COMMITTEE ON GLACIERS OF THE AMERICAN GEOPHYSICAL UNION

Report for 1931-1932.

PAR

M. François E. Matthes

At its annual meeting, May, 1931, the Section of Hydrology of the American Geophysical Union, recognizing the desirability indeed, the need of there being in the United States, as in Europe, a central agency that shall keep systematic records of the annual variations of glaciers, decided to create a standing committee for this purpose. Accordingly there was formed the Committee on the Hydrology of Glaciers, since renamed Committee on Glaciers.

The principal duty of this committee was stated to be: « To obtain and interpret systematic records of the advance and retreat of glaciers in the United States, including Alaska ». The committee, however, is to concern itself aslo with related records of the movement of the ice in glaciers, with climatic conditions affecting the regimen of glaciers, and with the discharge of water from glaciers. Its field is, broadly, the study of the physics and hydrology of existing glaciers, as distinct from the work and products of ancient glaciers. This field, it will be seen, corresponds closely to that of the Commission Glaciologique appointed by the Section d'Hydrologie Scientifique of the Union Internationale de Géodésie et Géophysique.

With the Commission Glaciologique the American Committee on Glaciers was instructed to coōperate, and with that organization, indeed, it has from the first been affiliated, being represented thereon by two of its members, Prof. Wm. H. Hobbs, who is Vice-President of the Commission, and Dr. Harry Fielding Reid, who has long been the American member of the Commission, and who previously served on the Commission Internationale des Glaciers prior to the World War.

The Committee is composed of the folloving members: François E. Matthes, Senior Geologist, U. S. Ceological Survey, Chairman; Dr. William H. Hobbs, Director, Department of Geology, University of Michigan, Vice-President, Commission Glaciologique; Dr. Harry Fielding Reid, Professor Emeritus of Dynamic Geology, Johns Hopkins University, member, Commission Glaciologique; Stephen R. Capps, Senior Geologist, Alaskan Branch, U. S. Geological Survey; Dr Lawrence Martin, Chief, Division of Maps, Library of Congress; William B. Osgood Fiels, Jr., New-York; Gerald L. Parker, District Engineer, Water Resources Branch, U. S. Geological Survey, stationed at Tacoma, Wash.; Carl P. Richards, Chairman of Research Committee of the Mazamas, Portland, Oregon; Rufus H. Sargent, Senior Topographic Engineer, Alaskan Branch, U. S. Geological Survey; Earl B. Trager, Assistant to the Chief, Branch of Research and Education, National Park Service.

The efforts of the Committee during the first two years of its existence naturally have been directed chiefly towards enlisting the active coöperation of organizations and individuals who might be depended upon to make annual measurements on specified glaciers and to secure data on snowfall, temperature, and other meteorological factors that need to be considered in the interpretation of the glacier records. These efforts, fortunately, have met with gratifying response from several organizations, notably from the National Park Service and the Forest Service, within whose respective domains most of the glaciers in the continental United States and Alaska are situated; also from the Mazamas, the mountaineering Club of Portland, Oregon, whose Research Committee for some years past has been making measurements of the recession and the rate of movement of the glaciers on Mount Hood.

For the great ice streams of Alaska it has been more difficult to obtain volunteer service, because of the remoteness of those ice streams, and because their vast size and their largescale oscillations necessitate rather elaborate measurements by triangulation or other surveyning methods.

Fortunately in 1931 two members of the Committee, Dr. Harry Fielding Reid and Mr. William B. Osgood Field, Jr., had opportunity to visit and study a number of the great tidal glaciers on the Alaskan coast. Dr. Reid, in company with Dr. C.-W. Wrigth, under the auspices of the U. S.. Geological Survey, visited Glacier Bay, in southern Alaska, and charted and photographed the fronts of 14 of the larger glaciers, thus obtaining data permitting comparison of the present position and tickness of each glacier with the position and thickness recorded 25 years previously by Dr. C.-W. Wright and his brother F.-E. Wright. Mr. Field, by reoccupying the transit and photographic stations used by previous expeditions, and by establishing new stations, charted the positions of 18 large glaciers on the north side of Prince William Sound, thereby determining the nature and amplitude of their oscillations since the last previous record. As a result there is at hand a considerable body of authentic data on the more recent oscillations of 32 of the Alaskan glaciers. Additional obser-vations and measurements were made in 1931 by Prof. Chester K. Wentworth and Mr L.-L. Ray, of Washington University, St. Louis, on a reconnaissance along the lower Copper River and Prince William Sound, and oriented photographs were taken by them of the Mendenhall, Taku, Herbert, and Norris glaciers in the vicinity of Juneau. These data, however, have not yet reached the Committee.

For the earlier oscillations of the glaciers on the Alaskan coast the Committee is assiduously collecting and studying the data and photographs secured by the different expeditions that have visited those glaciers during the last 40 years. Already the Committee has in its files nearly 1000 indexed photographs of Alaskan glaciers, among which 427 taken by the Harriman Alaska Expedition of 1899, for which the committee is indebted to Dr. C. Hart. Merriam; 110 photographs received from Mrs. Dora Keen Handy, who made two expeditions, in 1914 and 1925; 38 photographs taken in 1931 by Dr. Harry Fielding Reid; 48 views taken from air planes, received from the Forest Service; and 270 views taken by Mr. Wm. B. Osgood Fiels, Jr.. Thus the Committee has laid the foundations for a reference collection of photographs that in the course of time is likely to become of great value to students of glaciology.

Even the reports of the earliest exploring expeditions — Russian, British, French, and Spanish — as far back as the latter part of the 18th century, are found to contain observations on Alaskan glaciers that are extremely enlightening as regards the extent of those ice bodies a hundred and even a hundred and fifty years ago. It is the aim of the Committee to assemble and correlate all scattered material of this kind so that ultimately it may be con concentrated into convenient form for study.

In this report the Committee has undertaken for the first time to present in tabular form all the data available for publication concerning the variations of glaciers in the continental United States and Alaska. This tabulation, it is realized, is by no means complete. A number of glaciers for which data exist are not included, but these, it is hoped, will be represented in future reports.

In general it has been the aim to conform closely to the simple and effective methods of tabulation employed by the Commission Glaciologique. In a number of instances, however, explanatory notes have seemed indispensable for the intelligent interpretation of the record; and for some of the Alaskan glaciers, whose great and often rapid advances and retreats are only imperfectly known from observations at irregular intervals, qualitative expressions have been used instead of quantitatives figures.

Special note has been made of every instance in which a glacier was reported to be advancing into mature forest, the event having special significance as indicating a maximum that had not been attained for a long period previously. As might be expected, a rough synchronism exists between the extreme advances of certain glaciers, especially between glaciers within the same district, but such synchronism of maxima is by no means general. Indeed, a comparison of the records of Alaskan glaciers impresses one chiefly with the prevailing lack of synchronism in their oscillations.

In Glacier Bay, for instance — the reach somewhat farther back into history than has been done in the tables — a great maximum appears to have occurred in the 18 th century, following a period during which the glaciers were much smaller than they are today. Since that maximum the glaciers have melted back as much as 97 km., and as a result open water now permits navigation far up towards the heads of the fiords. On the other hand, in Lituya Bay, but a few kilometers to the northwest, the glaciers are now larger than in 1786, when La Pérouse visited that locality. In Yakutat Bay the glaciers were in retreat throughout most of the 19th century, and similar conditions obtained in the Copper River Basin. Yet farther to the northwest, in Prince William Sound, some of the glaciers are now much larger than they have been for the greater part of a century. The Yale and Smith glaciers appear recently to have attained their culmination, and the Harriman and Harvard glaciers, which are the trunk glaciers of Harriman Fiord and College Fiord respectively, are still actively advancing into territory that has not been occupied by them for at least half a century.

Among the glaciers in the continental United States particular interest attaches to those on Mount Rainier, in the State of Washington, which are comparable in magnitude to the glaciers on the Alps of Europe. One of them, the Nisqually (8 km. in length), has been the subject of annual measurements by the National Park Service ever since 1918. Its record, as is evident from the tables appended to this report, has been one of uninterrupted and gradually accelerated recession throughout the period of 14 years. What is more, the few observational but nevertheless reliable data from the 19th century show that the Nisqually has been in a state of recession ever since 1857, the year of its discovery. The total shortening it has suffered since that date is 962 meters. If all the glaciers on Mount Rainier have been shortened by proportionate amounts, the total shrinkage of the ice mantle of that peak must reach an impressive figure. (The aggregate area of glacier ice on the cone of Mount Rainier in 1911 was 110 km^2., as determined by the topographic parties of the U. S. Geological Survey.) The case of the Nisqually, however, is of interest not merely because it affords unmistakable evidence of a climatic change that is now in progress, but also because it has important economic aspects. The city of Tacoma derives its hydroelectric power from the Nisqually River, which issues from the Nisqually Glacier. So greatly reduced during recent years has been the flow of that river, in consequence of the wasting away of the glacier, that the citizens of Tacoma have become alarmed lest their source of power should become undependable in the near future. Elaborate topographic surveys of the lower third of the glacier are now being made annually by the Tacoma engineers, for the purpose of determining the rate at which the wastage of the glacier is progressing. It was, indeed, this economic problem created by the shrinking of the Nisqually Glacier that in 1931 focussed the attention of American hydrologists upon the need of an agency to systematize the measurement of glaciers in the United States*, and that thus led to the appointement of the Committee on Glaciers.

Scarcely less significant than the recession of the large glaciers on Mount Rainier is the wasting away and the gradual disappearance of the smaller glaciers in the Sierra Nevada of California and on the different ranges of the Rocky Mountains. Upon the observations that are being made annually on these small glaciers, indeed, the Committee places especial value, for these small glaciers, being confined largely to their cirques, and having but very short dissipators, respond in general more promptly to variations in snowfall and temperature than long glaciers, and their oscillations therefore reflect more truly the trend of the climatic changes that are taking place.

Highly significant is the discovery made by Park Naturalist C. A. Harwell, of Yosemite National Park, California, in 1931, that the small cirque glacier under Merced Peak, which was the first « living glacier » to be discovered by John Muir, in 1871, has vanished altogether, only its moraines remaining to attest its former presence ; for fresh moraines of the same type, according to the observations of François E. Matthes, occur in hundreds of cirques throughout the Sierra Nevada, and it is therefore a fair inference that literally hundreds of small cirque glaciers have vanished from that range since the seventies of the last century.

Curiously the glaciers in the Sierra Nevada were the only ones, among those observed in the United States, that showed gains rather than losses in 1932. The explanation is found in the excessive snow precipitation that occurred in the Sierra Nevada during the winter of 1931-32.

In closing attention is invited to certain observations made in the

* François E. Matthes : Glacier measurements in the United States, Transactions, American Geophysical Union, 1931, pp. 211-215.

United States and in southern Alaska, showing that several cycles of glacier advance and glacier recession have taken place in alternation during the last 1000 years or more. In Glacier Bay, in 1931, Dr Harry Fielding Reid and Dr. C.-W. Wright discovered a bank of glacial till and outwash material containing two buried layers of soil with stumps and trunks of forest trees. The upper layer is 27m. below the top of the bank ; the lower layer is 17m. lower down. There are thus indicated two former periods during which Glacier Bay was free of ice and covered by mature forests, and two periods of glaciation during which those forests were again destroyed. The duration of the ice free intervals must in each case have been of the order of several centuries at least, for the rings of growth in the buried trees show that some of them had attained an age of 250 years ; and, besides, the present vegetation in Glacier Bay, after progressive deglaciation for 137 years, is still extremely scant.

On the southwest side of Mount Hood, in the Cascade Range of Oregon, in 1926, Judge Fred W. Stadter, a member of the Mazamas, discovered a tangled mass of the tree trunks protruding from beneath a moraine deposited by the Zigzag Glacier. The remains of this ancient forest are situated near the level of the present timber line, yet the trees of which it was composed were tall and straight, like those that now grow at lower levels. It is to be inferred, therefore, that the climate of the Cascade Range formerly was much milder and wetter than at present, and that since then there has been a change to greater frigidity, as a result of which the glaciers advanced, overwhelming the forests. The maximum of that advance is now long past and the glaciers have again retreated far up the slopes of the peak.

Coroborative evidence of a period of mild, rainy conditions that was followed recently by a period of more rigorous climate, has been found in the northern portion of the Cascade Range, State of Washington, by Mr. A. H. Sylvester, formerly Supervisor of the Wenatchee National Forest. This evidence consists of the remnants of a forest of giant Douglas firs (*Pseudotsuga taxifolia*) at altitudes of 1800 to 2100 m. — that is, in the timber line zone where normally only alpine species of short stature occur. Some of these firs measure 1.5 to 2 m. in diameter and are estimated to be between 500 and 600 years old. It is Mr. Sylvester's belief that these trees date back to a time when mild, rainy conditions prevailed at altitudes where the precipitation now is in the form of snow at almost all times of the year, and that they have survived the more wintry conditions that have since set in. If, however, mild, rainy conditions endured for many centuries at the high levels mentioned, then it seems very improbable that any glaciers remained in existence on the Cascade Range, save possibly on a few peaks of exceptional elevation such as Mount Rainier and Glacier Peak. It would follow that nearly all of the present glaciers on the Cascade Range have come into being since the termination of the mild, rainy period mentioned — that is, within the last three or four centuries — and that they are in no sense remnants of the great ice streams of the Pleistocene epoch, as is generally supposed.

Whether the epoch if mild, rainy conditions in the Cascade Range is or is not to be correlated with one of the two similar cycles indicated for southern Alaska by the buried forest soils in Glacier Bay, remains to be demonstrated. It is to be hoped that this problem may be given further study in the near future, so that our knowledge of these very recent climatic fluctuations, which directly preceded our own times, shall be more complete.

For the Committee :
François E. MATTHES
Chairman.

MOUNT RAINIER, WASHINGTON

Data from National Park Service

(Distances in meters)

Glacier	1930-1931	1931-1932
Nisqually	— 15	— 15
Emmons	— 43 (?)	— 5
Carbon		— 11
South Tahoma		— 11
Paradise		— (?)

COMPLETE RECORD OF NISQUALLY GLACIER

1857-1885	— 230*	1924-1925	— 22
1885-1892	— 40*	1925-1926	— 26
1892-1918	— 400*	1926-1927	— 13
1918-1919	— 18	1927-1928	— 27
1919-1920	— 14	1928-1929	— 16
1920-1921	— 32	1929-1930	— 36
1921-1922	— 20	1930-1931	— 15
1922-1923	— 13	1931-1932	— 15
1923-1924	— 25		

* Figures obtained from historical records.

MOUNT HOOD, OREGON

Data from Research Committee, Mazamas

(Distances in meters)

Glacier	1925-1927	1927-1928	1928-1929	1929-1930	1930-1931	1931-1932
Eliot	< .... — 12 .... >					no change
Coe			| no change	<.. — 13 ....>		— 6
Ladd		<... little change ...>		<.. — 5 (?) ......>		no change

YOSEMITE NATIONAL PARK AND ADJOINING PARTS OF THE SIERRA NEVADA, CALIFORNIA

Data from National Park Service

(Distances in meters)

Glacier	1931-1932
Lyell (west lobe)	+ 5 (?)*
Lyell (east lobe)	+ 20 (?)*
Maclure	+ 16 (?)*
Dana	+ 12
Conness	+ (?)*
Kuna	+ (?)*
Koip	+ (?)*

* Owing to the heavy snowfalls that occured in the Sierra Nevada during the winter of 1931-1932 the glaciers remained covered with snow throughout the ensuing summer, and as a consequence the positions of their fronts could not be determined with accuracy.

GLACIER NATIONAL PARK, MONTANA

Data from National Park Service

Glacier	1931-1932
Grinnell	— (?)
Blackfoot (west lobe)	— (?)
Blackfoot (east lobe)	— (?)
Sperry (Edwards lobe) ...	+ (?)
Sperry (Gunsight lobe) ...	+ (?)
Agassiz	

Early snowfalls in the autum of 1932 made accurate measurements impossible.

WIND RIVER RANGE, WYOMING

Data from C. K. Wentworth

(Distances in meters)

Glacier	1906-1930
North Gannett	— 400 to — 800
East Gannett	shrunk laterally
West Gannett	?

Distances estimated with reference to positions shown on topographic map of 1906.

GLACIER BAY, ALASKA

Data compiled by Harry F. Reid and C. W. Wright

(Distances in kilometers)

Glacier	1879-1892	1892-1906	1906-1929	1929-1931
Muir	— 2.9	— 8.5	— 10.0	+ 0.6
Adams [a]	— 2.9	— 5.6	— 4.3	+ 3.5
Casement [a] ...	— 2.9	<....... — 11.6 ....>		+ 2.7
Plateau [a]	— 2.9	<....... — 8.9 ....>		+ 3.4
Carroll				— 1.8
Rendu				— 1.0
Grand Pacific ..	— 5.2	— 12.4	<....... — 9.4 ....>	
Johns Hopkins .	— 7.9	— 4.3	<....... — 14.5 ....>	
Lamplugh [b] ...	— 7.9	<....... — 1.9 ....>		
Reid	— 1.3	— 0.6	<....... — 1.1 ....>	
Hugh Miller	— 2.4	— 2.9	— 2.6	+ 1.3
Charpentier	— 3.5	— 3.0	— 2.9	+ 6.1 (?)
Geikie	— 2.1	— 1.3	— 0.6	— 1.4
Wood	— 1.9	— 0.6	— 2.4	+ 1.1

a) Formerly a tributary of Muir Glacier, Measurements include tributary and Muir Glacier when they were united.

b) Formerly a tributary of Johns Hopkins and Grand Pacific glaciers. Measurements include Lamplugh, Johns Hopkins, and Grand Pacific, when they were united.

NORTHERN PART OF PRINCE WILLIAM SOUND, ALASKA

Data compiled by William B. Osgood Fiels, Jr.

(Distances in meters unless otherwise stated)

Glacier	18 ?-1892	1892-1899	1899-1909	1909-1911	1911-1914	1914-19 ?	19 ?-1931
Columbia (West front)	advance invading mature forest	recession interrupted by slight readvance	+ 370	+ 150	— 8	+ 40	— 270

Glacier	18 ?-1892	1892-1897	1897-1908	1908-1910	1910-1914	1914-19 ?	19 ?-1931
Columbia (Heather Island Front)	advance invading mature forest	recession and readvance	recession	+ 226	— 9	+ 60	recession followed by advance to within 76 m. of 1910 position
Columbia (East front)							— 460 to — 760
Columbia (East terminus)							— 120 to — 240

NORTHERN PART OF PRINCE WILLIAM SOUND, ALASKA (CONT'D)

(Distances in meters unless otherwise stated)

Glacier	1898-1910	1910 1914	1914 1931
Valdez	recession	<........ — 220 (unmeasured advance 1905-1908) ....>	<........ — 380 ....>
Shoup	<..................... front practically stationary but thickness greatly reduced ....>		

Glacier	1898-1899	1899-1905	1905-1909	1909-1910	1910-1914	1914-1925	1925-1931
Meares	<...... + 2.4 km. ......>		<.. advance invading mature forest ..>		<.. Advance of about one hundred meters ..>		
Yale (East margin)	little change	<....... + 230 ....>			<................ + 200 ....>		
Yale (Center)	<... little change ....>						
Harvard		little change	+ 180 invading mature alders	+ 30 to + 50	— 6	<.... + 400 to + 430 ....>	
Smith		<........ + 180 ....>		+ several hundred meters	recession, and shrinkage	<.. advance followed by recession still in progress ..>	
Bryn Mawr		little change	<........ + 150 ....> invading forest 50 years old		slight recession	<.... — 460 to — 600 ....>	
Vassar		little change	<........ + 150 ....>		?	<.... marked recession ....>	
Wellesley	recession	<..... little change .....>		advance	recession	<.. + several hundred meters ..>	

NORTHERN PART OF PRINCE WILLIAM SOUND, ALASKA (CONT'D)

(Distances in meters unless otherwise stated)

Glacier	? -1898	1898-1899	1899-1909	1909-1910	1910-1914	1914-1925	1925-1931
Barry	advance into mature forest	— 800 m. to 1.2 km.	— 3.4 km.	E. side — 490 W. side — 150	E. side — 2.1 km. W.side— 600	recession	little change

Glacier	18 ?-1899	1899-1905	1905-1909	1909-1910	1910-1914	1914-1925	1925-1931
Serpentine	— 400 to — 800	little change	— 400	<...... little change ......>		<......... — 600 ....>	
Baker	great advance	slight recession	little change	advance	slight recession	<........ recession ....>	
Cataract	maximum advance	<...... little change ......>		advance	advance and slight recession	recession back of 1909 position	advance still back of 1909 position
Roaring	advance ?	slight recession	<...... slight advance ......>		advance	<..... slight recession .....>	
Harriman	recession ?	<.... E. side — 320 ....> <.. W. side, no change ..>		E. side +320 W.side +210	slight advance	E. side advanced several hundred feet	+ 60 to + 90
Toboggan			+ 120, then — 190	— 23	<................ — 254 ....>		

Glacier	18 ?-1899	1899-1900	1900-1909	1909-1910	1910-1914	1914-1925	1925-1931
Surprise	advance	— 160	— 1.8 km.	<...... little change ......>		recession	recession

KENAI PENINSULA, ALASKA

Data from U. S. Coast and Geodetic Survey

Distances in meters

Glacier	185?-1907	1907-1925	1925-1927
Mc Carty	**— 400**	**— 1600**	**— 1600**