position of the front of the glacier in 1909 is shown in Plates XXIII, *B*, and XXIV, *A*.

---

[1] Grant, U. S., and Higgins, D. F., Reconnaissance of the geology and mineral resources of Prince William Sound, Alaska: Bull. U. S. Geol. Survey No. 442, 1910, Pl. II.

[2] Quoted by Davidson, op. cit., p. 23.



A. EAST PART OF FRONT OF TEBENKOF GLACIER.

From point B, figure 5. July 5, 1909. Photograph G 114.

A. SPLIT GLACIER.

From point F, figure 15. August 2, 1909. Photograph G 232.

BLACKSTONE GLACIER.

The Blackstone Glacier surrounds the head of Blackstone Bay, sending down from a very extensive ice field no less than ten ice

FIGURE 5.—Map of Blackstone Bay July 5, 1909. Occupied points indicated by circles, intersected points by crosses.

streams (fig. 5). Two of these streams have discharging cliffs at sea level, and two others on the east side of the bay reach just to high tide on gravel aprons formed at the lower ends of the alpine valleys occupied by the glaciers. The earlier maps show the south end of Willard Island covered with ice, but as the south end of the island has a very deceptive appearance till one comes close to it and as the size and density of the vegetation on the island indicate several decades of growth, it is altogether probable that the ice has not been as far north as Willard Island within the time of which we have record, namely, since 1794.

There is very good evidence, however, that much earlier, perhaps two centuries ago, the front of the Blackstone Glacier did extend well up to the north end of Willard Island. In figure 5 a line shows the approximate position of this ancient ice front. North of this line the island is heavily forested, but south of it the character of the cover changes abruptly, and there consists only of sparse fir trees and a dense growth of shrubbery. On the west side of the island a small gravel point marks the position of the old terminal moraine. No precise location for the old front could be determined on the west side of the bay. On the east side of both island and bay is a notable accumulation of morainal material extending across from the island to the mainland, under a shallow channel in which tidal currents run very swiftly. The two points south of point C in figure 5 may be modified remains of two recessional moraines. Although the island itself is very sparsely timbered south of the old ice front, the gravel deposits on the east side of the bay are heavily timbered. The development of sparse and dense forests in approximately the same period is doubtless due to the more favorable conditions for forestation upon the gravel than on the bare glaciated rock of the island.

The scenery in view from the small eminence on the south end of Willard Island is nearly as wild and desolate as that at the head of Harriman Fiord. To the south, from west to east, a vast ice field almost barren of nunataks stretches back to a brilliant white sky line. From the central mass many tongues of ice lap down over the smooth rock slopes or break off into the sea. It requires little effort of the imagination to picture all these tongues coalesced into one giant ice stream filling the whole head of the bay and extending far down over Willard Island to the ancient moraine.

Photographs of glaciers of Blackstone Bay.

G 112. Front of Tebenkof Glacier. July 5, 1909.

G 113. Here reproduced as Plate XXIII, *B*. Front and west side of Tebenkof Glacier from point A, figure 5. July 5, 1909. Point A is on the top of a rocky islet or reef at the east side of the entrance to the small bay on the south side of, and near the lower part of, Blackstone Bay.

G 114. Here reproduced as Plate XXIV, *A*. East side of front of Tebenkof Glacier from point B, figure 5. July 5, 1909. Point B is on the end of the point at the west side of the entrance to the small bay on the south side and near the lower part of Blackstone Bay.

G 115. Northerly lobe of Blackstone Glacier, which does not reach tidewater, from point C, figure 5. July 5, 1909. Point C is on a low, treeless island near the east shore of Blackstone Bay and about 3 miles north of the head of the bay.

G 116. Main part of front of Blackstone Glacier, from point C, figure 5. July 5, 1909.

G 213 and 214. Panorama of front of Blackstone Glacier from point D, figure 5. July 5, 1909. Point D is the top of the small round hill, 60 or 70 feet above the sea, on the south end of Willard Island. It is about 200 yards north of the southern extremity of the island.

PORT NELLIE JUAN.

GENERAL FEATURES.

Port Nellie Juan (Pl. XXV), sometimes called Kings Bay after a prospector who had a cabin near its head, is the most extensive embayment on the west coast of Prince William Sound. The long southwestern arm of Port Nellie Juan was not shown on the earlier maps, nor were the glaciers of this port indicated. The first map showing the details of the upper half of this bay was made by S. Applegate in 1887.[1] We visited Port Nellie Juan on August 8 and 9, 1908. The accompanying map and the information obtained in August, 1908, embody all the data known to us concerning the glaciers of this port. The glaciers on the west side of Port Nellie Juan were not seen at close range, so the locations of their fronts (Pl. XXV) are only approximate.

South of the central part and east of the southern part of Port Nellie Juan is a snow field of unknown but considerable extent. Several glaciers flow north and west from this field, and two of them, the Nellie Juan and the Falling glaciers, reach tidewater. On the west side of the southern part of the port are other glaciers, one of which, the Taylor, reaches sea level. At the head of Port Nellie Juan the water is shallow and is kept very muddy by Kings and Nellie Juan rivers and smaller streams bringing charges of silt from the neighboring glaciers. These streams come from what is probably one of the largest ice-covered areas of the Kenai Peninsula.

ULTRAMARINE GLACIER.

The Ultramarine Glacier, so named because of the clear blue color of the ice near its end, is situated at the head of Blue Fiord, the second deep indentation from the entrance in the southeastern coast of Port Nellie Juan. The glacier comes within about a quarter of a mile of tidewater, and the western part of its front extends beyond the eastern two-thirds and rests on a glacial flat. The eastern part of the front rests on a rock ridge about 300 feet above the sea. On this ridge is a marked bare zone, and there is another at the side of the glacier. The front of the glacier was not visited, but at a distance this bare zone appeared as if the ice had retreated from it in

[1] Davidson, George, op. cit., pp. 26-27, map 11.

the last two or three years. Applegate's map referred to above indicates that the glacier in 1887 reached to tidewater along its whole front. The forest in front of the eastern part of the glacier shows that this part could not have extended so far. The western part may have reached tidewater at that time, but even this is doubtful. Our observations on this glacier were made at a distance of about a mile and a half.

NELLIE JUAN GLACIER.

The Nellie Juan Glacier (Pls. XXV and XXVI) is the largest, at least in breadth of front, on Port Nellie Juan, after which it is named. The front of the glacier is distinctly in view from the entrance of the port and rests on a gravel beach, most of which is covered by high tide; near the center of the front the ice is bathed even by low-tide water. On each side of the lower part of the glacier is a distinct bare zone of smoothed granite, 100 to 500 feet wide, which ends abruptly at the edge of a forest-covered tract. This zone is prominently developed on a granite knob, almost an island, at the west side of the glacial front. Crossing the top of this knob is a small moraine (at point A, Pl. XXV) from 1 to 10 feet high and 5 to 30 feet wide. This moraine contains fragments of dead wood, and just north of it is an area of scattered trees some of which are a foot in diameter. South of the moraine is some vegetation—moss, grass, alders 5 feet high, and a few spruce trees 4 feet high. Most of the vegetation disappears halfway from the moraine to the ice front. From the extreme summit (point A, Pl. XXV) of the above-mentioned granite knob the nearest point of the moraine is 48 feet distant in a direction S. 10° W. From the same summit the extreme front of the glacier bears S. 74° E., and the nearest point of the ice is 500 feet S. 13° W.

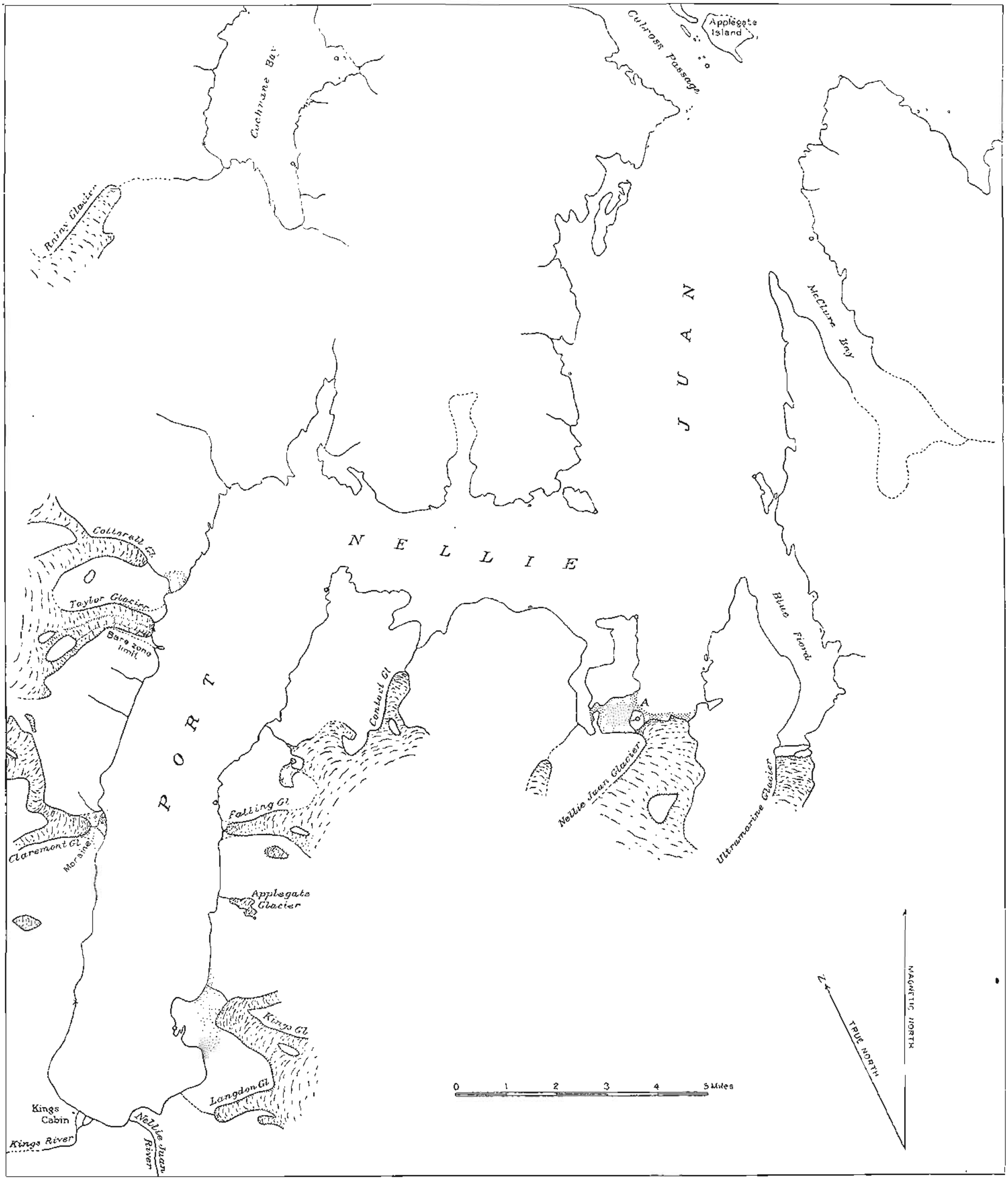
The moraine noted above marks the farthest advance of the ice since the growth of the present forest—that is, for a century, and most probably for two or three centuries. This maximum advance in historical time occurred at least 20 years ago and probably much earlier.

FALLING GLACIER.

Falling Glacier is a small ice stream on the east side of the southern stretch of Port Nellie Juan. On August 8, 1908, a small tongue from the ice just reached the sea. In front of the glacier, however, is a bare zone, which has been covered by the ice within a very few years. When this zone was covered the glacier had a tidal front of about 1,200 feet.

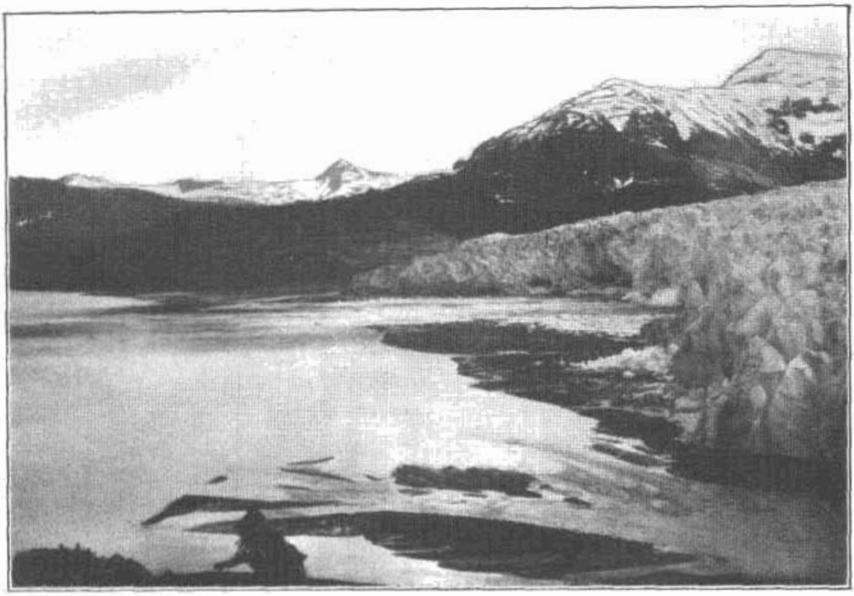
TAYLOR GLACIER.

The Taylor Glacier is the only one that reaches tidewater on the west shore of Port Nellie Juan. This glacier has a medial moraine



MAP OF PORT NELLIE JUAN.

August 8 and 9, 1908. Occupied points indicated by circles, intersected points by crosses. Shore line mostly from rapid boat traverse.



A. FRONT OF NELLIE JUAN GLACIER.

From point A, Plate XXV, the summit of a granite knob at the west side of the glacier front. August 8, 1908. Photograph G 51.

B. WEST SIDE OF NELLIE JUAN GLACIER.

From point A, Plate XXV. August 8, 1908. Photograph G 52.

and a marked bare zone along each side of its lower end. We did not examine the Taylor Glacier carefully and have little information concerning it other than that shown on the map and in three of the photographs listed below. The freshness of the bare zone indicates that the maximum advance of the glacier since the present forest has grown up took place only a very few years ago. In this advance the front of the glacier reached a line about a quarter of a mile beyond its present position and had an extent of a mile along tidewater. Applegate's map of 1887 shows a glacier, probably the Taylor, reaching not quite to the water.

Photographs of glaciers of Port Nellie Juan.

G 49. Nellie Juan Glacier from northwest end of island near east shore of Port Nellie Juan, about 5 miles north-northeast of the glacier. August 8, 1908.

G 50. Ultramarine Glacier from distance of about 1½ miles. August 8, 1908.

G 51. Here reproduced as Plate XXVI, *A*. Front of Nellie Juan Glacier from point A, Plate XXV. August 8, 1908. Point A is about 175 feet above sea level on the extreme top of a granite knob, almost an island, on the west side of the front of the glacier.

G 52. Here reproduced as Plate XXVI, *B*. West side of Nellie Juan Glacier from point A, Plate XXV. August 8, 1908.

G 53. Moraine, forested and forestless zones at point A, Plate XXV. August 8, 1908.

G 54. A more distant view of same locality as No. G 53.

G 55. Nellie Juan Glacier from a point about 2 miles north. August 8, 1908.

G 56. Taylor Glacier from small island on east side of Port Nellie Juan and about one-half mile south of entrance to the upper part of the port. August 8, 1908.

G 57. Front of Falling Glacier. August 8, 1908.

G 58. Front of Taylor Glacier. August 9, 1908.

G 59. Front of Taylor Glacier. August 9, 1908.

ICY BAY.

GENERAL FEATURES.

No glaciers exist near tidewater on Prince William Sound between Port Nellie Juan and Icy Bay (fig. 6), which is a fiord extending from the southwestern part of the sound. The axis of Icy Bay runs northeast and southwest, and the fiord is approximately 10 miles long. This bay has been represented on maps as about 4 miles long and as having an east and west axis. It was not until after the United States Geological Survey reconnaissance of 1908 that the bay was delineated with approximate accuracy.[1] The errors in mapping arose from the fact that Vancouver's representation of this bay was followed in later maps, and he had reported,[2] as quoted by Davidson, that the bay was "terminated by a compact body of ice that descended from high perpendicular cliffs to the water side." At that date (1794) it is very probable that the glaciers in Nassau

[1] Grant, U. S., and Higgins, D. F., Copper mining and prospecting on Prince William Sound: Bull. U. S. Geol. Survey No. 379, 1909, Pl. IV.

[2] Trans. and Proc. Geog. Soc. Pacific, 2d ser., vol. 3, 1904, p. 23.

Fiord, the large bay on the northwest side of Icy Bay, completely filled that fiord and extended into, but not across, the main part of Icy Bay. This, together with the extensive discharge of ice from these glaciers (combined as one), probably prevented close inspection of the bay and the discovery of its upper part.

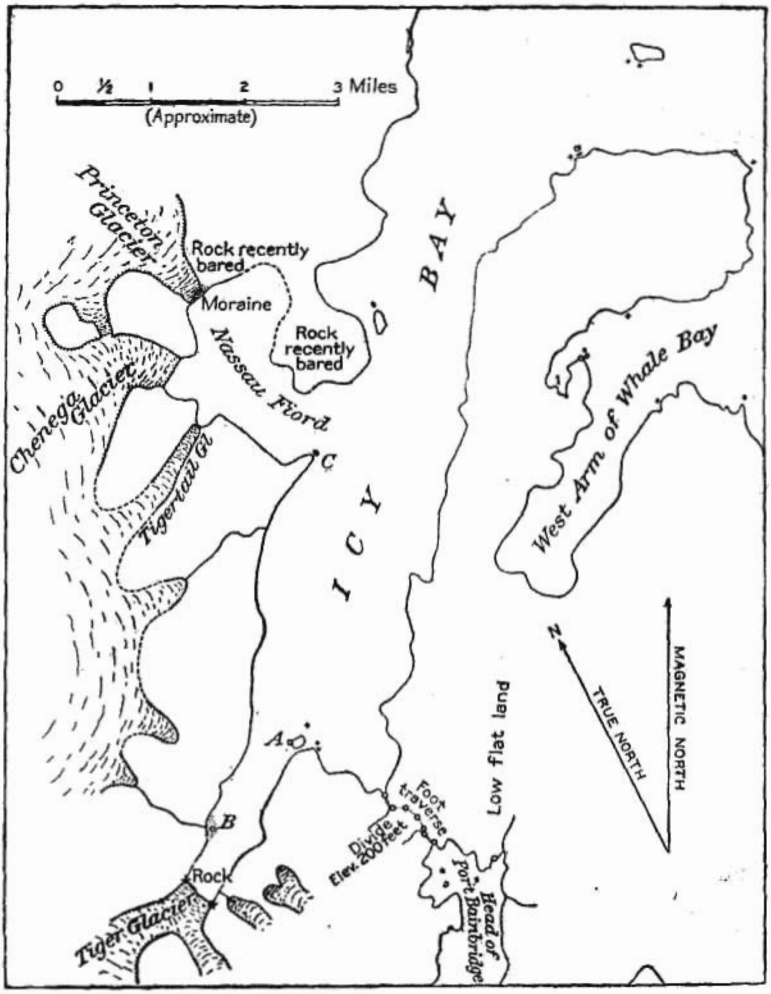
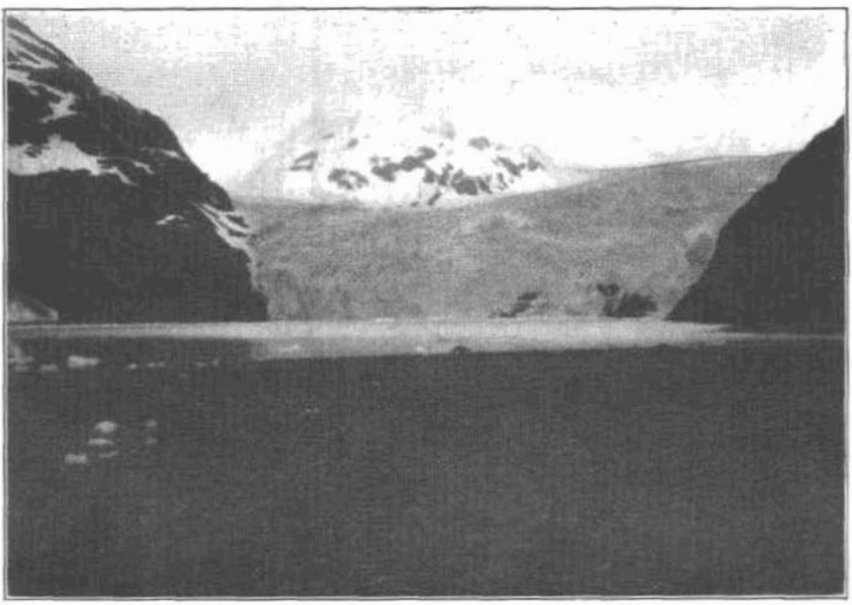


FIGURE 6.—Map of Icy Bay August 5, 1908. Occupied points indicated by circles; intersected points by crosses.

Our visit to Icy Bay was on August 5, 1908, when we made a hasty reconnaissance of the bay, came within half a mile of the Tiger Glacier, and obtained our information concerning the Chenega and Princeton glaciers from the rock islet (point C, fig. 6) at the entrance to Nassau Fiord. In the following year Icy Bay was visited by the George W. Perkins party. The names here used, except the name

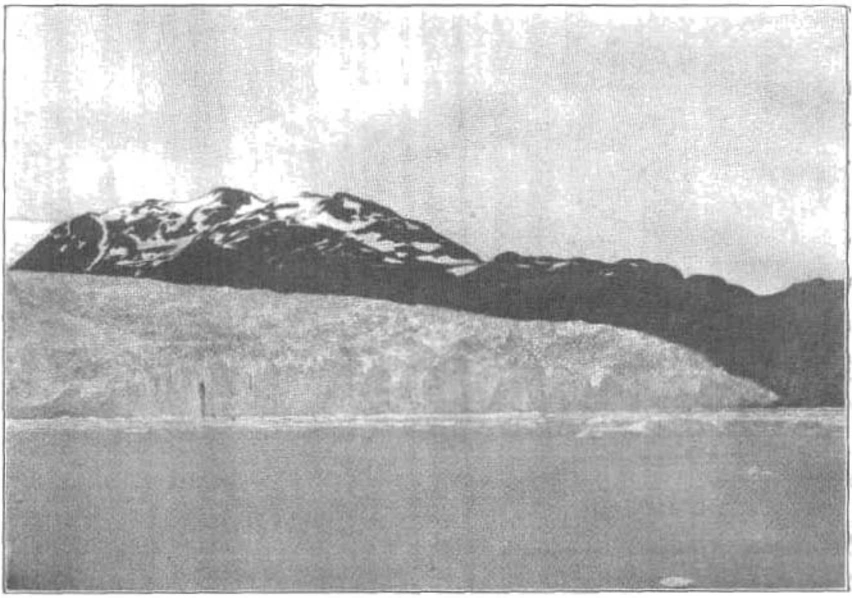
A. CHENEGA AND PRINCETON GLACIERS.

From point C, figure 6. Chenega Glacier on left. August 5, 1908. Photograph G 48.

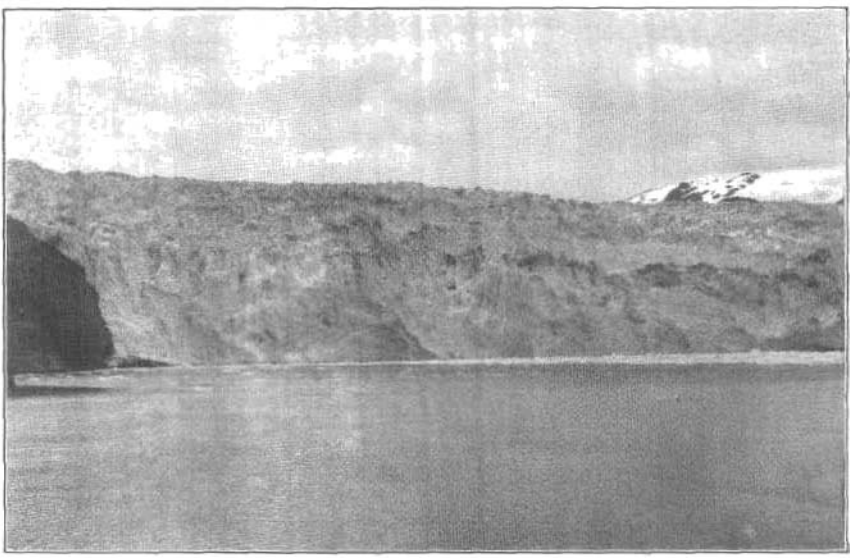


B. TIGER GLACIER.

From point B, figure 6. August 6, 1908. Photograph G 45.



A. NORTH PART.



B. SOUTH PART.

FRONT OF CHENEGA GLACIER.

August 19, 1909. From photographs by W. E. Carlin for the George W. Perkins party.

Chenega Glacier and the name Princeton for the glacier immediately northeast of the Chenega, are those proposed by that party. The Chenega, the main discharging glacier in Icy Bay, has long been known locally by this name, and the name has been published at least three times.[1]

PRINCETON GLACIER.

The Princeton Glacier is the most northeasterly ice stream discharging into Nassau Fiord of Icy Bay. The glacier has apparently a massive moraine along most of its front and reaches tide water only at its western side (Pl. XXVII, *A*). This glacier is not discharging rapidly. Further particulars concerning it will be found under the Chenega Glacier.

CHENEGA GLACIER.

The Chenega Glacier reaches tidewater at the head of Nassau Fiord, is discharging abundantly, and is the ice stream which furnishes most of the floating ice so common in and about the mouth of Icy Bay. From the top of a small rock island at the entrance to Nassau Fiord (point C, fig. 6) both the Chenega and Princeton glaciers are in full view (Pl. XXVII, *A*). From this point true bearings were taken as follows: (1) Extreme right of front of Princeton Glacier, N. 8° W.; (2) extreme left of front of same glacier, N. 19° W.; (3) extreme right of front of Chenega Glacier, N. 28° W.; the extreme left of the same glacier is not in view from this point.

On August 19, 1909, the George W. Perkins party approached much nearer to the Chenega Glacier. Photographs made by members of this party show much less floating ice in Nassau Fiord than was present in August of the preceding year. They obtained good views of the front of this glacier, which are here reproduced, through the courtesy of Messrs. Perkins and Carlin, in Plate XXVIII.

The rock surface about the entrance to Nassau Fiord has been recently glaciated and no forest has developed on it. The entrance to this fiord as well as the peninsula at the north side of the entrance were covered by ice undoubtedly within the last 100 years and quite possibly within a much shorter period. The Indians living at the settlement of Chenega have a tradition that the Chenega Glacier reached to the mouth of Icy Bay about 100 years ago, but the growth of the forest about the bay and even well up past the mouth of Nassau Fiord precludes this idea. The tradition would refer more reasonably to the mouth of the northern arm (Nassau Fiord) than to Icy Bay itself.

[1] Bull. U. S. Geol. Survey No. 284, 1906, p. 79; Bull. U. S. Geol. Survey No. 299, 1906, p. 172; U. S. Coast and Geod. Survey chart No. 8550, Aug., 1909.

TIGER GLACIER.

The Tiger Glacier reaches tidewater at the extreme head of Icy Bay. The front of the glacier is steep and the eastern part of it was discharging in 1908 with fair rapidity. The western half of the front shows a ledge of rock just emerging from under the ice (Pl. XXVII, *B*). In a photograph taken by W. E. Carlin, of the George W. Perkins party, on August 19, 1909, this ledge is completely covered by an advance of the glacier. The amount of this advance can not be determined from the photographs, but it probably does not exceed a few hundred feet and may be less than 100 feet.

Photographs of glaciers of Icy Bay.

G 44. Tiger Glacier from point A, figure 6. August 5, 1908. Point A is on the western end of the largest island at the east side of the entrance to the upper narrow portion of Icy Bay.

G 45. Here reproduced as Plate XXVII, *B*. Tiger Glacier from point B, figure 6. August 5, 1908. Point B is on the flat, exposed at low tide, at the mouth of a small glacial stream entering the upper narrow portion of Icy Bay about 1¼ miles southwest of point A.

G 46 and 47. Panorama of Chenega and Princeton glaciers, from point C, figure 6. August 5, 1908. Point C is the top of a rock islet at the southwest side of the entrance to Nassau Fiord.

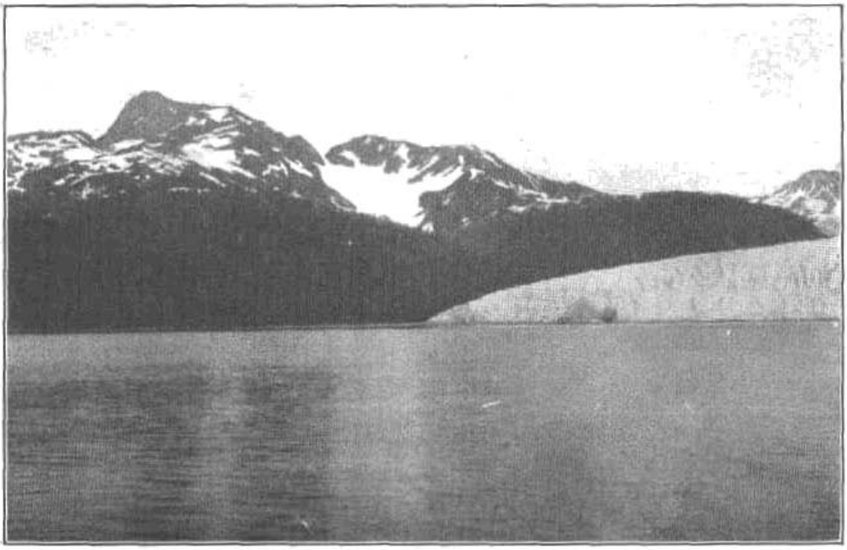
G 48. Here reproduced as Plate XXVII, *A*. Chenega and Princeton glaciers, from point C, figure 6. August 5, 1908.

BAINBRIDGE GLACIER.

The Bainbridge Glacier is the only tidewater glacier on Port Bainbridge. A mile north of this glacier is a smaller one ending about 500 feet above sea level. The Bainbridge Glacier does not appear on the earlier maps, although it is in view from ships passing Point Elrington. The first map known to us that shows this glacier is a small one published in 1906.[1] The glacier had, however, been known long before that date and the name Bainbridge is in common use locally. We saw the glacier from a distance in 1905 and on August 3, 1908, visited it and mapped its front (fig. 7).

The Bainbridge Glacier ends on a glacial flat, and the central part of the front is reached by the usual high tide, so that an ice cliff is developed along this part of the front. This cliff is approximately 100 feet in height, and its top is composed of ragged ice pinnacles singularly free from débris and showing in sunlight a beautiful play of greenish-blue colors. Near the northern part of the ice front is a push moraine, 10 feet high, which in places stands directly at the edge of the ice and at other places is as much as 60 feet away. This moraine is very fresh and probably was formed in the summer of 1908. The moraine includes fragments of trees and toward the

[1] Grant, U. S., Copper and other mineral resources of Prince William Sound: Bull. U. S. Geol. Survey No. 284, 1906, p. 79.



A. FRONT OF BAINBRIDGE GLACIER.

From point A, figure 7. August 3, 1908. Photograph G 40.

B. SOUTH PART OF FRONT OF BAINBRIDGE GLACIER.

From point B, figure 7. August 3, 1908. Photograph G 43.

A. ICE FRONT, PUSH MORAINE, AND DEAD TREES AT NORTH SIDE OF FRONT OF BAINBRIDGE GLACIER.

August 3, 1908. Photograph G 41.

B. PUGET GLACIER.

From point A, figure 8. July 11, 1909. Photogragh G 117.

north encroaches upon a spruce forest, many of whose trees have been killed by being partly buried in glacial outwash (Pl. XXX, *A*). Between the south part of the front (Pl. XXIX, *B*) and the forest is a small irregular bare zone of rock.

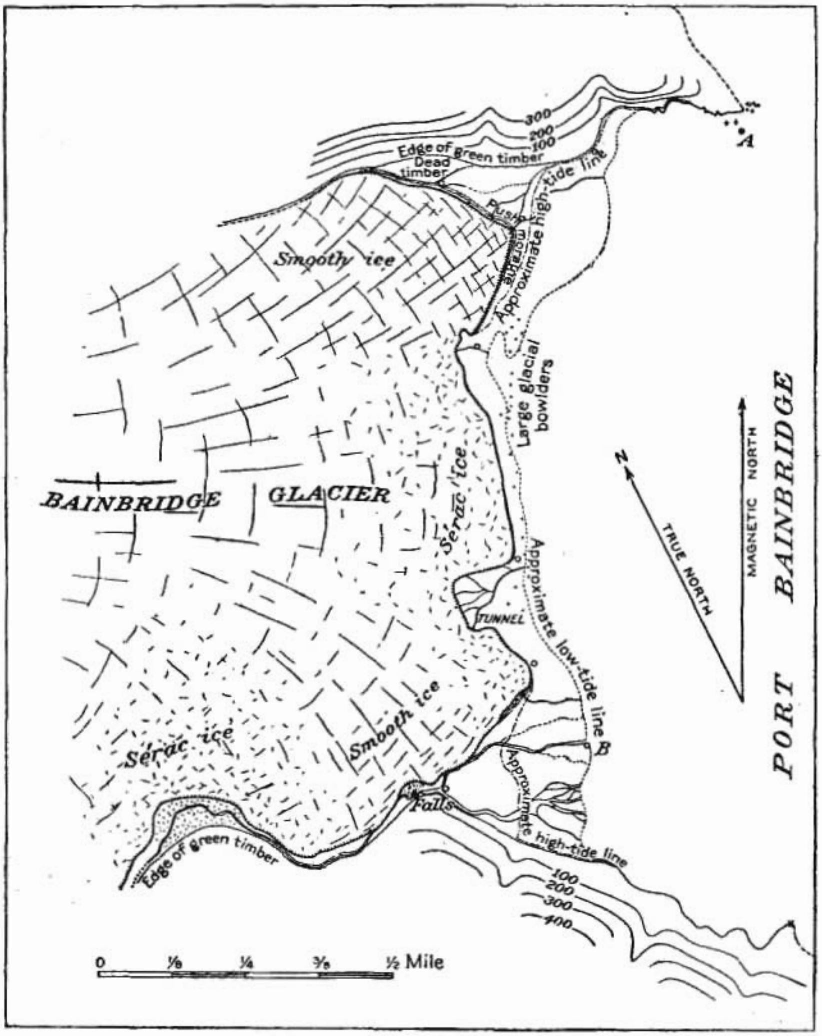


FIGURE 7.—Map of front part of Bainbridge Glacier August 3, 1908. Occupied points indicated by circles; intersected points by crosses.

The photographs here reproduced (Pls. XXIX, *A* and *B*, and XXX, *A*) mark the position of the front of the Bainbridge Glacier on August 3, 1908, and will be of service in determining future advance or retreat. In 1908 the ice was practically if not absolutely at its limit of maximum advance since the growth of the present forest.

Photographs of Bainbridge Glacier.

G 39. Bainbridge Glacier from east side of Port Bainbridge and just north of north entrance to Hogg Bay. August 2, 1908.

G 40. Here reproduced as Plate XXIX, *A*. Front of Bainbridge Glacier from point A, Figure 7. August 3, 1908. Point A is on the top of the most southerly reef at the north entrance to the shallow bay in which is the Bainbridge Glacier; this reef is covered by the ordinary high tide.

G 41. Here reproduced as Plate XXX, *A*. North part of front of Bainbridge Glacier, showing push moraine, overturned trees, and dead forest. August 3, 1908.

G 42. Detail of front of Bainbridge Glacier. August 3, 1908.

G 43. Here reproduced as Plate XXIX, *B*. South part of front of Bainbridge Glacier from point B, Figure 7. August 3, 1908. Point B is at low-tide line on the south bank of one of the larger glacial streams.

GLACIERS OF THE SOUTHERN SHORE OF KENAI PENINSULA.

CAPE PUGET TO CAPE RESURRECTION.

Between Prince William Sound and Resurrection Bay, or more strictly between Capes Puget and Resurrection, there are at least four marked indentations of the shore line having valleys opening into them. Each of these valleys contains a glacier. From east to west these glaciers are the Puget, the Excelsior, an unnamed glacier, and the Ellsworth. This coast lacks good harbors that are not exposed to the southerly winds and except for Day Harbor has been seldom visited and not carefully mapped. Our delineation of this shore (see southwest corner of Pl. I and east edge of Pl. II, in pocket; also figs. 8 and 9) shows more details than other maps but can not be regarded as accurate.

PUGET GLACIER.

The Puget Glacier, to which we apply the name of the adjacent cape and bay, ends about a mile and a quarter from the head of Puget Bay. This glacier is shown on Tebenkof's map [1] (1852) and probably also on Vancouver's map, though it is omitted from recent United States Coast and Geodetic Survey charts (Nos. 8502 and 8550). We visited the head of Puget Bay on July 11, 1909, at which time the accompanying sketch map (fig. 8) was made and the glacier was photographed (Pl. XXX, *B*).

The surface of the upper part of the Puget Glacier is smooth, but about a mile and half above its lower end the glacier narrows and for half a mile its surface is steep and much crevassed. It then widens and becomes smooth again but farther down passes over a cliff, on the top of which the western side of the glacier ends in an ice wall estimated to be 200 feet in height. The blocks of ice which fall over the cliff from this wall probably do not consolidate, although this was not conclusively shown by our observations. The eastern part of the ice stream comes over this cliff in a much crevassed condition and then

---

[1] Davidson, George, op. cit., p. 20, map 5.

becomes smoother and deploys toward its end. Beyond the end of the glacier is a bare zone of considerable extent, between which and the sea is a mature forest. The bare zone appears to have been occupied recently by the glacier. Davidson[1] states that the glacier ended half a mile from the shore; this distance was probably taken from the older maps (Tebenkof's or Vancouver's), for evidently it was not carefully measured. We did not go nearer the glacier than point A, figure 8.

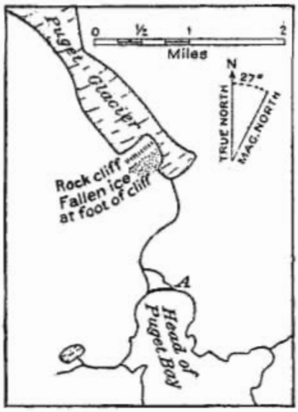


FIGURE 8.—Sketch map of Puget Glacier and head of Puget Bay July 11, 1909.

EXCELSIOR GLACIER.

The name Excelsior is in use locally for this glacier; we do not know when the name was applied and have heard of no other name being used for this ice stream, which is shown on the earlier maps.[1] We passed within 2 miles of the glacier on July 11, 1909. Its front appears to be within half a mile of the sea. On the east is a very wide bare zone between the ice and the forest, and on the west there is also a bare zone, but this is not so clearly seen. The glacier ends on a low gravel flat, the central part of which is bare of vegetation. From the appearance of these bare zones it seems that the Excelsior Glacier has been considerably larger within a few years, and its front may have reached the sea very recently.

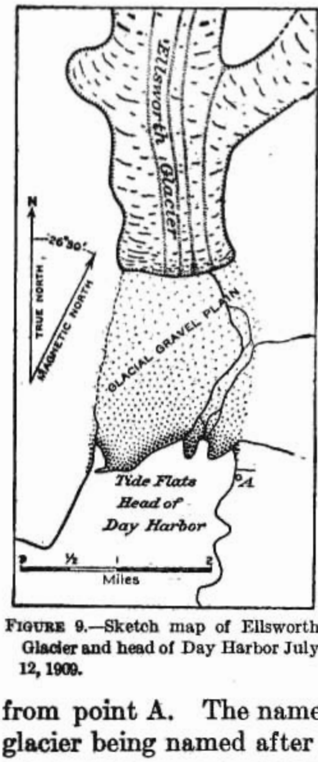


FIGURE 9.—Sketch map of Ellsworth Glacier and head of Day Harbor July 12, 1909.

ELLSWORTH GLACIER.

The Ellsworth Glacier is situated at the head of Day Harbor, the first bay east of Resurrection Bay. This glacier is not mentioned by Davidson and evidently did not appear on the maps of Tebenkof or Vancouver. It is shown as reaching tidewater on United States Coast and Geodetic Survey chart 8502 (1907). We visited the head of Day Harbor on July 12, 1909, at which time the accompanying sketch map (fig. 9) of the glacier was made, mainly from point A. The name Ellsworth Glacier is in use at Seward, the glacier being named after H. E. Ellsworth of that place.

[1] Davidson, George, op. cit., p. 20, map 5.

The Ellsworth Glacier is an ice stream of considerable length and low slope. It ends about a mile and three-quarters from tidewater. The glacier carries four well-marked medial moraines, and the eastern part of its front is covered with much débris. Two feeders join it from the east. About opposite the upper feeder is a nunatak, and a little south of this feeder and farther west is another nunatak of small size, both of which rise only a little above the ice surface. On the west side of the end of the glacier is a bare zone perhaps 200 feet in height (Pl. XXXI, *A*). On the east side of the end is a morainic deposit, also bare of vegetation, and there are some morainic hillocks in front of the glacier. Part of the outwash plain is covered with vegetation. We did not visit the front of the glacier and therefore have no information as to recent retreat or advance, except for the bare zone noted above. It is very improbable that this glacier has reached tidewater within historic time.

West of the head of Day Harbor are two other north-south valleys. The eastern one contains two small glaciers some 8 or 10 miles from the sea, and on the western side of the western valley is another small glacier about 4 miles from the sea. In the mountains west of the head of Day Harbor are several cirques, one of which contains the small glacier just noted. Three other cirques have moraines across their fronts and possibly may contain small glaciers.

Photographs of glaciers between Capes Puget and Resurrection.

G 117. Here reproduced as Plate XXX, *B*. Puget Glacier from point A, figure 8. July 11, 1909. Point A is near the east end of the beach at the head of Puget Bay.

G 118. West side of front of Excelsior Glacier from boat. July 11, 1909.

G 119. East side of front of Excelsior Glacier from boat. July 11, 1909.

G 120. Ellsworth Glacier from boat. July 12, 1909.

G 121. Here reproduced as Plate XXXI, *A*. Ellsworth Glacier from point A, figure 9. July 12, 1909. Point A is the top of a drift hill about 60 feet above sea level, undercut on the north side, at the northeast corner of Day Harbor. The summit of the hill is forested, and the station is at the edge of the forest and at the top of the steep northerly slope.

G 215. Hanging valley and cirque possibly containing a glacier, at west side of head of Day Harbor. July 12, 1909.

RESURRECTION BAY.

Resurrection Bay is the most northerly extending indentation of the coast line of the Gulf of Alaska between Prince William Sound and Cook Inlet. The high mountains east of this bay carry several small glaciers, which end far above sea level, and on the west side of the bay is the Bear Glacier, the largest ice stream to reach the sea on the Kenai Peninsula.

THUMB COVE GLACIERS.

On August 21 and 22, 1908, we made a short trip to Thumb Cove (locally known as Porcupine Bay), and in visiting the prospects in this vicinity made a sketch (fig. 10) and took a few notes on the glaciers near this little bay. Although these glaciers, when viewed from the bay, seem to be clinging to the mountains as hanging glaciers, a visit to them reveals the fact that they occupy well-defined valleys. The Spoon and Prospect Glaciers especially occupy well-developed cirques whose walls are in places nearly a thousand feet sheer. The Porcupine Glacier was not visited, but its front could be very well seen from tidewater.

The Prospect Glacier was named from the fact that S. E. Likes has done considerable prospecting along the back cirque wall. The front of the glacier is breaking over a small rock cliff. The Spoon Glacier was so named on account of its smooth, glassy, round front, which reminds one approaching from below of the inverted end of a huge spoon. The Porcupine Glacier bears the local name of the bay.

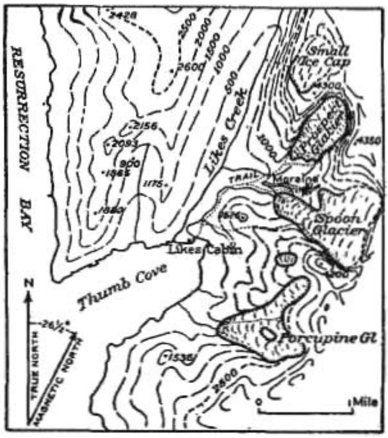


FIGURE 10.—Sketch map of Thumb Cove glaciers, Resurrection Bay, August 21, 1908. Crosses indicate copper prospects; shore line and elevations from United States Coast and Geodetic Survey; contour interval 500 feet.

The bare areas about the fronts of all these glaciers indicated in 1908 a minimum recorded extent of the ice. Between the Prospect and Spoon glaciers is an abandoned medial moraine. It is about 80 feet high in the highest parts, its top is sharp, and its sides are very steep, for they have not yet adjusted themselves to an angle less than that of repose for the material of the moraine. Bowlders of prodigious size are common. The largest one seen was estimated as equal to a 20-foot cube. The condition of the vegetation on the moraine indicates that several decades have passed since these glaciers coalesced.

Just north of the Prospect Glacier is what appears to be a small ice cap covering the top and upper part of the western slope of a mountain more than 4,000 feet in height.

GODWIN GLACIER.

The Godwin Glacier is on the east side of Resurrection Bay directly east of Seward, and is the source of Godwin River. The glacier ends about 3 miles from the bay at an altitude of approximately 1,000 feet. The end of the glacier is forked, and in front of it, as seen from the bay, is a bare zone about a quarter of a mile wide. Next to this is another zone of similar width covered with bushes, after which comes a forest extending to sea level.

BEAR GLACIER.

The Bear Glacier ends on a gravel flat on the west side of Resurrection Bay 12 miles south of Seward. The name Bear Glacier is in use at Seward. Our visit to this glacier was made on July 20 and 21, 1909. No accurate information concerning the glacier, except its existence and the fact that it reaches sea level, was available before the publication of chart No. 8538 of the United States Coast and

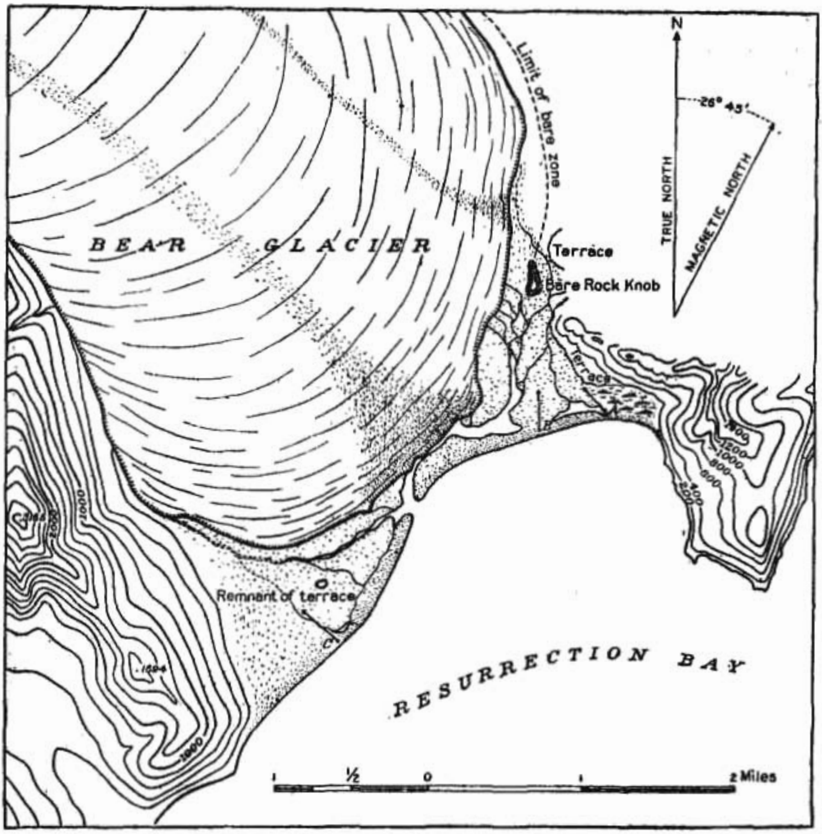
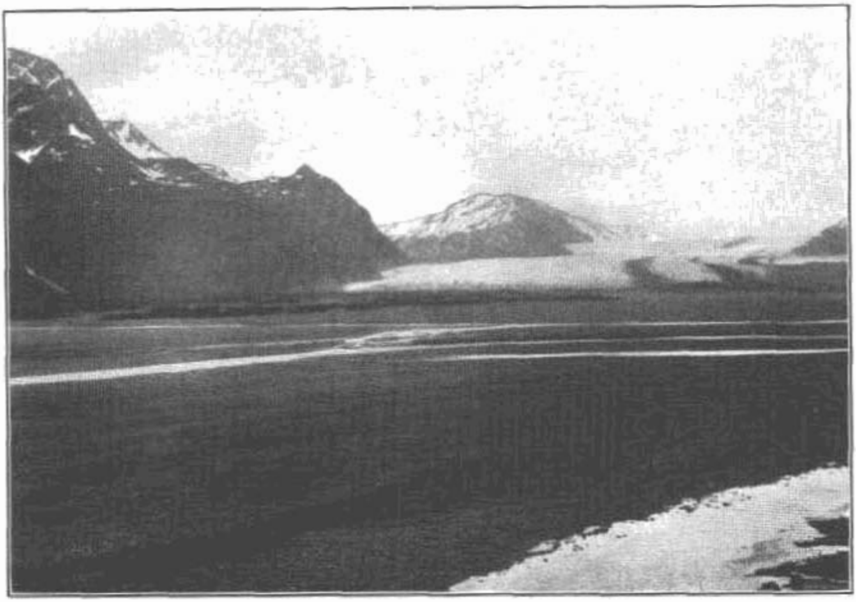


FIGURE 11.—Map of front part of Bear Glacier July 20 and 21, 1909. Occupied points indicated by circles; arrows show directions in which photographs were taken; elevations from United States Coast and Geodetic Survey chart No. 8538; contour interval, 200 feet.

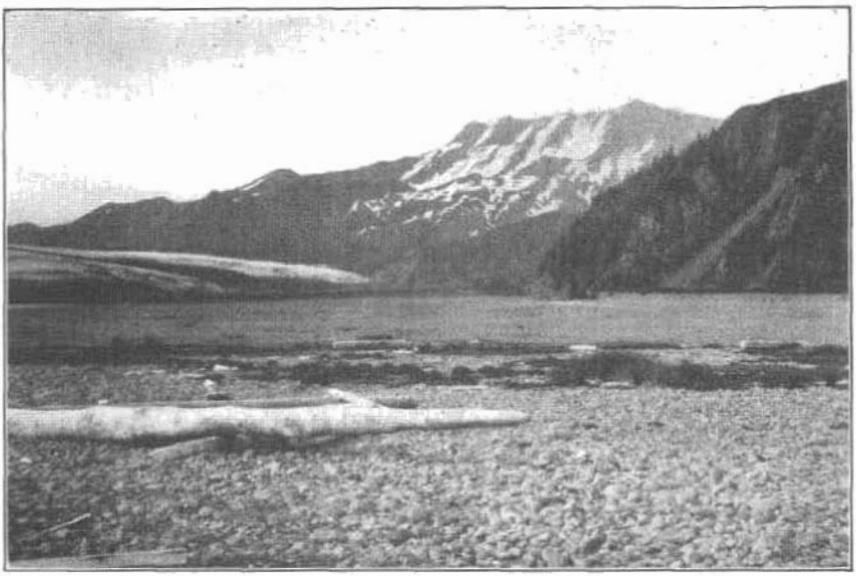
Geodetic Survey. This map shows that the front of the glacier was in essentially the same position in 1905 as it was in 1909.

The Bear Glacier has a comparatively low slope and carries two large medial moraines (fig. 11). The gravel flat on which the glacier rests is partly covered by the highest tides, and apparently a combination of highest tide and strong southerly wind brings waves over the greater part of it. Along the center of the ice front high tide reaches the glacier. On the east side of the flat is a gravel terrace



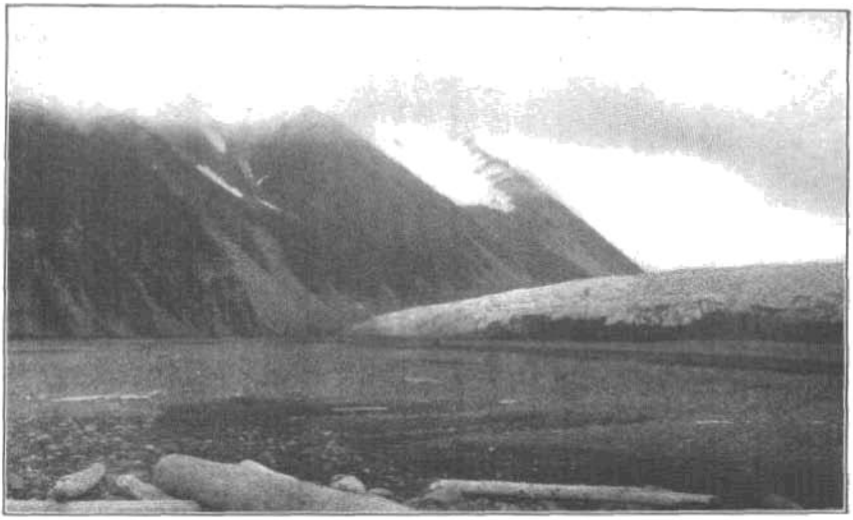
A. ELLSWORTH GLACIER.

From point A, figure 9. July 12, 1909. Photograph G 121.



B. EAST PART OF FRONT OF BEAR GLACIER.

From point B, figure 11. July 20, 1909. Photograph G 123.



A. WEST PART OF FRONT OF BEAR GLACIER.

From point C, figure 11. July 21, 1909. Photograph G 124.

B. NORTH PART OF AIALIK GLACIER.

From point A, Plate XXXIII. July 23, 1909. Photograph G 221.

(Pl. XXXI, *B*) covered with grass and a few bushes; the terrace at its south end is at high-tide level and rises about 30 feet in going northward a mile. A small remnant of apparently the same terrace persists on the western part of the glacial flat. The top of the terrace probably represents the surface of the outwash plain as it was when the glacial front stood farther back than at present.

Northeast of the glacial front is a bare rock face about 200 feet high, evidently recently glaciated, and south of this is a rocky island in the glacial flat. The northwestern side of the island is bare of timber, but the southeastern side is wooded. West of the glacier front is a bare zone about 200 feet high (Pl. XXXII, *A*), which extends a quarter of a mile beyond the ice front. This bare zone has been invaded recently by talus cones, and its upper side is not sharply marked. The glacier front, therefore, has been perhaps a quarter of a mile in advance of its present position in comparatively recent years, but has not been farther advanced than that distance since the growth of the present forest.

The probable fluctuations of the Bear Glacier since the growth of the present forest may be recorded as: (1) A maximum advance to and into the forest, perhaps 25 or more years ago; (2) a retreat of an unknown distance, during which an outwash plain (now represented by remnants of a terrace) was constructed at a higher level than the present plain; and (3) an advance to the present position, which is perhaps a quarter of a mile short of the maximum mentioned above.

Photographs of glaciers of Resurrection Bay.

G 63. View northeastward into Thumb Cove from boat, showing small ice cap on left, névé field of Spoon Glacier on right and Prospect Glacier in center, with surrounding peaks. August 21, 1908.

G 64. Same as G 63; a closer view. August 21, 1908.

G 65. Porcupine Glacier and surrounding mountains from boat near head of Thumb Cove. August 21, 1908.

G 122. East part of front of Bear Glacier from point A, figure 11. July 20, 1909.

G 123. Here reproduced as Plate XXXI, *B*. East part of front of Bear Glacier from point B, figure 11. July 20, 1909.

G 124. Here reproduced as Plate XXXII, *A*. West part of front of Bear Glacier from point C, figure 11. July 21, 1909.

G 125. Bear Glacier from boat. July 21, 1909.

AIALIK BAY.

GENERAL FEATURES.

Aialik Bay is the deep bay just west of Resurrection Bay. Both the point between these two bays and the shores of Aialik Bay are very irregular, being indented by many approximately semicircular small bays and coves, which represent old glacial cirques partly or completely drowned. (See Pl. XXXIII.) The drowning is most pronounced at the south end of the bay, and the cirque floors rise gradually until at the north end they lie above sea level.

On the eastern shore of the upper half of Aialik Bay are four small glaciers. On the western shore of the bay are other glaciers high up in the mountains, and three large glaciers reach tidewater. (See Pl. XXXIII.) These three ice streams, as well as the Bear Glacier, come from an immense snow field lying northwest of Aialik Bay. The depth and extent of this snow field are unknown, but it is one of the largest, if not the largest, on the Kenai Peninsula. Glaciers from the western side of this snow field drain into Tustumena Lake and probably others into Skilak Lake.[1]

AIALIK GLACIER.

The Aialik Glacier reaches tidewater at the west side of the extreme head of Aialik Bay, whence the name here applied. This glacier is not mentioned by Davidson,[2] and so probably was not shown on Vancouver's and Tebenkof's maps. It is shown as reaching tidewater on chart No. 8502 of the United States Coast and Geodetic Survey (1907). We visited the Aialik Glacier on July 23, 1909, and most of our observations were made from the top of Squab Island, a mile east of the southern part of the front of the glacier and 100 feet above sea level (point A, Pl. XXXIII).

The glacial front is a cliff, estimated to be 200 feet high, from which ice is being discharged rapidly. There is no medial moraine on the Aialik Glacier, and the lateral moraines, especially the one on the northeast side, are not large. At the center of the front a small mass of rock has just been uncovered by the ice, and another small mass appears about a third of the way from the center to the north end of the front (Pl. XXXII, *B*). On each side of the glacier is a marked bare zone, and in the bare zone on the south side is a lateral moraine (Pl. XXXIV, *A*). When the ice extended over this bare zone, possibly 10 years ago, the front was about a quarter of a mile in advance of its present position. Much more advanced positions of the Aialik Glacier, occupied several centuries ago, are indicated by shoals, caused by morainic accumulations, stretching across the head of Aialik Bay opposite and a mile north of the front of the Pederson Glacier.

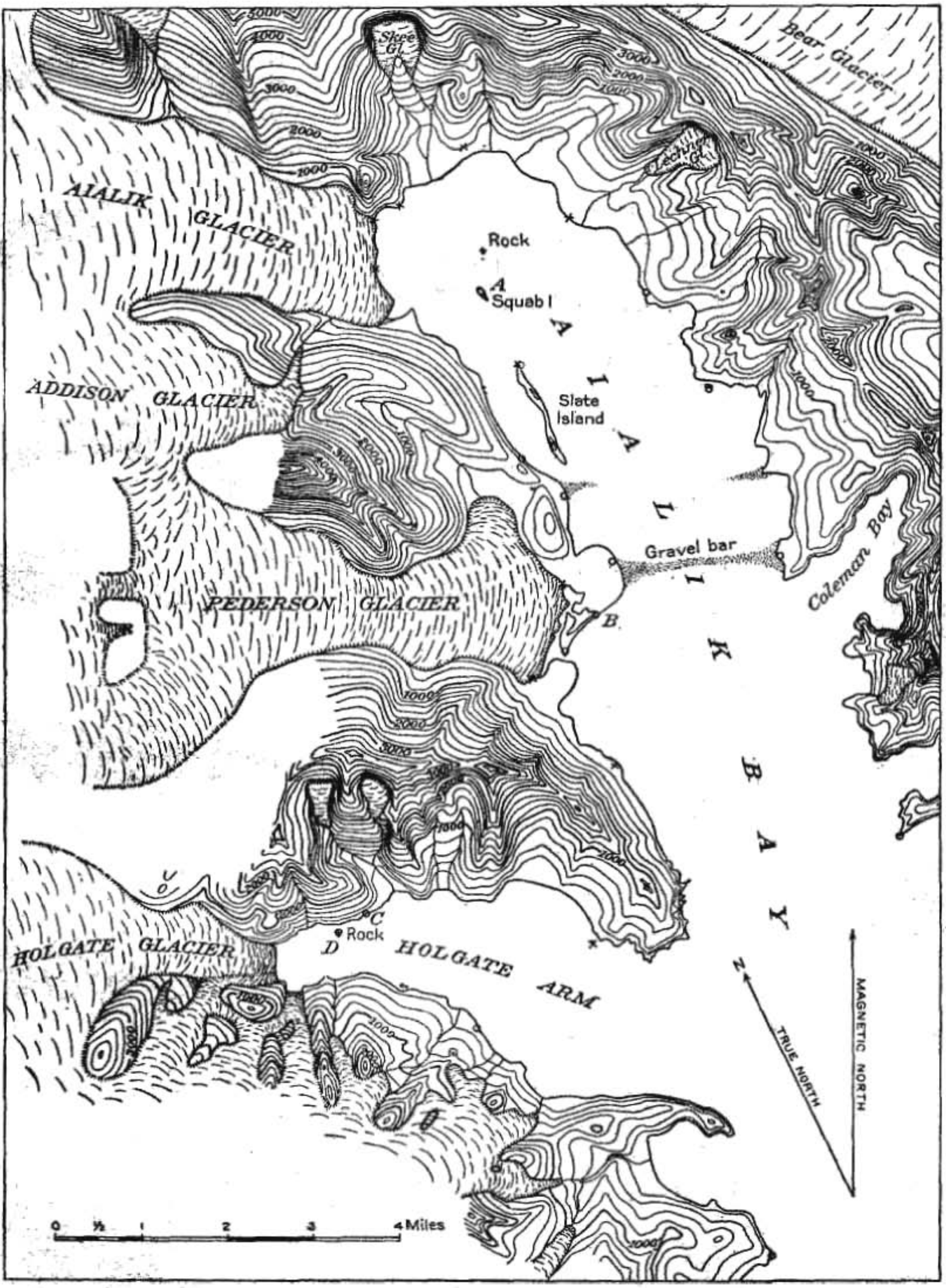
PEDERSON GLACIER.

The Pederson Glacier ends 4 miles south of the Aialik Glacier. Davidson[2] states that the Pederson Glacier is shown by Tebenkof (1852), and that it ends half a mile from the sea. We visited this glacier on July 23, 1909.

Toward its end the Pederson Glacier is smooth; it deploys upon a glacial flat, and the center of its front is reached by high tide (Pl.

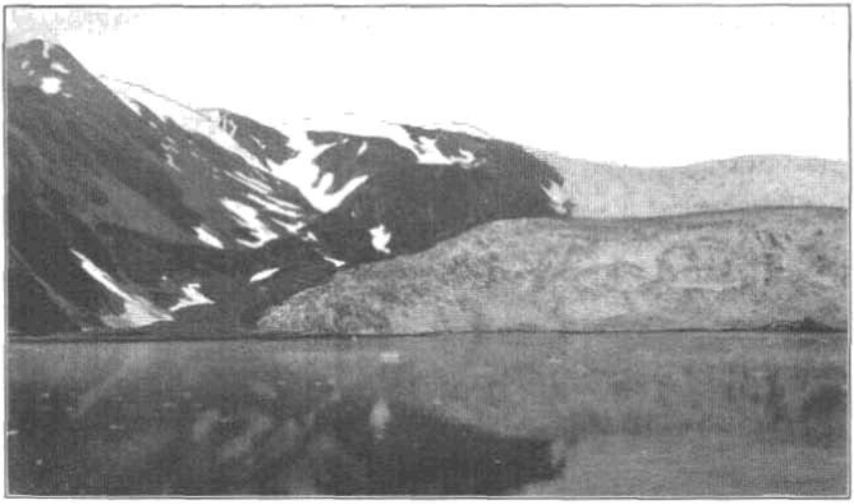
[1] Recently the extent of this great snow field, especially to the west and north, has been determined by R. H. Sargent, of the United States Geological Survey.

[2] Op. cit., p. 19, map 4.



MAP OF UPPER PART OF AIALIK BAY.

July 22-24, 1909. Occupied points indicated by circles, intersected points by crosses. Contour interval 200 feet.

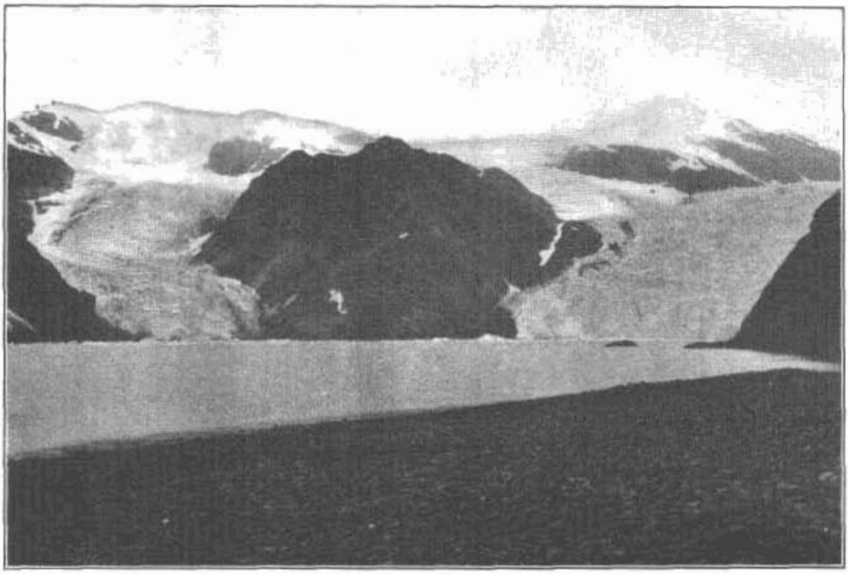


A. SOUTH PART OF FRONT OF AIALIK GLACIER.

From point A, Plate XXXIII. July 23, 1909. Photograph G 220.

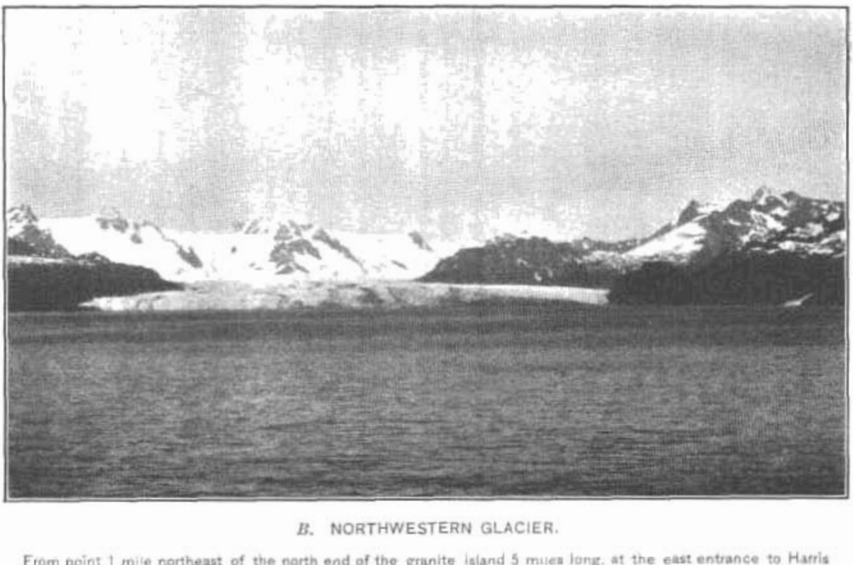
B. NORTH PART OF FRONT OF PEDERSON GLACIER.

From point B, Plate XXXIII. July 23, 1909. Photograph G 130.



A. HOLGATE GLACIER.

From point C, Plate XXXIII. July 24, 1909. Photograph G 132.



B. NORTHWESTERN GLACIER.

From point 1 mile northeast of the north end of the granite island 5 miles long, at the east entrance to Harris Bay. July 27, 1909. Photograph G 138.

XXXIII). The northern part of the front forms a perpendicular cliff of ice perhaps 100 feet high. This glacier has no medial moraine and has a well-marked bare zone on each side of the front. On the north side this zone is approximately 200 feet high where it touches the ice, and it extends a third of a mile east from the present front of the glacier (Pl. XXXIV, *B*). Along much of the front, a quarter to a third of a mile from the ice, are remnants of a low moraine, which has now been nearly cut away by the waves. On this moraine are herbaceous plants and some alders about 2 feet high. The moraine was probably deposited at the time when the glacier advanced to the edge of the bare zone mentioned above. This advance may have been made 15 years ago and apparently was the maximum advance of the glacier since the advent of the present forest. The earlier recorded position of the ice front mentioned by Davidson was probably close to its position in 1909.

HOLGATE GLACIER.

The Holgate Glacier lies at the head of Holgate Bay, the main westerly branch of Aialik Bay. This glacier is mentioned by Davidson as nearly reaching the beach and is shown on Tebenkof's map (1852).[1] We examined this glacier from points C and D, Plate XXXIII, on July 24, 1909.

The Holgate Glacier reaches tidewater in two streams separated by a small mass of rock, which not many years ago was a nunatak in this glacier. (See Pls. XXXIII and XXXV, *A*.) The northern and larger stream is discharging rapidly, but the discharge from the southern stream is small. Near the south side of the larger stream is a small medial moraine, but the glacier as a whole is free from medial moraines. The same statement can be made concerning the other glaciers on the west side of Aialik Bay. They all come from an extensive snow field that has few bare peaks rising above its surface.

About three-fourths of a mile east of the front of the northern stream of the Holgate Glacier is a rounded reef, recently glaciated and now covered by the highest tides. (See point D, Pls. XXXIII and XXXV, *A*). There are no trees on the sides of Holgate Bay within 1½ miles of its head, and beyond this the forest is sparse. There are no bushes and very few herbaceous plants close to sea level from the glacier to a point a quarter of a mile east of the reef mentioned above. The rock mass between the two parts of the glacial front has bushes only on its upper half on the front and on its upper fourth on the sides. (Pl. XXXV, *A*.) In very recent years, then, possibly within the twentieth century, the front of the Holgate Glacier was about a mile in advance of its position in 1909.

[1] Davidson, George, loc. cit.

On the southwestern side of Holgate Bay several ice tongues descend the mountain sides but do not reach within a few hundred feet of sea level. Most of these glaciers lie in shallow valleys, and all come apparently from the same part of the great snow field that feeds the Holgate Glacier.

Photographs of glaciers of Aialik Bay.

G 127. Pederson Glacier from boat. July 22, 1909.

G 128. South part of front of Aialik Glacier from point A, Plate XXXIII. July 23, 1909. Point A is the top of a rocky islet a mile east of the glacier.

G 129. North part of front of Aialik Glacier from point A, Plate XXXIII. July 23, 1909.

G 130. Here reproduced as Plate XXXIV, *B*. North part of front of Pederson Glacier from point B, Plate XXXIII. July 23, 1909.

G 131. South side of front of Pederson Glacier from point B, Plate XXXIII. July 23, 1909.

G 132. Here reproduced as Plate XXXV, *A*. Holgate Glacier from point C, Plate XXXIII. July 24, 1909. Point C is on a shingle beach on the north side of Holgate Bay, about 1.2 miles from the glacier.

G 133. North part of Holgate Glacier from point D, Plate XXXIII. July 24, 1909. Point D is on a large rock reef, which is apparently covered by the highest tides, and is shown in photograph G 132 (Pl. XXXV, *A*).

G 134. South part of Holgate Glacier from point D, Plate XXXIII. July 24, 1909.

G 135. Glaciers on south side of Holgate Bay from boat. July 24, 1909.

G 220. Here reproduced as Plate XXXIV, *A*. South part of front of Aialik Glacier from point A, Plate XXXIII. July 23, 1909.

G 221. Here reproduced as Plate XXXII, *B*. North part of front of Aialik Glacier from point A, Plate XXXIII. July 23, 1909.

G 222. Glaciers on south side of Holgate Bay from boat. July 24, 1909.

G 223. Holgate Glacier from point C, Plate XXXIII. July 24, 1909.

G 224. South part of Holgate Glacier from point D, Plate XXXIII. July 24, 1909.

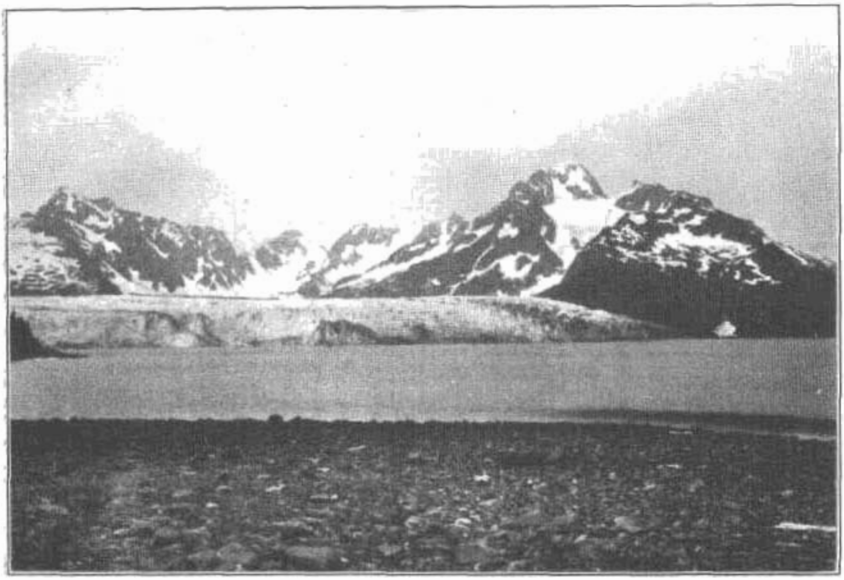
G 225. North part of Holgate Glacier from point D, Plate XXXIII. July 24, 1909.

NORTHWESTERN GLACIER.

The Northwestern Glacier (fig. 12) reaches the ocean at the head of Harris Bay, the second large bay southwest of Resurrection Bay. This glacier is one of the largest ice streams of the Kenai Peninsula and is in full view from the open ocean, forming, with its surrounding lofty peaks, the most striking scenic feature of the southern shore of the Kenai Peninsula. The Northwestern Glacier, which we named after Northwestern University, is shown by Tebenkof[1] as reaching almost to the sea. We visited this glacier on July 26 and 27, 1909, and examined it from points 1 to 5 miles distant and also from a boat less than a mile from the glacier front.

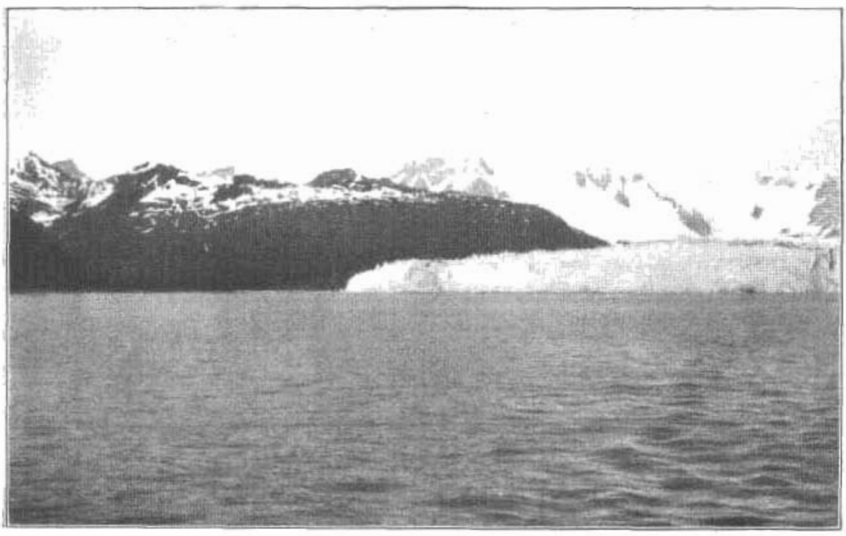
The Northwestern Glacier descends from a large ice field northwest of Harris Bay. Eight or 10 miles from the water several peaks stand out above the edge of this ice field, and from the vicinity of these peaks ice streams descend rapidly to a wide, low valley, which

[1] Davidson, George, loc. cit.



A. EAST PART OF FRONT OF NORTHWESTERN GLACIER.

From point A, figure 12. July 26, 1909. Photograph G 137.



B. WEST PART OF FRONT OF NORTHWESTERN GLACIER.

From boat. July 27, 1909. Photograph G 140.

the main glacier follows to the sea. The glacier shows on its surface a number of well-marked medial moraines, six of which come down to its tidewater front; at least two others end in the hills on the north (Pl. XXXV, *B*). The peaks just mentioned and the medial moraines coming from them are of reddish granite, and in consequence the surface of the glacier is striped with bands of a buff color. The west quarter of the front of the glacier forms a steep cliff and is discharging rapidly. The eastern half of the front lies on a gravel flat, the eastern part of which is not covered by high tide. On each side of the front there is a bare zone between the glacier and the forest (Pl. XXXVI). This zone extends a quarter of a mile beyond the front of the glacier and is estimated to reach 150 feet in height above the surface of the glacier near its front.

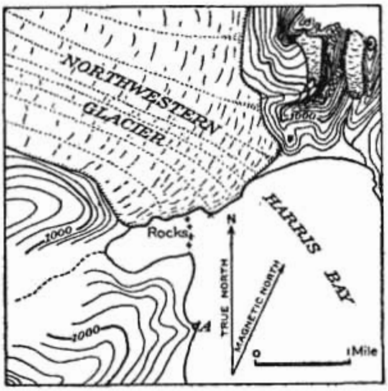


FIGURE 12.—Sketch map of front part of Northwestern Glacier July 23, 1909. Occupied points indicated by circles, intersected points by crosses. Contour interval, 200 feet.

The front of the Northwestern Glacier was in 1909 about a quarter of a mile back of its position of maximum advance since the growth of the present forest. This maximum position was occupied perhaps 10 to 15 years ago.

Photographs of Northwestern Glacier.

G 136. Northwestern Glacier from boat. July 26, 1909.

G 137. Here reproduced as Plate XXXVI, *A*. Eastern part of front of Northwestern Glacier from point A, figure 12. July 26, 1909. Point A is at the base of the rocky spit connecting a small island with the west shore of Harris Bay, about 1.2 miles south of the front of the Northwestern Glacier.

G 138. Here reproduced as Plate XXXV, *B*. Northwestern Glacier from end of point on south side of the second large bay from the glacier on the east side of Harris Bay. This point is just northeast of the north end of the granite island 5 miles long at the eastern entrance to Harris Bay. July 27, 1909.

G 139. Same position as G 138; the camera was turned a little more to the left. July 27, 1909.

G 140. Here reproduced as Plate XXXVI, *B*. Western part of front of Northwestern Glacier from boat. July 27, 1909.

G 226. Northwestern Glacier. July 26, 1909.

TWO ARM BAY.

Two Arm Bay, thus called locally from its form, lies 18 miles west of Chiswell Islands and 12 miles northeast of Pye Islands. (See Pl. II, in pocket.) Tebenkof, as quoted by Davidson,[1] in-

[1] Davidson, George, loc. cit.

dicates a glacier coming close to but not reaching tidewater at the head of each arm of this bay. The same glaciers, the western one coming to sea level, are shown on United States Coast and Geodetic Survey chart No. 8502 (1907). We visited the heads of both arms of this bay in July, 1909. There is no glacier to be seen on the western arm, and we noted no evidence of the presence of one in historic times; neither do the streams entering the bay, as far as we saw, carry glacial silt. About the head of the eastern arm of this bay, however, are at least four small glaciers whose waters reach the bay. These ice streams end about 1,000 feet above sea level, and one of them evidently comes from the same great ice field from which the Northwestern and McCarty glaciers flow. Our recollection is that there is a mature forest separating all these glaciers from the sea, so they have not reached nearly to tidewater in historic times.

NUKA BAY.

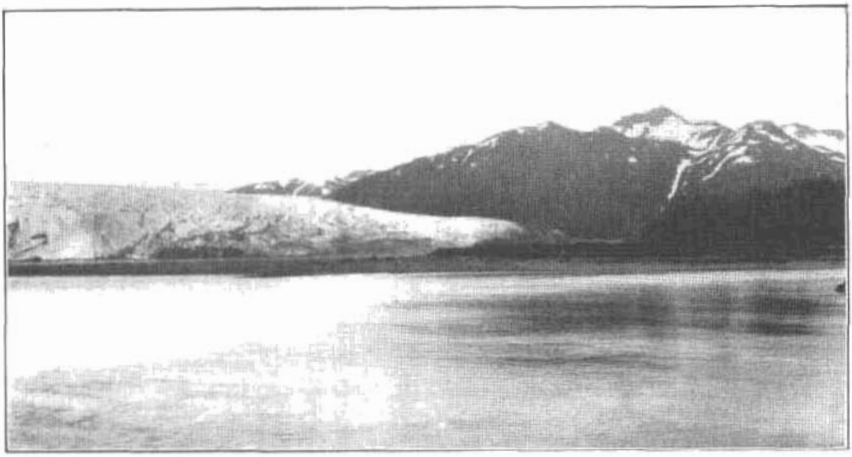
GENERAL FEATURES.

Nuka Bay is the large inlet lying just west and northwest of the Pye Islands. It has several arms or branches. At the head of the eastern arm is the McCarty Glacier, the most westerly to reach tidewater on the southern shore of the Kenai Peninsula. The Split Glacier ends about 2 miles from the head of the northern arm. On the southwest shore of the northwest arm are at least four glaciers, but none of them end near sea level. The western arm (Yalik Bay) has no glaciers draining into it. On the western side of Nuka Bay south of Yalik Bay are two larger glaciers, Yalik and Petrof, and several smaller ones which do not reach the sea but whose waters drain into Nuka Island Passage. The information here given concerning the glaciers of Nuka Bay was obtained between July 30 and August 8, 1909.

M'CARTY GLACIER.

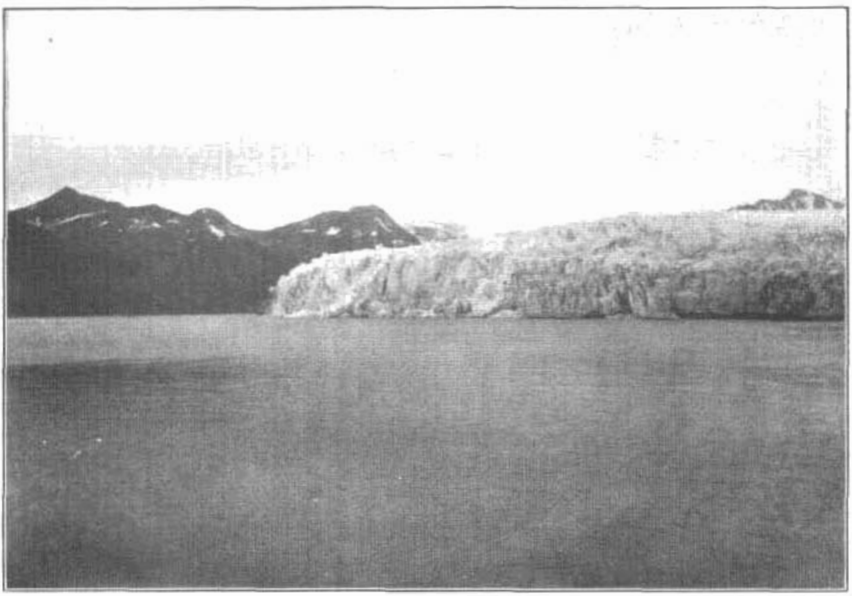
The McCarty Glacier reaches the sea at the head of the northeastern arm of Nuka Bay (fig. 13). The glacier was named by residents of the locality after William McCarty, of Seward. It has a prominent medial moraine in its western half, which stands up above the ice surface as a ridge. The front of the glacier deploys in semicircular form on a gravel flat, which is mainly above sea level. At the center of its front, however, the glacier reaches tidewater and in places presents a steep wall about 200 feet high. From this wall blocks of ice fall into the water, which is so shallow that the larger icebergs do not float away.

East of the front of the McCarty Glacier is a broad pitted plain, and nearer the ice are morainic ridges which mark an advance of



A. EAST PART.

Photograph G 143.

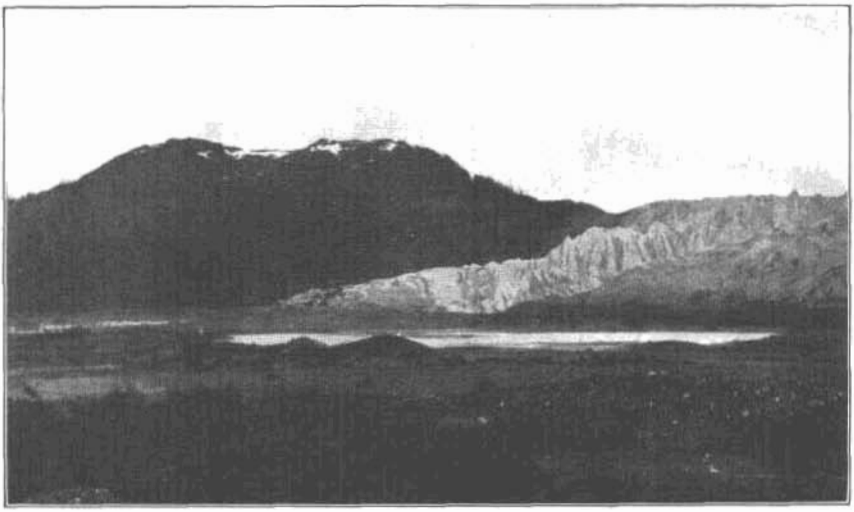


B. CENTRAL PART.

Photograph G 144.

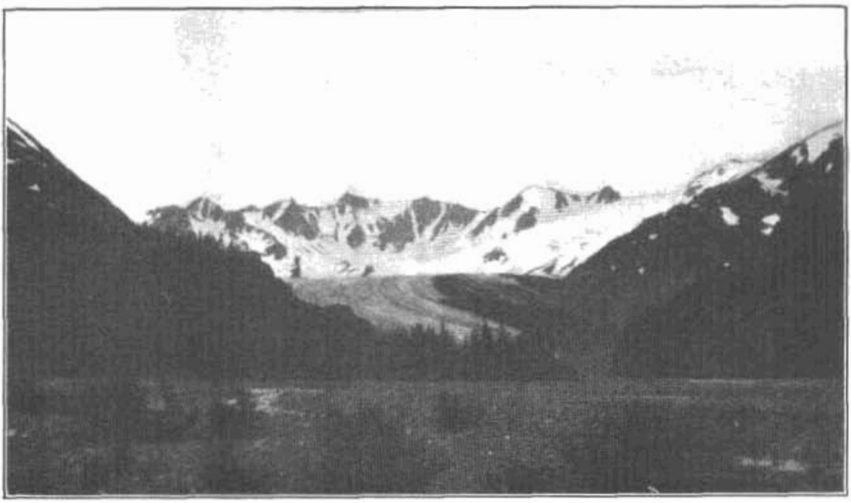
FRONT OF McCARTY GLACIER.

From point A, figure 13. July 30, 1909.



A. WEST SIDE OF McCARTY GLACIER.

From point B, figure 13. July 30, 1909. Photograph G 228.



B. SPLIT GLACIER.

From point G, figure 15. August 2, 1909. Photograph G 233.

the ice some years ago. Between the glacier and Delight Lake these morainic ridges reach a height of 60 feet. South of this lake a rock ridge extends westward within about a quarter of a mile of the glacier. This ridge is shown on the right side of Plate XXXVII, *A*. The end of the ridge is of bare rock and has been glaciated up to a height of 250 feet, at which elevation the ice invaded a mature forest and killed many of the trees, which are now without bark and most of which are lying on the ground. Standing among the dead trees are live spruces, the largest of which are 12 feet high and 6 inches in diameter. The advance of the ice that destroyed the large trees and constructed the morainic ridges just mentioned occurred perhaps 50 years ago and is the extreme advance of the eastern part of the glacier since the growth of the present forest.

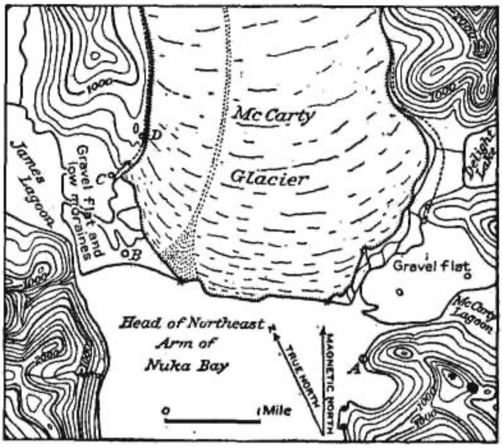


FIGURE 13.—Map of front part of McCarty Glacier July 30, 1909. Occupied points indicated by circles, intersected points by crosses. Dotted lines at sides of glacier indicate limits of bare zones. Contour interval, 200 feet.

On the west side of the glacial front is a gravel plain with two lines of low morainic ridges, one near the outer edge of the plain and one within about a quarter of a mile of the ice. These morainic accumulations were probably synchronous, respectively, with the old and young lateral moraines shown in figure 14.

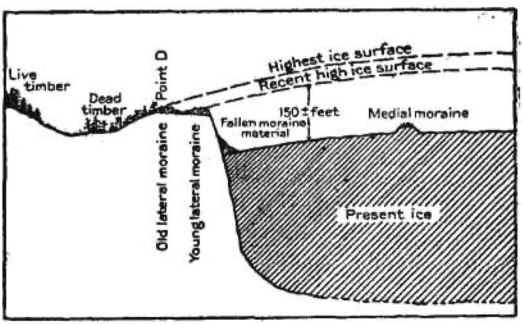


FIGURE 14.—Diagrammatic cross section of west side of McCarty Glacier, taken east and west through point D of figure 13. Vertical scale greatly exaggerated.

The extreme western side of the McCarty Glacier falls abruptly over the point of a rock ridge some 350 feet high. (See Pl. XXXVIII, *A*.) From the top of this ridge and just west of the ice (point D, fig. 13) an excellent view of the glacier and its environs is obtained. Here are two lateral moraines now beyond the edge of the ice. The older and outer of these moraines is not very well defined and ranges from a few feet to 12 feet in height. Moss and young spruce trees cover most of its surface, and in it are many fragments of tree trunks and stumps. Just outside this moraine on the west is a forest practically all whose trees near the ice were killed at the time, apparently, at which the moraine was formed (fig. 14). These trees are in about the same stage of decay as the fragments of wood in the moraine and are all in a more advanced stage than the trees at any other locality described in this report where a forest has been invaded by the ice, except those of the forest destroyed by the maximum advance of the eastern part of the Columbia Glacier. The advance that killed these trees was the maximum of the western part of the McCarty Glacier since the growth of the present forest and probably occurred at the time of the maximum advance shown on the eastern side of the same glacier.

East of the lateral moraine just described is a similar but much younger one. On this there is little moss, but many young spruce trees 1 to 12 inches high.

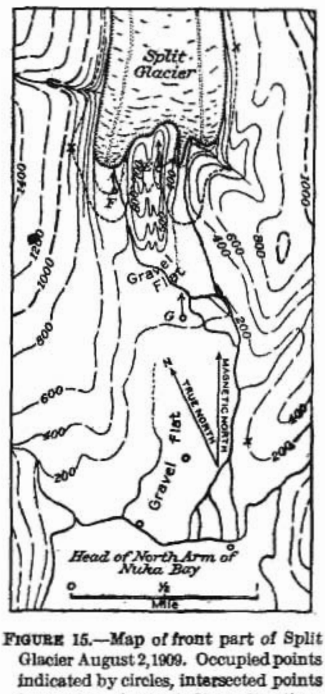


FIGURE 15.—Map of front part of Split Glacier August 2, 1909. Occupied points indicated by circles, intersected points by crosses. Arrows indicate directions in which photographs were taken. Contour interval, 200 and 100 feet, the smaller interval being used in the immediate vicinity of the glacier front. Dotted lines about front of glacier indicate limits of recent advances.

SPLIT GLACIER.

The Split Glacier ends in the upper part of a steeply graded, gravel-filled valley at the head of the north arm of Nuka Bay (Pl. XXXVIII, *B*). The front of the glacier is bifurcate, because of a rock ridge near its center. About the edge of the ice is a bare zone, whose limits are shown by the outer dotted line on the map (fig. 15). On the central ridge and the hills on the side of the valley this bare zone is sharply marked, but in the center of the valley it merges into the bare gravel floor. Within this zone is a smaller one, indicated by the inner dotted line on the map, marking the limit of a more recent advance of the ice. The distance from the forest on the eastern part of the central ridge north to the ice is a little over a fourth of a mile. As one walks from the forest-covered part of this ridge northward toward the glacier he passes at first through a dense growth of alders, grass, and moss, which gradually becomes smaller and less dense as the ice is approached, thus indicating a very gradual retreat of the glacier from its maximum advance since the advent of the present forest.

The narrow tongue of ice projecting from the eastern part of the glacial front is a débris-covered remnant of the ice of the most recent advance. The low area between point F, shown in figure 15, and the front of the western lobe of the glacier is occupied by gravel-covered ice, which seems to be floating on water, and parts of the

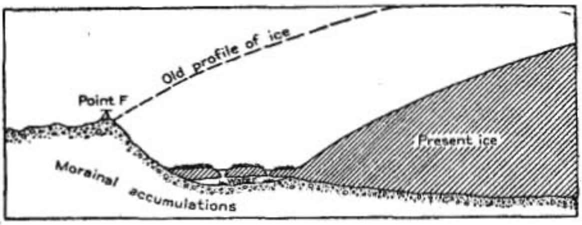


FIGURE 16.—Diagrammatic cross section of front edge of Split Glacier.

ice have caved in because of the weight of the gravel. (See Pl. XXIV, *B*, and fig. 16.)

The Split Glacier with its surrounding mountains forms a scene of quiet color and beauty not excelled by any among the glaciers of Prince William Sound and the southern part of the Kenai Peninsula. The ice front is smooth and easy of access, and the glacier would probably afford an easy route for exploration from Nuka Bay across to the head of Kachemak Bay of Cook Inlet.

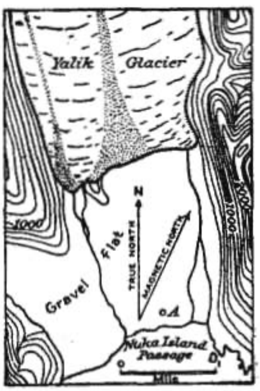


FIGURE 17.—Sketch map of front part of Yalik Glacier August 7, 1909. Contour interval, 200 feet.

YALIK GLACIER.

The Yalik Glacier ends on a steep gravel flat about 2 miles north of the northwestern side of Nuka Island Passage (fig. 17). The glacier was named from the small settlement of Yalik, which formerly existed on the southern of the two western arms of Nuka Bay. This glacier has two prominent medial moraines, which spread toward the end of the ice, so that about half of the frontal edge of the glacier is débris-covered. There is a bare zone along the glacier front, and at the edge of this zone is a forest that was invaded by the ice some years ago. Part of the gravel plain in front of the glacier is forested, as is a rock ridge rising out of the plain near the western part of the glacier front. In places, especially toward the eastern side of the plain, the forest has been partly buried and many trees have been killed by outwash from the glacier (Pl. XXXIX, *A*). This probably occurred at the time of the advance marked by the limit of the bare zone along the ice front.

PETROF GLACIER.

The Petrof Glacier ends on a gravel plain west of Nuka Island Passage and about a mile from the sea (fig. 18). This glacier was named after Ivan Petrof, who was special agent for Alaska of the Tenth Census (1880).

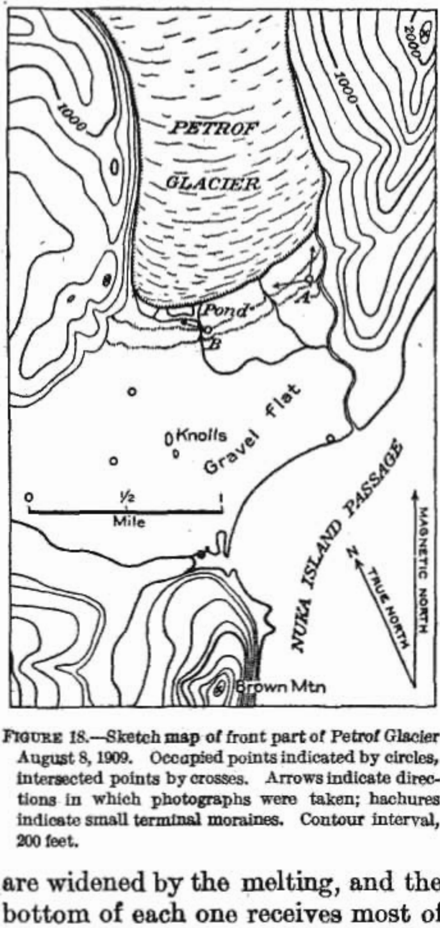


FIGURE 18.—Sketch map of front part of Petrof Glacier August 8, 1909. Occupied points indicated by circles, intersected points by crosses. Arrows indicate directions in which photographs were taken; hachures indicate small terminal moraines. Contour interval, 200 feet.

The Petrof Glacier has no medial moraines; it has no lateral moraine along its eastern side and only a small one along its western side. A bare zone extending along both the east and the west parts of the ice front has been encroached upon by small vegetation (Pls. XXXIX, *B*, and XL, *A*). Two small terminal moraines cross the upper end of the gravel flat in front of the glacier.

In front of the Petrof Glacier are small ridges, 1 to 5 feet wide and 6 to 18 inches high. Some are 200 feet in length (Pl. XL, *B*). They run out from the ice front and in places cross small push moraines. These ridges are connected with radial fissures in the thin edge of the ice and are formed by débris falling into these fissures from the melting front of the ice. The fissures are widened by the melting, and their sides become sloping; thus the bottom of each one receives most of the drift which lies on the surface of the ice in a space two to four times the width of the ground uncovered by the fissure. As the ice front retreats the débris deposited in the fissures stands up as small ridges.

Photographs of glaciers of Nuka Bay.

G 142. McCarty Glacier from boat. July 30, 1909.

G 143. Here reproduced as Plate XXXVII, *A*. East part of front of McCarty Glacier from point A, figure 13. July 30, 1909.

G 144. Here reproduced as Plate XXXVII, *B*. Central part of front of McCarty Glacier from point A, figure 13. July 30, 1909.

G 145. Here reproduced as Plate XXXIX, *A*. East part of front of Yalik Glacier from point A, figure 15. August 7, 1909.

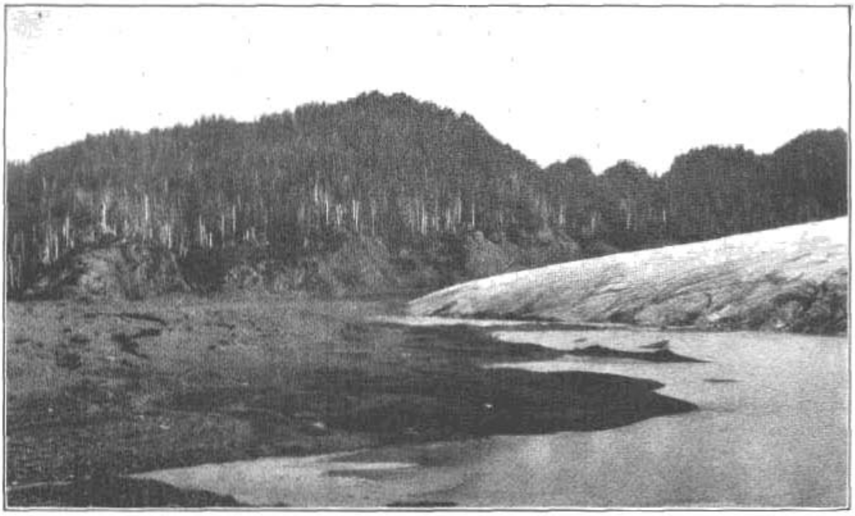
G 146. Central and western part of front of Yalik Glacier from point A, figure 17. August 7, 1909.

A. EAST PART OF FRONT OF YALIK GLACIER.

From point A, figure 17. August 7, 1909. Photograph G 145.

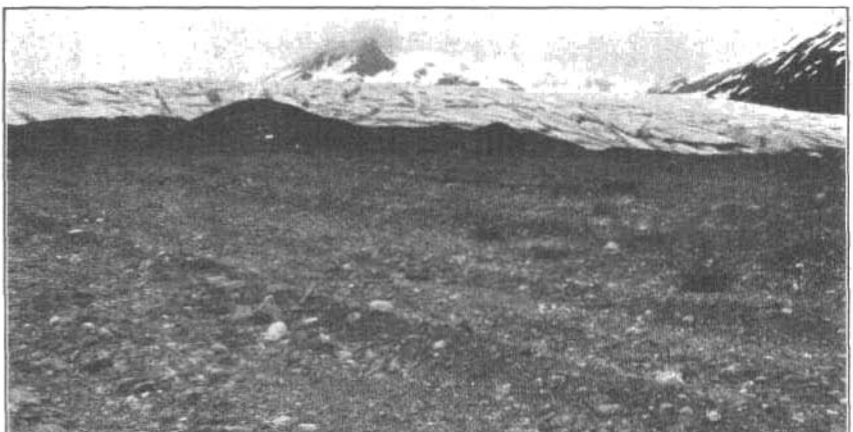
B. EAST PART OF FRONT OF PETROF GLACIER.

From point A, figure 18. August 8, 1909. Photograph G 238.



A. WEST PART OF FRONT OF PETROF GLACIER.

From point B, figure 18. August 8, 1909. Photograph G 240.



B. SMALL RIDGES IN FRONT OF PETROF GLACIER.

August 8, 1909. Photograph G 239.

G 147. Central and eastern part of front of Petrof Glacier from boat. August 9, 1909.

G 228. Here reproduced as Plate XXXVIII, *A*. West part of front of McCarty Glacier from point B, figure 13. July 30, 1909. Point B is a small gravelly knoll about 7 feet high; it is the nearest to the sea and highest grassy knoll on the glacial flat, and is about 600 feet north of the beach.

G 229. West side of McCarty Glacier from point C, figure 13. July 30, 1909. Point C is a small bare gravelly knoll at the edge of the bare zone and a few hundred feet south of a forested rock ridge.

G 230. McCarty Glacier from boat. July 31, 1909.

G 231. Split Glacier from point E, figure 15. August 2, 1909. Point E is the highest bare rock knob on the east side of the central ridge in front of this glacier. This point is marked by a cross cut in the bedrock and by a cairn. Point E is shown in Pl. XXXVIII, *B*.

G 232. Here reproduced as Plate XXIV, *B*. Split glacier from point F, figure 15. August 2, 1909. Point F is the northmost and highest point of a bare gravel ridge, from which point there is a rather steep descent east to a stream leading from the glacier.

G 233. Here reproduced as Plate XXXVIII, *B*. Split Glacier from point G, figure 15. August 2, 1909. Point G is marked by a cairn, and bearings from it are as follows: (1) N. 66° 30′ E. to a prominent fall, about 1,000 feet above the sea, east of the glacier; (2) N. 20° 30′ E. to the buff-colored cliff on which is point E; (3) N. 28° W. to the mountain shoulder (appearing as a sharp peak from point G), about 1,200 feet above sea level, above the west part of the front of the glacier.

G 234. Split Glacier from boat. August 3, 1909.

G 235. Yalik Glacier from boat. August 6, 1909.

G 236. Yalik Glacier from boat. August 6, 1909.

G 237. West part of front of Petrof Glacier from point A, figure 18. August 8, 1909. Point A is the top of a prominent gravel knoll on the east side of the valley, and bearings from it are as follows: (1) N. 46° E. to a brownish-pink rock lens near the east part of the front of the glacier; (2) N. 65° W. to the top of the prominent mountain which lies about a mile and a half west of the front of the glacier; (3) S. 39° W. to a large cleft in the north side, and two-thirds of the distance to the top, of the prominent mountain (Brown Mountain) near the coast and south of the glacial flat.

G 238. Here reproduced as Plate XXXIX, *B*. East part of front of Petrof Glacier from point A, figure 18. August 8, 1909.

G 239. Here reproduced as Plate XL, *B*. Small ridges in front of Petrof Glacier. August 8, 1909.

G 240. Here reproduced as Plate XL, *A*. West part of front of Petrof Glacier from point B, figure 18. August 8, 1909. From point B bearings are as follows: (1) S. 41° E. to the south end of the timber on the ridge southeast of the front of the glacier; (2) S. 29° W. to the cleft mentioned under G 237; (3) S. 38° W. to the middle and highest of the three sharp conical points on the west flank of Brown Mountain.

PORT DICK.

Port Dick, named by Portlock in 1786, is an embayment of considerable size just northwest of Point Gore. About a mile northwest of the head of the northern arm of Port Dick is a small glacier which terminated in 1909 about 1,000 feet above the sea. This is, as far as our knowledge goes, the most southern glacier on the Kenai Peninsula. About 3 miles north-northeast of the head of the above arm is another glacier, which also drains into Port Dick. Some of the maps [1] show a glacier (the Southern) coming close to sea level north

[1] Bull. U. S. Geol. Survey No. 277, 1906, Pl. 13. Chart U. S. Coast and Geod. Survey No. 8502, 1907.

of the end of the west arm of Port Dick and extending north to near the head of Tutka Bay of Kachemak Bay. There is no evidence of a glacier in the lower 4 miles of the valley which enters the end of the west arm of Port Dick from the north, and the stream in this valley, as well as the stream here entering Port Dick from the west, is clear and shows no evidence of glacial waters. Evidently the Southern Glacier, if such a glacier exists, lies entirely northwest of the divide between Port Dick and Tutka Bay and drains only into the latter bay.

KACHEMAK BAY.

On the southeastern side of Kachemak Bay of Cook Inlet are at least four glaciers, which approach but do not reach the sea. These are the most westerly glaciers of which we have knowledge on the Kenai Peninsula. From southwest to northeast these glaciers are the Southern, which drains into Tutka Bay, the Doroshin, the Wossnessenski, and the Grewingk. These glaciers, except the last, have not been studied and described, at least so far as we have been able to discover. The Grewingk was visited by W. H. Dall in 1880 and in 1892 and 1895.[1] The results of his mapping of this glacier were incorporated in charts of the United States Coast and Geodetic Survey. Dall again visited the Grewingk Glacier with Gilbert in 1899, and the latter has described this glacier in detail.[2] The writers have not seen the glaciers of Kachemak Bay.

SUMMARY.

Some of the glaciers here described—the Valdez, the Shoup, the Columbia, the glaciers of Port Wells, and the Bear—have been under observation at two or more times during a period of 10 years. There are practically no observations, however, fixing definitely the positions of the glacial fronts of the others earlier than 1908 or 1909, and for information regarding their retreat or advance recourse must be had to the relations of their fronts in 1908 or 1909 to the surroundings and especially to the forest growth which mantles most of the coast from sea level to an altitude of several hundred feet. Reference is here made to the slow-growing coniferous forest and not to deciduous alders and cottonwoods, which in some places, especially on sand and gravel areas, rapidly cover ground recently abandoned by glaciers or by glacial drainage. Much of this forest consists of a mature growth of large trees on a moss-and-soil zone of considerable thickness. Trees 100 years of age, and some probably much older, are thought to be abundant, and these are growing among fallen and decaying trunks

[1] Dall, W. H., Bull. Phil. Soc. of Washington, vol. 6, 1884, pp. 33-36; Bull. U. S. Geol. Survey No. 84, 1892; Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, p. 789.

[2] Gilbert, G. K., Alaska, vol. 3, Harriman Alaska Expedition, 1904, pp. 97-102.

of similar size. The time necessary for the development of such a mature forest is undoubtedly much longer than the age of the oldest living trees, and consequently there seems to be good reason to affirm that the present conditions of forest growth were present toward the end of the eighteenth century, when Cook and Vancouver visited this district. The expression "since the growth of the present forest," which is here used of necessity many times, refers, then, to an indefinite period, which can not be less than 100 years, and which in all probability is of several centuries duration.

The forest undoubtedly varies in age from place to place depending on environment. Our observations lead to the conclusion that on sand and gravel areas the deciduous forest is likely to be established first, and that this first forest is later replaced by the slower growing conifers; on areas underlain by till the evergreen forest is sometimes developed directly, and the earlier cycle of deciduous growth is entirely lacking. The growth of the coniferous forest and even that of the smaller herbaceous plants is a slower process than is sometimes thought, as can be determined from dated photographs showing conditions along the front of the Columbia Glacier. The location of the forest with reference to the open sea and its warm moist winds is also an important ecologic factor. The luxuriant forest in front of the Columbia, Bainbridge, and Northwestern glaciers may, therefore, be no older and may even be considerably younger than the sparse, small, and stunted forest toward the heads of such inlets as Unakwik Bay, Port Wells, and Icy Bay; indeed, at the extreme heads of some inlets conditions may be so unfavorable as to prohibit forest growth entirely.

The Valdez Glacier has fluctuated somewhat since 1900, but its front was in 1909 not far from its position at the earlier date. Sometime between 1905 and 1908 there was an advance of 300 feet or more followed by a retreat. Within a century the glacier has probably been considerably in advance of its present position.

The Shoup Glacier has remained nearly stationary during the last 10 years and is now near its maximum position of advance in the last 50 years.

The central part of the Columbia Glacier retreated about 360 feet between 1897 and 1905. In 1908 it advanced 100 feet and in 1909 the advance was continued into the forest, the ice front reaching by August 23, 1909, a point 120 feet in advance of its maximum of 1897. In 1909 the western side of the ice stream was farther in advance than at any time since the growth of the present forest. The maximum recorded on the eastern side of the glacier was perhaps 50 years ago. At some time since the establishment of present conditions the glacier front has been considerably farther back, perhaps a mile or more.

The Meares Glacier changed little between 1905 and 1909, during which period it was near its maximum advance since the growth of the present forest.

The Yale Glacier has shown little change since 1899, and is at present about as far advanced as it has been within the last 50 years, but before this period it was much further advanced than now.

The Harvard Glacier showed little change between 1899 and 1905, but in 1909 had advanced half a mile. This and the other glaciers of College Fiord have probably been much larger within a century.

The Smith Glacier has advanced about 600 feet since 1899, and this advance probably was made since 1905.

The Bryn Mawr Glacier in 1905 was in approximately the same position as in 1899. In 1909 it had advanced about 500 feet.

The Vassar Glacier has probably had the same history since 1899 as the Bryn Mawr, its advance since 1905 being about 500 feet.

The Wellesley Glacier was apparently as far advanced in 1909 as at any time within the five previous years, but was probably more advanced some 15 years ago.

The Barry Glacier shows more retreat in the last 10 years than any other ice stream here described. Its maximum advance since the growth of the present forest was reached perhaps 25 years ago. From 1899 to 1905 this glacier retreated 1.2 miles; from 1905 to 1908, 0.4 mile; from 1908 to 1909, 0.5 mile. This is a total retreat of 2.1 miles in the last 10 years.

The Serpentine Glacier reached its maximum since the growth of the present forest a few years before 1899. In 1905 its position was approximately the same as in 1899, but in 1909 the ice front had retreated a quarter of a mile and was half a mile farther back than the maximum position before 1899.

The Baker Glacier shows a small retreat between 1899 and 1905, but in 1909 the ice was probably farther advanced than four years earlier.

The Surprise Glacier retreated 0.1 mile in recent years before 1899. This retreat was probably continued in 1905, and in 1909 the glacier was 1.1 miles farther back than its maximum in recent years.

The Cataract Glacier has probably varied little in the last 10 years and has not been much in advance of its present position in the last 25 years.

The Harriman Glacier retreated on its eastern side about 700 feet between 1899 and 1909, half of this retreat taking place before 1905. The western side of the glacier has changed little since 1899.

The Dirty Glacier was a little more advanced in 1905 than in 1909.

The Toboggan Glacier retreated 723 feet between 1905 and 1909, but at some period between these dates it was farther advanced than in 1905. This glacier has recently reached its maximum advance since the growth of the present forest.

The glaciers of Harriman Fiord have probably not, within the last century or two, been very much in advance of the maxima recorded on page 70.

The Tebenkof Glacier has retreated a short distance in the last 10 or 15 years.

The Blackstone Glacier has retreated about 3 miles within the last 200 years or more.

The Ultramarine Glacier shows some retreat in the last few years.

The Nellie Juan Glacier has in the last 20 years or more retreated 500 feet from its maximum advance since the growth of the present forest.

The Falling Glacier has retreated some in the last few years.

The Taylor Glacier has retreated about a quarter of a mile in the last few years.

The Princeton and Chenega glaciers were in about the same position in 1909 as in 1908. At some previous time, within 100 years, these glaciers filled Nassau Fiord out to Icy Bay, being then about 2 miles in advance of their present positions.

The Tiger Glacier advanced probably 100 feet between the summers of 1908 and 1909.

The Bainbridge Glacier in 1908 was close to its maximum since the growth of the present forest.

The Puget Glacier has retreated in recent years; before the retreat began it was at its maximum advance since the growth of the present forest.

The Excelsior and Ellsworth glaciers have also retreated in recent years.

The Bear Glacier was essentially in the same position in 1909 as in 1905, but perhaps 25 years ago it reached its maximum advance since the growth of the present forest, bringing it about a quarter of a mile in front of its present position. At some date within 25 years the glacier was considerably farther back than it is at present.

The Aialik Glacier is now about a quarter of a mile farther back than it was some 10 years ago, when it reached its maximum within recent times.

The Pederson Glacier some 15 years ago was about a third of a mile in advance of its present position. At that date it reached its maximum since the growth of the present forest.

The Holgate Glacier has within recent years been about a mile in advance of its present position.

The Northwestern Glacier some 10 or 15 years ago was about a quarter of a mile in front of its present position. That advanced position is the maximum since the growth of the present forest.

The McCarty Glacier has retreated about a quarter of a mile within the last 50 years or less; at some time during that period it occupied its most advanced position since the growth of the present forest.

The Split Glacier is now about a quarter of a mile farther back than its maximum position since the growth of the present forest.

The Yalik and Petrof glaciers have also retreated from their maximum positions since the growth of the present forest.

The Barry, Surprise, Chenega, Princeton, and Holgate glaciers have shown a considerable retreat within recent years; the amount of this retreat ranges from a mile to more than 2 miles. The retreat of the Barry and Surprise glaciers has taken place mainly within the last 10 years. The retreat of the others has covered a longer period—that of some perhaps 50 or more years. The Columbia and Bainbridge glaciers have advanced recently to their maximum positions since the growth of the present forest, and the Harvard Glacier and the glaciers on the west side of College Fiord have advanced in the last 10 years, the main advance taking place since 1905. Some of the glaciers have shown alternate retreat and advance since they have been under observation, and very probably many others would show similar fluctuations were there sufficient data to reveal them. These fluctuations take place, not only in different glaciers but also in different parts of the same glacier. Retreats are easily recognized, but advances, unless there are accurate records of previous positions, are difficult to measure and sometimes to detect; thus some of the glaciers that are now in a position somewhat back of their maxima since the growth of the present forest may still be much in advance of their position a few years ago.

The history of the glaciation of the district under discussion includes the formation of an extensive Pleistocene ice sheet, which extended to the sea and reached upward on the mountains to altitudes which decrease toward the main coast line where the glaciation extended about 2,000 feet above present sea level. Since this period of maximum glaciation there has been a marked decrease in the extent of the ice-covered areas, until now only valley glaciers reach the sea. This withdrawal of the ice was probably punctuated by temporary advances and the present is only an epoch in the long history since the maximum Pleistocene glaciation. Earth movements have also played a part, as yet little known, in this history; changes on Prince William Sound are still taking place,[1] and since the maximum period of glaciation there has been a considerable sinking of the coast line in much of the area and between Resurrection and Nuka bays there are numerous drowned cirques. (See Pl. II, in pocket.) On the whole, the glaciers here studied do not give uniform evidence as to a general retreat or a general advance within the last half century; some are evidently in a period of retreat and others in a period of advance, and the general balance between retreat and advance can not be accurately determined by data now at hand.

[1] Grant, U. S., and Higgins, D. F., Reconnaissance of the geology and mineral resources of Prince William Sound, Alaska: Bull. U. S. Geol. Survey No. 443, 1910, p. 17.

INDEX.

A. — Page.

Aialik Bay, description of 57-58
map of 58
Aialik Glacier, description of 58
fluctuation of 58, 71
photographs of, list of 60
plates showing 57, 58
Amherst Glacier, position of 25
Applegate, S., map by 45

B.

Bainbridge Glacier, description of 50-51, 71, 72
map of front part of 51
photographs of, list of 52
plates showing 50, 51
Baker Glacier, description of 35-36
fluctuation of 36, 70
photographs of, list of 39-40
plate showing 36
Baltimore Glacier, figure showing 28
position of 27
Barry Glacier, fluctuation of 34-35, 70, 72
photographs of, list of 38-39
plates showing 34, 35
Bear Glacier, description of 56-57
fluctuation of 57, 71
map of front part of 56
photographs of, list of 57
plates showing 56, 57
Bettles Glacier, source of 27
Billings Glacier, course of 40
source of 27
Blackstone Bay, description of 41-42
map of 43
Blackstone Glacier, description of 43-44
map showing 43
retreat of 44, 71
Brilliant Glacier, position of 25
Brooks, A. H., reference to 9
Bryn Mawr Glacier, description of 31
figure showing 28
fluctuation of 31, 70
photographs of, list of 32-33
plates showing 30, 31

C.

Cantwell, G. G., photographs of glaciers by .. 11
Canyon Creek Glacier. *See* Shoup Glacier.
Carlin, W. E., photographs of glaciers by 11, 49
Cascade Glacier, position of 35
Cataract Glacier, description of 36-37, 70
plate showing 37
Chenega Glacier, description of 49, 71, 72
photographs of, list of 50
plates showing 48, 49

Page.

College Fiord, glaciers surrounding 27
map of northern part of 28
plate showing 31
Columbia Bay, map of 18
Columbia Glacier, edge of, plates showing ... 18, 19
fluctuation of 18-23, 68, 69, 72
front of, plates showing 18, 22, 23
front part of, map of 18
invasion of forest by, plate showing 20
photographs of, list of 23-24
push moraine at front of, plate showing .. 20
Cook, James, exploration by 8
map by 9
Crescent Glacier, position of 25
Curtis, E. S., photographs of glaciers by 10

D.

Dall, W. H., exploration by 8
reference to 68
Davidson, George, list of glaciers by 9, 18
reference to 41, 52, 58, 59, 60, 61
Day Harbor, sketch map showing 53
Delta, formation of, at Valdez 12
Dirty Glacier, description of 37-38, 70
photographs of, list of 39-40
Doroshin Glacier, position of 68

E.

Earthquake, effects of, at Valdez 12
Ellsworth Glacier, description of 53-54
sketch map showing 53
photographs of, list of 54
plate showing 56
retreat of 54, 71
Excelsior Glacier, description of 53
photographs of, list of 54
retreat of 53, 71

F.

Falling Glacier, description of 46
retreat of 46, 71
Field work 7
Fluctuations of glaciers, summary of 68-72
Forest, growth of 68-69
Freemantle Glacier. *See* Columbia Glacier.

G.

Gannett, Henry, reference to 34, 36, 37
Gilbert, G. K., descriptions of glaciers by 8-9, 18, 19, 22, 30, 37
on the Yale Glacier 28
photographs of glaciers by 10
reference to 27, 31, 33, 68

Page.

Godwin Glacier, description of............... 55
Grewingk Glacier, position of................ 68

H.

Harriman Fiord, description of............... 33-34
map of.................................. 34
plate showing........................... 34
Harriman Glacier, description of............. 37
photographs of, list of..................... 39-40
plate showing............................... 37
retreat of.................................. 37, 70
Harvard Glacier, description of.............. 29-30
figure showing.............................. 28
fluctuation of........................... 30, 70, 72
front of, plates showing.................... 30
photographs of, list of..................... 32-33
Holgate Glacier, description of.............. 59-60
photographs of, list of..................... 60
plate showing............................... 59
retreat of............................... 59, 71, 72
Hunt, P. S., photographs of glaciers by...... 11

I.

Icy Bay, description of...................... 47-49
map of...................................... 48

K.

Kachemak Bay, glaciers near.................. 68
Kenai Peninsula, southern part of, reconnaissance map of.................In pocket
Kings Bay. *See* Port Nellie Juan.

L.

Lowe River, plate showing.................... 12

M.

McCarty Glacier, cross section of west side of, figure showing.................... 63
description of.............................. 62-64
fluctuation of.............................. 64, 71
map of front part of........................ 63
photographs of, list of..................... 66-67
plates showing.............................. 62, 63
Maps showing glaciers, references to......... 8, 9
preparation of.............................. 9-10
Martin, Lawrence, reference to............... 9, 18
photographs of glaciers by.................. 11
Meares Glacier, description of............... 25-26
fluctuation of.............................. 26, 70
map showing................................ 26
photographs of, list of..................... 26
plate showing............................... 23
Mendenhall, W. C., exploration by............ 8
on the glaciers of Portage Bay.............. 40-41
photographs of glaciers by.................. 10
reference to................................ 27
Merriam, C. H., photographs of glaciers by... 10
Mount Emerson, position of................... 27
Mount Gilbert, position of................... 33
Mount Muir, position of...................... 33

N.

Nellie Juan Glacier, description of.......... 46
photographs of, list of..................... 47
retreat of.................................. 46, 71
plates showing.............................. 46

Page.

Northwestern Glacier, description of......... 60-61
photographs of, list of..................... 61
plates showing.............................. 59, 60
retreat of.................................. 61, 71
sketch map of front part of................. 61
Nuka Bay, glaciers near...................... 62

P.

Paige, Sidney, field work by................. 7
photographs of glaciers by.................. 10
Passage Canal, glaciers near................. 40
Pederson Glacier, description of............. 58-59
fluctuation of.............................. 59, 71
photographs of, list of..................... 60
plate showing............................... 58
Pedro Glacier, position of................... 25
Perkins, G. W., party of................. 11, 48, 49
Petrof Glacier, description of............... 66
map of front part of........................ 66
photographs of, list of..................... 67
plates showing.............................. 66, 67
retreat of.................................. 66, 72
Photographs of glaciers, sources of.......... 10-11
Pigot Glacier, source of..................... 27
Porcupine Bay. *See* Thumb Cove.
Porcupine Glacier, description of............ 55
sketch map showing.......................... 55
Portage Bay, glaciers near................... 40-41
Portage Glacier, description of.............. 40-41
Port Dick, glaciers near..................... 67-68
Port Nellie Juan, description of............. 45
map of...................................... 46
Port Valdez, description of.................. 11-12
glaciers on................................. 12
Port Wells, description of................... 26-27
Prince William Sound, reconnaissance map of.......................... In pocket.
Princeton Glacier, description of........ 49, 71, 72
photographs of, list of..................... 50
plate showing............................... 48
Prospect Glacier, description of............. 55
sketch map showing.......................... 55
Puget Glacier, description of................ 52-53
map showing................................ 53
plate showing............................... 51
retreat of.................................. 71

R.

Radcliffe Glacier, figure showing............ 28
relation of, to Harvard Glacier.............. 30
Rainy Glacier, map showing................... 43
Ranney Glacier, position of.................. 25
Reid, H. F., on fluctuations of the Valdez Glacier.......................... 14
reference to................................ 9
Resurrection Bay, glaciers near.............. 54

S.

Sargent, R. H., reference to................. 58
Schrader, F. C., exploration by.............. 8, 13
photographs of glaciers by.................. 10
Serpentine Glacier, fluctuation of........... 35, 70
photographs of, list of..................... 39-40
Seth Glacier, course of...................... 40
Shoup Bay, map of............................ 16

Page.
Shoup Glacier, description of................ 15
fluctuation of...................... 15-17, 68, 69
front of, plates showing.................. 16
map showing.......................... 16
photographs of, list of.................. 17-18
Smith Glacier, description of................ 30-31
figure showing......................... 28
fluctuation of.......................... 31, 70
Southern Glacier, position of................ 67-68
Spencer, A. C., photographs of glaciers by... 10
Split Glacier, cross section of front edge of, figure showing.................. 65
description of.......................... 64-65
fluctuation of...................... 64-65, 72
map of north part of..................... 64
photographs of, list of.................. 67
plates showing......................... 42, 63
Spoon Glacier, description of................ 55
sketch map showing..................... 55
Surprise Glacier, description of.............. 36
fluctuation of...................... 36, 70, 72
photographs of, list of.................. 39-40
plate showing.......................... 36

T.

Tarr, R. S., reference to...................... 9, 18
photographs of glaciers by............... 11
Taylor Glacier, description of................ 46, 47
photographs of, list of.................. 47
retreat of.............................. 47, 71
Tebenkof, M. D., maps by.................. 9
reference to............................ 52
See also Davidson, George.
Tebenkof Glacier, description of............ 42
fluctuation of.......................... 42, 71
map showing.......................... 43
photographs of, list of.................. 44
plates showing......................... 38, 42
Thumb Cove, glaciers near.................. 54-55
glaciers near, photographs of, list of...... 57
sketch map showing..................... 55
Tiger Glacier, advance of.................... 50, 71
description of.......................... 50
photographs of, list of.................. 50
plate showing.......................... 48
Tigertail Glacier, map showing.............. 48
Toboggan Glacier, description of............ 38
fluctuation of.......................... 38, 70
Toboggan Glacier, photographs of, list of.... 39
plate showing.......................... 38
Travel, routes of, over glaciers............... 12-13
Two Arm Bay, glaciers near.................. 61-62

U.

Ultramarine Glacier, description of.......... 45-46
photographs of, list of.................. 47
retreat of.............................. 47, 71
Unakwik Inlet, description of................ 25
map showing.......................... 26
photographs of, list of.................. 26
Unakwik Peak, position of.................. 25

V.

Valdez, earthquake at........................ 12
vicinity of, map of...................... 11
Valdez Glacier, delta of, plate showing....... 12
description of.......................... 12-13
fluctuations of..................... 13-14, 68, 69
front of, plates showing.................. 13
photographs of, list of.................. 14-15
southwest view of, plate showing......... 12
Vancouver, George, exploration by.......... 8
maps by............................... 9
quoted................................ 47
Vassar Glacier, description of................ 31-32
figure showing......................... 28
fluctuation of.......................... 32, 70

W.

Washington Glacier. *See* Barry Glacier.
Wedge Glacier, trees near.................. 37
Wellesley Glacier, description of............ 32
fluctuation of.......................... 32, 70
Wossnessenski Glacier, position of.......... 68

Y.

Yale Glacier, description of.................. 27-29
figure showing......................... 28
fluctuation of.......................... 29, 70
front of, plates showing.................. 28
photographs of, list of.................. 32
Yalik Glacier, description of................ 65
map of front part of..................... 65
photographs of, list of.................. 66-67
plate showing.......................... 66
retreat of.............................. 65, 72

RECENT SURVEY PUBLICATIONS ON ALASKA.

[Arranged geographically. A complete list can be had on application.]

All these publications can be obtained or consulted in the following ways:

1. A limited number are delivered to the Director of the Survey, from whom they can be obtained free of charge (except certain maps) on application.

2. A certain number are delivered to Senators and Representatives in Congress for distribution.

3. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they can be had at prices slightly above cost. The publications marked with an asterisk (*) in this list are out of stock at the Survey but can be purchased from the Superintendent of Documents at the prices stated.

4. Copies of all Government publications are furnished to the principal public libraries throughout the United States, where they can be consulted by those interested.

GENERAL.

*The geography and geology of Alaska, a summary of existing knowledge, by A. H. Brooks, with a section on climate, by Cleveland Abbe, jr., and a topographic map and description thereof, by R. U. Goode. Professional Paper 45, 1906, 327 pp. $1.

*Placer mining in Alaska in 1904, by A. H. Brooks. In Bulletin 259, 1905, pp. 18–31. 15 cents.

The mining industry in 1905, by A. H. Brooks. In Bulletin 284, 1906, pp. 4–9.

The mining industry in 1906, by A. H. Brooks. In Bulletin 314, 1907, pp. 19–39.

*The mining industry in 1907, by A. H. Brooks. In Bulletin 345, 1908, pp. 30–53. 45 cents.

*The mining industry in 1908, by A. H. Brooks. In Bulletin 379, 1909, pp. 21–62. 50 cents.

The mining industry in 1909, by A. H. Brooks. In Bulletin 442, 1910, pp. 20–46.

The mining industry in 1910, by A. H. Brooks. In Bulletin 480, 1911, pp. 21–42.

*The mining industry in 1911, by A. H. Brooks. In Bulletin 520, 1912, pp. 19–44. 50 cents.

Railway routes, by A. H. Brooks. In Bulletin 284, 1906, pp. 10–17.

*Railway routes from the Pacific seaboard to Fairbanks, Alaska, by A. H. Brooks. In Bulletin 520, 1912, pp. 45–88. 50 cents.

Geologic features of Alaskan metalliferous lodes, by A. H. Brooks. In Bulletin 480, 1911, pp. 43–93.

*Tin resources of Alaska, by Frank L. Hess. In Bulletin 520, 1912, pp. 89–92. 50 cents.

*Administrative report, by A. H. Brooks. In Bulletin 259, 1905, pp. 13–17. 15 cents.

Administrative report, by A. H. Brooks. In Bulletin 284, 1906, pp. 1–3.

Administrative report, by A. H. Brooks. In Bulletin 314, 1907, pp. 11–18.

*Administrative report, by A. H. Brooks. In Bulletin 345, 1908, pp. 5–17. 45 cents.

*Administrative report, by A. H. Brooks. In Bulletin 379, 1909, pp. 5–20. 50 cents.

Administrative report, by A. H. Brooks. In Bulletin 442, 1910, pp. 5–19.

Administrative report, by A. H. Brooks. In Bulletin 480, 1911, pp. 5–14.

*Adminstrative report, by A. H. Brooks. In Bulletin 520, 1912, pp. 7–18. 50 cents.

Report on progress of public land surveys during 1910, by A. H. Brooks. In Bulletin 480, 1911, pp. 15–20.

*Notes on the petroleum fields of Alaska, by G. C. Martin. In Bulletin 259, 1905, pp. 128–139. 15 cents.

The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin 250, 1905, 64 pp.

Markets for Alaska coal, by G. C. Martin. In Bulletin 284, 1906, pp. 18–29.

The Alaska coal fields, by G. C. Martin. In Bulletin 314, 1907, pp. 40–46.

Alaska coal and its utilization, by A. H. Brooks. In Bulletin 442, 1910, pp. 47–100.

*The possible use of peat fuel in Alaska, by C. A. Davis. In Bulletin 379, 1909, pp. 63–66. 50 cents.

The preparation and use of peat as a fuel, by C. A. Davis. In Bulletin 442, 1910, pp. 101–132.

*The distribution of mineral resources in Alaska, by A. H. Brooks. In Bulletin 345, pp. 18–29. 45 cents.

Mineral resources of Alaska, by A. H. Brooks. In Bulletin 394, 1909, pp. 172–207.

*Methods and costs of gravel and placer mining in Alaska, by C. W. Purington. Bulletin 263, 1905, 362 pp. 35 cents. Abstract in *Bulletin 259, 1905, pp. 32–46. 15 cents.

*Prospecting and mining gold placers in Alaska, by J. P. Hutchins. In Bulletin 345, 1908, pp. 54–77. 45 cents.

*Geographic dictionary of Alaska, by Marcus Baker; second edition by James McCormick. Bulletin 299, 1906, 690 pp. 50 cents.

*Water-supply investigations in Alaska in 1906–7, by F. F. Henshaw and C. C. Covert. Water-Supply Paper 218, 1908, 156 pp. 25 cents.

Maps.

*Alaska, topographic map of; scale 1:2,500,000; preliminary edition, by R. U. Goode. Contained in Professional Paper 45. $1. Not published separately.

*Map of Alaska showing distribution of mineral resources; scale, 1:5,000,000; by A. H. Brooks. Contained in Bulletin 345. 45 cents.

Map of Alaska; scale, 1:5,000,000; by Alfred H. Brooks.

Map of Alaska showing distribution of metalliferous deposits, by A. H. Brooks. Contained in Bulletin 480. Not issued separately.

Map showing distribution of mineral resources in Alaska, by A. H. Brooks; scale, 1:5,000,000. Price 20 cents. Also included in *Bulletin 520. 50 cents.

SOUTHEASTERN ALASKA.

*Preliminary report on the Ketchikan mining district, Alaska, with an introductory sketch of the geology of southeastern Alaska, by Alfred H. Brooks. Professional Paper 1, 1902, 120 pp. 25 cents.

*The Porcupine placer district, Alaska, by C. W. Wright. Bulletin 236, 1904, 35 pp. 15 cents.

*The Treadwell ore deposits, by A. C. Spencer. In Bulletin 259, 1905, pp. 69–87. 15 cents.

*Economic developments in southeastern Alaska, by F. E. and C. W. Wright. In Bulletin 259, 1905, pp. 47–68. 15 cents.

*The Juneau gold belt, Alaska, by A. C. Spencer, pp. 1–137, and A reconnaissance of Admiralty Island, Alaska, by C. W. Wright, pp. 138–154. Bulletin 287, 1906, 161 pp. 75 cents.

Lode mining in southeastern Alaska, by F. E. and C. W. Wright. In Bulletin 284, 1906, pp. 30–53.

Nonmetallic deposits of southeastern Alaska, by C. W. Wright. In Bulletin 284, 1906, pp. 54–60.

The Yakutat Bay region, by R. S. Tarr. In Bulletin 284, 1906, pp. 61–64.

Lode mining in southeastern Alaska, by C. W. Wright. In Bulletin 314, 1907, pp. 47–72.

Nonmetalliferous mineral resources of southeastern Alaska, by C. W. Wright. In Bulletin 314, 1907, pp. 73–81.

Reconnaissance on the Pacific coast from Yakutat to Alsek River, by Eliot Blackwelder. In Bulletin 314, 1907, pp. 82–88.

*Lode mining in southeastern Alaska in 1907, by C. W. Wright. In Bulletin 345, 1908, pp. 78–97. 45 cents.

*The building stones and materials of southeastern Alaska, by C. W. Wright. In Bulletin 345, 1908, pp. 116–126. 45 cents.

*Copper deposits on Kasaan Peninsula, Prince of Wales Island, by C. W. Wright and Sidney Paige. In Bulletin 345, 1908, pp. 98–115. 45 cents.

The Ketchikan and Wrangell mining districts, Alaska, by F. E. and C. W. Wright. Bulletin 347, 1908, 210 pp.

*The Yakutat Bay region, Alaska: Physiography and glacial geology, by R. S. Tarr; Areal geology, by R. S. Tarr and B. S. Butler. Professional Paper 64, 1909, 186 pp. 50 cents.

*Mining in southeastern Alaska, by C. W. Wright. In Bulletin 379, 1909, pp. 67–86. 50 cents.

Mining in southeastern Alaska, by Adolph Knopf. In Bulletin 442, 1910, pp. 133–143.

The occurrence of iron ore near Haines, by Adolph Knopf. In Bulletin 442, 1910, pp. 144–146.
A water-power reconnaissance in southeastern Alaska, by J. C. Hoyt. In Bulletin 442, 1910, pp. 147–157.
Geology and mineral resources of the Berners Bay region, Alaska, by Adolph Knopf. Bulletin 446, 1911, 58 pp.
Mining in southeastern Alaska, by Adolph Knopf. In Bulletin 480, 1911, pp. 94–102.
The Eagle River region, by Adolph Knopf. In Bulletin 480, 1911, pp. 103–111.
The Eagle River region, southeastern Alaska, by Adolph Knopf, including detailed geologic and topographic maps. Bulletin 502, 1912, 61 pp.
The Sitka mining district, Alaska, by Adolph Knopf. Bulletin 504, 1912, 32 pp.
The earthquakes at Yakutat Bay, Alaska, in September, 1899, by R. S. Tarr and Lawrence Martin. Professional Paper 69, 1912, 135 pp.

Topographic maps.

Juneau special map; scale, 1: 62,500; by W. J. Peters. For sale at 10 cents each or $3 for 50.
Berners Bay special map; scale, 1 : 62,500; by R. B. Oliver. For sale at 10 cents each or $3 for 50.
Topographic map of the Juneau gold belt, Alaska. Contained in *Bulletin 287, Plate XXXVI, 1906. 75 cents. Not issued separately.
Kasaan Peninsula, Prince of Wales Island. No. 520–A; scale, 1 : 62,500; by R. H. Sargent, D. C. Witherspoon, and J. W. Bagley. For sale at 10 cents each or $3 for 50.
Copper Mountain and vicinity, Prince of Wales Island, scale, 1: 62,500; by R. H. Sargent. For sale at 10 cents each or $3 for 50.

CONTROLLER BAY, PRINCE WILLIAM SOUND, AND COPPER RIVER REGIONS.

*The mineral resources of the Mount Wrangell district, Alaska, by W. C. Mendenhall. Professional Paper 15, 1903, 71 pp. Contains map of Prince William Sound and Copper River region; scale, 12 miles=1 inch. 30 cents.
*Bering River coal field, by G. C. Martin. In Bulletin 259, 1905, pp. 140–150. 15 cents.
*Cape Yaktag placers, by G. C. Martin In Bulletin 259, 1905, pp. 88–89. 15 cents.
*Notes on the petroleum fields of Alaska, by G. C. Martin. In Bulletin 259, 1905, pp. 128–139. 15 cents. (Abstract from Bulletin 250.)
The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin 250, 1905, 64 pp.
Geology of the central Copper River region, Alaska, by W. C. Mendenhall. Professional Paper 41, 1905, 133 pp.
Copper and other mineral resources of Prince William Sound, by U. S. Grant. In Bulletin 284, 1906, pp. 78–87.
Distribution and character of the Bering River coal, by G. C. Martin. In Bulletin 284, 1906, pp. 65–76.
Petroleum at Controller Bay, by G. C. Martin. In Bulletin 314, 1907, pp. 89–103.
Geology and mineral resources of Controller Bay region, by G. C. Martin. Bulletin 335, 1908, 141 pp.
*Notes on copper prospects of Prince William Sound, by F. H. Moffit. In Bulletin 345, 1908, pp. 176–178. 45 cents.
*Mineral resources of the Kotsina and Chitina valleys, Copper River region, by F. H. Moffit and A. G. Maddren. In Bulletin 345, 1908, pp. 127–175. 45 cents.
Mineral resources of the Kotsina-Chitina region, by F. H. Moffit and A. G. Maddren. Bulletin 374, 1909, 103 pp.
*Copper mining and prospecting on Prince William Sound, by U. S. Grant and D. F. Higgins, jr. In Bulletin 379, 1909, pp. 87–96. 50 cents.
*Gold on Prince William Sound, by U. S. Grant. In Bulletin 379, 1909, p. 97. 50 cents.
*Mining in the Kotsina-Chitina, Chistochina, and Valdez Creek regions, by F. H. Moffit. In Bulletin 379, 1909, pp. 153–160. 50 cents.
*Mineral resources of the Nabesna-White River district, by F. H. Moffit and Adolph Knopf. In Bulletin 379, 1909, pp. 161–180. 50 cents.
Mineral resources of the Nabesna-White River district, by F. H. Moffit and Adolph Knopf; with a section on the Quaternary, by S. R. Capps. Bulletin 417, 1910, 64 pp.
Mining in the Chitina district, by F. H. Moffit. In Bulletin 442, 1910, pp. 158–163.
Mining and prospecting on Prince William Sound, by U. S. Grant. In Bulletin 442. 1910, pp. 164–165.

Reconnaissance of the geology and mineral resources of Prince William Sound, Alaska, by U. S. Grant and D. F. Higgins. Bulletin 443, 1910, 89 pp.
Geology and mineral resources of the Nizina district, Alaska, by F. H. Moffit and S. R. Capps. Bulletin 448, 1911, 111 pp.
Headwater regions of Gulkana and Susitna rivers, Alaska, with accounts of the Valdez Creek and Chistochina placer districts, by F. H. Moffit; including geologic and topographic reconnaissance maps. Bulletin 498, 1912, 82 pp.
The upper Susitna and Chistochina districts, by F. H. Moffit. In Bulletin 480, 1911, p. 127.
*The Taral and Bremner districts, by F. H. Moffit. In Bulletin 520, 1912, pp. 93–104. 50 cents.
*The Chitina district, by F. H. Moffit. In Bulletin 520, 1912, pp. 105–107. 50 cents.
*Gold deposits near Valdez, by A. H. Brooks. In Bulletin 520, 1912, pp. 108–130. 50 cents.
Coastal glaciers of Prince William Sound and Kenai Peninsula, Alaska, by U. S. Grant and D. F. Higgins. Bulletin 526, 1913, 84 pp.
The Hanagita-Bremner region, Alaska, by F. H. Moffit. Bulletin —. (In preparation.)

Topographic maps.

Copper and upper Chistochina rivers; scale, 1:250,000; by T. G. Gerdine. Contained in Professional Paper 41. Not issued separately.
Copper, Nabesna, and Chisana rivers, headwaters of; scale, 1:250,000; by D. C. Witherspoon. Contained in Professional Paper 41. Not issued separately.
Controller Bay region; No. 601 A; scale, 1:62,500; by E. G. Hamilton. Price 35 cents a copy or $21 per hundred.
Headwater regions of Gulkana and Susitna rivers; scale, 1:250,000; by D. C. Witherspoon and C. E. Giffin. Contained in Bulletin 498. Not published separately.

COOK INLET AND SUSITNA REGION.

The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin 250, 1905, 64 pp.
*Coal resources of southwestern Alaska, by R. W. Stone. In Bulletin 259, 1905, pp. 151–171. 15 cents.
*Gold placers of Turnagain Arm, Cook Inlet, by F. H. Moffit. In Bulletin 259, 1905, pp. 90–99. 15 cents.
*Mineral resources of the Kenai Peninsula: Gold fields of the Turnagain Arm region, by F. H. Moffit, pp. 1–52; Coal fields of the Kachemak Bay region, by R. W. Stone, pp. 53–73. Bulletin 277, 1906, 80 pp. 25 cents.
Preliminary statement on the Matanuska coal field, by G. C. Martin. In Bulletin 284, 1906, pp. 88–100.
*A reconnaissance of the Matanuska coal field, Alaska, in 1905, by G. C. Martin. Bulletin 289, 1906, 36 pp.
Reconnaissance in the Matanuska and Talkeetna basins, by Sidney Paige and Adolph Knopf. In Bulletin 314, 1907, pp. 104–125.
Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska, by Sidney Paige and Adolph Knopf. Bulletin 327, 1907, 71 pp.
*Notes on geology and mineral prospects in the vicinity of Seward, Kenai Peninsula, by U. S. Grant. In Bulletin 379, 1909, pp. 98–107. 50 cents.
Preliminary report on the mineral resources of the southern part of Kenai Peninsula, by U. S. Grant and D. F. Higgins. In Bulletin 442, 1910, pp. 166–178.
Outline of the geology and mineral resources of the Iliamna and Clark lakes region, by G. C. Martin and F. J. Katz. In Bulletin 442, 1910, pp. 179–200.
Gold placers of the Mulchatna, by F. J. Katz. In Bulletin 442, 1910, pp. 201–202.
The Mount McKinley region, by A. H. Brooks, with descriptions of the igneous rocks and of the Bonnifield and Kantishna districts, by L. M. Prindle. Professional Paper 70, 1911, 234 pp.
A geologic reconnaissance of the Iliamna region, Alaska, by G. C. Martin and F. J. Katz. Bulletin 485, 1912, 138 pp.
Geology and coal fields of the lower Matanuska Valley, Alaska, by G. C. Martin and F. J. Katz; including detailed geologic and topographic maps. Bulletin 500, 1912, 98 pp.
*Gold deposits of the Seward-Sunrise region, Kenai Peninsula, by B. L. Johnson. In Bulletin 520, 1912, pp. 131–173. 50 cents.

*Gold placers of the Yentna district, by S. R. Capps. In Bulletin 520, 1912, pp. 174–200. 50 cents.

The Yentna district, Alaska, by S. R. Capps. Bulletin 534, 1913, 75 pp.

Preliminary report on a detailed survey of part of the Matanuska coal fields, by G. C. Martin. In Bulletin 480, 1911, p. 135.

A reconnaissance of the Willow Creek gold region, by F. J. Katz. In Bulletin 480, 1911, p. 152.

Topographic maps.

*Kenai Peninsula, northern portion; scale, 1:250,000; by E. G. Hamilton. Contained in Bulletin 277. 25 cents. Not published separately.

Reconnaissance map of Matanuska and Talkeetna region; scale, 1:250,000; by T. G. Gerdine and R. H. Sargent. Contained in Bulletin 327. Not published separately.

Mount McKinley region; scale, 1:625,000; by D. L. Reaburn. Contained in Professional Paper 70. Not published separately.

Lower Matanuska Valley; scale, 1:62,500; by R. H. Sargent. Contained in Bulletin 500. Not published separately.

SOUTHWESTERN ALASKA.

*Gold mine on Unalaska Island, by A. J. Collier. In Bulletin 259, 1905, pp. 102–103. 15 cents.

*Gold deposits of the Shumagin Islands, by G. C. Martin. In Bulletin 259, 1905. pp. 100–101. 15 cents.

*Notes on the petroleum fields of Alaska, by G. C. Martin. In Bulletin 259, 1905, pp. 128–139. 15 cents. (Abstract from Bulletin 250.)

The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin 250, 1905, 64 pp.

*Coal resources of southwestern Alaska, by R. W. Stone. In Bulletin 259, 1905, pp. 151–171. 15 cents.

The Herendeen Bay coal fields, by Sidney Paige. In Bulletin 284, 1906, pp. 101–108.

*Mineral resources of southwestern Alaska, by W. W. Atwood. In Bulletin 379, 1909, pp. 108–152. 50 cents.

Geology and mineral resources of parts of Alaska Peninsula, by W. W. Atwood. Bulletin 467.

Outline of the geology and mineral resources of the Iliamna and Clark Lake region, by G. C. Martin and F. J. Katz. In Bulletin 442, 1910, pp. 179–200.

A geologic reconnaissance of the Iliamna region, Alaska, by G. C. Martin and F. J. Katz; including geologic and topographic reconnaissance maps. Bulletin 485, 1912, 138 pp.

Topographic maps.

The Balboa-Herendeen Bay and Unga Island region; scale, 1:250,000; by H. M. Eakin. Contained in Bulletin 467. Not issued separately.

The Iliamna region; scale, 1:250,000; by D. C. Witherspoon and C. E. Giffin. Contained in Bulletin 485. Not issued separately.

YUKON BASIN.

*The coal resources of the Yukon, Alaska, by A. J. Collier. Bulletin 218, 1903, 71 pp. 15 cents.

*The gold placers of the Fortymile, Birch Creek, and Fairbanks regions, by L. M. Prindle. Bulletin 251, 1905, 89 pp. 35 cents.

Yukon placer fields, by L. M. Prindle. In Bulletin 284, 1906, pp. 109–131.

Reconnaissance from Circle to Fort Hamlin, by R. W. Stone. In Bulletin 284, 1906, pp. 128–131.

The Yukon-Tanana region, Alaska; description of the Circle quadrangle, by L. M. Prindle. Bulletin 295, 1906, 27 pp.

The Bonnifield and Kantishna regions, by L. M. Prindle. In Bulletin 314, 1907, pp. 205–226.

The Circle precinct, Alaska, by A. H. Brooks. In Bulletin 314, 1907, pp. 187–204.

*The Yukon-Tanana region, Alaska; description of the Fairbanks and Rampart quadrangles, by L. M. Prindle, F. L. Hess, and C. C. Covert. Bulletin 337, 1908, 102 pp. 25 cents.

*Occurrence of gold in the Yukon-Tanana region, by L. M. Prindle. In Bulletin 345, 1908, pp. 179–186. 45 cents.

*The Fortymile gold-placer district, by L. M. Prindle. In Bulletin 345, 1908, pp. 187–197. 45 cents.

*Water-supply investigations in Alaska, 1906 and 1907, by F. F. Henshaw and C. C. Covert. Water-Supply Paper 218, 1908, 156 pp. 25 cents.
*Water supply of the Fairbanks district in 1907, by C. C. Covert. In Bulletin 345, 1908, pp. 198–205. 45 cents.
The Fortymile quadrangle, by L. M. Prindle. Bulletin 375, 1909, 52 pp.
Water-supply investigations in Yukon-Tanana region, 1906–1908, by C. C. Covert and C. E. Ellsworth. Water-Supply Paper 228, 1909, 108 pp.
*The Fairbanks gold-placer region, by L. M. Prindle and F. J. Katz. In Bulletin 379, 1909, pp. 181–200. 50 cents.
*Water supply of the Yukon-Tanana region, 1907–8, by C. C. Covert and C. E. Ellsworth. In Bulletin 379, 1909, pp. 201–228. 50 cents.
*Gold placers of the Ruby Creek district, by A. G. Maddren. In Bulletin 379, 1909, pp. 229–233. 50 cents.
*Placers of the Gold Hill district, by A. G. Maddren. In Bulletin 379, 1909, pp. 234–237. 50 cents.
*Gold placers of the Innoko district, by A. G. Maddren. In Bulletin 379, 1909, pp. 238–266. 50 cents.
The Innoko gold-placer district, Alaska, with accounts of the central Kuskokwim Valley and the Ruby Creek and Gold Hill placers, by A. G. Maddren. Bulletin 410, 1910, 87 pp.
Sketch of the geology of the northeastern part of the Fairbanks quadrangle, by L. M. Prindle. In Bulletin 442, 1910, pp. 203–209.
The auriferous quartz veins of the Fairbanks district, by L. M. Prindle. In Bulletin 442, 1910, pp. 210–229.
Placer mining in the Yukon-Tanana region, by C. E. Ellsworth. In Bulletin 442, 1910, pp. 230–245.
Occurrence of wolframite and cassiterite in the gold placers of Deadwood Creek, Birch Creek district, by B. L. Johnson. In Bulletin 442, 1910, pp. 246–250.
Water supply of the Yukon-Tanana region, by C. E. Ellsworth. In Bulletin 442, 1910, pp. 251–283.
The Koyukuk-Chandalar gold region, by A. G. Maddren. In Bulletin 442, 1910, pp. 284–315.
Placer mining in the Yukon-Tanana region, by C. E. Ellsworth and G. L. Parker. In Bulletin 480, 1911, p. 172.
Water supply of the Yukon-Tanana region, 1910, by C. E. Ellsworth and G. L. Parker. In Bulletin 480, 1911, p. 217.
Mineral resources of the Bonnifield region, by S. R. Capps. In Bulletin 480, 1911, p. 235.
Gold placer mining developments in the Innoko-Iditarod region, by A. G. Maddren. In Bulletin 480, 1911, p. 270.
*Placer mining in the Fortymile and Seventymile river districts, by E. A. Porter. In Bulletin 520, 1912, pp. 211–218. 50 cents.
*Water supply of the Fortymile, Seventymile, and Eagle districts, by E. A. Porter. In Bulletin 520, 1912, pp. 219–239. 50 cents.
*Placer mining in the Fairbanks and Circle districts, by C. E. Ellsworth. In Bulletin 520, 1912, pp. 240–245. 50 cents.
*Water supply of the Fairbanks, Salchaket, and Circle districts, by C. E. Ellsworth. In Bulletin 520, 1912, pp. 246–270. 50 cents.
*The Rampart and Hot Springs regions, by H. M. Eakin. In Bulletin 520, 1912, pp. 271–286. 50 cents.
*The Ruby placer district, by A. G. Maddren. In Bulletin 520, 1912, pp. 287–296. 50 cents.
*Gold placers between Woodchopper and Fourth of July creeks, upper Yukon River, by L. M. Prindle and J. B. Mertie, jr. In Bulletin 520, 1912, pp. 201–210. 50 cents.
The Bonnifield region, Alaska, by S. R. Capps; including geologic and topographic reconnaissance maps. Bulletin 501, 1912, 162 pp.
A geologic reconnaissance of a part of the Rampart quadrangle, Alaska, by H. M. Eakin. Bulletin 535, 1913, 38 pp.
A geologic reconnaissance of the Fairbanks quadrangle, Alaska, by L. M. Prindle; with a detailed description of the Fairbanks district, by L. M. Prindle and F. J. Katz, and an account of lode mining near Fairbanks, by P. S. Smith. Bulletin 525, 1913, 220 pp.
The Koyukuk-Chandalar region, Alaska, by A. G. Maddren. Bulletin 532, 1913, 119 pp.
A geologic reconnaissance of the Circle quadrangle, Alaska, by L. M. Prindle. Bulletin 538. (In preparation.)
The Iditarod-Ruby region, Alaska, by H. M. Eakin, with geologic and topographic reconnaissance maps. Bulletin ——. (In preparation.)

Topographic maps.

Fortymile quadrangle; No. 640; scale, 1: 250,000; by E. C. Barnard. Price, 10 cents a copy or $3 for 50.

Fairbanks quadrangle; No. 642; scale, 1: 250,000; by T. G. Gerdine, D. C. Witherspoon, and R. B. Oliver. Price, 20 cents a copy or $6 for 50.

Rampart quadrangle; No. 643; scale, 1: 250,000; by D. C. Witherspoon and R. B. Oliver. Price, 20 cents a copy or $6 for 50.

Fairbanks district; No. 642A; scale, 1: 62,500; by T. G. Gerdine and R. H. Sargent. Price, 20 cents a copy or $6 for 50.

*Yukon-Tanana region, reconnaissance map of; scale, 1: 625,000; by T. G. Gerdine. Contained in Bulletin 251, 1905. 35 cents. Not published separately.

*Fairbanks and Birch Creek districts, reconnaissance maps of; scale, 1: 250,000; by T. G. Gerdine. Contained in Bulletin 251, 1905. 35 cents. Not issued separately.

Circle quadrangle, Yukon-Tanana region; scale, 1: 250,000; by D. C. Witherspoon. Price 50 cents a copy. Also contained in Bulletin 295.

SEWARD PENINSULA.

*A reconnaissance of the Cape Nome and adjacent gold fields of Seward Peninsula, Alaska, in 1900, by A. H. Brooks, G. B. Richardson, and A. J. Collier. In a special publication entitled "Reconnaissances in the Cape Nome and Norton Bay regions, Alaska, in 1900," 1901, 180 pp. 50 cents.

*A reconnaissance in the Norton Bay region, Alaska, in 1900, by W. C. Mendenhall. In a special publication entitled "Reconnaissances in the Cape Nome and Norton Bay regions, Alaska, in 1900," 1901, 38 pp. 50 cents.

*A reconnaissance of the northwestern portion of Seward Peninsula, Alaska, by A. J. Collier. Professional Paper 2, 1902, 70 pp. 30 cents.

*The tin deposits of the York region, Alaska, by A. J. Collier. Bulletin 229, 1904, 61 pp. 15 cents.

*Recent developments of Alaskan tin deposits, by A. J. Collier. In Bulletin 259, 1905, pp. 120–127. 15 cents.

*The Fairhaven gold placers of Seward Peninsula, by F. H. Moffit. Bulletin 247, 1905, 85 pp. 40 cents.

The York tin region, by F. L. Hess. In Bulletin 284, 1906, pp. 145–157.

Gold mining on Seward Peninsula, by F. H. Moffit. In Bulletin 284, 1906, pp. 132–141.

The Kougarok region, by A. H. Brooks. In Bulletin 314, 1907, pp. 164–181.

*Water supply of Nome region, Seward Peninsula, Alaska, 1906, by J. C. Hoyt and F. F. Henshaw. Water-Supply Paper 196, 1907, 52 pp. 15 cents.

Water supply of the Nome region, Seward Peninsula, 1906, by J. C. Hoyt and F. F. Henshaw. In Bulletin 314, 1907, pp. 182–186.

The Nome region, by F. H. Moffit. In Bulletin 314, 1907, pp. 126–145.

Gold fields of the Solomon and Niukluk river basins, by P. S. Smith. In Bulletin 314, 1907, pp. 146–156.

Geology and mineral resources of Iron Creek, by P. S. Smith. In Bulletin 314, 1907, pp. 157–163.

The gold placers of parts of Seward Peninsula, Alaska, including the Nome, Council, Kougarok, Port Clarence, and Goodhope precincts, by A. J. Collier, F. L. Hess, P. S. Smith, and A. H. Brooks. Bulletin 328, 1908, 343 pp.

*Investigation of the mineral deposits of Seward Peninsula, by P. S. Smith. In Bulletin 345, 1908, pp. 206–250. 45 cents.

*The Seward Peninsula tin deposits, by Adolph Knopf. In Bulletin 345, 1908, pp. 251–267. 45 cents.

*Mineral deposits of the Lost River and Brooks Mountain regions, Seward Peninsula, by Adolph Knopf. In Bulletin 345, 1908, pp. 268–271. 45 cents.

*Water supply of the Nome and Kougarok regions, Seward Peninsula, in 1906–7, by F. F. Henshaw. In Bulletin 345, 1908, pp. 272–285. 45 cents.

*Water-supply investigations in Alaska, 1906 and 1907, by F. F. Henshaw and C. C. Covert. Water-Supply Paper 218, 1908, 156 pp. 25 cents.

Geology of the Seward Peninsula tin deposits, by Adolph Knopf. Bulletin 358, 1908, 72 pp.

*Recent developments in southern Seward Peninsula, by P. S. Smith. In Bulletin 379, 1909, pp. 267–301. 50 cents.

*The Iron Creek region, by P. S. Smith. In Bulletin 379, 1909, pp. 302–354. 50 cents.

*Mining in the Fairhaven precinct, by F. F. Henshaw. In Bulletin 379, 1909, pp. 355–369. 50 cents.

*Water-supply investigations in Seward Peninsula in 1908, by F. F. Henshaw. In Bulletin 379, 1909, pp. 370–401. 50 cents.

Geology and mineral resources of the Solomon and Casadepaga quadrangles, Seward Peninsula, by P. S. Smith. Bulletin 433, 1910, 227 pp.
Mineral resources of the Nulato-Council region, by P. S. Smith and H. M. Eakin. In Bulletin 442, 1910, pp. 316–352.
Mining in Seward Peninsula, by F. F. Henshaw. In Bulletin 442, 1910, pp. 353–371.
Water-supply investigations in Seward Peninsula in 1909, by F. F. Henshaw. In Bulletin 442, 1910, pp. 372–418.
A geologic reconnaissance in southeastern Seward Peninsula and the Norton Bay-Nulato region, by P. S. Smith and H. M. Eakin. Bulletin 449, 1911, 146 pp.
*Notes on mining in Seward Peninsula, by P. S. Smith. In Bulletin 520, 1912, pp. 339–344.
Geology of the Nome and Grand Central quadrangles, Alaska, by F. H. Moffit. Bulletin 533, 1913, 140 pp.
Surface water supply of Seward Peninsula, Alaska, by F. F. Henshaw and G. L. Parker, with a sketch of the geography and geology, by P. S. Smith, and a description of methods of placer mining, by Alfred H. Brooks; including topographic reconnaissance map. Water-Supply Paper 314, 1913, 317 pp.

Topographic maps.

The following maps are for sale at 10 cents a copy or $3 for 50:

Casadepaga quadrangle, Seward Peninsula; No. 646 C; scale, 1:62,500; by T. G. Gerdine.
Grand Central quadrangle, Seward Peninsula; No. 646 A; scale, 1:62,500; by T. G. Gerdine.
Nome quadrangle, Seward Peninsula; No. 646 B; scale, 1:62,500; by T. G. Gerdine.
Solomon quadrangle, Seward Peninsula; No. 646 D; scale, 1:62,500; by T. G. Gerdine.

The three following maps are for sale at 50 cents a copy or $15 for 50:

Seward Peninsula, northeastern portion of, topographic reconnaissance of; scale, 1:250,000; by T. G. Gerdine.
Seward Peninsula, northwestern portion of, topographic reconnaissance of; scale, 1:250,000; by T. G. Gerdine.
Seward Peninsula, southern portion of, topographic reconnaissance of; scale, 1:250,000; by T. G. Gerdine.

Seward Peninsula, southeastern portion of, topographic reconnaissance of; scale, 1:250,000. Contained in Bulletin 449. Not published separately.

NORTHERN ALASKA.

*A reconnaissance from Fort Hamlin to Kotzebue Sound, Alaska, by way of Dall, Kanuti, Allen, and Kowak rivers, by W. C. Mendenhall. Professional Paper 10, 1902, 68 pp. 30 cents.
*A reconnaissance in northern Alaska across the Rocky Mountains, along the Koyukuk, John, Anaktuvuk, and Colville rivers, and the Arctic coast to Cape Lisburne, in 1901, by F. C. Schrader and W. J. Peters. Professional Paper 20, 1904, 139 pp. 40 cents.
*Coal fields of the Cape Lisburne region, by A. J. Collier. In Bulletin 259, 1905, pp. 172–185. 15 cents.
*Geology and coal resources of Cape Lisburne region, Alaska, by A. J. Collier. Bulletin 278, 1906, 54 pp. 15 cents.
The Shungnak region, Kobuk Valley, by P. S. Smith and H. M. Eakin. In Bulletin 480, 1911, pp. 271–305.
The Squirrel River placers, by P. S. Smith. In Bulletin 480, 1911, pp. 306–319.
*Geologic investigations along the Canada-Alaska boundary, by A. G. Maddren. In Bulletin 520, 1912, pp. 297–314. 50 cents.
*The Alatna-Noatak region, by P. S. Smith. In Bulletin 520, 1912, pp. 315–338. 50 cents.
The Noatak-Kobuk region, by P. S. Smith. Bulletin 536. (In preparation.)

Topographic maps.

*Fort Yukon to Kotzebue Sound, reconnaissance map of; scale, 1:1,200,000; by D. L. Reaburn. Contained in Professional Paper 10. 30 cents. Not published separately.
*Koyukuk River to mouth of Colville River, including John River; scale, 1:1,200,000; by W. J. Peters. Contained in Professional Paper 20. 40 cents. Not published separately.

O