ELISHA HANSON

THE
NATIONAL
GEOGRAPHIC MAGAZINE

VOLUME IV, 1892

W J McGee, *Chairman*
Herbert G. Ogden C. Hart Merriam
Publication Committee

WASHINGTON
PUBLISHED BY THE NATIONAL GEOGRAPHIC SOCIETY
1893

OFFICERS OF THE NATIONAL GEOGRAPHIC SOCIETY

1892

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ILLUSTRATIONS

PUBLICATIONS OF THE NATIONAL GEOGRAPHIC SOCIETY

Regular Publications

In addition to announcements of meetings and various circulars sent to members from time to time, the Society issues a single serial publication entitled The National Geographic Magazine. During the first two years of the existence of the Society this serial was issued in quarterly numbers. With the beginning of the third year of the Society and the third volume of the Magazine the form of publication was changed, and the serial now appears at irregular intervals in parts or brochures (designated by pages and designed either for separate preservation or for gathering into volumes) which consist either of single memoirs or of magazine brochures made up of articles, notes, abstracts and other geographic matter, together with the Proceedings and other administrative records of the Society.

The *Magazine* is mailed free to members of the Society and to exchanges. The first three volumes, as well as the separate brochures of the fourth and the complete volume, are sold at the prices given below by the Secretary, Mr F. H. Newell, U. S. Geological Survey, Washington, D. C.

	To Members.	To the Public.
Volume I, 1889: 4 numbers, 334 pages, 16 plates and 26 figures	$1 40	$2 00
Volume II, 1890: 5 numbers, 344 pages, 10 plates and 11 figures	1 40	2 00
Volume III, 1891: 5 brochures, 296 pages, 21 plates and 8 figures	1 60	3 00
Volume IV, 1892: Comprising—		
The Evolution of Commerce; Annual Address by the President, Gardiner G. Hubbard: pp. 1–18, March 26, 1892	$0 10	$0 25
Studies of Muir Glacier, Alaska; by Harry Fielding Reid: pp. 19–84, pls. 1–16, March 21, 1892	75	1 00
Geography of the Air; Annual Report by Vice-President General A. W. Greely: pp. 85–100, March 18, 1892	10	25
The Mother Maps of the United States; by Henry Gannett: pp. 101–116, pl. 17, March 31, 1892	15	25
An Expedition through the Yukon District; by C. Willard Hayes: pp. 117–162, pls. 18–20, May 15, 1892	30	50
Magazine brochure, pp. 163–208, February 8, 1893	20	50
Administrative brochure, pp. 209–213, i–xxiv, February 20, 1893	15	25
	$1 75	$3 00

IRREGULAR PUBLICATIONS

In the interests of exact bibliography, the Society takes cognizance of all publications issued either wholly or partly under its auspices. Each author of a memoir published in THE NATIONAL GEOGRAPHIC MAGAZINE receives 25 copies, and is authorized to order any number of additional copies at a slight advance on the cost of press-work and paper: and these separate brochures are identical with those of the regular edition issued by the Society. Contributors to the magazine brochures are authorized to order any number of copies of their contributions at a slight advance on cost of press-work and paper, provided these separates bear the original pagination and a printed reference to the serial and volume from which they are extracted; but such separates are bibliographically distinct from the brochures issued by the Society. The *Magazine* is not copyrighted, and articles may be reprinted freely; and a record of reprints, so far as known, is kept.

The following separates and reprints from volume iv have been issued:

Edition uniform with the Brochures of the Magazine

Pages	1–18:	125	copies,	March	26,	1892.
"	19–84, plates 1–16:	500	"	"	21,	"
"	85–100,	125	"	"	18,	"
"	101–116, plate 17:	25	"	"	31,	"
"	117–162, plates 18–20:	225	"	May	15,	"

Special Editions

Pages	163–176:	50	copies,	without	covers,	February	10,	1893.
"	189–197:	25	"	"	"	"	"	"
"	198–200:	25	"	"	"	"	"	"
"	201–202:	25	"	"	"	"	"	"
"	v:	1,500	"	"	"	"	17,	"

Reprints

Pages	56–62,	plate 16:	50	copies,	with	covers,	March	30,	1892.
"	56–74,	" 16:	100	"	"	"	"	"	"

FOURTH ANNUAL REPORT OF THE SECRETARIES

(*Presented to the Society December 23, 1891*)

Membership.—The Society was organized in January, 1888, with a membership of 165. At the end of the first year the membership was 209; of the second, 228; of the third, 392, and at the end of this, its fourth year, the membership is 430.

Since the last annual meeting the membership has been increased by the election of 78 new members. It has been decreased by the resignation of 11 members; by the death of 3 members; by the failure to qualify of 14 members; by declining membership 8, and by the dropping of members for non-payment of dues 4. There has thus been a net increase of 38 members, and the present membership is 430, as above stated.

The deceased members were Mr Z. T. Carpenter, Hon William Windom, and Mr A. E. Woodward.

The membership is classified as follows:

Active	333
Corresponding	92
Life	5
Total	430

Meetings.—The Society has held 25 meetings during the year, of which 11 were for the reading and discussion of papers; 11 were free public lectures; one was a public lecture at which an admission fee was charged; one was a field meeting at Shendun, Virginia, June 3 and 4, and one was the annual business meeting. Of these, 15 were regular and 10 were special meetings.

Board of Managers.—The Board of Managers has held 17 meetings for the transaction of the business of the Society. The average attendance was 9; the largest attendance of the 17 members composing the board being 13, and the smallest 4.

There is one vacancy in the board, caused by the resignation of Captain Rogers Birnie, Junior, on May 15.

Explorations.—The work of exploration in Alaska begun last year was continued during the present one. Funds for the purpose were provided, as last year, in part by private subscription, in part by payment from the treasury of the Society, and in part by the United States Geological survey. Material aid was also kindly furnished by the Revenue Marine bureau of the Treasury department and by the Navy department in transporting the party from Puget sound to Alaska and return.

The exploration was led by Mr I. C. Russell, geologist, of the United States Geological survey, who with six men left Port Townsend May 30 on the United States revenue steamer *Bear*, Captain M. A. Healy commanding, and reached Icy bay, Alaska, June 6. A distressing accident occurred at the very beginning of the exploratory work. When landing in the surf at Icy bay, three boats were capsized, resulting in the drowning of six persons, viz, Lieutenant L. L. Robinson, Cockswain James Hassler, and seamen T. F. Anderson, Archibald Nelson and Henry Smith, and Will C. Moore, a member of Mr Russell's party.

This mournful accident did not, however, as it might easily have done, defeat the plans for the summer's work. After landing, the party at once proceeded on its difficult way across the broken ice of the Malaspina and Agassiz glaciers toward mount Saint Elias, and established a permanent camp at an elevation of about 8,000 feet. From this permanent camp a climb of about 6,500 feet more toward the summit was made, when they were driven back by storms. Stormy weather continued for 12 days, when it was decided to be unwise to wait longer merely for the purpose of scaling the summit. Reluctantly, therefore, the party returned to Icy bay, measured a base line about three miles long, and determined the altitude of mount Saint Elias by vertical angles taken from each end of the base line, the resulting height being 18,100 feet. This work completed, the party proceeded southward and eastward along the border of Malaspina glacier to Disenchantment bay, studying and photographing the peculiar phenomena there exhibited. Entering Disenchantment bay and proceeding toward its head, a large and hitherto unknown arm of the sea was discovered lying east of and parallel to the eastern shore of Yakutat bay. On October 8, the work of the season having been completed, the party was taken on board the United States steamer *Pinta*, Lieutenant-Commander Washburn Maynard commanding, transported to Sitka, and thence returned by mail steamer to Port Townsend.

INCORPORATED
A.D. 1888.

NATIONAL GEOGRAPHIC SOCIETY

President: Hon Gardiner G. Hubbard.
Vice-President of the Air: General A. W. Greely, U. S. Army.
Vice-President of Life: Professor C. Hart Merriam.
Vice-President of the Sea: Lieutenant Everett Hayden, U. S. Navy.
Vice-President of Geographic Art: Henry Gannett, Chief Topographer U. S. Geological Survey.
Vice-President of Land: Professor T. C. Mendenhall, Superintendent U. S. Coast and Geodetic Survey.
Vice-President of Commercial Geography: General R. N. Batchelder U. S. Army.
Secretary: Mr F. H. Newell (Washington, D. C.).
Corresponding Secretary: Miss E. R. Scidmore (Washington, D. C.).
Treasurer: Mr Charles J. Bell (Washington, D. C.).

GOLD MEDAL AND GEOGRAPHIC CERTIFICATES FOR 1893

The subject of the Essay in competition for the *Gold Medal and Geographic Certificates* of the National Geographic Society, for the year 1893, will be—

THE RIVER SYSTEMS OF THE UNITED STATES.

ANNOUNCEMENT.

The NATIONAL GEOGRAPHIC SOCIETY, with a view of encouraging the study of geography in the public schools of the United States, has instituted gold medals and certificates which are to be awarded annually, in each state, to such pupil of a public high school as shall write the best original geographic essay on a subject to be selected by a committee of the Society. It is intended that each essay shall pertain to the continent of North America, and that it shall be comprehensive in its scope and limited in its length, so as to afford opportunity for originality of treatment. The coöperation of State Superintendents of Education is sought by the Society. The best essayist of each state will receive a certificate of proficiency from the NATIONAL GEOGRAPHIC SOCIETY. The Geographic Gold Medal of the NATIONAL GEOGRAPHIC SOCIETY will be awarded to the best essayist of the entire country, while the second essayist will receive a certificate of honorable mention.

The subject of the essay for 1893 will be: The River Systems of the United States.

RULES.

1. Essays will be received only from such public high schools as formally announce their intention to compete by May 31, 1893.
2. All essays must be entirely composed by the student, who must certify on honor that he has not received aid from any person.
3. No essay shall exceed 2,000 words in length.
4. In each state the Superintendent of Public Schools, if his coöperation can be secured, will select, by such process as he deems advisable, the three best essays, which shall be passed on by a committee of the NATIONAL GEOGRAPHIC SOCIETY in order to select the best essay for each state and for the United States.
5. The certificate issued to the best essayist of each state shall set forth in proper terms that ——, being one of —— essayists from —— public high schools in the state of ——, is awarded this certificate by the NATIONAL GEOGRAPHIC SOCIETY for his proficiency in geographic science.
6. No certificate shall be awarded to any competitor unless, in the opinion of the judges, the essay offered possesses sufficient merit to justify such award.

It is desired that the superintendent of public schools in each state shall select, by such method as he deems advisable, the three best essays, and from the collection of such essays the committee of the NATIONAL GEOGRAPHIC SOCIETY will select the best essay for each state and for the United States.

One of the most important aims of the NATIONAL GEOGRAPHIC SOCIETY is to stimulate and make more practical the study of geography, particularly with reference to America. The Society therefore seeks the coöperation of all educational workers in making its labors more efficient and general. To this end, gifts for medals and scholarships are solicited, and identification with the Society by active membership and personal effort is suggested.

The Society already comprises among its active workers a considerable number of geographic scientists, who have given liberally of their time and efforts with a view of stimulating public interest in geographic education. The Society is a working one, and in its efforts to exercise an educational influence over the whole of the United States feels justified in asking liberal support from public-spirited citizens. The Society numbers over seven hundred members, and has active representatives in every state and territory.

General A. W. Greely, United States Army, Professor T. C. Mendenhall, Superintendent of the United States Coast and Geodetic Survey, and Professor W. B. Powell, Superintendent of Public Schools of the District of Columbia, constitute the committee charged with the award of the prizes for 1893.

The results of the season's exploration are believed to be valuable and important, and will be published the coming year in the National Geographic Magazine.

Publications.—During the year volume ii of the National Geographic Magazine was completed by the publication of number 5, consisting chiefly of administrative matter, together with title pages, indexes, etc., of both volumes i and ii.

The form of publication was changed early in the present year. The new rules adopted February 6 are printed on pages 311–314 of volume ii of the magazine. The general effect of the change instituted by these rules is to substitute for a publication at stated intervals, a publication of single papers or memoirs at irregular intervals, as offered and accepted for publication. Under this new mode of publication 204 pages of volume iii of the National Geographic Magazine have been published and distributed. The principal part of volume iii so far published consists of Mr Russell's report on the exploration of the mount Saint Elias region in 1890.

Marcus Baker,
C. A. Kenaston,
Secretaries.

FOURTH ANNUAL REPORT OF THE TREASURER

(*Presented to the Society December 23, 1891*)

To the President and Members of the National Geographic Society:

I have the honor to submit herewith my annual report, showing receipts and disbursements for the year ending December 23, 1891.

The receipts for dues for 1891 amount to $1,460, showing an increase over the receipts for 1890 of $171.

The assets of the Society are—

Note of M. N. Thompson, secured by deed of trust...	$750 00
Cash with Bell & Co....	36 39
Dues for 1891, unpaid....	214 00
	$1,000 39

The liabilities are—

Balance due on note of Bell & Co....	$500 00
Interest on above note to date....	22 50
Outstanding bills, not yet presented (about)....	80 00
	$602 50

C. J. Bell,
Treasurer.

Dr. THE TREASURER *in account with* THE NATIONAL GEOGRAPHIC SOCIETY. Cr.

Date	Item		Amount
1891.			
Dec. 23.	To balance on hand Dec. 26, 1890		$41 62
	Cash received for dues: 1889	5 00	
	" " " " 1890	146 00	
	" " " " 1891	1,460 00	
	" " " " 1892	30 00	
	" " " life membership	50 00	
			1,691 00
	Proceeds from lecture		141 00
	Interest on loan		45 00
	Subscriptions to mount St Elias expedition		85 50
	Loan from Bell & Co.		750 00
	Subscription to the publication fund		100 00
			$2,854 12

Date	Item	Amount
1891.		
Dec. 23.	By cash paid for—	
	Preparation of report, mount St Elias expedition, 1890	$124 60
	Publication of the magazine	988 25
	Expenses of meetings and lecture	615 70
	Rent of Cosmos Club hall	39 00
	Clerical assistance to the secretary and treasurer	220 00
	Subscription to mount St Elias expedition	328 31
	Bell & Co., on account of note	250 00
	Sundries, including postage, freight, stationery, joint directory, &c.	251 87
	Balance on hand (on deposit with Bell & Co)	36 39
		$2,854 12

WASHINGTON, D. C., *December 23, 1891.*

C. J. BELL, *Treasurer.*

REPORT OF THE AUDITING COMMITTEE

(*Presented to the Society January 8, 1892*)

To the President and Members of the National Geographic Society:

We, a committee appointed at the annual meeting of the Society to audit the accounts of the Treasurer for the year ending December 23, 1891, beg to submit the following report:

The statement of the receipts, consisting of dues from members, receipts from lecture, interest on loan and subscriptions to the exploration fund, has been examined and found correct.

The vouchers for expenditures and checks in payment therefor have been examined, compared and found correct.

We have examined the bank book, showing the account with Messrs Bell & Co, and found the balance to be $36.39, as reported.

P. H. Christie,
E. E. Haskell,
Middleton Smith,
Committee.

PROCEEDINGS

OF THE

NATIONAL GEOGRAPHIC SOCIETY

(Abstract of Minutes)

January 22, 1892. *61st meeting.*

Meeting held in the Assembly Hall of the Cosmos Club. Mr G. K. Gilbert in the chair.

On motion it was voted that the amendment to the By-laws proposed December 23, 1891, be adopted, viz: In article iv, instead of five vice-presidents read "six vice-presidents," and insert at the end of the list of departments of geographic science, after geographic art, the words "commercial geography."

The vice-presidents delivered their annual reports.

Mr Ogden, for the department of the geography of the land, spoke of the progress made in methods of geodetic work.

Mr Hayden, for the department of geography of the sea, spoke on the subject of "Transatlantic steam lanes," exhibiting three charts showing the changes in position of these lanes.

General Greely's report, on the geography of the air, was read by title. *Printed in this volume, pages 85-100.*

Mr Gannett, for the department of geographic art, read a paper on "Mother maps of the United States," illustrating his statements by a large map showing diagramatically the value for mapping purposes, of the various surveys in the United States. *Printed in this volume, pages 101-116, plate 17.*

January 29, 1892. *Special meeting.*

Meeting held in the Lecture Hall of Columbian University. Vice-President Hayden in the chair. Attendance, 400.

Professor C. A. Kenaston read a paper on "The Bryant Expedition to Grand Falls, Labrador," and at the conclusion showed a number of lantern slides made from photographs taken during the course of the expedition.

February 5, 1892. *62d meeting.*

Meeting held in the Assembly Hall of the Cosmos Club. Mr G. K. Gilbert in the chair. Attendance, 80.

The following amendment to the By-laws was proposed: In article III, last paragraph, strike out all words following "nominations for membership," etc, so that the paragraph shall read "The election of members shall be intrusted to the Board of Managers."

Dr C. Willard Hayes read a paper on "A new track in Alaska," describing a new route pursued by the Schwatka party, of which he was a member, in the explorations of last year, and illustrating the relative positions by a large wall map. *Printed in this volume, pages 117–162, plates 18–20.*

February 12, 1892. *Special meeting.*

Meeting held in the Lecture Hall of Columbian University. Vice-President Ogden in the chair. Attendance, 200.

Professor Charles Sprague Smith delivered a lecture on "Iceland," illustrating his subject by lantern slides showing views in portions of the island and various objects of interest in connection with its history.

February 19, 1892. *63d meeting.*

Meeting held in the Lecture Hall of Columbian University. President Hubbard in the chair. Attendance, 200.

Mr Lysander Dickerman read a paper on "Art and architecture of the ancient Egyptians," exhibiting on the screen a large number of photographs of ancient temples and pyramids.

February 24, 1892. *Special meeting.*

A social meeting was held at Wormley's hotel from 9 to 12 p m for the purpose of bringing the members together for mutual acquaintance. Attendance, 220.

February 26, 1892. *Special meeting.*

Meeting held in the Lecture Hall of the National Museum. Attendance, 150.

Mr Gilbert Thompson read a paper on "Military surveying during the Civil War," and was followed by Major Jed. Hotchkiss, who graphically described the map-making operations of the topographers of the Confederate army, showing at the same time numerous original maps of historical value.

March 4, 1892. *64th meeting.*

Meeting held in the Assembly Hall of the Cosmos Club. Vice-President Hayden in the chair. Attendance, 150.

By vote of the Society the following amendment to the By-laws was adopted: In article III, last paragraph, strike out all words following "Nominations for membership," etc, so that the paragraph shall read: "The election of members shall be intrusted to the Board of Managers."

The subject of the evening, the "Alaskan Boundary Survey," was introduced by Dr T. C. Mendenhall, who was followed by Mr John E. McGrath and Mr J. Henry Turner. The papers were illustrated by lantern slides. Remarks were afterward made by Dr George M. Dawson. *Printed in this volume, pp. 177–197.*

March 11, 1892. *Special meeting.*

Meeting held in the Universalist church. President Hubbard in the chair. Attendance, 350.

Mr Joseph Stanley-Brown delivered an address on "The Seal islands of Alaska," illustrated by pictures of the islands.

March 18, 1892. *65th meeting.*

Meeting held in the Lecture Hall of the National Museum. Vice-President Ogden in the chair. Attendance, 250.

Mr G. K. Gilbert read a paper on "Coon butte and the canyon Diablo meteorites." A number of lantern slides were exhibited, illustrating the topography and geology of the area, and two large meteorites were also shown.

March 25, 1892. *Special meeting.*

Meeting held in the Lecture Hall of the National Museum. Mr G. K. Gilbert in the chair. Attendance, 305.

Dr W. A. Croffut gave a sketch of a trip through Greece and Palestine, describing in particular the city of Jerusalem and the church of the Holy Sepulchre, illustrating his remarks by lantern slides.

April 1, 1892. *66th meeting.*

Meeting held in the Lecture Hall of the National Museum.

Professor Leslie A. Lee, of Bowdoin College, gave an illustrated lecture on the "Cruise of the *Albatross* through the Straits of Magellan."

April 8, 1892. *Special meeting.*

Meeting held in the Lecture Hall of the National Museum. Vice-President Hayden in the chair. Attendance, 375.

Lieutenant C. H. Harlow, U S N, gave a description of a trip through Bolivia, illustrating his topic by lantern slide views taken at various points in the country.

April 15, 1892. *67th meeting.*

Meeting held in the Lecture Hall of the National Museum. Attendance, 435.

Mr W. H. Holmes, of the Bureau of Ethnology, gave an illustrated lecture on the "Cliff Dwellers." At the close of the lecture remarks were made by Major J. W. Powell.

April 22, 1892. *Special meeting.*

Meeting held in the Lecture Hall of the National Museum. President Hubbard in the chair. Attendance, 400.

Dr John Murray, F R S E, gave a description of the cruise of the *Challenger* and summed up some of the results of the investigation of the ocean bottom. The descriptions of the deep-sea mud and ooze were profusely illustrated by lantern slides.

April 29, 1892. *68th meeting.*

Meeting held in the Assembly Hall of the Cosmos Club. Vice-President Hayden in the chair. Attendance, 100.

Lieutenant S. W. B. Diehl, U S N, gave a lecture on "The compensation of the compass on board iron ships," illustrating his remarks by diagrams, and exhibiting a ship's binnacle together with the various magnets and other apparatus employed.

Professor Cleveland Abbe spoke briefly on terrestrial magnetism.

May 6, 1892. *Special meeting.*

Meeting held in the Lecture Hall of the National Museum. Vice-President Hayden in the chair. Attendance, 268.

Reverend Professor John P. Peters delivered a lecture on "Mesopotamia," describing the country and his experience there during his two seasons' work of excavation. A large number of lantern slides were shown.

May 13, 1892. *69th meeting.*

Meeting held in the Lecture Hall of the National Museum. Vice-President Hayden in the chair. Attendance, 307.

Mr Talcott Williams delivered an address on "The gates and straits of Europe," describing the influence of the surface configuration on the development of civilization.

May 20, 1892. *Special meeting.*

Meeting held in the Builders' Exchange Hall. President Hubbard in the chair. Attendance, 700.

Mrs M. French-Sheldon gave a description of her journey in Africa, illustrating her remarks with lantern slides made from photographs taken on the trip.

May 27, 1892. *Field meeting.*

About 75 members left Washington for Annapolis, where they were received by the secretary of state of Maryland and welcomed on behalf of Governor Brown, who was detained at Baltimore. The historic State House was first visited, and, after dinner, the Chase mansion. Proceeding then to the Naval Academy, the members were, through the kindness of Superintendent Phythian and Commandant Chester, transferred to the cruiser *Philadelphia*, which, with other vessels of the squadron, was anchored in the bay. Returning to the grounds, the party was enabled to witness dress parade. After supper the Society, through the courtesy of the Governor, held a meeting in the House of Delegates, addresses being made by Messrs Gilbert, McGee, D. J. Randall, and W. J. Hull, the two gentlemen last named giving incidents of the history of the place. Following this was an original poem by Mr Croffut. On motion of Reverend Gilbert F. Williams, it was voted "That the thanks of this Society be extended to the governor of the state of Maryland for his courteous tendering of this room for the meeting of the Society and for the privilege of entrance to every part of this historic building; that our thanks be also extended to the superintendent of the Naval Academy and to Captain C. M. Chester, U S N, for giving the Society the opportunity of visiting one of the new cruisers of the navy and also for the special parade at the academy; also to the lady managers of the old Chase mansion for the opportunity of inspecting that building, and to

Messrs Randall and Hull for the interesting narratives of incidents of local history." At the close of the meeting the Society returned to Washington.

November 11, 1892. *70th meeting.*

Meeting held in the Assembly Hall of the Cosmos Club. President Hubbard in the chair. Attendance, 25.

In the absence of the Secretary, Mr Baker was elected Secretary *pro tempore.*

The evening was devoted to a consideration of the program of exercises for this session. The President announced it as thus far drafted, and invited suggestions. It was generally understood that the program should consist of a series of popular lectures, alternating with meetings to be held at the Cosmos Club Hall, of somewhat more informal character and devoted to short or technical papers, with discussions.

November 25, 1892. *71st meeting.*

Meeting held in the Assembly Hall of the Cosmos Club. Vice-President Greely in the chair. Attendance, 40.

Mr W J McGee gave an address on "Geographic changes produced by earthquakes," describing phenomena observed within the area of the New Madrid earthquake of 1811 to 1813.

December 2, 1892. *Special meeting.*

Meeting held in the Universalist Church. Vice-President Greely in the chair. Attendance, 500.

Miss Annie S. Peck, of Providence, Rhode Island, delivered an illustrated lecture on "Athens, the modern city of Greece."

December 9, 1892. *72d meeting.*

Meeting held in the Assembly Hall of the Cosmos Club. Vice-President Greely in the chair. Attendance, 80.

Mr Henry Gannett, Geographer of the Eleventh Census, read a paper on "Movement of population in the United States," illustrated by about 40 charts. The paper was discussed by Messrs Ogden, Baker, Gilbert, Thompson, Johnson and Greely. *To be printed in volume V.*

December 16, 1892. *Special meeting.*

Meeting held in the Builders' Exchange Hall. Vice-President Greely in the chair. Attendance, 400.

Mr Romyn Hitchcock read a paper on "China," especial reference being made to a trip from Shanghai to Pekin. The lecture was illustrated by a number of stereopticon views made from photographs taken on the trip, including a number showing the great wall of China.

December 23, 1892. *73d (5th annual) meeting.*

Meeting held in the Assembly Hall of the Cosmos Club. President Hubbard in the chair. Attendance, 40.

Professor W. B. Powell, Superintendent of Public Schools, read a paper on "Methods of teaching geography in the Schools." The paper was discussed by General Greely and Dr Mendenhall.

After a recess the 5th annual meeting convened.

The joint report of the Secretaries was presented and adopted.

The annual report of the Treasurer was presented and referred to an auditing committee consisting of Messrs Winston and Wainwright and Dr Anita Newcomb McGee.

The annual election of officers for the year 1893 was then held, with the following result:

President—Gardiner G. Hubbard.

Vice-Presidents—H. G. Ogden (land);
Everett Hayden (sea);
A. W. Greely (air);
C. Hart Merriam (life);
Henry Gannett (art);
R. N. Batchelder (commercial geography).

Treasurer—C. J. Bell.

Recording Secretary—F. H. Newell.

Corresponding Secretary—Eliza Ruhamah Scidmore.

Managers—Marcus Baker,
H. F. Blount,
G. K. Gilbert,
John Hyde,
W J McGee,
T. C. Mendenhall,
W. B. Powell,
Edwin Willits.

FIFTH ANNUAL REPORT OF THE SECRETARIES

(*Presented to the Society December 23, 1892*)

Membership.—The membership of the Society is now 693. It is continuing to increase, and by the coöperation of all interested should, it is to be hoped, soon reach 1,000. The rate of progress is shown by the following figures.

At the end of the first year, 1888, the membership was 209; at the end of 1889 it was 228, an increase of 9 per cent; at the end of 1890 it was 392, an increase during the year of 72 per cent; at the end of 1891 it was 430, an increase of 10 per cent, and at the end of 1892 it is 693, or an increase of 61 per cent.

Classifying the membership, it is found that there are 478 active, 208 corresponding, and 7 life members. Taking the active members alone, the total number at the end of 1890 was 331; at the end of 1891, 333, an increase of 2 only, and at the end of 1892, 478, an increase of over 40 per cent. The greatest relative gain is in the corresponding membership, the number increasing from 57 in 1890 to 92 in 1891 and to 208 in 1892, a gain in the last year of over 100 per cent.

It may be well to note at this point that the corresponding members, being non-resident, are not able to take advantage directly of the meetings of the Society, and that their interest in the organization is sustained mainly by the publications. Continual addition to the membership of this class, therefore, must necessitate greater attention to the demands of readers of geographic literature.

During the year 323 members have been elected, 23 members have resigned, 5 died, 6 declined membership, 13 failed to qualify, and 13 have been dropped for non-payment of dues. The net increase thus has been 263, and the present total membership is 693, as stated above. The deceased members were: E. J. Pond, January 23, 1892; Dr J. H. Chapin, March 14, 1892; Professor John Goodison, October 19, 1892; Lieutenant Frederick Schwatka, November 2, 1892 and Captain John M. Dow, November 4, 1892.

Meetings.—There have been 30 meetings or assemblies of the members of the Society. Of these 14 were regular meetings and

16 special. The latter number includes one social at Wormley's hotel on February 24, a field meeting at Annapolis, Maryland, on May 27, and also the lawn party at Twin Oaks, where by invitation of the President fully 300 members and guests were handsomely entertained.

One of the regular meetings was for the election of officers and transaction of business. The remaining 26 meetings, regular and special, were devoted mainly to lectures or reading of papers, and the average attendance was 242. On 15 evenings the lectures or papers were illustrated by use of the stereopticon, and on these evenings the attendance averaged 316. When lantern slides were not used the average attendance was 131, or less than half.

There has been no regularity in regard to place of meeting. The hall of the Cosmos club has been used 9 times, there being an average of 85 members and guests present; the hall of Columbian University 4 times, the audience averaging 225 persons; the National Museum lecture-room 10 times, averaging 290 persons, and other halls or churches 4 times, averaging 500 persons.

The subjects under discussion by the various speakers have been widely diverse, embracing nearly every quarter of the globe. Greatest attention has been paid to northern regions, 6 evenings being devoted to Alaska, Greenland, Iceland, Labrador, etc.

Managers.—The Board of Managers have held 18 meetings for the transaction of business of the Society. Of these 15 were regular and 3 special. The highest attendance of the 17 members was 15, and the average was about 9.

No explorations have been attempted, but the efforts of the managers have been directed toward strengthening the Society in every way.

A change in the By-laws was adopted March 4, 1892, by which the election of new members was greatly facilitated, being left more directly in the hands of the Board of Managers. A new office, that of Vice-President of commercial geography, was created at the beginning of the year, but as yet remains unfilled.

Publications.—During the year six brochures have been published, one of these forming the last number of volume iii and five the larger portion of volume iv of the magazine.

F. H. Newell,
Eliza R. Scidmore,
Secretaries.

FIFTH ANNUAL REPORT OF THE TREASURER

(Presented to the Society December 23, 1892)

To the President and Members of the National Geographic Society:

I have the honor to submit herewith my annual report, showing receipts and disbursements for the year ending December 23, 1892.

The receipts for dues for 1892 amount to $2,165, an increase over the receipts for 1891 of $705.

The assets of the Society are:

Amount invested in American Security and Trust Company 5 per cent bonds	$300 00
Cash with Bell & Company	205 31
Dues for 1892, unpaid	271 00
	$776 31

The liabilities are:

Outstanding bills (about)	$215 00

The cash on hand includes $50, dues for one life membership, which should be reserved and invested in accordance with instructions received from the Board of Managers.

Very respectfully,

C. J. Bell,
Treasurer.

DR. THE TREASURER *in account with* THE NATIONAL GEOGRAPHIC SOCIETY. CR.

Date			
1892.			
Dec. 23.	To balance on hand Dec. 23, 1891		$36 39
	Cash received for dues: 1889	5 00	
	" " " " 1890	32 00	
	" " " " 1891	117 00	
	" " " " 1892	2,165 00	
	" " " " 1893	95 00	
	" " " life membership	50 00	
			2,464 00
	Subscriptions to publication fund		110 00
	Note of M. N. Thompson, $750, and interest, $22.62		772 62
	Interest on investment		4 43
	Sales of magazine		423 91
			$3,811 35

Date		
1892.		
Dec. 23.	By cash paid for—	
	Publication of magazine	$1,019 76
	Expenses of meetings	831 63
	Clerical assistance to the Secretary and Treasurer	240 00
	Balance of note, Bell & Co, $500, and interest, $25.54	525 54
	American Security and Trust Company, 5 per cent bonds at par (life membership dues invested)	300 00
	Deficit on social meeting, $70.09, and on annual excursion, $43.47	113 56
	Subscription to Robinson relief fund	100 00
	Subscription to Royal Scottish Geographical Magazine	73 26
	Sundries, including postage, freight, stationery, joint directory, &c	402 29
	Balance on hand (on deposit with Bell & Co)	205 31
		$3,811 35

WASHINGTON, D. C., *December 23, 1892.*

C. J. BELL, *Treasurer.*

REPORT OF THE AUDITING COMMITTEE

(*Presented to the Society January 6, 1893*)

To the President and Members of the National Geographic Society:

We, a committee appointed at the annual meeting of the Society to audit the accounts of the Treasurer for the year ending December 23, 1892, beg to submit the following report:

The Treasurer's statement of the receipts, consisting of dues from members, interest on investments and sale of magazines, has been examined and found correct, as shown by the books of his office.

The vouchers for expenditures and checks in payment therefor have been examined, compared, and found correct.

We have examined the bank book, showing the account with Messrs Bell and Co, and found the cash balance to be two hundred and five and thirty-one hundredths dollars ($205.31), as stated.

The three bonds for $100 each, registered in the name of the Society, were submitted to us for inspection.

Isaac Winston,
D. B. Wainwright,
Anita Newcomb McGee, M D,
Committee.

Vol. IV, pp. 1-18 March 26, 1892

THE

NATIONAL GEOGRAPHIC MAGAZINE

THE

EVOLUTION OF COMMERCE

ANNUAL ADDRESS BY THE PRESIDENT

HON GARDINER G. HUBBARD

WASHINGTON
Published by the National Geographic Society

Price, 25 cents.

VOL. IV, PP. 1-18 MARCH 26, 1892

THE

NATIONAL GEOGRAPHIC MAGAZINE

THE EVOLUTION OF COMMERCE.

ANNUAL ADDRESS BY THE PRESIDENT,

HON GARDINER G. HUBBARD.

(Presented to the Society January 15, 1892.)

For over three thousand years the great highway for commerce has been from India by the Persian gulf and the Euphrates or by the Red sea to the Mediterranean, and thence through the Mediterranean by Gibraltar to western and northern Europe, and in our day thence to America.

Along this route cities and nations have sprung up, increased in wealth and power, and passed away, giving place to other cities and nations further westward. These nations have been great carriers and distributors of minerals and goods, as well as capitalists and bankers, or carriers, bankers and manufacturers; in either case controlling the commerce of the world. This control has never for any long period been held by the same race, but has passed from one nation to another, always from the east toward the west.

The earliest highway of commerce was from India through the Persian gulf, up the Euphrates to the Mediterranean; and carpets and precious stones were then as now carried over this route. Explorations and surveys for a railroad have been recently made along this "our future highway to India." Caravans brought spices from Arabia and rich stuffs from Babylon and Nineveh to the shore of the Red sea. Solomon made a navy of ships and Hiram sent in the navy his "Servants, shipmen that had knowledge of the sea, and they brought gold from Ophir, great plenty of almug trees, and precious stones."

Tyre and Sidon founded colonies on the shores of the Mediterranean, enslaving the Spaniards and compelling them to work the mines of gold and silver already opened in Spain. Their ships sailed through the Mediterranean, by the Pillars of Hercules, into the Atlantic ocean, turning northward to England for tin and copper and on into the Baltic sea for furs and amber; turning southward along the western coast of Africa, passing certainly two thousand miles to the equator and probably rounding the cape of Good Hope into the Indian ocean. Products from the west were brought in ships to Tyre and Sidon and exchanged for the goods of the east, their merchants making profits on each transaction both as merchants and as carriers. Tyre and Sidon became wealthy, luxurious, and effeminate. Some of their citizens saw in Africa a richer soil and a better situation for a large city, and founded Carthage. The Carthagenians inherited the trade of Tyre and Sidon, and in addition opened highways to Egypt and into the interior of Africa, bartering their wares in Egypt for corn and grain and in Africa for ivory, gems and slaves. They planted colonies in Africa and Sicily, and for a time were successful rivals of Greece and Rome.

The rule of the ocean transferred from Asia to Africa remained there but a short time, for the day of Europe came with the rise of Greece and Rome.

The Greeks founded colonies in Asia Minor, Sicily, and Italy. The ruins of great cities with Grecian temples and amphitheaters are found at Girgenti and Syracuse in Sicily, at Pæstum and other places in Italy. Under Pyrrhus, their armies were defeated by the Romans and her colonies captured. Deprived of these, her power rapidly declined and she became a Roman province.

Rome.

Rome founded few colonies, but she conquered the nations of Asia, Africa, and Europe, and brought under her sway cities, kingdoms and empires. She boasted of five hundred cities in her Asiatic province that had been founded or enlarged and beautified by the Cæsars. One hundred and twenty vessels each year brought the goods of India from the delta of the Ganges, and large fleets from Egypt came laden with corn and grain. She imported from every country, but exported little, paying for her imports by taxes levied on her colonists.

A. D. 200. Rome was the first power to incorporate conquered states into her dominion and extend citizenship to all the people in her empire; so that Paul could say in truth, "I am a Roman citizen and to Cæsar I appeal." So salutary and beneficial was her rule that under it these countries prospered more than under their own rulers. What Rome seized with strong hand she defended, and in return for taxation gave protection. She has no more enduring monument than her roads, the remains of which are now found in every country of Europe. Though built as military and post-roads, they were used largely for commerce. All started from the golden mile-stone in the forum; one ran over the Brenner pass northeastward to the Baltic sea, another followed the northwestern coast of the Mediterranean to Spain and southern France, another crossed the Alps and extended through France to the British channel and through England to Scotland, where the Romans built a wall, ruins of which now bear witness to its strength. Another way went southward to Naples and Brindisi, and another led eastward to Macedonia and Greece. As these were the only roads in all these countries, it was truly said, "All ways lead to Rome;" and over them the messengers of Cæsar travelled more rapidly than the mail-carrier of our fathers on our mail routes.

Venice and Genoa.

After five hundred years of empire Rome fell, and the dark ages followed. From A. D. 400 to A. D. 800 commerce and trade died out. The only vessels on the Mediterranean and Baltic were piratical crafts; Jerusalem and the Holy Land were captured by the Turks; the Crusades began, forerunners of a higher civilization and more extended commerce. Thousands and tens of thousands of people from all parts of Europe and all ranks of life, bearing the pilgrim's badge—the blood-red cross,—journeyed toward the Holy Land, first in vast crowds led by 1096–1291. Peter the Hermit, then in great armies led by kings and generals. For two hundred years this movement continued. Venice and Genoa furnished ships to carry the armies of France from Italy to the Holy Land. The Venetians were shrewd merchants and drove hard bargains, stipulating for cessions of land at the best commercial points and adequate compensation for their services. After the failure of each Crusade they brought back remnants of the troops and pilgrims, and with them the products of Asia Minor, and books and art treasures from Greece. These were distributed all over Italy, and led to the renaissance of the thirteenth and fourteenth centuries.

The trade with the east brought power and wealth to Venice and Genoa. They founded colonies on the Black sea, in Asia Minor, and on the Asiatic coast. Venice alone had three thousand merchant vessels. Their commerce was not confined to the borders of the Mediterranean, for the goods of the Orient were distributed by the way of Augsburg and Nuremberg to the interior of Germany and to the towns of the Hanseatic confederation. Thus commerce was opened with the interior of Europe.

By the failure of the Crusades the power of the Turks,
1450. which had been for the time checked, grew and increased.
They conquered the holy places of the earth, Asia Minor and Syria, and finally, crossing into Europe, gained Constantinople. The colonies of Venice and Genoa were captured; their fleets disappeared from the Mediterranean. In western Europe the Spaniards under Ferdinand and Isabella conquered the Moors, who for many ages had occupied the larger portion of Spain; and as the Crescent appeared in eastern Europe, the Cross triumphed in the west.

Spain and Portugal.

Then a new power appeared upon the stage. Spain and Portugal entered upon an era of exploration and discovery in regions unknown to Venice and Genoa. Commerce, which in the middle ages had been confined to the Mediterranean sea, was now extended to the countries on the Atlantic ocean, and the Cape Verde islands, Madeira, and the Canaries were discovered. In one generation (between 1470 and 1500 A. D.) more and greater discoveries were made than in any other period of the world's history. The Portuguese sailed along the eastern coast of Africa and rounded the cape of Good Hope; Vasco de Gama crossed the Indian ocean to India; Columbus sailed westward to find the Orient, and discovered a New World; Magellan circumnavigated the globe; Balboa crossed the isthmus of Panama and was the first to see, on the same day, the sun rise out of the Atlantic and set in the Pacific; and soon the eastern and western coasts of America were explored from Newfoundland to cape Horn and from cape Horn to Panama.

Both Portugal and Spain claimed all the new world, and as they could not agree upon a division of territory they referred the matter to the pope, who divided the new world between them. The Atlantic became the great highway for commerce, while the Mediterranean was deserted, and Venice and Genoa existed only in the past.

The commerce of Portugal was coextensive with her dominion, which extended from Japan and the Spice islands and India to the Red sea, thence to the cape of Good Hope; and with their possessions on the eastern and western shores of the Atlantic and in Africa and Brazil completed their maritime empire, the most extensive the world has ever seen. Then a single fleet of one hundred and fifty to two hundred and fifty caracks sailed from the port of Goa to Lisbon; now there sails but one vessel a year from all India.

From Spain ships sailed both to the Caribbean sea and to cape Horn and thence to Chile and Peru, or directly northwestward from cape Horn to the Philippine islands. Spain conquered Mexico, Central America, and all South America except Brazil. The gold and silver of Peru and Chile and the goods of the Orient were brought to Spain and Portugal. As their wealth and power increased the spirit of exploration decreased, and for nearly two hundred years the Spanish ships sailed in a fixed course by the same lanes, exploring the ocean neither toward the north nor the south, leaving undiscovered the great continent of Australia and numerous groups of islands.

The Spanish and Portuguese leaders were cavaliers who despised all commerce excepting in gold and silver, all kinds of manufactures, all manual labor, and the cultivation of the ground; they came not to colonize, but to satisfy by the labor of the enslaved aborigines their thirst for gold and silver. The whole political power was retained by the king of Spain and administered by Spaniards. While the silver and gold of America and the wealth of the Indies poured into the treasuries of Spain they wanted nothing more. Like ancient Rome, they took all the wealth of the conquered countries, making no return; but they did not, like Rome, give wise and equitable laws and a stable government to the countries they conquered.

The Netherlands.

The inhabitants of the Netherlands were manufacturers, and supplied the markets of Spain and Portugal and their colonies, thus reaping as large profits from their trade with these countries as the Spanish and Portuguese from the mines of gold and silver.

No part of Europe, says Motley, seemed so unlikely to become the home of a great nation as the low country on the northwestern coast of the continent, where the great rivers, the Rhine and Scheldt, emptied into the North sea, and where it was hard to tell whether it was land or water. In this region, outcast of ocean and earth, a little nation wrested from both domains their richest treasures.

The commerce of the Hanseatic towns, which had depended for their trade on Venice and Genoa, became less and less as the glory of those cities waned. Antwerp, with its deep and convenient rivers, stretched its arms to the ocean and caught the golden harvest as it fell from its sisters' grasp. No city, except Paris, surpassed it in population, none approached it in splendor. It became the commercial center and banker of Europe; five thousand merchants daily assembled on its exchange; twenty-five hundred vessels were often seen at once in its harbor, and five hundred daily made their entrance into it. The manufactures of Flanders and the Netherlands had been noted for many generations, and now vastly increased and were distributed all over the world. The Netherlands, though the smallest, became the wealthiest nation of Europe. Then came the long-continued war with Spain, ending in the siege and fall of Antwerp and in the imposition of such taxation as no other country had ever endured. As Antwerp had grown on the ruins of the Hanseatic towns, so her fall became England's gain.

France and England.

In America, north of Mexico, neither silver nor gold had been found to tempt the Spanish and Portuguese. The larger portion of the northern Atlantic coast was one long sand beach, broken by great estuaries and the mouths of great rivers; the rest was rocky and rugged, the temperature generally cold, the land unfertile and barren. For these reasons North America was left to the French and English. The French claimed Canada and the whole of the territory of the United States save a narrow strip of land on the Atlantic coast. The French population was small and was made up principally of fur traders and half-breeds; Great Britain held New England, Virginia and the Carolinas.

After the first fever of religious colonization had passed, about the commencement of the eighteenth century, there was scarcely any emigration from England to America and but little trade between the two countries. The population of North America was small, its commerce less, with little profit to the European merchants. The country possessed no peculiar advantages for the production of articles of value in foreign markets; there was nothing, therefore, to invite immigration or commerce.

The chief inducement to the English to navigate the Atlantic was the hope of capturing the treasure-laden Spanish galleons and the rich Spanish cities.

Sir Francis Drake, Sir Walter Raleigh, and other navigators, aided by Queen Elizabeth, with bands of buccaneers, refugees from all countries though mostly Englishmen, explored the recesses of the Caribbean sea, crossed the isthmus of Panama, and launched their little vessels on the Pacific. In fifteen years they captured five hundred and forty-five treasure ships, sacked many towns, trained the English seamen, and laid the foundation for the navy of Great Britain.

The growth of English commerce was slower than that of Spain, Portugal or Holland, and it was not until the middle of the eighteenth century, or two hundred and fifty years after the discovery of America, that she entered upon that career which gave her the control of the ocean. Her commerce was built up by protective laws, founded on the Navigation Act of 1651, which prohibited foreign vessels from carrying to or from England the commerce of any country but its own. These laws were universally regarded as among the chief causes and most important bulwarks of the prosperity of Great Britain, and they were continued until English ships controlled the carrying trade of the world, and were not finally repealed until 1854.

The mechanical devices of Watt, Arkwright, and other great inventors gave to England that supremacy in manufactures which she has ever since retained. The French revolution a little later aroused the fear of the statesmen, merchants, and capitalists of England that the energy of the new republic would be as omnipotent in mercantile affairs as on the field of battle. They believed that France might regain the colonies and with them the commerce she had lost, and therefore England declared war against Napoleon, which was carried on almost continuously from 1793 to 1815. The shipping of the continent disappeared or was captured by the fleets of England; the colonies, and with them the commerce, of Spain and Portugal, Holland and France, passed to England; and though she is still burdened with the debt then created, she has never lost the commerce and carrying trade she then obtained.

The population of the colonies of Great Britain is about one-sixth of the entire population of the globe; and their territory comprises eighty per cent of the available temperate regions of the earth belonging to the Anglo-Saxon race.

The commerce of England has given wealth to her bankers and merchants, and employment to her artisans, ship-builders, iron-workers, miners and manufacturers. Her exports of produce and manufactures have increased five hundred per cent in fifty years, or from $356,000,000 in 1840 to $1,577,000,000 in 1890, and are carried by her ships to every quarter of the globe. Though dependent on America for her food supplies, these are moved in British ships. The commerce of the world pays tribute to the bankers of London and makes that city the money center of the world. Her best market is India, and from India comes her largest imports; next to these from the United States.

India.

Egypt, Nineveh and Babylon in prehistoric times, Tyre and Sidon and Greece under Alexander, Carthage and Rome under the Cæsars, Venice and Genoa in the middle ages, Portugal and Holland, and lastly England, have drawn great stores of wealth from India.

From India science and literature were handed on to Europe, and from India has come the religion of more than half of the human race. For India the Spanish sailed westward; for India the Portuguese sailed eastward; Portugal was the first to reach the goal and obtain the prize. Greater riches have been drawn from India than from the gold and silver mines of America, since for all ages it has been the storehouse from which treasures were derived. Portugal held India from about 1500 to 1600. Ships brought the silks and precious stones of India to Lisbon, where they were sold to the Dutch and distributed by them through Europe. Spain conquered Portugal, and to avenge herself on Holland excluded her merchants from Lisbon. They then sailed directly for India, dispossessed the Portuguese, and the commerce of India was for the next hundred years controlled by Holland.

Then for a short time India was divided between France and England, but under Lord Clive and Warren Hastings the possessions of France passed to the East India company, and when their charter expired it was made a province of the crown and the Queen of England became Empress of India.

Unlike Rome and Spain in their dealings with conquered nations, England gives a fair exchange for all she takes, and rules in India for India, giving a more stable and equitable government than India ever before enjoyed.

Today Tyre, Sidon, and Carthage are known only by their ruins; the glory of Greece and Rome, of Venice and Genoa, has passed; the power of Spain and Portugal has waned, while India is developing a social, moral, and political prosperity, with wealth and commerce unknown in any former period of her history.

Suez Canal.

Much of the trade of India in ancient times passed through a canal connecting the Red sea with the Mediterranean, the remains of which still exist, and efforts to reopen it have been made at different times by Egypt without success. In 1856 de Lesseps obtained concessions from the khedive for the Suez canal, and commenced the work under the direction of the best engineers of Europe. De Lesseps applied to English capitalists for help, but they were deterred by Lord Palmerston, who said he "Would oppose the work to the very end." Mr Stevenson, the engineer, supported Lord Palmerston, declaring that "The scheme was impracticable, except at an expense too great to warrant any expectation of returns." The emperor of France lent his name to the company, and large sums of money were raised in France; but the canal was constructed mainly by the money and laborers of Egypt. It was opened in 1869, and immediately English steamers began to sail through the canal, and the route around the cape of Good Hope was almost abandoned. Other flags soon followed, and the commerce with India and the east, so long lost to Venice and the ports of the Mediterranean, was revived.

In 1875 Lord Beaconsfield purchased for England a controlling interest in the Suez canal, and England now rules both Egypt and the canal. The vessels of all the maritime nations of the world are constantly passing through the canal, with the single exception of those of the United States.

Colonies.

The commerce of the great nations of the world has been principally with their colonies or dependencies, and from this commerce they have derived their wealth. The mother country in return for its real or nominal protection, and for its own aggrandizement, has restricted the commerce of her colonies.

The European nations adopted four classes of restrictions :

1. Restricting the exportation of goods from the colony except to the mother country.

2. Restricting the importation of goods from foreign countries into the colonies.

3. Restricting the exportation or importation of goods excepting in ships of the mother country.

4. Restricting the manufacture even of their own raw products by the colonies. So strong was this feeling in England that even Lord Chatham declared in Parliament, "The British colonies of North America have no right to manufacture even a nail or a horseshoe."

Most of these restrictions have been removed, though the result still remains.

The Phœnicians, Carthagenians, and Greeks had colonies on the Mediterranean. The Romans conquered and held as subjects, nations and empires. Venice and Genoa had colonies on the Black and Mediterranean seas. Spain and Portugal held as dependencies all Central America, South America, Africa, India, and the islands of the Pacific. The Dutch republic and France planted colonies in India and America. England has colonies in every part of the world, and on her dominion the sun never sets.

Germany, France, Portugal, and Russia, appreciating the necessity of colonies for the extension of their commerce and for opening new markets for their manufactures, are planting colonies, France in Cochin China, Germany on the eastern and western coasts of Africa and the islands of the Pacific. Portugal, aroused to a new life, is determined to hold her remaining possessions in Africa; Russia is steadily adding to her dominions in Asia, and her railway from the Caspian sea to Samarcand has opened in western and a part of central Asia a market for her manufactures and commerce hitherto supplied by Great Britain.

United States.

The United States is the only nation that has become great without colonies and without foreign commerce and shipping. Its vast extent of territory, where the east and west, the north and south, are separated more widely than the colonies of Tyre and Sidon or of Carthage and Rome from the mother countries; the great variety of climate, the fertile soil, its varied occupations and manufactures, and a widely distributed population, have created an enormous inland commerce and given that trade and wealth which other countries find in commerce and exchange with their colonies. Our population, wealth, internal commerce, exports and imports have increased at a more rapid rate than those of any other nation in a similar period. This is not due in any great degree to immigration, for our population has increased in no greater ratio since this immigration commenced than before, and experts believe that it would have been as large and more homogeneous without immigration. We had at one time a large foreign commerce, and our merchants were the first to establish direct trade with China and the East Indies; the Stars and Stripes were seen floating on every sea and flying in every harbor, and for years we were the second maritime nation of the world.

The commerce of the world passed from wooden sailing ships to side-wheel steamers, to iron and then to steel propellers; England was a worker in iron and machinery of every kind, we were not. The civil war came and hastened the day which was sure to come. Our shipping faded away faster than it had arisen, while that of Great Britain increased as rapidly as ours decreased. This was not owing to a decrease of our foreign trade, for during the last twenty years our exports and imports have increased more than twice as rapidly as those of Great

Britain.* Eighty-seven per cent of these exports and imports are carried in British ships, consigned to English houses which have been established in every large port in the world, and the proceeds are usually remitted to the London banker.

Fortunately, our flag never disappeared from our inland waters and from our coasting trade; for foreigners are excluded from the coasting trade, even where the ports are fifteen thousand miles apart by water.

The substitution of steamers for sailing ships and of steel for wooden propellers, which took place from ten to twenty years ago on the ocean, is now going rapidly on upon our lakes. Where in 1886 there were but six steel propellers, now there are sixty-eight; and of 2,225 vessels on the northern lakes, 1,153 are steamers, 902 are sailing vessels. The action of Congress in providing for the construction and equipment of war vessels by competition has led our ship-builders within the last eight years to establish ship-yards and machine shops where the largest ships can be built, and we are now building as large and fast vessels of war as England. Our ship-builders claim that they can construct ships equal in carrying capacity, speed and strength to those of Great Britain, and at no greater cost; though they cannot be run so cheaply because our sailors are better housed, fed and paid than those of other nations. The day will surely come when commerce will make her last movement westward, when America, lying between Europe and Asia, with her boundless mineral and agricultural resources, her manufacturing facilities, her extended sea-coasts, will be the foremost nation and New York the commercial capital of the world.

Nicaragua Canal.

From New York to San Francisco by land is about 3,000 miles, by water it is about 15,000 miles; yet, notwithstanding the greater distance, freight is constantly sent by water. From San Francisco it is about the same distance by water to either New York or London. If a waterway could be opened across the isthmus of Panama from one ocean to the other, the distance from New York to San Francisco would be diminished more than

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* The exports of the United States have increased 112 per cent, the exports and imports 92 per cent; the exports of Great Britain 35 per cent, her exports and imports 37 per cent.

one-half, and San Francisco would be over 2,000 miles nearer New York than London. The first proposition for canals connecting the two oceans was made in 1550, suggesting two routes, by Panama and Nicaragua; and explorations and surveys of both have been frequently made, and various attempts made for their construction.

The success of the Suez canal induced M de Lesseps to undertake the connection of the two oceans by the construction of the Panama canal, believing that the tonnage passing through it would equal that of the Suez canal. This work has not been successful; the canal remains unfinished, with no prospects of completion.

Several hundred miles north of Panama is the lowest continental divide; 148 feet above tide water on the Pacific slope of this divide is lake Nicaragua, connected by the river San Juan with the Atlantic; up this river and through this lake, some thirty years ago, was one of the regular ways of intercommunication, both for freight and passengers, between New York and California.

The Maritime Canal company and the Canal Construction company, organized by Americans, have obtained concessions from Nicaragua, and have made surveys for canal, slack water and lake navigation from Greytown on the Atlantic through lake Nicaragua to Brito on the Pacific, a distance of 170 miles. A harbor has been opened at Greytown and considerable work performed on the canal. The Panama route had the great advantage of an open channel from ocean to ocean, whereas the Nicaragua route requires several locks to cross the divide; but Brito is some six or seven hundred miles nearer California than Panama, a saving in distance that will compensate for the delay in locking. The opening of this canal will be the greatest benefit that could be conferred upon our commerce and shipping.

Freights by water between New York and California are now so high that a large portion goes by railroad. The effect that this canal should produce will be evident if we consider the great difference in expense between land and water carriage. Rail rates between New York and Chicago are a trifle over six mills per ton per mile, while the ocean rates on grain to Liverpool in 1888 were about half a mill per ton per mile; and one mill per ton per mile, or three dollars per ton from New York to Liverpool, is said to be a fair rate, while the all-rail rate between New

York and San Francisco averages from forty to eighty dollars per ton, according to the class to which the freight belongs. It takes from seven to ten days to go from New York to Liverpool, twice as long from New York to San Francisco by rail, thirty days by Panama, and one hundred and twenty days by the all-water route around cape Horn.

The opening of this canal will therefore reduce the freight on goods between the east and west at least three-fourths and possibly more. It will give us a free, easy and cheap communication by water between the eastern and western states; our commerce will be built up, and the wealth and commerce of the Atlantic coast and the population of the states on the Pacific coast will be increased in a wonderful manner.

The opening of this route will give a demand for large steamships, and when we have such ships large ship-yards and machine-shops will spring up, and these alone are wanted to enable us to build and run ships on the Atlantic ocean in competition with Great Britain. Then the prediction of Mr Cramp will be fulfilled, that Englishmen will be asking one another, "Can we build ships as economically as they do in the United States?"

Modes of Conveyance.

The earliest transportation of merchandise was by caravans. The first caravan of which we have any certain account was that of the Ishmaelites and Moabites, who, while they were traveling from Gilead with their camels, bearing spices, balm and myrrh to Egypt, bought Joseph of his brethren and sold him as a slave to Potiphar. These caravans were formed of merchants banded together for protection, under a guide and leader, sometimes numbering several hundred, with one thousand camels in a caravan. They traveled from seventeen to twenty miles a day, but only in the spring and autumn months. At night they stopped at caravansaries, where free lodging was furnished to men and beasts. In Turkistan and Arabia all trade and travel was by similar caravans until the railroad was opened across the desert by Merv and the Oxus to Samarcand.

Navigation was first by boat, and ages afterward by vessels. The earliest vessels of which we have any account were employed in carrying cattle down the Nile, and were propelled by sails and rowers. The vessels, at first small and with a few rowers, were slowly increased in size and number of rowers until three, four and even five banks of oars, one over the other, were used. They were often from 150 to 175 feet long, and from 18 to 26 feet in breadth, drawing from 10 to 12 feet of water and sometimes carrying two hundred rowers and several hundred men. All these ships were without decks, whether sailing on the Mediterranean or Atlantic. They sailed by day, putting into harbor at night, and never losing sight of land unless driven by stress of weather. At first they sailed only with the wind, but by slow degrees they learned to tack; then decks were built over the stern and prow, leaving the mid-ships exposed to the high seas. This class of vessels, sometimes with banks of oars. continued until the middle of the last century. In the early part of the fifteenth century smaller but stronger vessels of better material were built for the voyages of discovery undertaken by the Portuguese. At this time also the mariner's compass was brought into general use, having been introduced from Arabia; eighty years later it found its way to England. Two of the vessels of Columbus were decked only at the prow and stern, and the three were manned by one hundred and twenty men.

The Armada of Queen Elizabeth was formed of merchant vessels fitted up as men-of-war, and not until the time of Charles the First were there any regular ships of war in England or, probably, in other countries.

Commerce was usually carried on by companies, with rules regulating the quantity of goods to be exported, so that the market should not be overstocked and unremunerative prices obtained. Sometimes the merchant was owner of the vessel, who adventured with his cargo and sailed in his own ship. The ships were constructed with little reference to speed, sailing forty or fifty miles a day.*

The steam engine came into use near the middle of the eighteenth century in England, and two generations passed before it was used on vessels. The first steamboat ran on the Hudson in 1807, in England in 1812. Then another generation passed before the ocean was crossed by the *Sirius* and *Great Western* in 1833. These ships sailed from seven to eight knots an hour. Ten years later iron ships were built; then came the propeller, the inven-

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*The breadth was about one-fourth the length, and not until within forty years were the proportions of one-tenth or one-twelfth of the breadth obtained.

tion of Ericsson, followed by vessels built of steel, and lastly the *City of Paris* and *Majestic*, carrying fifteen hundred tons of freight and sailing five hundred knots a day or twenty knots an hour.

Until the present century all commerce between remote points was by water, excepting in the Roman Empire. After the downfall of Rome there was neither commerce nor travel and no use for roads, the cost of transportation even for a short distance exceeding the value of the goods.

The railroad was introduced about the same time into England and America, and was rapidly extended into every country. The steam engine on land and water has revolutionized the methods of transportation and created a new commerce. "The movement of goods in a year on all the through routes of the world did not then equal the movement on a single one of our trunk lines of railroad for the same period." Formerly it cost ten dollars to move a ton of freight one hundred miles; now it can be moved thirteen hundred miles for the same sum. The grain and corn from our western lands, then not worth the transportation to the sea-coast, are now sold in London, and our prairies yield to the western farmer greater profit than the grain lands of England yield to the farmer there. The land commerce created by steam probably exceeds today the commerce carried on the water.

The cost of moving freight by railroads varies greatly in different parts of the United States and in different countries. The highest cost west of the Rocky mountains is two and a quarter times more than in some of our middle states. The average freight receipts per ton per mile in this country is $0.922, which is less than those of any other country, although the Belgian and Russian rates are not much higher. In England the rates are from fifty to seventy per cent higher than in America, and in the other countries of Europe higher than in England.

In England and America the railroads are operated by private companies in competition.

In France railroads are operated by private companies regulated by law, the country being divided among different lines of road. Lines are constructed by private companies and run at rates fixed by the government.

In Belgium and Germany the principal roads are owned and operated by the government.

Our system has yielded the best results to the people.

The commerce which was in olden times transported only twenty or twenty-five miles a day is now moved five hundred miles a day by water and eight hundred miles by land. Correspondence, then carried no faster than freight, is now borne by telegraph to the farthest ends of the world.

All these changes have taken place within a single generation; for our fathers could not travel any faster than Alexander or Cæsar. Steamships, railroads and telegraphs within that time have transformed all commercial transactions and the methods of commercial business. Formerly eight months were required to execute an order in India or China and obtain the return; now one day is sufficient. These commercial changes caused a revolution in the modes of business, and were the main factors which produced the monetary disturbances of 1873, the effects of which we yet feel, so long has it taken the world to adjust itself to its new relations.

The Future of Commerce.

The commerce of the world originated in Asia; it was carried to Africa and thence to Europe, and from Europe to America. This movement can go no farther westward, for on the other side of the Pacific is China, which has successfully resisted every attempt of the European to encroach upon her domains, and India with its teeming population of two hundred and fifty millions; so that America, the last of the continents to be inhabited, now receives the wealth of India and Asia pouring into it from the west, and the manufactures and population of Europe from the east. Here the east and west, different from each other in mental power and civilization, will meet, each alone incomplete, each essential to the fullest and most symmetrical development of the other. Here will be the great banking and commercial houses of the world, the center of business, wealth and population.

The end is not yet. Inventions are increasing in a geometric rather than an arithmetic progression. The limit of steam power has not been reached, for with a high temperature in the steam-boiler the addition of a few pounds of coal increases the steam power so greatly that we are unable either to control or to use it.

Electricity has just begun to offer new opportunities to commerce. We are no longer compelled to carry our factories to the water power, for by the electric wire the power may be brought to the house of the operative, and we may again see the private workman supersede the factory operative. A few cars and small vessels are moved by electricity—the forerunner of greater things. We know little of this new agency, but its future growth must be more rapid and more wonderful than that of steam.

The secretary of the Smithsonian Institution (Mr. Langley) tells us that "before the incoming of the twentieth century, aerial navigation will be an established fact."

"The deeper the insight we obtain into the mysterious workings of nature's forces," says Siemens, "the more we are convinced that we are still standing in the vestibule of science; that an unexplored world still lies before us; and however much we may discover, we know not whether mankind will ever arrive at a full knowledge of nature."

Vol. IV, pp. 19-84, pls. 1-16 March 21, 1892

THE
NATIONAL GEOGRAPHIC MAGAZINE

STUDIES OF
MUIR GLACIER, ALASKA

HARRY FIELDING REID

WASHINGTON
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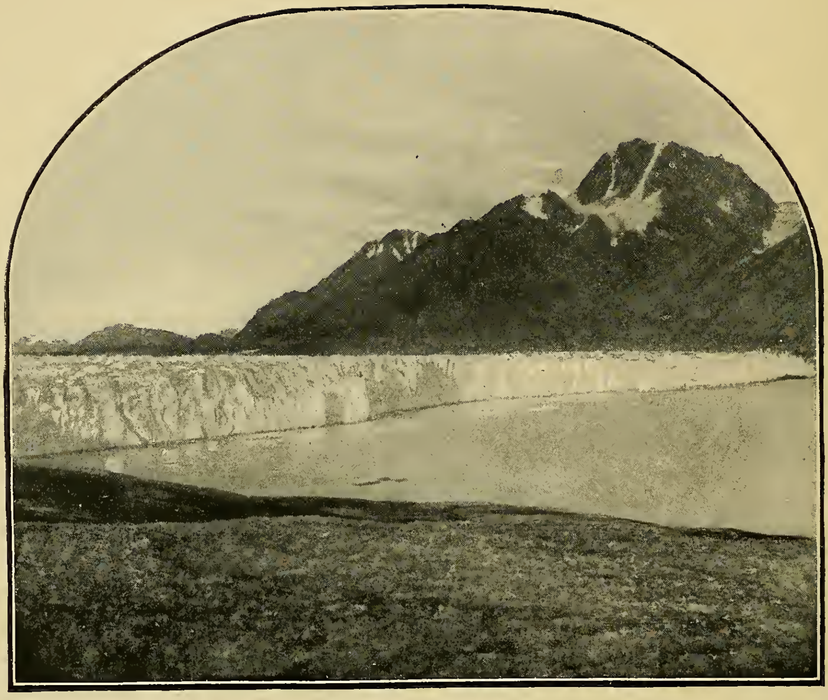

FRONT OF MUIR GLACIER AND MOUNT CASE, LOOKING EASTWARD.

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THE

NATIONAL GEOGRAPHIC MAGAZINE

STUDIES OF MUIR GLACIER, ALASKA.

BY HARRY FIELDING REID.

(*Accepted for publication December 11, 1891.*)

CONTENTS.

ILLUSTRATIONS.

Introduction and Narrative.

A desire to see the Alaskan coast more thoroughly than is possible to ordinary tourists led to the formation of a party to spend the summer of 1890 encamped there.

The description of Muir glacier by Professor Wright* turned our attention to that point. Its accessibility and the interest

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* The Ice Age in North America, 1889, chap. iii.

awakened by its reported motion of 70 feet a day decided us to camp at its mouth and study the glacier and its neighborhood as thoroughly as time would permit. The first requisite was a reliable map of the region. None such existed, and we determined to devote much time to a survey and to make a map which would show with some accuracy the extent and form of the glacier and the positions of the mountains which surmount it, and also serve to determine what changes may take place in the future. We also planned a careful measure of the motion of the ice, a determination of the magnetic elements, a regular meteorologic record, a study of the geology of the region, a collection of plants, and observations of all indications of change in the extent of the glacier, the amount of glacial erosion, etc.

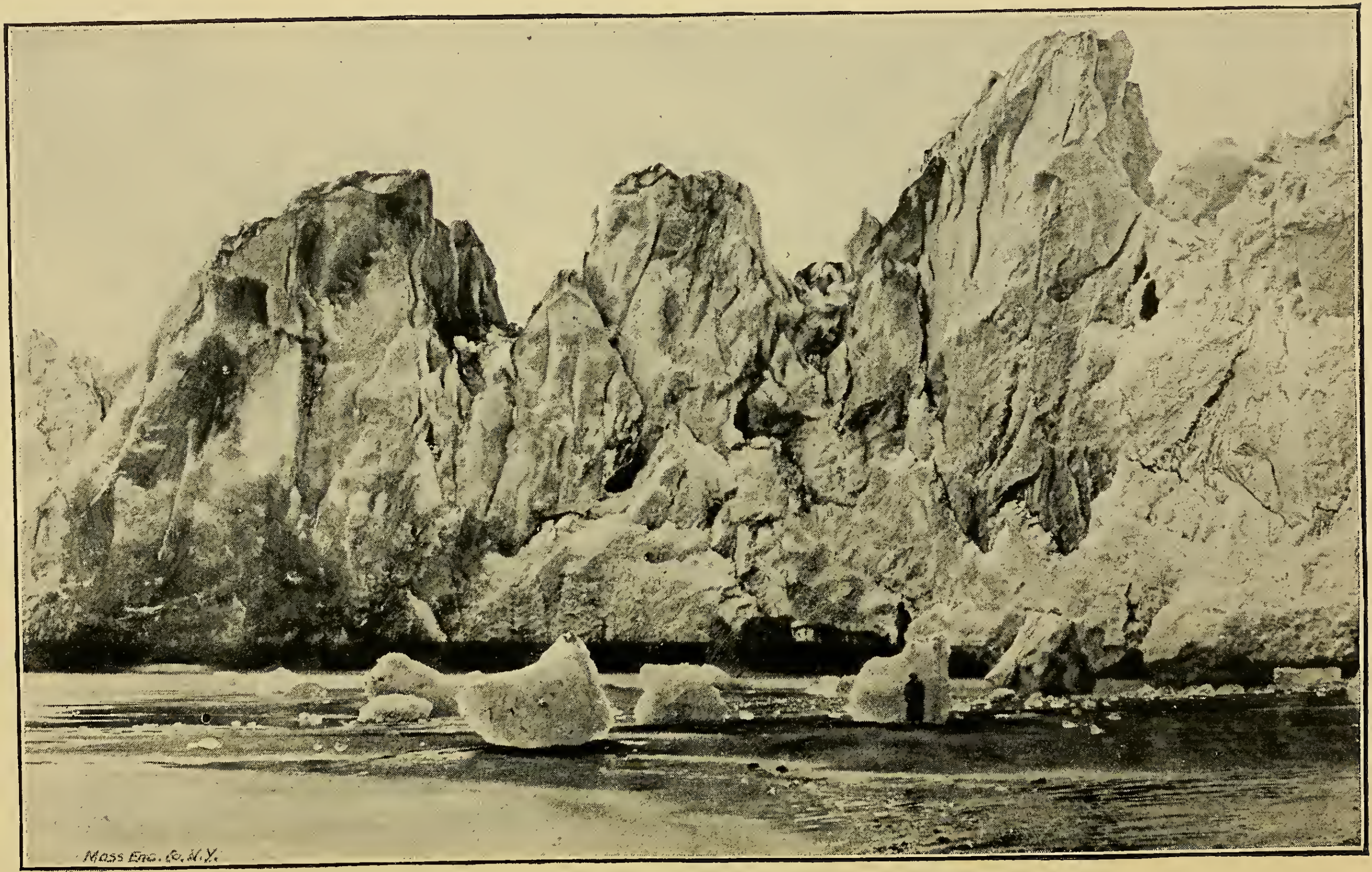
The party consisted of Mr H. P. Cushing, who took charge of the meteorologic records, the geologic observations, and the collection of plants; Messrs H. McBride, R. L. Casement, J. F. Morse, C. A. Adams, and the writer. It gives me pleasure to acknowledge that it would have been impossible to accomplish the work if it had not been for the cheerful and efficient aid which all my companions rendered.

Muir glacier seems to have been known only to the Indians until 1879, when it was visited by Professor John Muir and Reverend Mr Young; but they were prevented by bad weather from much exploration. In 1886 Professor G. F. Wright devoted a month to its study. We are indebted to him for a very interesting description. Until our visit, in 1890, these were the only attempts to obtain any accurate knowledge of the glacier. Glacier bay offers the luxury of exploration. Visited weekly during the summer by the steamers of the Pacific Coast Steamship company, the explorer can take with him everything necessary to his comfort, can renew supplies when necessary, can receive and despatch his mail, and still be in a region of which little is known—a region of great interest to the geologist and student of physical geography. It seems strange that it is not more thoroughly studied.

On July 1st the *George W. Elder* cast anchor in Muir inlet, not far from the glacier, and landed our instruments, tents, personal baggage, and provisions on the eastern shore. We found Professor Muir and Mr Loomis encamped there. They had come also to study the glacier, and added much to the pleasure of our stay. We immediately set to work to put up our tents, and before evening everything was in good shape. We brought boards from Juneau for flooring, tables, etc, which added materially to our comfort and convenience. A book-shelf held our small library of works on glaciers, logarithmetic tables, etc. A gasoline stove enabled us to cook our meals with ease, and camp-stools permitted us to eat them in comfort. This was to be our base-camp, and, in honor of Professor Muir, we named it *camp Muir*. Here we stayed until the middle of September, making various excursions of several days' duration to points too distant to be visited in one day, always, however, leaving two of our party at camp to make the meteorologic observations. We had with us a row-boat 16 feet long, provided with a sail, and during our stay we bought from the Indians a small dugout canoe which would carry three persons.

On one occasion, in company with Professor Muir, we rounded the western headland of Muir inlet and pushed a mile or two up Glacier bay. The water was so full of floating ice, in pieces large and small, that our progress was very slow, and we finally landed for the night, hoping to find clearer water the next day. In this we were disappointed, and therefore rowed back again and crossed the bay to the large island opposite Muir inlet. It was in this limestone island that Mr Cushing found the fossils which make it probable that these rocks are of Paleozoic age. Later in the evening we returned to camp Muir. On another occasion, following Professor Muir's example, we made sleds on which we packed our blankets, provisions, and instruments, and spent five days exploring and mapping the eastern part of the glacier. We ascended Tree mountain (2,700 feet) and Snow dome (3,300 feet), which, though of moderate elevation, command excellent views. Another time we visited the stations marked *S* and *T* on the accompanying map (plate 14), and ascended one of the peaks just to the westward. We also ascended Pyramid peak, approaching it by the valley of the Dying glacier. The weather unfortunately was misty, so that we added little to our knowledge of the mountains toward the west, except to see that they were numerous and did not seem to surround any very large valleys like that occupied by Muir glacier.

Shorter excursions were made on all clear days to points more easily accessible. Among these the most interesting were connected with the measure of the motion of the ice. To plant our flags where we wanted them required us to make a way among



ICE PINNACLES AT END OF MUIR GLACIER.

the crevasses, which offered great difficulties. Some experience in the Alps had taught me what means were necessary for progress in such places and what precautions should be taken to avoid accidents. We were always roped together, and were provided with ice-axes which served to cut steps in places where we could not otherwise stand. Balancing on narrow ridges, creeping along steep walls, or crossing crevasses on pieces of ice that had fallen in and bridged them over, were the usual methods of progress. Our precautions, however, rendered accident impossible.

When at Pyramid harbor, in Lynn canal, we engaged William York to go with us to help in camp-work. At the end of the first month, finding the work too confining for him, he left us with our consent and made his way back to Pyramid harbor, following the stream down Main valley to Lynn canal. After his departure we did all the camp-work ourselves.

The officers of the steamships were very courteous to us. Captain Carroll brought us all the material, ready cut, to make a house with two windows and a door. It was put up during a rainy spell, when we could not do any work away from camp. Indians, or as they are called in this region "Siwashes," had sealing camps in Glacier bay, but only visited the inlet when the steamers brought tourists, with whom they carried on a lively trade.

GENERAL GEOGRAPHY.

The southeastern extremity of Alaska consists almost entirely of an archipelago, which occupies a space nearly three hundred and fifty miles long and a hundred miles wide. The islands, large and small, are closely packed together, and the waterways between them are deep and narrow, and often form long straight canals. The islands are mountainous and precipitous, affording few landing places. Their slopes are densely wooded, mostly with spruce. The rough surveys of Vancouver a hundred years ago, as revised later by Tebenkof and others, were until 1867 largely relied on as supplying the most accurate information of parts of the coast. Since that year the explorations and surveys made by the United States Coast and Geodetic survey under the direction of Assistant Davidson, acting Assistant Dall, and, during the period from 1881 to the present time, by naval officers of the navy attached to the same survey, have resulted in the publications of charts and other data making known the more important channels and waterways with ample accuracy for navigation.

Southeast of the Alaska-British Columbia boundary the islands become larger and the waterways wider. Cross sound and Icy strait form the northwestern boundary of the archipelago. From them two deep inlets, Lynn canal and Glacier bay, stretch toward the north and northwest, forming, with the Pacific ocean, two peninsulas. The great Fairweather group of mountains occupies the western part of the peninsula between Glacier bay and the Pacific. The eastern part is occupied by another and much lower range, whose peaks rise about 5,000 or 6,000 feet above the sea. Their northeastern slopes are gradual and are covered with large glaciers, some of which reach tide-water and discharge icebergs into Glacier bay. Between these two ranges there seems to be a deep valley, which drains the eastern slopes of the Fairweather group. This is probably filled by a long narrow glacier discharging into Taylor or Dundas bay. Little was known of the peninsula between Glacier bay and Lynn canal before our expedition mapped its northern part, except that it is entirely made up of glacier-bearing mountains, whose peaks are from 5,000 to 7,000 feet high.

Northwest of Cross sound the character of the coast changes abruptly; the coast line becomes continuous, without outlying islands, and broken by few inlets; and mountains of great height rise immediately from the water's edge. We can, therefore, topographically divide the southeastern coast of Alaska into two regions. The line between them passes along Cross sound; then follows the valley just northeast of the Fairweather range for 40 or 50 miles, beyond which point we know nothing whatever about it. This topographic difference seems to be accompanied by a geologic difference. Mr Russell has shown that the St. Elias alps are of Tertiary origin;* and probably the Fairweather group belongs to the same range, though I believe it has not been explored. If this is true, the Fairweather mountains are of Tertiary origin, while the rocks forming the mountains about Muir glacier, and probably the rest of the same topographic region toward the southeast, belong to the Paleozoic and Archean.† Another difference is quite marked. Mr Russell has found raised

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* Nat. Geog. Mag., vol. iii, 1891, p. 172.

† See Supplements I and II.

MOUNT WRIGHT AND UPPER PART OF DIRT GLACIER, FROM SHOULDER OF MOUNT CASE.

beaches about Yakutat bay,* indicating that the land there has risen, whereas the submerged trees in Muir inlet show that this region is sinking. These striking facts seem to show that the valley between the Fairweather mountains and Glacier bay follows the line of an immense fault, which brings Tertiary and Paleozoic rocks into close juxtaposition. It is most unfortunate that we have no observations on the Fairweather mountains that will enable us to confirm or correct this interesting indication.

Glacier Bay and Muir Inlet.

Glacier bay itself has not been surveyed; the delineation in the coast survey charts is correct only in its general outline. It trends northwest and southeast, and is about forty miles long by ten wide. There are a great many islands in the bay. The Beardslee islands, which fill the eastern side for a distance of about twenty miles from its mouth, are made up, at any rate in part, of modified glacial till, and are generally thickly wooded, as are also the shores in the lower part of the bay. The channels between these islands are narrow, and often give one the impression of waterways cut through the land. The islands in the upper part of the bay are quite different; they are of solid rock, and are scored, polished, and rounded by glacial action. They occur singly, are usually elongated, and have the longer axis parallel to the nearest shore. They, like the mainland, descend abruptly into the water, and only at long intervals can even a small beach be found. In this part there are no trees. Several glaciers force their way down to the water level and discharge bergs into the bay; most of them end in narrow inlets two or three miles back from the bay proper. Muir glacier is of this type; its inlet, which runs nearly north and south, has its southwestern terminus on Glacier bay about five miles from the end of the glacier; the eastern shore line rounds gradually into the bay without well marked headlands. The inlet gradually narrows as we approach the glacier, being about one and a half miles wide at its upper end. On each side are deposits of roughly stratified sands and gravels, covered with a thin layer of moraine débris. On the western side these deposits form a comparatively level plateau from 150 to 200 feet high, which extends about four miles south of the present ending of the gla-

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* Op. cit., p. 82.

cier, and is about a mile wide. Its surface bears a number of shallow lakes; and here and there deep ravines mark the positions of former watercourses. The western subglacial stream has cut a gorge through this plateau, and exposed the buried forest described by Professor Wright (see page 39). For three-quarters of its length, the plateau ends on the water side in precipitous bluffs, below which there is a narrow beach, only covered by the highest tides. On the eastern side the bluffs only extend for a half mile or so; the upper surface of the deposit is not a plateau, but slopes gradually down to the bed of the glacial stream at the foot of the mountains. This stream empties into the inlet just below where the bluffs end. South of the stream the deposits slope gradually up from the beach to a height of about 400 feet against the mountain side.*

The inlet is quite deep. Professor Wright reports a sounding by Captain Hunter of 516 feet about 1,300 yards south of the present position of the ice front. Captain Carroll last summer (1890) found within a hundred yards of the ice-front a depth of 720 feet. This does not necessarily indicate that the inlet increases in depth as we approach the immediate neighborhood of the ice, for the earlier sounding may not have been taken in the deepest part of the channel.

MUIR GLACIER.

General Features.

Muir glacier occupies a depression in the mountains about 35 miles long and from 6 to 10 wide. It is fed by a great number of tributaries, of which the first northern, the second northern, and the northwestern are by far the largest. These again are made up of many smaller glaciers. The general slope of the surface, based on a barometric reading made between Tree mountain and Granite canyon, is about 1° 15′. The appearance of the glacier toward the northwest indicates that the slope there is about the same. The total area drained by this system is about 800 square miles; the actual surface of the ice being about 350 square miles. The area draining into Muir inlet is about

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* For an excellent description of these deposits see "Notes on the Muir glacier region" by Mr H. P. Cushing in Am. Geol., vol. viii, 1891, pp. 207–230, pl. iii, and map; c. f. ibid., vol. ix, 1892, pp. 190–197.

WHITE GLACIER.

700 square miles. Most of the precipitation which falls on this area flows off as water in the subglacial streams; the rest, compressed into ice, is forced through the narrow gateway 2½ miles wide into the inlet, where the glacier terminates in a vertical wall of ice varying from 130 to 210 feet above the water surface, from which large masses are continually separating to become icebergs (see page 48 and plates 1, 2 and 13). As already stated, the depth of the water is in places 720 feet; and as this is not enough to float a mass of ice rising so high above the water as Muir glacier, the ice must reach to the very bottom and must attain a thickness of 900 feet. The actual length of the ice-front facing the water is 9,200 feet, or 1¾ miles.

On each side the glacier sends forward a wing, which rises in the shape of a wedge over the stratified sands and gravels of the shore.* The upper surfaces of the wings, like the ice-front, are about 200 feet above the water level. This applies only to the parts of the wings overlooking the inlet; the parts nearer the side mountains are 50 to 100 feet lower; and here the ice ends like an ordinary alpine glacier. The wings are fringed by treacherous quicksands, which support large stones and look firm enough; but the tourist who steps upon them carelessly will quickly sink in over his ankles. These quicksands are composed of fine glacial mud, thoroughly soaked with water from the melting ice.

The ice-front has a wonderful coloring. Places from which ice has recently broken off are deep blue, sometimes almost black. This color lightens under exposure to the air and sun, and in a few days becomes pure white. All stages are represented in the ice-front, which therefore shows all shades of blue in striking variety. The blue color of the ice is caused by the absorption of the other constituents of the light passing through it, and is exactly analogous to the hues of colored glasses. When exposed to the sun and rain the ice undergoes a kind of weathering near its surface, which prevents the blue light within from passing out and reflects nearly all of the light which falls on it from outside; so that we then see merely ordinary white light reflected, practically unchanged, from the ice.

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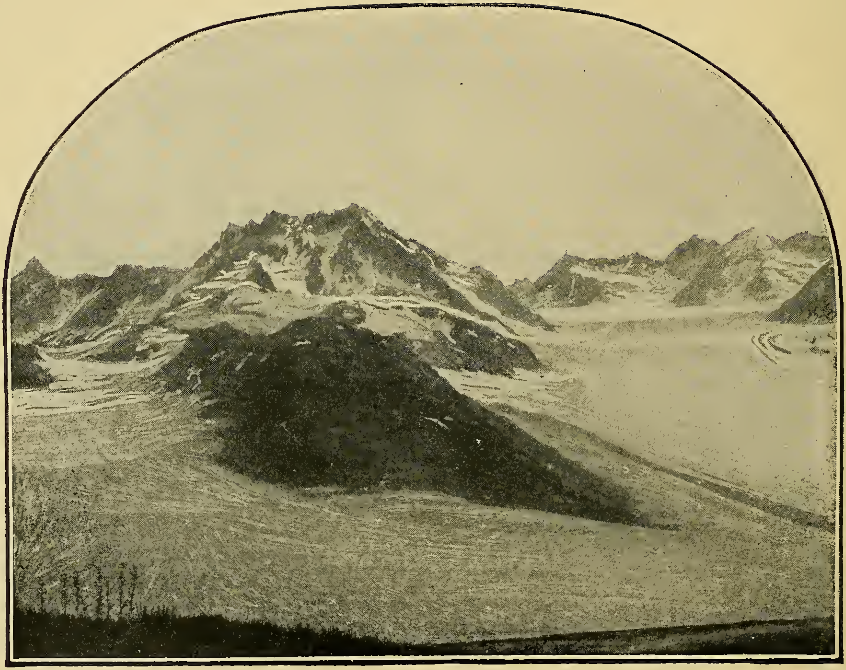
*Mr Cushing has published (op. cit., pl. iii) a reproduction of a photograph showing the glacier riding on the these gravels.

Tributaries.

Beginning at the right, we find three tributaries coming in from the southeast. The Dirt glacier (see plate 3) sweeps around in a great curve from behind mount Wright; its lower part is completely covered with débris for fully a mile and a half from its mouth; above this the glacier is particularly clean. The White glacier (see plate 4), which joins the Muir just beyond mount Case, is remarkably beautiful. Arising in a circle of snowy mountains it flows down a deep narrow valley at an angle of about 10°, its perfectly white surface marked by the wonderfully symmetrical parallel curves of three or four dark moraines. It is about four miles long and half a mile wide. A little further is the southeastern tributary (see plate 5), fed by a number of smaller glaciers. This glacier is not hemmed in by mountains but crosses a divide east of a_{15}, over which the ice flows into some valley on the other side. This divide has an altitude of 2,000 or 2,500 feet. About ten miles southeast of our camp a large glacial stream discharges into Glacier bay. It must drain the southern side of the mountains which bound these three tributaries.

Still further eastward is Main valley, which, though it probably once contained a tributary, is now an outlet of Muir glacier. The ice flows down this valley in a stream three miles wide, apparently with a very slow motion. A few miles down the valley the ice ends in a high wall facing Main lake, into which it occasionally discharges a berg. The stream draining this lake flows through a broad flat valley of sands and gravels toward the southeast, and finally empties into Lynn canal. The three valleys entering the eastern side of Main valley also have flat gravel-covered floors, through which rush the streams from the snow fields and small glaciers at their heads. Two of these valleys are beyond the present termination of the glacier. Formerly the ice must have extended across their mouths, hemming them in and converting them into lake beds. The upper valley is now in just this condition. The lake which occupies it has been called Berg lake on account of the great number of icebergs in it last summer (1890). Just north of the entrance to Main valley lies Girdled glacier, so called on account of the moraine which completely surrounds it (see plates 6 and 11). It can be seen from the end of Muir glacier, but is so foreshortened that one



THE SOUTHEASTERN TRIBUTARY, FROM TREE MOUNTAIN.

would not suspect that the visible portion is 3½ miles long. West of and separated from Girdled glacier only by a narrow ridge is Granite canyon, a deep gorge with precipitous sides, running about eight miles into the heart of the mountains.* The ice slopes downward into the canyon, whose drainage, however, must be back under the ice; for although I was unable to see every point of the ridge which closes in the further side of this valley, I could see sufficient of it from different points of observation to convince me that no part of it is less than a thousand feet above the floor of the valley. This curious condition seems to be due to the fact that the valley once contained a tributary glacier, which on account of the present smaller supply of ice and the reflection of the heat from the northern side of the canyon has melted down more rapidly than the surface of the main glacier, so that now (although this I could not see) the glaciers draining into this valley are probably entirely separated from the ice entering at its mouth. The tributaries so far mentioned supply none of the ice which forms the ice-front in Muir inlet; all the ice coming from them that does reach the end of the glacier is compressed into about 800 yards between the ice-front and the mountain on the east. If a line were drawn from the nunatak *H* to the eastern side of the first northern tributary and a second line toward the northwest at right angles to the first, the sources of all the ice which reaches the ice-front would lie in the quadrant between them.

The first and second northern tributaries and the main glacier present no striking peculiarities (see plate 7). These are immense streams of ice, fed by innumerable small glaciers. The mountains which rise between them and through them are deeply laden with snow, and toward the northwest seem to raise only their summits through the icy sea. The extremities of these branches could not be clearly determined, although they all seem to connect by low divides with valleys beyond. The northwestern tributary heads in two beautiful white conical mountains, which we called the Snow cones. A part of its ice flows over the divide between l_3 and l_5, and joins a large glacier which is probably identical with the one entering the head of Glacier bay. The western tributary supplies no ice to the ice-front; moreover,

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*This was named from the crystalline nature of the rock, which, however, according to Professor Williams' report (supplement ii), is not a true granite.

its snow fields are too small and too low to supply ice for a glacier of its width, and it is evidently melting away. At its western extremity it crosses over a divide and flows into a valley beyond.

The mountains immediately surrounding Muir glacier are not high, the highest peaks being between 5,000 and 7,000 feet. The mountains which first attract the attention of the visitor are mount Wright,* mount Case,† and Pyramid peak (see plates 1, 3 and 8)—the first two by their jagged crests, seamed by snow corloirs; the last by its symmetrical form; all three by their proximity. The more distant mountains seem to lack somewhat in individuality. This is largely due to their distance, for they are from fifteen to thirty miles away. All is bare and bleak, and the scenery is entirely lacking in picturesqueness. If we go out on the ice as far as *H* the three bold peaks of mount Young show themselves over Tree mountain (see plate 9), and the beautiful Snow cones at the head of the northwestern tributary can be seen.

Surface of the Glacier.

The surface of the ice presents the honeycombed appearance common to all glaciers; it crunches under the foot, making walking very tiresome, and rapidly wears out one's boots. This surface ice varied very much with the weather. Sometimes after rain the ice was hard, smooth, and blue; sometimes the rain increased the roughness.

Crevasses.

The eastern part of the glacier was free from all large crevasses; none in this part were too large to be stepped over. This, of course, indicates a small differential motion, not necessarily a small actual motion. That this, however, is also small follows from our measures, which show that although all the ice supply from the eastern part of the glacier is crowded through a narrow space between the ice-front and the mountain to the east, still the greatest motion here is only about two inches a day (see page 45). The amount of crevassing in the other parts of the

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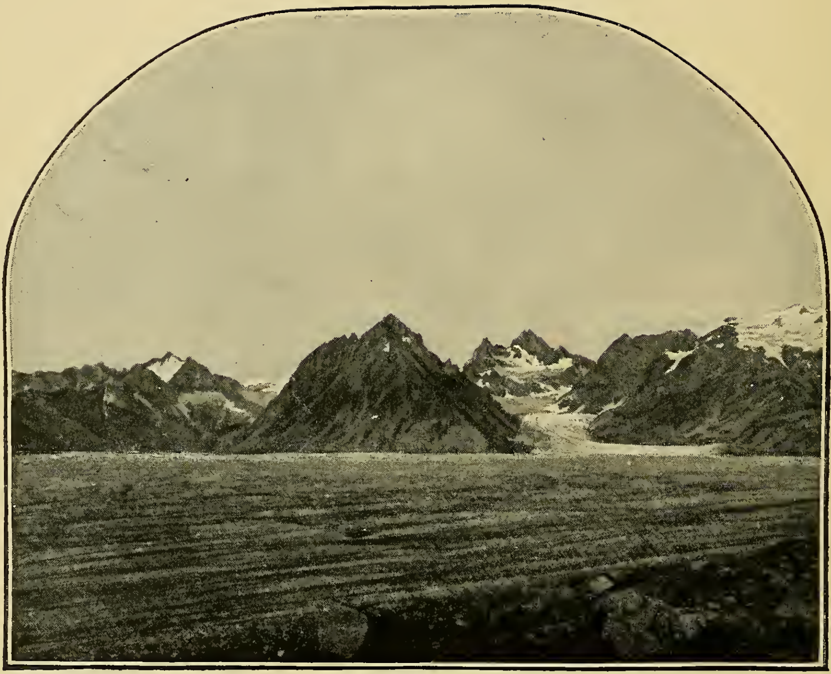
* Named after Professor G. Frederick Wright, who spent some time studying Muir glacier in 1886. He has described it in his Ice Age in North America, chap. iii.

† Named after the Case School of Applied Science, Cleveland, Ohio.



GIRDLED GLACIER, FROM P.

glacier varies much with the locality. From an elevated point such as *V*, from which the minor irregularities are not prominent, the general smoothness seems broken over limited areas, like the surface of a still lake ruffled in places by puffs of wind. These are, of course, where the bed of the glacier presents some irregularity. Below them the sides of the crevasses are again pressed together, and the surface resumes its general smoothness. The increase in the width of crevasses during the summer was very noticeable. In the beginning of September we were unable to cross the northwestern tributary, although earlier in the season Professor Muir crossed it without much difficulty.

The place where the crevasses were most marked was the immediate neighborhood of the glacier's mouth. Here two sets of crevasses cutting each other obliquely divided the ice into great lozenge-shaped masses, which, under the influence of the sun, rain and winds, melted, in some cases into narrow ridges, in others into sharp pinnacles. The ice, white near the surface, becomes bluer and bluer as one looks deeper into a crevasse, which finally ends in a dark narrow crack. This gives the impression of immense depth, but I do not believe that any of these crevasses are much over 150 feet deep. We sounded one and found it 123 feet. The best evidence, however, lies in the sections of the crevasses shown in the photograph of the ice-front from which plate 13 is reproduced, in which the crevasses do not extend to the water level, which in this part of the ice-front is less than 200 feet below the surface of the ice. The ribbon structure of Forbes was everywhere visible. On many of the pinnacles it could be seen cutting the stratification at a high angle.

Melting and Drainage.

The stakes put in the ice to measure the motion of the eastern part rose about 14 inches in 7 days, which indicates a melting of about 2 inches a day. This method is not reliable, and we can consider the result as only approximate. In this particular portion of the glacier the ice is very friable, and the water does not collect on the surface in pools and streams, but sinks through the ice and is carried off by some crevasse. The portions just west of *G* and between White glacier and *I* contain many surface streams which pour into crevasses or moulins; but none of these streams were two large to leap, and all of them were perfectly clear.

After falling into a crevasse the water sometimes reaches the bed of the glacier and sometimes flows along a channel in the ice. We saw a very good example of such a channel. When we first came to the glacier, early in July, there was a large opening like a sewer in the face of the ice-front near the eastern shore, some fifty or a hundred feet above tide-water, from which issued a strong stream of very muddy water. The opening must have been 200 square feet in cross-section, of which one-half was occupied by the stream. Now, muddiness is a characteristic of water which has flowed along the bed of a glacier, clearness of the surface water; I therefore infer that this stream was part of the water which flowed along under the ice in the shallow side of the glacier and was diverted into some channel or crevasse which ended in the ice-front. During our stay the mouth of the stream steadily sank, until it was on a level with the water of the inlet. This may have been due to either of two causes: (1) the course of the channel may have been upward as it approached the ice-front, so that as the ice melted and broke away the section exposed was at lower levels; or (2) the stream may have deepened its bed by cutting and melting (see page 42, note).

On each side of the inlet large streams issue from the end of the ice at a number of points, and after rapid courses of between a mile and a mile and a half empty into the inlet, forming quite large deltas. These streams were about thirty feet wide and two feet deep. The current is so swift that they roll down stones as large as one's fist; but the principal material that they carry off is in the form of fine mud. We used this water largely in our camp, and found that although most of the mud would precipitate when allowed to stand for a few hours, still the water remained quite turbid even after three or four days. The muddy character of the water in the inlet a little west of the middle of the ice-front shows that another stream must discharge in that region, either under or through the ice. A small part of the drainage of the glacier passes down Main valley, but this does not amount to very much. I think the principal sources of the stream in this valley are from the snow-fields and smaller glaciers on its sides.

Moraines and Débris Cones.

The moraines of Muir glacier, seen from an eminence, are very striking. Coming from many quarters, they sweep in bold curves

MAIN ICE STREAM OF MUIR GLACIER, FROM V.

across the ice converging toward the inlet. Many of them rise 30 or 40 feet above the general level of the ice; but near the glacier's mouth they have become so diffused or have lost so much of their material in crevasses that they do not affect the general surface. In fact, the moraines which cross the crevassed region near the end of the glacier have almost entirely disappeared. It is only from an elevated point that they can be traced.

The moraines from the east are large and much massed together. A large moraine from the eastern side of the southeastern tributary curves around and entirely closes in the end of that glacier and unites with several moraines from its western side into a confused mass, which the time at our disposal did not permit us to separate. Among these moraines occurs the marble mentioned by Professor Wright. The moraines from White glacier unite with those just mentioned a short distance below its mouth, beyond which they approach closer and closer to the mountains. They look like huge earthworks holding up the clean ice of this tributary 20 or 30 feet above the general surface of the glacier. Dirt glacier is completely closed in by a moraine across its mouth. Above this comes a zone of comparatively clean ice, and then for a mile or more the glacier is so completely covered by débris that no ice can be seen. Girdled glacier also is completely hemmed in by a moraine.

The next group of moraines, coming from Main valley and Granite canyon (see plate 10), unite near *I*, where they are apparently reinforced, and finally flow down the steep slope east of the ice-front. These moraines are quite different from any I have ever seen or read of. They have two ends, but no beginning. From the region lying between Tree mountain and Granite canyon the ice slopes in both directions toward the glacier's mouth and into Main valley. The former slope, as has been said, is a little over 1°; the latter is two or three times as much. Two of the moraines have their upper terminations in Berg lake; a third ends in Main lake. To this group belongs also a moraine which issues from Granite canyon, flows around Girdled glacier, and ends against the side of the mountain a short distance down Main valley, or follows the mountain side to Berg lake. Another moraine, issuing from Granite canyon, curves as though about to flow into Main valley and then abruptly changes its direction and flows to Muir inlet (see plate 11).

A large moraine stretches from nunatak *H* to the corner of the ice-front and then scatters over the projecting wing. At first sight the nunatak seems to furnish the material of this moraine, but closer observation shows that this is not so. Mr Cushing called my attention to the fact that although the material of this moraine is largely dark igneous rock, the nunatak is a light granitoid rock; and, moreover, the débris on the nunatak is almost entirely of the same rock as the nunatak itself. Two moraines issuing from the east side of the first northern tributary come to an end about half way between Snow dome and *H* (an explanation of these moraines appears on page 36. The remaining moraines are like those with which we are familiar on other glaciers, and call for no special mention. Some must be over 20 miles in length. Their origins are lost in the snows of the higher parts of the glacier. Sand cones and glacier tables also occur where the conditions are suitable.

The moraines from *I* end in a long sharp ridge, the ice of which is hidden by only a thin covering of stones of small size. There are two other similar ridges between this one and the side of the glacier, which, however, are not connected with moraines. All the large-sized débris seems to have slid off the steep side and left only the smaller fragments. South of the eastern end of nunatak *G* we found two very curious cones of rolled stones. The stones were about the size of billiard balls and rested on the ice underneath just at the angle of repose, so that the slightest disturbance, such as a little melting of the supporting ice, would cause some to roll down. Their edges were rounded, and they presented exactly the appearance of having been knocked about by running water. Their uniform size shows that some agent has been at work rejecting both smaller and larger pieces. Perhaps they were collected by a stream at some point on the side of *G* and an avalanche carried them out upon the ice. Other cones occur near these, but are not composed of similar material.

Former Extension and recent Diminution of the Glacier.

Professor Wright has pointed out the facts which show that Muir glacier has been both much larger and much smaller than it is at present. The existence of erratics, rounded knobs, and glacial scratches at points considerably above the present level of the ice shows the first; the existence of the buried forest on the western side of Muir inlet and of old logs on some of the moraines show the latter. He has also collected the following

MOUNT WRIGHT, FROM V.

evidence to show that the glacier is at present retreating, and that its retreat is quite rapid, viz: The absence of forests in the upper part of Glacier bay, the existence of fresh striæ and of glacial débris in situations where the material could not have resisted erosive agencies for any great length of time, the small amount of débris fallen from the mountains on the eastern side of the inlet, the small amount of vegetation on the shore near the glacier, the transverse ridges on the shore, the mass of detached melting ice in front of the glacier, and, finally, the account of Vancouver, which makes it probable that a large part of Glacier bay was filled with solid ice a hundred years ago.*

To these evidences I may add the following observations: On the sides of the mountains bordering the glacier, and especially in the gullies on the northern slopes, there are masses of ice extending a hundred feet or more above the present level of the glacier. This ice has been protected from very rapid melting by the débris which covers it. It must have been a connected part of the glacier not many years ago. On the northeastern side of Tree mountain there is a spur which projects into the ice of Main valley. On its upper side and near its end the ice is only some 10 or 20 feet below its top; on the lower side the ice is much lower. Across this spur in a direction parallel to the valley were some small stream beds, beginning abruptly at the upper side, whose source must have been the melting ice when it was level with the top of the spur. The whole spur was covered with bowlders, sand, and some fine detritus. The stream beds were marked only by the disposition of the sand. The fine detritus must assuredly have been washed away by the rain and melting snow if the spur had been uncovered many years. The ice between *G* and the nunatak to the west is at a higher level than the western or northwestern tributaries and slopes both toward the north and the south. As this region has no independent source of supply, it must have obtained its ice from the northwestern or western tributaries, which therefore must have been at a higher level than they are now. If this subsidence had been due entirely to melting, the surfaces of these two tributaries would not have sunk more rapidly than that of the ice connecting them. We are therefore forced to conclude not only that the ice is melting away, but also that it is flowing away. This process has

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* Ice Age in North America, 1889, pp. 51–57.

been noticed among the Swiss glaciers by Forbes and by Agassiz as a seasonal change, the glacier partly flowing away during the summer and thickening up again during the winter. The loss incurred in this way by the Muir glacier in the summer is not made up during the ensuing winter, for the difference in level just mentioned is far too great to have been produced in one season.

The stratified deposits on the shores of Muir inlet are covered by a thin layer of moraine a foot or two thick; scarcely thicker, in fact, than the moraine which covers the end of the glacier. If the ice had not retreated rapidly this deposit would have been much thicker. The mass of detached ice mentioned by Professor Wright has entirely disappeared.

The moraines extending from the lakes in Main valley to Muir inlet seem explicable only on the supposition that this valley once contained a glacier tributary to the Muir, and that the supplies of snow having diminished in this region more rapidly than in the northwest this tributary has diminished much more rapidly than the Main glacier, until now the flow is actually reversed. The two moraines issuing from Granite canyon and flowing one into Main valley and the other into Muir inlet are also due to the same cause. The moraine extending from *H* to the ice-front, and composed of material quite different from the granitoid rock of *H*, is readily explained by the former greater thickness of the ice. The moraine which comes from the first northern tributary probably flowed just over *H*, and when the ice here was not very thick the very steep southern face of *H* must have caused a break in its continuity, so that the ice and moraine fell over this slope to the surface of the glacier below. The accumulation of detritus here is the source of this moraine, and it has not yet been entirely carried off.

In a valley connecting the western side of Muir inlet with the upper part of Glacier bay there lies a small glacier which we have called Dying glacier. It is about 3 miles long, slopes both eastward and westward, and has moraines running from end to end. It has no real feeders, although a tributary joins it on the south. It must be the remnant of a much larger glacier, deriving its supplies from the lateral valleys; probably also, perhaps principally, from the great ice stream which filled the upper part of Glacier bay, with which it must have had connection. At present its highest point is 760 feet above tide, an elevation much

MOUNT YOUNG.

lower than the surface of the ice when at its greatest flood. It is now without supply, and is rapidly melting away.

Another element of the diminution of the glacier, and one which would appeal much to most persons, is the retreat of the ice-front. In the four years between Professor Wright's visit, in 1886, and my own, in 1890, the ice-front receded more than 1,000 yards (see further, page 41).

Extent and Date of the last great Advance.

On the northeastern side of Tree mountain the lower slopes are covered with moraine débris and with very slight vegetation. At a height of about 2,000 feet above tide large trees (spruce) are found growing, some of which are quite a foot in diameter and must be over a hundred years old. Above this limit the mountain is free of erratics. On the opposite side of Main valley there is a very noticeable line about the same height, marked by a variation in the shrubbery, although there are no trees on these mountains. This, then, is the highest point reached by the glacier in this part. The rounding and scratches show that nunatak *G*, 1,855 feet above tide, was covered, as were also the islands in Glacier bay, one of which (Willoughby) is 1,000 or 1,500 feet high. The height of scratches and erratics in the neighborhood of the glacier's mouth we did not determine, but the height given by Professor Wright (2,500 feet) seems to me a little too high. At *V* (3,000 feet) no erratics were found, and as the ground here is well adapted to retain them we must conclude that the glacier did not rise to this height. I am inclined to think the scratches observed by Professor Wright at a height of 3,700 feet* are due to local causes.

The advance of the ice from Muir and other glaciers of Glacier bay must have been near its maximum at the time of Vancouver's visit, 100 years ago, for it seems probable from his narrative that the ice extended below Willoughby island, and the large trees on the islands in the lower part of Glacier bay show that it did not extend that far. That the height given, 2,000 or 2,500 feet, was that of the last great advance seems pretty certain from the freshness of the scratches up to that limit. Moreover, if at the

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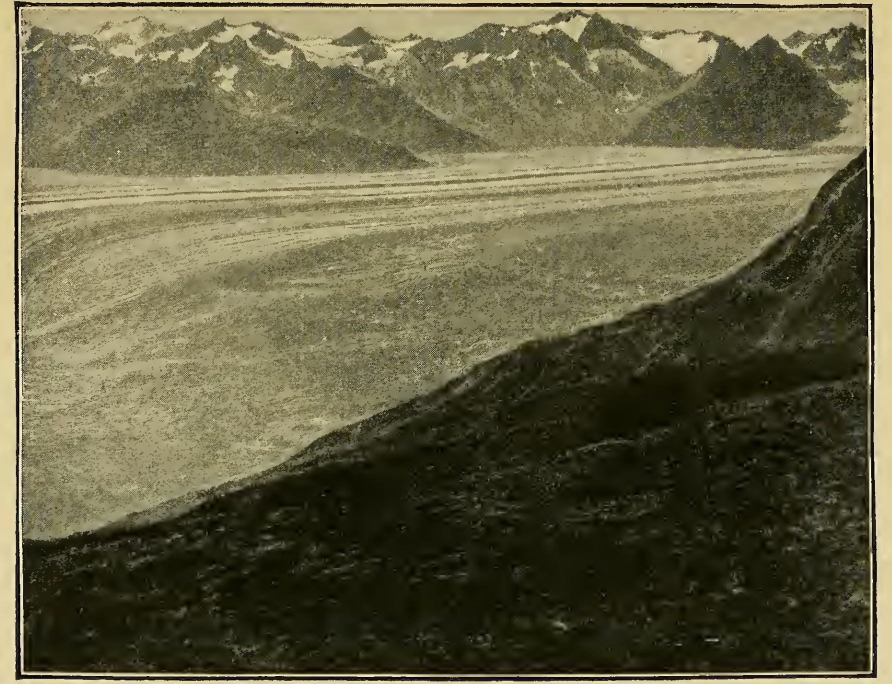
*This would make the ice at this point several hundred feet higher than at Tree mountain, which is extremely improbable. Probably only a small error would be made if we take 2,000 feet as the maximum height of the ice near its present ending.

time of Vancouver's visit the ice extended below Willoughby island and had a front 300 feet high, it would have to be about 2,000 feet high on mount Wright to give a surface slope of 50′; and a slope of 1°, which is certainly not excessive, would correspond to a height of about 2,500 feet on mount Wright.

Another point is worthy of notice. From the divide between Tree mountain and Granite canyon the ice is flowing in both directions and is receiving no supply. The surface of the ice here is now about 1,250 feet high. If we suppose the surface melting at the rate of 2 inches a day (the rate observed near the glacier's mouth) for 90 days in the year, and if we entirely neglect the loss due to the flow of the ice, we find that it must sink about 15 feet a year. At this rate it would have been at its hightest, some 800 or 1,000 feet above its present surface, between 50 and 70 years ago; and if we also consider the loss due to flow, the greatest height must have been reached still more recently. This rate of loss could not have continued for a longer period or the glacier would now be lower than it is. It follows that from 50 to 70 years ago, or less, the rate of loss of ice in the region near Tree mountain was diminished by a supply which was undoubtedly derived from Main valley. This conclusion is supported by the moraines in main valley. They could not have retained their present course, flowing in two directions, for a long period without becoming very attenuated. Taking these facts into consideration, it does not seem unreasonable to believe that the greatest extent of the glacier was reached 150 or 200 years ago.

Evidence that the last Advance was of Short Duration.

I have already mentioned the stratified deposits on the shores of Muir inlet over which the ice now rides. We find a similar state of things at the eastern end of Dying glacier, where the ice rests on earlier deposits. In a gully on the northeastern side of Tree mountain the ice detached from the main glacier is resting on débris. Although sand and gravel form a pretty solid bed, it is hardly possible that they should have resisted the grinding action of the glacier for many centuries, especially when the ice was much thicker than it is now. Mr Cushing has called my attention to the fact that a gully on the eastern side of *H* and others on *G* do not correspond in direction to the glacial scratches, and therefore could not have been excavated by the glacier. Many geologists would consider this a proof of the inability of the glacier to accomplish much erosion; otherwise the



MORAINES EXTENDING FROM MAIN VALLEY PAST OPENING IN GRANT CANON.

sides of the gullies would have been planed down and these features obliterated. We can, however, equally well look upon it as evidence that the ice did not cover them for a very long period.

The trees of the buried forest (see plate 12) must have grown when the glacier was smaller than it is now. The sand and gravel was then carried in among them until they were completely buried, after which the glacier pressed forward and moved over the sand. Now, these trees are most probably of the same species as the spruce now growing in the neighborhood of Juneau (see supplement iii), and therefore it seems we should reckon the time elapsed since they were alive in centuries rather than in thousands of years. Another evidence lies in the logs found on moraines and on mountain slopes. We found them in the moraine in front of White glacier, on the moraine issuing from the eastern side of the first northern tributary, on the eastern shore of Muir inlet south of the stream, in the gully east of camp, and in gullies on the northeastern side of *G*; in fact, over most of the region about the southeastern part of the glacier. In these gullies they seemed much covered with débris, coarse and fine, which has apparently protected them from being ground up by the ice. Now, it hardly seems possible that this wood should not all have been carried away long ago if its origin had not been comparatively recent.

Before the advance the glacier must have been very much smaller than at present to allow the region about the first northern tributary, which is now bare and bleak, to support trees; and it must have remained smaller for several hundred years to allow the trees of the buried forest, some of which are two feet or more in diameter, to attain their size. A piece of one of these trees shows 22 rings in a thickness of one-third of an inch, which would give a rate of growth of one inch in diameter in 33 years. It seems probable that this very slow rate does not apply to the whole life of the tree, but only to its later years. The wood was from the outside.

Although the evidences indicating a short duration for the last advance of the glacier is not decisive, still this supposition seems to be in harmony with all the facts. Probably the principal objection that can be urged against it is that the changes are much more rapid than any we are familiar with. Let me, however, call attention to certain historical facts collected by Venetz and Agassiz, which show that during the middle ages, from perhaps the tenth to the sixteenth centuries, the glaciers of the Alps were much less extensive than at present, and that horses were able to cross passes now considered difficult by mountaineers. During the seventeenth and eighteenth centuries the glaciers increased, attaining their greatest extent in the beginning of this century.* At present they are in general retreating. This shows a variation almost as great and almost as rapid as that mentioned for the glaciers of Glacier bay.

A possible Cause of the recent Retreat.

When the tide in Muir inlet is very low one can see on its eastern shore the stumps of large trees, which Professor Muir assures me are in place. The trees must have grown, of course, above high tide; they are now twenty feet below that level. Although I cannot say so with certainty, it is not unreasonable to suppose that these trees, like those of the buried forest, are spruce, and of the same species as those now growing in Alaska; but we must remember that any results deduced from this supposition have no more weight than the supposition itself. If, therefore, these trees were growing at the same time as those of the buried forest, there has been a subsidence of the land of at least 20 feet since the last advance of the glacier; it may have been much more; if so, it would have produced an increase in the mean annual temperature, which would have increased the rate of melting and would also have decreased the proportion of the solid to the liquid precipitation; and on account of the general lowering of the mountains, more of the moisture from the ocean may have been carried over them and precipitated further inland. All of these results would tend to diminish the extent of the glacier. Not only that, but the diminution itself would increase the rate of diminution, for the presence of extensive snow-fields must lower the mean annual temperature (see page 52) and thus increase the proportion of snow to the total precipitation. If for any cause these snow-fields become smaller, their influence on the mean temperature becomes less, the snowfall is diminished, and the snow-fields become smaller still. So we see that anything causing a slight change in the mean temperature may result finally in quite a large variation in the extension of the glacier, although this large variation may reach its limit only long after the cause which started it has ceased to

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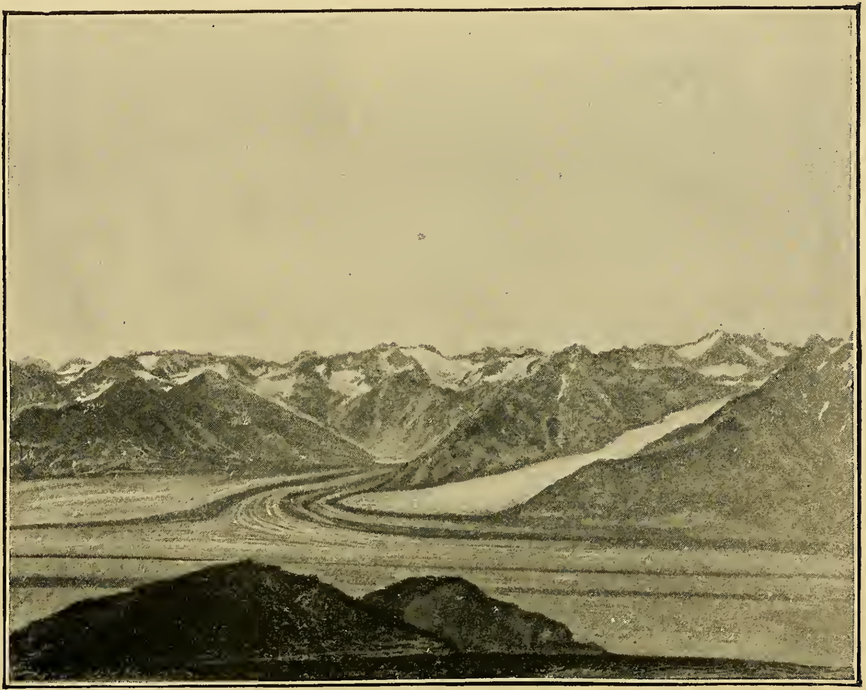
*Agassiz, Études sur les Glaciers, 1840, chap. xvi.



GIRDLED GLACIER, FROM TREE MOUNTAIN.

act. The ends of glaciers are rarely stationary; they seem always to be advancing or retreating; the suggestions above show that this is just what is to be expected. In other words, glaciers are never exactly in stable equilibrium with the surrounding conditions.

Changes to be expected.

Main lake and Berg lake are now separated by a very short distance, and it will not be long before they unite. This will result in the draining of Berg lake, which event will probably be marked by a flood. The melting of ice in Main valley must be rapid, for the great extent of its termination there presents a large surface for melting. When this termination has receded two or three miles and the surface of the ice has sunk two or three hundred feet, the ice from the first northern and from the southeastern tributaries will probably be in part deflected into Main valley. The small lake which occupies a lateral valley opening into Granite canyon will probably extend as the ice diminishes and perhaps occupy a large part of the canyon itself.

Professor Wright has kindly sent me some photographs which he took of the glacier in 1886. By comparing these with our own we can readily fix on our map, within 100 yards, the position of the ice-front at the time of Professor Wright's visit. This shows that in the four years from 1886 to 1890 the western end of the ice front has receded 1,200 yards and the eastern end 750 yards. The center also has receded about 1,200 yards, so that the average recession of the ice-front is a little over 1,000 yards in four years or, say, a mile in seven years. Professor Muir writes me that the notes of his first visit to the glacier in 1879 show that the ice then extended about to our station *D*; the rate of retreat deduced from this accords fairly well with that given above. The ice-front, therefore, must have extended as far as island *C* 20 years ago. Below *C* I think the retreat was more rapid; for there the glacier presented a much wider front to the water from which a correspondingly larger quantity of ice must have broken off, and this could hardly have been entirely compensated for by a greater velocity of flow on account of the many obstructions in the neighborhood of the present position of the ice-front. It does not seem at all incredible that the ice from the various glaciers of Glacier bay may have united to fill a large part of the bay a hundred years ago. Professor Wright's interpretation of Vancouver's description seems perfectly in accord with what our observations would lead us to conclude.

The retreat is probably not regular but faster some years than others, and even varies considerably at different parts of the same season. For two or three weeks in August, 1890, there was scarcely any fall of ice; in the two weeks following the fall was so rapid that a great bay fully a quarter of a mile deep was made in the eastern part of the ice-front, which was before this only slightly concave. Plate 13, from a photograph taken on September 7, 1890, shows this indentation. I have collected on the map (plate 15) the positions of the ice-front at several periods; this shows the retreat at a glance much better than it can be described in words. The changes in the shape of the front will also be evident.

The present rate of recession of the ice-front in Muir inlet, a mile in seven years, will probably be exceeded in the near future; for it has reached a point where the conditions change. The deposits which support the wings are almost at the water level at the ice-front, and slope down at an angle of 6° or 7°; a little further back they will be below the water level and the ice-front will be broader, resulting in an increased amount of loss by breakage and hence a more rapid retreat. Ten or 15 years will probably see Dirt glacier on the east and the western tributary on the west entirely separate from the main ice stream.

Dying glacier is rapidly disappearing; in 15 or 20 years I think its bed will be empty. The maps I have made will enable us to determine with considerable accuracy the amount of these changes in the future. I should, however, say that although the northern end of Main lake is in its right place, the southern end is only approximately determined. The ends of Dying glacier are also only approximate.*

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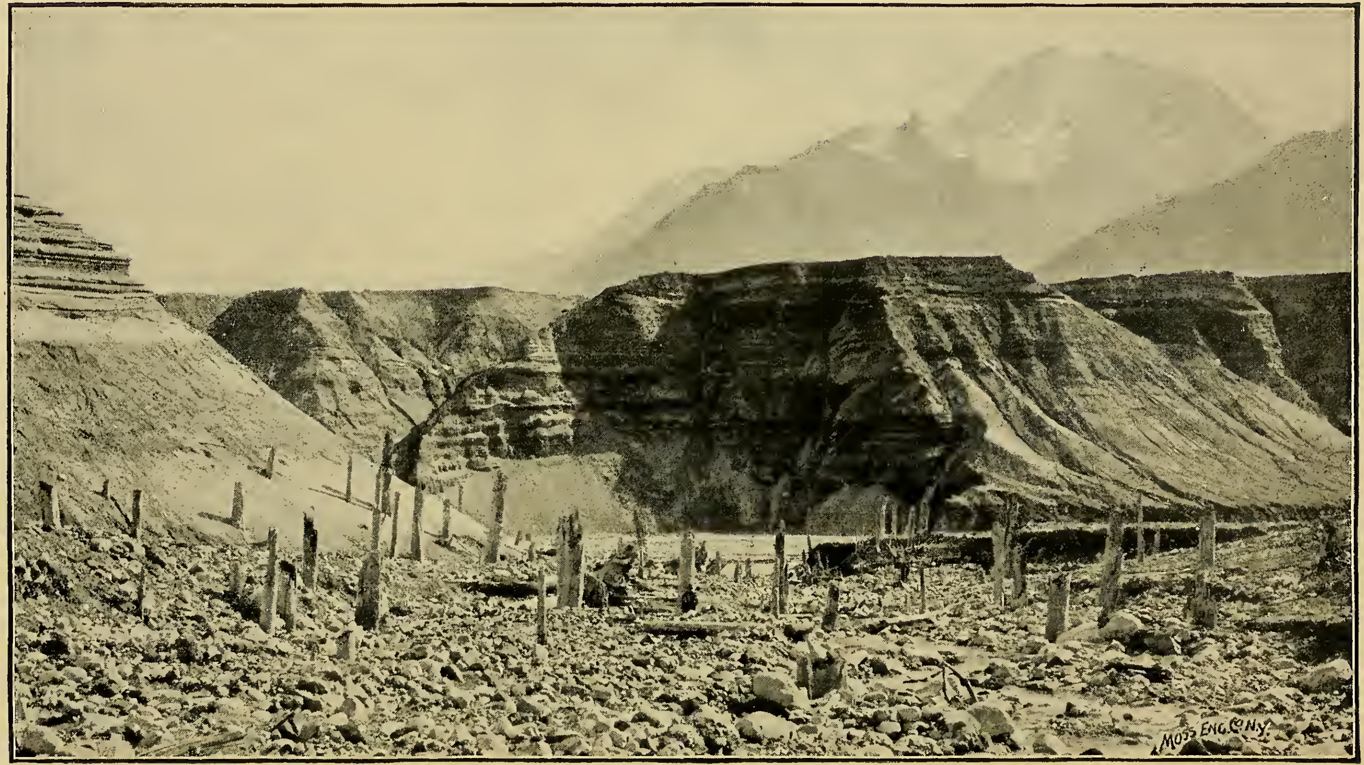
* Note added November, 1891. From photographs and descriptions sent me by Miss E. R. Scidmore I find that there have been some changes in the ice-front in the past year. The northwestern corner seems to have advanced slightly; the northeastern corner has receded 50 or 100 yards, and the rest of the front, which is nearly a straight line, has retreated some 300 yards since July 26, 1890. It is not, however, quite so far back as the extreme end of the bay formed just before we left in 1890. The stream which issued from the ice at the northeastern corner now comes out from under the wing and rushes across the beach, which it thus separates from the ice-front. The large glacial stream on the east will undoubtedly follow the channel of this stream before long and fulfill Professor Wright's prophecy (Ice Age in North America, p. 54).



BURIED FOREST.

Motion of the Ice.

I had hoped to make an extended series of measurements of the motion at different parts of the glacier, but the pressure of other work and the great extent of the ice forced us to be content with a measure of the motion near the mouth. The reported motion of 70 feet a day was so great that we felt that careful precautions must be taken to avoid all error. We determined not to trust to sighting on pinnacles, but to set out a series of flags whose identity could not be mistaken. The middle part of the glacier is deeply crevassed, and in reaching the proper positions for planting the flags considerable difficulties were met; but, as in all such matters, this only added zest to the undertaking, and we set ourselves to the task of crossing the ice near its end. In this we were unsuccessful, although when setting out the flags we made five or six attempts, first from one side and then from the other. The furthest points reached from opposite sides were about 500 yards apart, and although this interval is greater than we wished, still it is not much greater than the average interval between the flags; and so our series was practically continuous (see map of ice-front, plate 15).

Two independent sets of measurements were made, the first on a series of ten flags from July 21 to 24, the second on a series of nine flags from August 4 to 8. The first three flags on each side were recovered after the first set of observations and replaced, so that observations on them extended from July 21 to August 8, a period of 18 days, with a corresponding increase in accuracy in the determination of their daily rate. Three or four days was about as long as the flags would stand before falling, although they were planted in holes 18 inches deep. The flags marked with one dash belong to the first period, those with two dashes to the second; the others were observed during both. No results were obtained from 7′, as it fell between July 21 and 24. The flags were observed from *E* and *K*, which were 5,513 yards apart, about three and one-quarter miles. These were the most available points of observation, and although they were not well adapted for determining with high accuracy the actual positions of the flags, still these positions were determined with quite sufficient precision. The direction of the motions could not be determined from our observations, for very small errors of observation produce large errors in this direction. This, however, was unimportant, for the direction is given by the moraines, which was about at right angles to the line *E–K*. The change in the positions of the flags could be well measured from these stations, as the motion made a large angle with the lines joining the station to the flags. The part of this motion at right angles to *E–K* was taken as the actual motion. We have thus for the first period, July 21 to 24, two independent measures, one from *E* and one from *K*, which agree very well. The average is given in the table. For the second period, observations of motion were made from *K* only. The observations on the side flags from *K*, which extended from July 21 to August 8, are given in the column headed iii, and in the last column are collected what I consider the most reliable results. It will be seen that the motion, scarcely observable at the sides, increases rapidly toward the center, where it amounts to about 7 feet a day. A consideration of the size of the instruments, their distance from the flags, and the size of the flags themselves, shows that there is a possible, though scarcely probable, error of some two feet in the determination of the motion of the center flags, and not more than half so much in that of the side flags.*

Table showing Motion of the Flags in the Ice.

Flag.		Dist. in feet from—		Daily Motion of Flags, in feet.			
No.	Color.	*E.*	*K.*	I.	II.	III.	IV.
1....	Black..	13,622	4,321	.0	.7	.0	.4
2....	Red ...	12,064	5,850	3.0	2.3	2.6	2.6
3....	Black..	11,155	6,614	4.4	4.9	5.9	5.9
4″ ..	Red ...	10,384	7,438	.. ...	6.6	......	6.6
4′ ...	Red ...	10,207	7,553	4.8	......	......	4.8
5′ ...	Black..	8,937	8,603	6.1	......	......	6.1
5″ ..	Black..	8,744	8,819	......	7.1	......	7.1
6′ ...	Red ...	8,498	8,921	7.2	......	......	7.2
7″ ..	Red ...	7,339	10,515	......	6.2	......	6.2
8....	Black..	6,378	11,106	5.7	6.9	6.2	6.2
9....	Red ...	5,226	11,936	4.3	4.8	4.9	4.9
10....	Red ...	3,652	13,275	.0	......	.7†	.7

I. Daily motion from July 21 to 24.
II. " " " August 4 to 8.
III. " " " July 21 to August 8.
IV. Best value of daily motion deduced from i, ii, and iii.

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* The flags were six feet long and three feet wide. The instruments were those used in our survey and described later (see p. 53, foot-note).

† This determination was made from *E* for the period July 21 to Aug. 4.

In addition to the flags, five stakes were planted in a line and about equal distances apart on the eastern side of the glacier, as shown in the map. Their movement was determined from August 6 to 29. The table gives the total movement during that time at right angles to the line of the flags, which was the direction of the slope. The direction of the moraine shows that this is approximately the direction of motion.

Movement of Stakes.

a	0
b	7 inches.
c	11
d	3.5
e	0

This amounts to about 2″ a day for the middle flag.

Conditions holding at the Ends of Glaciers.

Alpine Glaciers.—It has been long recognized that the comparatively stationary position of the end of a glacier is due to the general equality between the quantity of ice flowing down and the quantity melted. The mean temperature of a valley increases as we descend; if, therefore, the end of the glacier should advance beyond the point where the rate of melting equals the rate of supply, the ice would melt more rapidly and the end would recede. If, on the other hand, the glacier should not reach this point, ice would flow down faster than it would melt, and the end of the glacier would advance. This point is not merely a point of equilibrium, but a point of stable equilibrium. This explanation is sufficient, so long as we merely look upon the end of a glacier as a whole. But when we consider each part of the end by itself we are met by difficulties which do not seem so far to have been noticed.

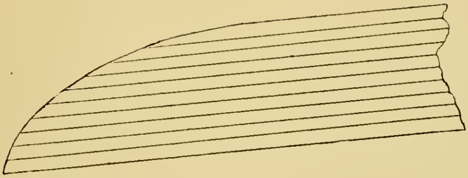

FIGURE 1—*End of an Alpine Glacier.*

As one approaches the end of the glacier the surface of the ice becomes steeper and steeper, and frequently becomes too precipitous to allow one to stand on it. The diagram (figure 1) shows the form of the surface cut by a longitudinal section. Now, why does the glacier assume this shape? We know that the surface of a drop of water or of a small quantity of honey on a plate will assume some such shape; but this is the result of molecular forces which can not have any appreciable effect on large bodies like a glacier. The end of a flowing lava stream will have a somewhat similar form, but this is a case of continued flow and not one of equilibrium. These analogies throw no light on the question. If we divide the glacier into layers by a series of surfaces parallel to the direction of flow, the condition that the end shall be stationary requires that the ice supplied by each layer shall be melted at its end. Now, the upper layers move more rapidly than the lower ones; therefore their ends must melt more rapidly. A glance at the diagram will show that, on account of the form of the end of the glacier, the ends of the upper layers expose a larger surface than the lower to the air and sun, resulting in their more rapid melting. This, although undoubtedly a part of the explanation, is not the whole of it, for the form of the glacier's end would be one of unstable equilibrium. If anything should cause the surface to become somewhat steeper, the exposed ends of the upper layers would become smaller, and these layers would no longer melt away rapidly as they advance; the surface would continue to grow steeper until the upper part would break off and thus restore the slope. Although glaciers have been observed to advance I have never heard of it occurring in this manner. A series of measurements of the rate and direction of motion, and the rate of melting at the end of some glacier, such as the Gorner or Morteratsch, in Switzerland, would undoubtedly throw light on this problem.

At the end of the valley of Norris glacier, Taku inlet, there is a broad expanse of gravel, etc, on which the glacier, after issuing from its gorge, spreads itself like a great fan, thus presenting a large surface to the air and sun; so that the melting of the ice is as rapid as the supply.* If it were prevented from spreading it would extend much further than it does, and would undoubt-

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* This level expanse must be either the accumulation of glacial débris or a delta formed when the glacier was less extensive than now.

END OF MUIR GLACIER, FROM V.

edly reach deep water. The Taku glacier, close by, finds no such support at the opening of its gorge, and therefore discharges into the water as a tide-water glacier. Davidson glacier, Lynn canal, has a termination exactly like that of the Norris. The great Malaspina glacier seems to be merely the united ends of the many large glaciers flowing from the St. Elias alps, expanded on the great plateau which borders these mountains on the south.*

Tide-water Glaciers.—The Muir glacier is an excellent example of this class. The inlet into which it pours increases in depth from the sides to not less than 720 feet near the middle; but the ice is so thick that even this depth is not sufficient to float it. Here we have an entirely different method of waste. The ice breaks off and floats away in the water as icebergs. What is it that regulates the rate at which the ice breaks off? What is the form of the glacier's end below the water? Above, it is practically vertical. I can only give a partial answer to these questions.

Suppose the end of Muir glacier were vertical from top to bottom; let us apply what we know of the motion of glaciers to this case and see what would follow. The more rapid motion of the upper part would result in its projection beyond the lower part, and this would become greater and greater until its weight was sufficient in itself to break it off. The extent of the projection before a break would occur depends evidently on the strength of ice. The water supports the ice by its buoyancy, so that the weight tending to cause fracture is slightly less than the weight of that portion of the ice which is above water. The line of fracture is determined by the position of some crevasse or some irregular melting below the surface. This form seems to be one of stable equilibrium, for if the ice should project too far it would break off, and if it did not project far enough no break would occur until its proper motion had carried it out further. That the ice for several hundred feet below the surface does not in general project further than that above is evident from the fact that I have frequently seen large masses, extending to the very top of the ice-front, shear off and sink vertically into the water, disappear for some seconds, and then rise again almost to their original height *before* turning over. If there were any projection within 300 feet of the surface, this mass would have struck it and

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*See Russell, Exp. to Mount St. Elias: Nat. Geog. Mag., vol. iii, 1891, p. 121.

been overturned so that it could not have arisen vertically out of the water.

Let us picture to ourselves what takes place at the end of the glacier, noting first that there are three ways in which the ice breaks away: (*a*) a piece may break off and fall over—this is the usual way with small pinnacles; (*b*) a piece may shear off and sink into the water—this is the usual way with the larger masses; or, again, (*c*) ice may become detached under water and rise to the surface. The diagrams in figure 2 illustrate what I conceive to be successive forms of the ice-front. They show how, after a number of pieces break off from above, one large piece will break off from below, but, in all probability, not from near the bottom. The broken line shows where the break occurs. The dotted lines show the form of the front just after the last break.

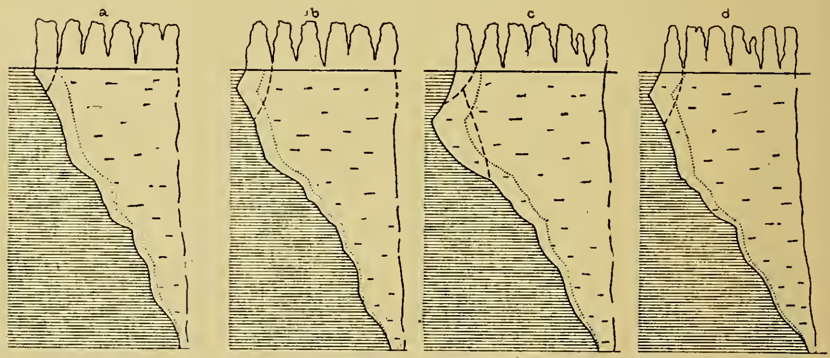

FIGURE 2—*End of a Tide-water Glacier.*

In addition to waste by breakage, there is the waste by melting. Above the water surface this is unimportant, for there the quantity of ice floated away is much greater than that melted; but near the bottom of the glacier, where the motion is very slow, the melting is the principal, probably the only, cause of waste, for the ice is in contact with water which is probably not very cold* and is, moreover, salt. That the ice does melt

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* Professor Wright found the surface water in Muir inlet to be 40° F. I did not take the temperature, but I was once much astonished on putting my hand into the water to find it not at all cold, although there was a large amount of ice floating about. This high temperature must be due to the tides and warm winds prevailing here, and to the comparatively warm sea near by.

below water more rapidly than it does in the air, is shown by the fact that icebergs roll over, which is due to this alone. It is quite possible that the icebergs darkened by mud and rock may not have come from the bottom, but may be merely exposing the side of some old crevasse into which débris from a surface moraine has fallen. The bergs which we saw rise from below the water usually came up after a very heavy fall from above, as though some crack had been started by the shock of the falling ice; only a few of them were discolored by débris; most were pure blue ice* Moreover, they did not rise very high out of the water. All this makes me think that they did not originate at any very great depth. Just as a stick thrown obliquely into the water may rise again at an angle, so a berg, on account of its shape, may rise so obliquely as only to reach the surface some distance from the ice-front, thus suggesting that the glacier sends out a foot along the bottom of the inlet, from the end of which the ice breaks off; but the considerations I have mentioned make it evident, I think, that this is not the case. A series of observations on the temperature and density of the water of Muir inlet at different depths and at different distances from the ice would undoubtedly afford information that would enable us to reason very accurately about the form of the ice-front below the water.

The ice at the bottom of the glacier in contact with its bed moves very slowly, and it is not improbable that the melting, where it meets the salt water, quite equals the advance. The slope from that point up is determined by the strength of the ice. If the progression of the bottom is greater than the rate of melting, the glacier will advance until it comes to a broader part of the fiord, and thus presents a broader front to the water. If the fiord were of uniform depth and breadth, the ice could only find a position of equilibrium at one end or the other.

The effect of the depth of the water in determining the position of the glacier's end is not apparent. As the depth is greater the pressure against the ice is greater, but at the same time the water produces a greater upward pressure on the ice, diminishing its pressure against its bed and thus reducing the friction. Although these effects cannot balance at all depths, I am unable to indicate which one is in general the stronger.

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*The discolored bergs seen by Mr Russell in Disenchantment bay are probably from the débris-covered parts of the neighboring glaciers.

If a glacier reaches water which is so deep that it does not touch the bottom, and the motion of the ice is more rapid at the bottom than the melting, then its end will be forced further and further into and deeper and deeper under the water, following the slope of the bed, until the buoyancy of the water is sufficient to break it off. The place where the fracture will occur, and the size of the iceberg formed, are problems of mechanics.

Glacial Erosion.

The general scratching and smoothing of rock by glaciers is familiar to all. Another method of erosion, not so generally recognized, was observed here. The spur of Tree mountain, which I have already mentioned and on which we camped one night, is a compact slate; parts of it were smoothed and scratched; other parts bore a confusion of mixed rock, the rock of the spur largely predominating; in still other places the bed-rock showed where angular pieces had been broken out, leaving holes which in some cases contained water. Near the summit of nunatak *H* is a rock-basin lake which must have been formed in the same way. It is about 40 feet long and 20 feet wide.* Its sides are much scratched; on one side the rock rises vertically eight or ten feet above the water. The rock which formerly filled this hole, separated probably by joints from the rock beneath, must have been torn out by the ice in its passage over the spot—not necessarily as a whole, but possibly by pieces. The rocks thus torn out are in part pushed by the glacier to its end, in part rubbed and ground into fine mud and carried off by the subglacial streams. This method of glacial erosion seems to me much more efficient in digging valleys than the simple scratching and smoothing that is so much more noticeable in valleys formerly occupied by glaciers.

Probably the best method available for determining the rate of erosion is to calculate the amount of sediment carried off by subglacial streams, as Professor Wright did. Repeating his calculation with the more accurate data at our disposal, we find that an average of about three-quarters of inch is eroded annually from the bed of Muir glacier.†

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* These dimensions are given from memory.

† The following data were used in this calculation: Area drained by glacier, 700 square miles; area of glacier bed, 350 square miles. If we assume no motion at bottom, then in the middle of the ice-front the quan-

The erosion, of course, cannot be uniform, but must vary much with the nature of the rock and the thickness and rate of motion of the ice. Near the mouth of the glacier all of these conditions coöperate to increase the action, for the rock is slate, the motion more rapid, and the thickness of the ice probably greater than elsewhere. It does not seem excessive to consider the erosion here five or ten times as great as the average. The sudden fall between *G* and *H* probably marks the line between the harder

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tity of ice carried out per day would be a triangle of 7 feet base (see page 44) and 920 feet altitude. Near the sides the triangle would have a smaller base and a less altitude. Let us suppose a wedge having 7 feet base and 560 feet altitude (half the greatest depth plus the height of the ice above water) and a breadth equal to the whole ice-front, 9,200 feet, to be breaking off daily; let us suppose this daily loss constant throughout the year (our ignorance of the law of glacial motion below the surface will not permit a closer approximation—double this quantity would certainly be too much, and would still only slightly affect our result). The Signal service sends me as the average of six years' observation of rainfall at Sitka 105.62 inches, and the average at Juneau 89.30 inches. Our own observations at camp Muir for two months gave about the same rainfall as at Juneau for the same period. I have therefore adopted 90 inches for the yearly precipitation (see appendix ii). The rest of the data I have taken from Professor Wright's account (Ice Age in North America, p. 64), viz: 708.48 grains of sediment in each United States gallon of water of the subglacial streams; specific gravity of this material, 2.5; loss by evaporation, one-eighth of precipitation. We thus find for the total precipitation over the area drained by the glacier, 146,300,000,000 cubit feet; annual loss in bergs reduced to water, 5,906,000,000 cubic feet; loss by evaporation, 18,300,000,000 cubic feet; leaving, say, 120,000,000,000 cubic feet of water per year carrying off sediment, which gives an average of about ¾ inch eroded from the whole bed of the glacier. It is assumed that all the water coming from the glacier is charged with sediment. This is in accord with observations so far as they go. The clean surface streams near the end of the glacier empty into the subglacial streams, from one of which the determination of the amount of sediment was made. It may be objected that much of this sediment comes from the surface moraines, the rocks either there disintegrating into fine material or falling through crevasses to the glacier bed and being there ground up. The clearness of the surface streams show that the former is not the case; and the fact that all the moraines on the surface of the glacier would hardly be enough to supply material equal to the sediment carried out in a single year is conclusive evidence against them both. We have not taken into consideration the material pushed out from under the glacier before it has been ground fine, and this is probably of large amount (although we have no means of measuring it) and would increase the above estimate of the erosion.

crystalline rock above and the softer slate below, and is probably due to the different rates of erosion of these rocks.

METEOROLOGICAL NOTES.

The prevalent wind on the Alaskan coast is from the southwest, but the glacier, by cooling the air in contact with it, produces a cold wind which slides down its slope. Thus a northeasterly wind blew continuously at our camp except occasionally when a strong southerly gale overcame it. On the western tributary the wind was from the west and in Main valley from the northwest; in fact, everywhere it flowed down the slope of the glacier. Its influence on the temperature was very marked. The mean temperature during July and August was 45°.1 F., about 10° lower than that at Juneau during the same period, although this latter place is only about 35 miles further southward. At no time during our stay, however, was a freezing temperature reached.

This cold wind did not usually extend very high; frequently mist could be seen moving northward not 1,000 feet above our camp, where the flag was streaming toward the south. The temperature was higher on elevations than lower down. At I (3,000 feet) the thermometer was once observed 6°.7 C. (12° F.) higher than at camp; also, at the same time, on the top of Tree mountain (2,700) the temperature was 4°.3 C. (7°.7 F.) higher than at camp. The increase of temperature with altitude causes an unusually rapid decrease of density in the atmosphere, with a corresponding increase in refraction, thus producing the mirage which is so common here. It is noticeable only when both the observer and the object are in the cold layer. A ray of light may reach the observer after following a horizontal path, or after rising slightly and then being refracted down again. The result is to make the object appear stretched out and to give it increased height. We often saw islands with apparently vertical sides; the icebergs in Glacier bay were magnified vertically so as to

FIGURE 3—*Diagram illustrating Refraction.*

MUIR GLACIER

ALASKA

Surveyed with Plane Table in 1890, by
HARRY FIELDING REID

Scale [illegible]

look like the ice-front of another glacier; the pinnacles of Muir glacier sometimes look like minarets. These appearances have given rise, by a considerable stretch of the imagination, to the so-called "Silent city," or "Phantom city," figured in some books which describe this region. This mirage is just the opposite to that seen in hot deserts. There the rays are bent up, making the image look as if it were reflected from the surface of water; here the rays are bent down; yet the bending is not sufficient to entirely separate the image from the object, but only makes the latter appear distended, as though it were made of rubber and had been stretched upward.

We had rather less rain than we expected: about one day in three was rainy during July and August; September was much wetter. There were no thunder-storms, and usually the rain was in small drops. In August auroræ were frequently seen, so frequently that I think they must have occurred every night; possibly all the time, although, of course, daylight would have masked them. Earlier in the summer the twilight, which lasted all night, would also have drowned them if they occurred.

THE SURVEY.*

A base line was measured off with a steel tape from *A* to *B* on the plateau on the western side of the inlet; here we found fairly even ground. The base was measured twice; first from *B* to *A*, then from *A* to *B*. The two values obtained were 962.301 and 962.330 meters respectively. The length adopted was 962.32 meters, = 1,052.8 yards. By means of small transits we then made a network of triangles and fixed the points *A B*, *D*, Camp, *E*, *K*, *L*, *M*, *b4*, *c2*. The maps were made entirely with the planetable. This instrument was set up at Camp, *D*, *E*, *H*, *L*, *N*, *O*, *P*, *R*, *S*, *T* and *V* for the general map. The map of

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* The instruments used in the survey were lent by the United States Coast and Geodetic Survey. They consisted of—1, a 30-meter steel tape, with which we measured the base line; 2, two small Casella transits, with 2¾-inch vertical and horizontal circles, divided to half degrees and reading by two verniers to minutes, which were used in the triangulation, in the measure of the motion of the ice, and in determinations of latitude; 3, a planetable 14 by 18 inches, with which the maps were actually made. In addition, we had four aneroids, only one of which, however, was found to yield reliable results. This one was used in determining the height of *V*, and the height of the glacier near *P*.

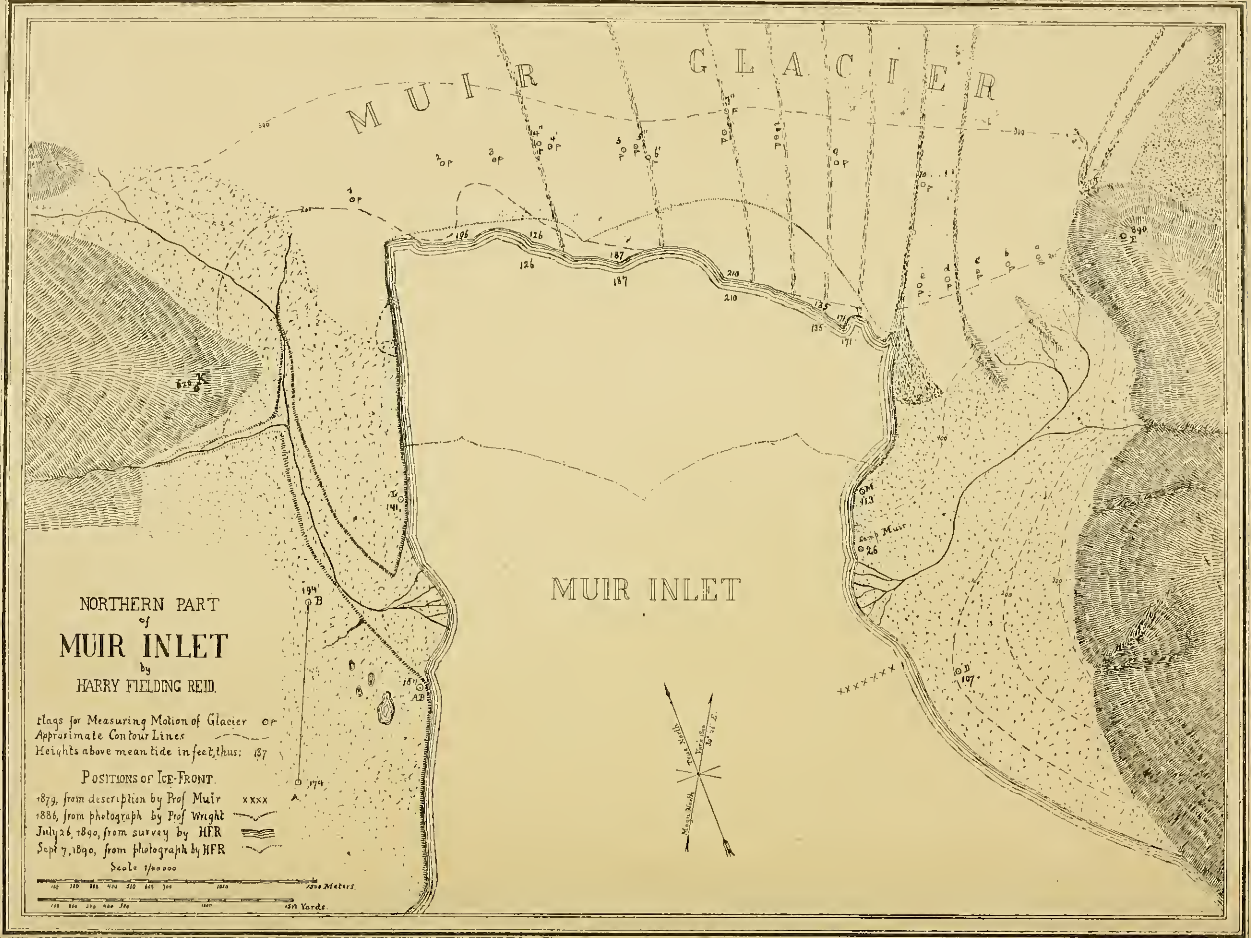
the inlet and ice-front was made from Camp, *D*, *L* and *M*. Photographs were made from many points, and these have been of the greatest use in drawing in the general topography. As to the accuracy of the maps I think that none of the points marked thus ⊙ are out of their place by 1% of their distance from *E*; many are much more accurately fixed. Many points where the rocks and ice were in contact, etc, were, of course, determined, but with much less accuracy.

In order to connect our map with any future survey that may be made in this region, we made two cairns of heavy stones, one at *D* and one at *E*. *D* is on the gravels on the eastern side of the inlet, at a height of 107 feet above mean tide. *E* is on a flat knoll of the ridge descending from mount Wright, at an elevation of 890 feet. The horizontal distance between *D* and *E* is 2,735 yards, and the line connecting them runs N. 41° 43′ E., astronomical.

The latitude of our camp was determined on several occasions; the average, 58° 49′.7, can hardly be in error by more than a half minute. The longitude was not determined; on first going into camp the chronometer was allowed to run down, and when we left, it stopped for some reason unknown. The chronometers of the steamers were not sufficiently accordant among themselves to give reliable results by comparison with our local time. The longitude adopted by reference to the best map of the region in the Coast Survey office is 136° 5′ W., which can hardly be in error by 5′.

On platting our map into the general chart of the United States Coast and Geodetic Survey, we see that the area we surveyed occupies much of the region between Lynn canal, Chilcat river, and the upper part of Glacier bay. The mountains on the eastern part of our map must be visible from Lynn canal, which is only ten or twelve miles distant. Davidson glacier must have tributaries in the mountains which close in Granite canyon. There is a rumor that the Chilcat Indians were accustomed to make the passage to Glacier bay over the Davidson and Muir glaciers. If this is true there is probably a low divide between some tributary of Davidson and the first northern tributary of Muir. This region, unfortunately, we were unable to see.

The scale of the general map is $\frac{1}{150000}$, which is large enough to show the detail we were able to make out, except in the neighborhood of the mouth of the glacier. I have added contour lines


NORTHERN PART
of
MUIR INLET
by
HARRY FIELDING REID.
Flags for Measuring Motion of Glacier
Approximate Contour Lines
Heights above mean tide in feet, thus: 187
POSITIONS OF ICE-FRONT
1879, from description by Prof Muir xxxx
1886, from photograph by Prof Wright
July 26, 1890, from survey by HFR
Sept 7, 1890, from photograph by HFR
Scale 1/40000
1500 Meters.
1500 Yards.
MUIR GLACIER
MUIR INLET
Camp Muir
True North
Magn North
Var'n 1890 30° 26' E.
K
B
A
AB
D
E
M
300
200
100
196
126
187
210
135
171
141
194
174
113
26
107
890
626

at 200-foot intervals; it must be remembered that these pretend to no accuracy, but merely serve to show the general form of the surface, as well as I can indicate it by aid of memory and photographs. The altitudes above mean tide which were determined trigonometrically are given in black figures; those determined by barometer or estimated, in blue figures. Camp Muir was estimated to be 25 feet above mean tide.

For the inlet I have made a separate map on a scale $\frac{1}{30000}$, which shows well the position of the flags we used for measuring the motion of the glacier and the form and position of the ice-front at various times. The contour lines here also are only very roughly approximate; the interval between them is 100 feet. The numbers give altitudes determined trigonometrically, except those on the contour lines, which are estimated.

SUPPLEMENT I.

NOTES ON THE GEOLOGY OF THE VICINITY OF MUIR GLACIER.

BY

H. P. CUSHING.

CONTENTS.

GENERAL FEATURES.

Both aqueous and igneous rocks occur in the vicinity of Muir glacier, and the plutonic rocks belong to two distinct periods. All the rocks of the vicinity have suffered much dynamically, the recent eruptives excepted. The whole series is much shattered and fissured. Three sets of fissures are generally readily made out, dividing the rock into small prismatic blocks. These fissure planes are seldom vertical, but present varying angles. Generally they are mere cracks, often filled by infiltration, but sometimes they have a width of several feet. The numerous small dikes of andesitic rock appear to have the same directions as the fissure systems, and were probably formed at the same time. Evidence of small faults of comparatively recent origin, involving these dikes and determined by their aid, is occasionally forthcoming, showing a certain amount of disturbance in the region since they were formed. Evidence of earlier faults is difficult to obtain, owing to the homogeneity of the rocks and the great difficulty in making determinations of dip on account of the obliteration of the bedding planes; but it is clear that a considerable amount of faulting took place prior to the formation of the dikes. The strike of the sedimentary rocks is about N. 50° W. (N. 80° W. magnetic). The dips are generally at high angles toward the south. but are extremely variable. Short monoclinals involving a considerable change of dip are not uncommon. Small anticlinals and synclinals occasionally occur, but are of minor importance, soon giving way to the prevailing southerly dip. These frequent variations in dip are well shown along the eastern shore of Headland island. A considerable fault is also shown about midway along this shore, clearly indicated by the difference of dip on the two sides; but the similarity of the rocks on both sides renders any determination of the amount of throw impossible. Sufficient country was not covered to at all clearly exhibit the type of mountain structure obtaining here. The dip is pretty persistently away from the diorite peaks, which were the most northerly ones reached. What lies beyond them no man knows. The work done makes it probable that we have here a tilted and raised block accompanied by faulting.

SEDIMENTARY ROCKS.

Two great series of sedimentary rocks are exposed in the Glacier bay region, one of argillite, the other of limestone; both are of great thickness. The limestone is the younger. The contact between the two is well shown on the eastern shore of the bay, has an extremely steep southerly dip, and reaches tidewater about eight miles south of the present front of Muir glacier.

The Argillite.—The mountains adjoining Muir inlet and the upper northeastern shore of Glacier bay and those surrounding the eastern part of Muir glacier amphitheater are entirely composed of slaty rocks (see geologic map, plate 16). The thickness of these argillites I was unable to determine, but it clearly reaches several thousand feet. They present three main phases:

1. Very hard, fine-grained, gray argillo-siliceous bands, of somewhat varying shades, occasionally approaching quartzite in character.
2. Equally abundant with the last, and with them making up

the larger portion of the series, are bands of nearly equal hardness of a blue or black slaty rock, containing a smaller arenaceous admixture than the last, but being somewhat calcareous. The first variety is more abundant in the lower portion of the series, the second in the upper. Both are very homogeneous and fine-grained, and extremely compact. The black variety weathers to a dark-brown color, the gray to a yellowish brown and sandy-looking surface. These give characteristic colors to the moraines in the southeastern portion of the amphitheater, a medial moraine sometimes appearing one color or the other as it is viewed from one side or the other. The extreme hardness of these slates is due to their metamorphosed condition. The degree of metamorphism is quite uniform throughout. So far as can be told by the eye, it has nowhere been carried to a point where recrystallization has begun, so that none of these rocks are at all schistose in character. The metamorphism and the numerous fissures which cut these rocks have nearly obliterated the old bedding planes, so that dips are generally most perceptible from a distance, owing to the banded appearance given by the presence of the two varieties. Little or no tendency to split on the original bedding planes is now shown, the fissures determining the shape and size of the blocks, which themselves often display the color bands. These bands are well shown in many places; for example, on the highly glaciated slopes of mount Wright which face the inlet.

3. Comparatively thin bands of more fissile, black graphitic slates are found interstratified with the others. These are found at numerous localities, and there are certainly several such bands, though their apparent number may be increased by faulting. They are softer than the other slates, and readily split into thin, even slabs. They become dotted with brown specks on weathering. The fissures which intersect the slates are commonly filled, wholly or in part, by crystalline calcite, somewhat binding unweathered blocks together. This is universally the case with the blue-black slates, and more commonly so with the gray; but such fillings do not occur in the graphitic slates. This would indicate that the calcareous matter was largely derived from the slates themselves, and that the graphitic slates lack it from having contained none originally. Generally these fillings are mere films, but occasionally wider fissures occur which contain calcite masses of considerable size. The large blocks of white crystalline

marble occurring on some of the moraines have had such a source. Two large calcite seams of this character show beautifully on the eastern face of Pyramid peak, looking, to an observer in Dying glacier valley, like rills of water on the mountain side. In the vicinity of the eruptives these fissures are often metalliferous, and occasional quartz veins occur.

Careful search for fossils was made in these argillites at many points, but no discovery rewarded the search. It is very possible that the series comprises rocks of more than one age. The whole is so homogeneous in appearance that its dissection, if dissection is possible, will be a matter of vast and painstaking labor.

The Limestone.—The mountains forming both shores of the larger part of Glacier bay, and all the islands in the bay except the two in Muir inlet and the Beardslee islands, are made up of metamorphic limestone. This first appears on the eastern side of the bay, forming the mountain peak just south of the peak of mount Wright, follows along the mountain summits for some little distance with slight dip, and then abruptly plunges down to the shore with a very steep southerly dip. Near its contact with the slates it contains considerable argillaceous admixture; otherwise it is an extremely pure dolomitic limestone, containing only a trace of insoluble matter. More commonly it is of a dark purplish tint, though some portions are drab. It is cut by the same fissure systems as the argillites, but is bound into a more compact mass by the calcite which everywhere completely fills the fissures, so that it disintegrates with less rapidity. Search for fossils in the limestone was rewarded at only one locality, on the island in Glacier bay nearly due south of Headland island. Here but a handful were found. The only recognizable forms were shells of *Leperditia*. Sections of large gasteropods showed beautifully on the highly polished limestone surface, but it was impossible to break out specimens which would give any indication of external form. I sent the collection to Professor H. S. Williams for examination. He replied that *Leperditia* was recognizable, while the others would scarcely repay careful examination; that the age was probably Paleozoic, but that the collection would warrant no more decisive statement. The superior limit of the limestone was not seen, but it has a thickness of several thousand feet. It appears conformable with the argillites below, indicating their probable Paleozoic age.

Eruptive Rocks.

Slides of all the eruptive rocks found in the district, ground by the United States Geological Survey, through the courtesy of the director, were sent to Dr George H. Williams for examination. It is much to be regretted that, owing to a misunderstanding, no field-notes were sent him. His paper accompanies this, and to it the reader is referred for the nature of the rock species under discussion (supplement ii). There are two main classes of igneous rocks in the district: (1) ancient eruptives occurring in large masses, classed as diorites by Dr Williams, and (2) more recent eruptives, occupying dikes generally of small size, which cut both the sedimentary and the older eruptive rocks.

The Diorites.—The northern and northeastern tributaries of Muir glacier have brought down on their moraines great quantities of diorite, derived from the mountains adjoining the upper portions of their valleys. These diorite mountains lie just north of those of argillite which form the southeastern boundary of the glacial amphitheater. I saw the rock in place only from a distance, and had no opportunity to examine the contact between it and the argillite. This renders it impossible to state which of the two is the older. No evidence of shore conditions is observable in the vicinity of the contact, nor is there any evidence perceptible to the eye that the argillites derived any of their material from the diorite, affording a slight negative evidence in favor of the diorite being the younger. To the eye the diorite seems to consist of nearly black hornblende and a white plagioclase, the hornblende largely predominating. A distinctly foliated arrangement is often observable, simulating a rough gneissic structure. In the main it is fine grained, but sometimes quite coarsely crystalline.

Quartz-diorite.—Another great plutonic mass, having a very different appearance from the last and completely separated from it in the region examined, is described as quartz-diorite by Dr Williams. Its outcrop is fan-shaped, running out toward the east, but having a great development toward the northwest and west. Nunataks *G* and *H* are composed of it, and also the mountains toward the west and northwest as far as the eye can reach, the peculiar light tint of the rock making it easily recognizable at some distance. The moraines that come down from that direction are almost entirely composed of this material. To the eye this rock consists of a mixture of white plagioclase and glassy quartz, in which is imbedded occasional prisms of hornblende which seldom have a length of less than a quarter of an inch; occasional plates of biotite also occur. The contact of this rock with the slates is best shown on the northern wall of the valley of the small glacier which lies north of Pyramid peak and was formerly tributary to Dying glacier. An angle in the wall cuts through the slates into the quartz-diorite, showing two contacts. The westerly one is sharp and nearly vertical. The eastern one is inclined toward the west, and numerous stringers are seen penetrating the slates. This indicates the more recent date of the eruptive rock. The slates in the near vicinity are apparently not greatly affected by the heat consequent on this outflow, but the same holds true of them when in juxtaposition to the more recent dikes, and is accounted for by the metamorphosed condition of the whole series.

Three small exposures of rock, clearly distinguishable from the main quartz-diorite mass macroscopically, but which Dr Williams also describes as quartz-diorite, occur. One of these is on the most northerly spur of mount Wright, at Mr Reid's station *E;* another forms the southern projection of the ridge west of Granite canyon; the third is found cutting the limestone on the shore of the bay 10 miles south of Muir glacier. Their relations to the main mass could not be determined. They are easily distinguishable from the main mass, which is very uniform in appearance, by their greater percentage of hornblende and their metalliferous contents. Their contacts with the adjoining rocks clearly indicate their outflow to be of later date than the deposition of those rocks.

These quartz-diorites are clearly quite old, and have suffered equally with the clastic rocks from the disturbances which the region has undergone. They are cut by the same sets of fissures, though not so numerously; they are also cut by the more recent dikes. Dr Williams strongly urges the ancient date of these diorite masses from his microscopic examination. This is corroborated by their appearance in the field and strengthens the meager fossil evidence obtained as to the early age of the clastic rocks.

Later Eruptives.—All the rocks previously described are cut by numerous small dikes of later date. The key to their arrangement was not apparent. They seem to lie in all possible attitudes and to dip in several directions, generally at high angles. They seem to follow the fissure systems. Their width is commonly but a few feet, but some were found twenty feet and over. They keep their width with great persistency for considerable distances. No surface flows were found. To the eye all these dike rocks strongly resemble one another. They have a nearly black or dark greenish color, a sandy appearance on weathered surfaces, and are generally distinctly porphyritic in structure, with considerable variation in the size of the porphyritic crystals. The specimens I collected from these small dikes and sent to Dr Williams he classifies without exception as diabases. From a somewhat larger and much decomposed dike on the ridge east of Dirt glacier valley I sent him a specimen which he describes as micropegmatite. What relation this dike bears to the diabase dikes could not be determined, and I found no others like it, though the loose pieces on the moraines show that they occur to the north. With this one exception, all the dikes seen presented a very uniform appearance, save for such slight differences of texture as depend on slight variations in the rate of cooling.

No evidence was found of successive outflows of varying character, though that may be furnished by the exploration of a wider area. The dike rock occurs in blocks of varying shapes and sizes. How much of this is due to fissuring and how much to contraction of cooling I cannot say. That a certain amount of dislocation has occurred since their formation is evinced by the fact that occasionally they are somewhat faulted. But their appearance in the field shows that they have suffered but little dynamically compared with the enclosing rocks.

No direct evidence was forthcoming, bearing on the age of these later eruptives; all that can be stated with certainty being that they are the youngest rocks hereabouts and are contemporary with a great disturbance of the region. Their appearance is very similar to that of certain eruptives of Tertiary age occurring in the Cordilleras further southward. The earlier eruptives indicate a certain amount of disturbance of Paleozoic or Mesozoic date in the region. At a later date further and greater movements took place, the rocks were upturned, faulted, and fissured, and certain of the fissures were penetrated by lavas of Tertiary habit.*

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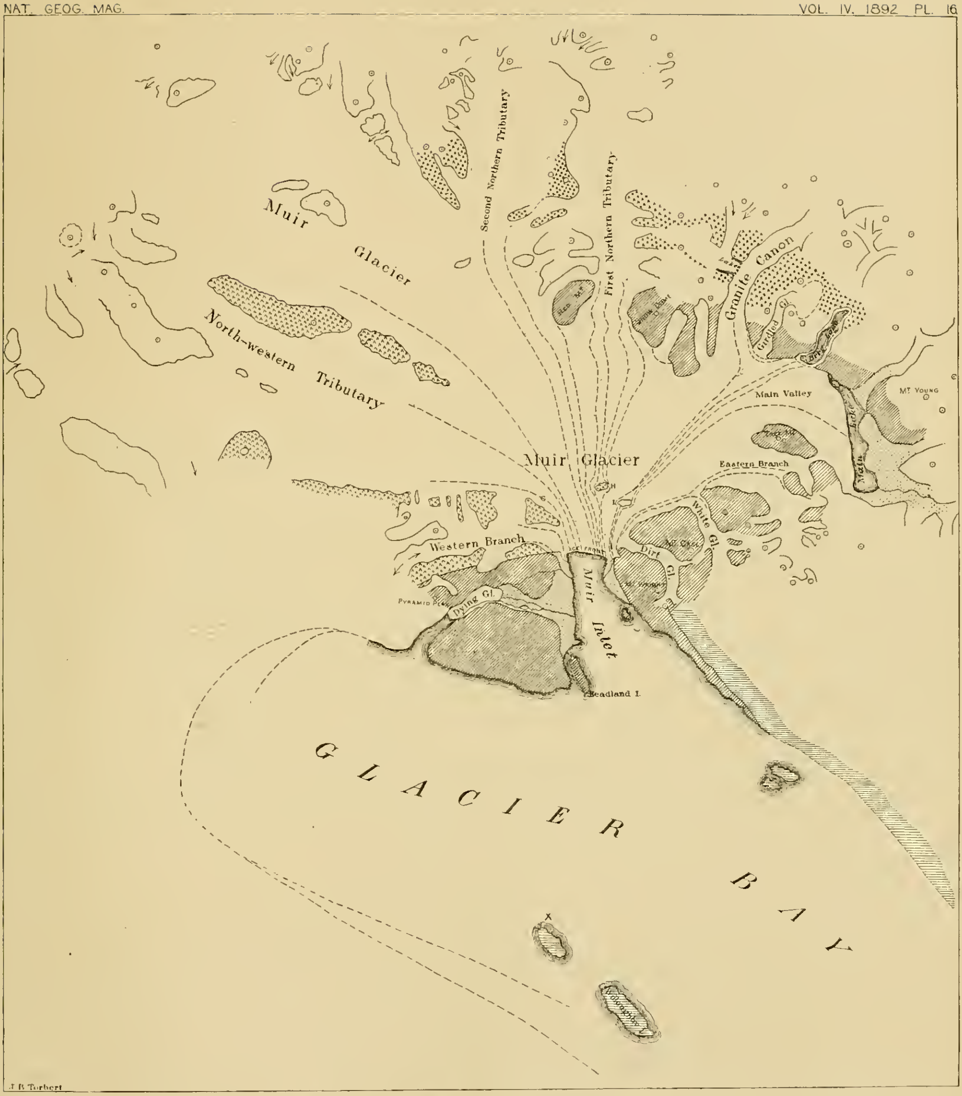
* These later eruptions probably took place at the time of the upheaval of the St. Elias range. See page 24 [H. F. R.].



▦ Diorite ▦ Quartz-diorite ▨ Argillites ▤ Limestone ▦ Glacial gravels ----Moraines X Island where fossils were found

Geologic Map
of
Muir Glacier Basin

By H. P. Cushing

SUPPLEMENT II.

NOTES ON SOME ERUPTIVE ROCKS FROM ALASKA.

BY

GEO. H. WILLIAMS, PH. D., OF JOHNS HOPKINS UNIVERSITY.

CONTENTS.

INTRODUCTION.

The rocks described in the following notes are for the most part comprised in a collection of fifty erratic bowlders and pebbles gathered near the foot of the Muir glacier by Professor H. F. Reid during his visit there in the summer of 1890. Forty-one of these specimens were examined microscopically, the others being too much altered to repay such a study. Microscopic sections of twelve specimens of eruptive rocks, collected *in situ* near the glacier by Mr H. P. Cushing, who accompanied Professor Reid, were also examined. The description of a single specimen (olivine-gabbro or forellenstein) obtained from the southern side of mount Cook by Mr I. C. Russell, of the United States Geological Survey, during the same season is also incorporated with the others.

Thanks are due to the director of the United States Geological Survey for his kindness in authorizing the preparation of the microscopic sections necessary for this investigation.

No elaborate or exhaustive study of this material was undertaken: first, because a preliminary examination showed that neither the intrinsic interest of the rocks nor their state of preservation warranted it; and still more because the bare petrographical description of a lot of disconnected hand-specimens, with no information in regard to their occurrence or geologic association, is of but doubtful value.

The real interest of this rock collection consists in the light it throws on the nature of the Alaskan mountains, which are for the present at least inaccessible to the geologist, and in the strong similarity between these specimens and the rocks which have been more carefully studied from portions of the Cordilleras and Great Basin farther southward.*

While none of the specimens in this small series give any clue to the nature or horizon of any sedimentary deposits, we do find in the coarsely crystalline diorites, quartz-diorites and gabbro a correspondence to the most ancient and probably Archean terranes occurring in the regions farther southward which are cut by dike rocks very similar to if not identical with those collected on the Muir glacier by Professor Reid. Although in the absence of geologic data this correspondence is only an indication, still it is too apparent to be overlooked. In the succeeding petrographical descriptions I shall therefore distinguish between the more coarsely crystalline plutonic rocks, whose structure indicates their occurrence in large masses, and the finer-grained though still for the most part holocrystalline rocks derived in all probability from dikes.

These latter rocks, as is usual in such series, cover a wide range, both structurally and mineralogically. The different types pass almost too gradually into one another to allow of any sharp division; and yet for convenience of description, rather than because they stand for any petrographically well-defined groups, they may be ranged under quartz-porphyry

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*See J. P. Iddings: Bull. U. S. Geol. Surv., no. 66, 1890, p. 9.

(rhyolite?), hornblende-porphyrite, augite-porphyrite and diabase.*

COARSE-GRAINED PLUTONIC ROCKS.

Not only does the structure of the more coarsely granular rocks examined by me from Alaska indicate that they originated, as above explained, under very different physical conditions from the more finely grained porphyritic specimens, but another of their characteristics renders it probable that they are also much more ancient than these. This is the evidence of extensive dynamic action to which they have been subjected, manifested in the fracturing, optical derangement, granulation, or metamorphism of the constituent minerals. The absence of such phenomena from the dike rocks is the second and more important reason for correllating the coarser specimens with a geologically earlier and possibly Archean terrane.

These plutonic rocks will be considered under the heads of diorite and gabbro.

Diorite.

Nine of the specimens collected by Professor Reid from the foot of the Muir glacier are representative diorites. They are numbered 1, 2, 3, 4, 5, 6, 7, 15 and 22. All are well preserved and differ from one another principally in the coarseness of their grain, in the evidences which they exhibit of dynamic action, and in their proportions of accessory pyroxene or biotite.

Augite-diorite.—Numbers 1 and 2, evidently identical, are rather coarse-grained augite-bearing diorites. Their principal constituent visible to the unaided eye is dark green hornblende, whose cleavage surfaces reach two centimeters in diameter. The spaces

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* The terms porphyry and porphyrite must be understood as used throughout this paper in a purely structural sense, with no reference to either geologic age or secondary alteration. In classifying a collection like this one, any reference to geologic age is plainly out of the question, and the specimens, while often much altered, still show the original structure of their groundmass with distinctness. This is in almost every case holocrystalline, and often quite coarsely crystalline, indicating in general a slower rate of cooling than that common to purely surface rocks. In this sense only then are the porphyries and porphyrites herein described supposed to differ from their less crystalline and more superficial equivalents, the rhyolites and andesites. In this usage I profit by the counsel of my friend, Mr J. P. Iddings, whose extensive researches among kindred rocks entitle him to speak with authority upon such a point.

between the hornblende individuals are filled with opaque white feldspar. The hornblende surfaces are often seen to be poikilitic, through a mottling with small idiomorphic feldspar crystals.

Under the microscope the hornblende is brown and pleochroic where freshest. It has the usual tendency to become green or colorless where it has undergone incipient alteration. It is closely associated with a quite abundant pale greenish-gray pyroxene. The two minerals are intimately intergrown, the small areas of the hornblende in the pyroxene looking as though they had resulted from the alteration of the latter mineral. A narrow fringe of hornblende frequently surrounds the pyroxene, while every grain of magnetite occurring in the pyroxene is bordered by a deep green hornblende zone. The feldspar is basic and much striated by twinning. It is also considerably altered to sericite and saussurite.

Augite-mica-diorite.—This rock (number 3) has a much finer grain than the preceding, and differs from it mineralogically in containing a considerable proportion of biotite. As a consequence of this the amount of its pyroxene is much less and occurs only as occasional cores surviving in the center of large hornblende individuals. The hornblende in this rock is full of inclusions which are irregularly distributed, like Judd's "schillerization" products.

Number 4 is a rock quite like the last, but which shows evidonce of intense dynamic action. It contains neither mica nor pyroxene in the particular section examined. All the constituents show the effects of pressure. The feldspar especially is bent, broken and dislocated, showing in a beautiful manner a peripheral granulation of the fragments.*

Number 5 is another augite-bearing mica-diorite, which, like the last described specimen, shows the extreme effect of dynamic action. Its feldspars are bent, broken and granulated, while its pale-gray pyroxene is peripherally altered to a new green hornblende, as is the case in the Saxon gabbros and granulites described by J. Lehmann.† Its mica scales are also greatly bent,

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* All of the four preceding rocks show a striking resemblance to the diorites described by the writer from the Cortlandt series from near Peekskill, on Hudson river, New York, in Am. Journ. Sci., 3d ser., vol. xxxv, 1888, p. 440.

† Untersuchungen über die Entstehung der altkrystallinischen Schiefergesteine, Bonn, 1884, pp. 193 and 230.

and the interior of its hornblende individuals is often granulated with quartz or albite, as in the Baltimore gabbro-diorites.*

Saussurite-diorite.—Number 6 is a rock similar to those described above, but much altered. Its triclinic feldspar is changed in part to scapolite, in part to saussurite. Its hornblende, of which there is comparatively little present, is largely changed to epidote and its biotite to chlorite. Considerable irregular areas of secondary quartz are also present.

Numbers 7 and 15 are medium-grained diorites with nearly idiomorphic feldspar crystals. They contain much twinned hornblende and accessory biotite. Number 15 differs only from 7 in containing more sphene and apatite.

Number 22 is another diorite much like the last, but whose hornblende has a poikilitic structure, being mottled with plagioclase crystals. This specimen also contains another mineral now wholly decomposed and undeterminable. It somewhat resembles biotite with calcite lenses, but it may once have been cordierite, as it greatly resembles the altered form of that mineral described and figured by the writer in a granite from the Black Forest, in Baden.† The groundmass of this rock consists of nearly idiomorphic plagioclase, much altered.

Number 44 is a diorite which differs from the others in being of a very much finer grain. In the hand-specimen it is dark green and quite aphanitic, while under the microscope it appears as a fine mixture of allotriomorphic green hornblende, plagioclase and sphene. This is evidently a dike rock.

Quartz-diorite.—Closely allied to the foregoing diorites and differing from them chiefly in their content of quartz, are six specimens collected *in situ* by Mr Cushing near the foot of the Muir glacier. These are somewhat more acid rocks than the quartz-free diorites, and are free from pyroxene. They contain either biotite or green hornblende, or both, in varying amounts. Their feldspar is a much striated and almost wholly idiomorphic plagioclase, with a finely developed zonal structure. The quartz, which is not particularly abundant, occupies the interstices between the well-formed feldspar crystals as the augite does in diabase. It is very plainly the last product of crystallization.

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* Bulletin U. S. Geological Survey, no. 28, 1886, pl. iii, fig. 1.

† Neues Jahrbuch für Min., Beil. Bd. ii, 1883, p. 598, taf. 12, fig. 1.

Gabbro of Mount Cook (Troctolite).

In the collection of Alaskan rocks intrusted to me by Professor Reid and Mr Cushing there are no representatives of gabbro, but a single specimen of this type collected in the summer of 1890 by Mr I. C. Russell on the southern side of mount Cook has been sent me by Mr J. S. Diller, of the United States Geological Survey, and may appropriately be noticed in this place.

This rock bears the closest macroscopic resemblance to the well-known forellenstein of Neurode in Silesia,* nor is the likeness less striking when the two rocks are compared under the microscope. The thin sections of the Alaskan rock which I have examined show an evenly granular aggregate of serpentine grains and a basic feldspar, which appears from its optical properties to belong to the labrador-anorthite series. The serpentine now contains no trace of the original olivine from which it has evidently been derived. The feldspar is striped with broad twinning lamellæ, and shows evidence of considerable alteration, although none of the constituents of this rock exhibit any indications of having been subjected to any particular dynamic action. Around each serpentine grain is a border of compact greenish hornblende, which for considerable distances belongs to single individuals.

To designate this peculiar modification of olivine-gabbro from which pyroxene is nearly or quite absent, the English petrographers employ a translation of the German term "forellenstein" (trout-stone) *troctolite.* As early as 1872 Professor Edward S. Dana proposed the name "ossipyte" to designate a rock from New Hampshire of the same mineral composition.†

FINE-GRAINED DIKE OR SURFACE ROCKS.

A goodly proportion of the specimens examined are fine-grained porphyritic rocks, covering a considerable range of types. Their structure indicates that they belong to small masses, which in all probability break through the crystalline complex of more coarsely granular rocks above described in the form of dikes, or perhaps in some instances cover them as surface flows. These

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* Vom Rath: Pogg. Ann., vol. 95, 1855, p. 551; and A. Streng: Neues Jahrbuch für Min., 1864, p. 257.

† Am. Journ. Sci., 3d ser., vol. iii, 1872, p. 49.

rocks, in spite of often possessing an extremely fine-grained groundmass, are in almost every instance holocrystalline. In only rare instances was there a truly amorphous base present in any appreciable amount. For this reason they will be classified for description (in accordance with the foot-note on page 65) as porphyries, porphyrites, and diabases.

Porphyry.

Micropegmatite.—The absence of granitic rocks is noticeable in the series examined from Alaska. The nearest approach to this type appears to be number 13, collected by Professor Reid. Both this and two other specimens which are related to it in the structure of their groundmass, are, however, more basic than we should expect true porphyries to be. They none of them contain any porphyritic quartz. Their phenocrysts are altogether hornblende and feldspar (mostly striated); so that, in the absenceof a complete analysis, they might perhaps be better classified as acid porphyrites.

Number 13 is a pale gray rock of medium grain, which under the microscope is found to be considerably altered. Its porphyritic hornblende is largely changed to epidote and chlorite. Its groundmass is rather coarse in texture, and consists almost entirely of the intimate intergrowth of quartz and feldspar known as micropegmatite. Allied to this specimen is number 7^2 of the suite collected *in situ* by Mr Cushing. This rock has rather an andesitic habit, consisting of porphyritic feldspar crystals or groups of crystals imbedded in a groundmass of smaller, but well-formed idiomorphic feldspars, mostly striated. These are not in actual contact, but are themselves connected by a still finer groundmass of quartz and feldspar, which are united in a very minute micropegmatitic growth. The idiomorphic feldspar forms a very large proportion of this rock. It is considerably altered. The ferro-magnesian constituents, whatever they once were (mica or hornblende), are comparatively rare, and are now almost completely changed to chlorite.

The third specimen, related both in composition and structure to the foregoing, is number 9 of Professor Reid's collection. Its phenocrysts are altogether striated feldspars. Its groundmass is rather fine grained and hypidiomorphic. The micropegmatite here manifests itself in an abundance of pseudospherulitic tufts and spheres, which grow out from the angles of the porphyritic crystals.

Quartz-porphyry.—The one specimen of the collection which may be classified without doubt as a quartz-porphyry or rhyolite is number 12 of Professor Reid's collection. This consists of a yellowish-white lithoidal groundmass, enclosing sharp crystals of bipyramidal quartz and orthoclase. Under the microscope the groundmass appears to be holocrystalline and obscurely granular. It is full of minute kaolin flakes, due to incipient alteration. The quartz crystals have their forms corroded with characteristic embayments of the groundmass. They are surrounded by a yellow stain. This rock is without doubt acid enough to belong to the rhyolite series, and it has a strong macroscopic resemblance to certain rhyolites; still, in accordance with the principles set forth in the foot-note on page 65, we may more consistently call it a quartz-porphyry on account of the holocrystalline character of its groundmass.

Porphyrite.

Hornblende-porphyrite.—By far the greater proportion of Professor Reid's fine-grained rocks contain amphibole as their only original ferro-magnesian constituent. The amount of this mineral present is usually very scanty, while both it and the feldspars are so altered and decomposed as to be hardly recognizable. Some dozen or more of these specimens, of which thin sections were made for study, are so uniform in structure and composition that they might readily have been derived from a single geologic source, while their weathered condition deprives them of any special interest or individuality.

One of these specimens, however, number 32, is in this respect an exception. It is a brownish-gray rock of typical andesitic habit, which is thickly studded with small white rectangular feldspars. Under the microscope these plagioclase phenocrysts are found to be peripherally and sometimes entirely altered to calcite. The groundmass of this rock is its most interesting feature. This consists of a rather coarse aggregate of idiomorphic or hypidiomorphic feldspar laths and crystalloids of brown hornblende. These are well developed in their prism-zone but are without terminations. They are somewhat altered to chlorite, but on the whole are remarkably well preserved. Magnetite is also abundant in the groundmass. If, as seems very probable, this rock is really a Tertiary andesite, then it is related to the older camptonite in a way similar to that in which the mica-trachyte of mount Catini, in Italy, described by Rosenbusch,* approaches the minettes.

The remainder of these andesitic rocks must be classified principally with reference to the structure of their groundmass. This is coarsest and most granular in numbers 8 and 17, where it is almost granitic, though with but little free quartz. The former is extensively altered, and the latter, though less so, has its hornblende and part of its feldspar phenocrysts changed to brightly polarizing epidote.

The remaining specimens form a series for the most part holocrystalline, though exhibiting as extreme members a few examples of unindividualized base. Their phenocrysts of plagioclase and hornblende are quite the same throughout. The holocrystalline groundmass, while differing considerably in fineness, is in some granular (19, 25 and 26) and in others microlitic or trachytic (34, 35, 28, 10 and 11). In number 37 a well marked flow structure is apparent in the arrangement of the little feldspar microliths. The uncrystallized character of the groundmass is most apparent in numbers 27 and 39.

Number 38, aside from being a typical andesite like the others, possesses an additional interest on account of containing numerous rounded grains of porphyritic quartz surrounded by absorption halos or zones, like those described by Mr J. S. Diller in basalt † and by Mr J. P. Iddings in basalt and other rocks.‡ This rock once contained an abundance of brown hornblende, which is now mostly altered to green hornblende or chlorite. Its groundmass is hypidiomorphic and granular. The absorption zones, whatever they once were, consist now mostly of green hornblende and calcite.

Augite-porphyrite (*Labradorite-porphyrite?*).—Number 31 is at once noticeable on account of its strong macroscopic resemblance to that well-known type of labrador-porphyrite, the so-called *porfido verde antico*, which is so common among the Roman lapidaries, and which is now known to have been extensively quarried for ornamental purposes by the Romans at Marathonise

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* Neues Jahrbuch für Min., 1880, ii, p. 206.

† Am. Journ. Sci., 3d series, vol xxxiii, 1887, p. 45.

‡ Bulletin U. S. Geological Survey, no. 66, 1890.

in southern Greece.* Under the microscope, however, the similarity is seen to be less close. The groundmass of the Alaskan specimen is much finer grained and more altered. It consists of hypidiomorphic laths of plagioclase, magnetite, and secondary calcite. The large pale green crystals of porphyritic feldspar are very much the same in both rocks.

Number 29 is a rock somewhat like that last described, but whose porphyritic crystals are neither so pronounced nor so abundant. Its groundmass is a network of panidiomorphic plagioclase laths connected by a mesostasis which was probably once a glass, but which now is a brown, extremely fine-grained, but brightly polarizing mass carrying chlorite and secondary amphibole. Magnetite is also abundant.

Number 46 is probably also classed as an augite-porphyrite. It is macroscopically a green aphanitic rock in which no porphyritic crystals are visible to the unaided eye. Under the microscope it proves to be a panidiomorphic aggregate of plagioclase and a pale gray pyroxene connected by a green interstitial serpentinous mass, which may represent an original glassy base. The feldspar and pyroxene of this rock are both quite fresh.

Number 36 may be either an augite-porphyrite or an augite-andesite. It is full of zonally banded phenocrysts of plagioclase and occasional glistening black augites. Under the microscope the porphyritic crystals are seen to be largely plagioclase. The pyroxenes have a pale-brown color in the section and are imbedded in an ophitic groundmass of feldspar laths, magnetite, and chlorite. There is some basaltic brown hornblende not infrequently intergrown with the pyroxene.

Diabase.

Quite a number of this suite of Alaskan rocks may with propriety be classed as diabases. These present a variety of structures through which they grade into the augite-porphyrites and andesites. Indeed, in the absence of all knowledge of the field relations, a sharp distinction between these types is impossible.

Number 21 of Professor Reid's collection is a dark close grained rock containing many ovoid white spots. The microscope shows it to possess a rather coarse typical ophitic structure with pale-gray pyroxene, which is surrounded and supplemented by ex-

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* See Rosenbusch: Mikr. Phys., 2nd ed., vol. ii, 1886, p. 499.

terior growths of brown basaltic hornblende. These two minerals are always in parallel position—*i. e.*, with their clinopinacoids in common and their extinction directions on the *same* side of their vertical axes, necessitating, as the writer has suggested before, the change of the plane usually designated the unit orthodome, $P\bar{\infty}$ (101), on hornblende to the basal pinacoid, 0P (001), for this mineral.[*]

The parallel growths of pyroxene and hornblende in this rock closely resemble those described and figured by Rohrbach in the Moravian teschenites.[†] The rock is in the main quite fresh, but contains considerable patches of serpentinous substance which from their form appear to represent former hypersthene individuals.

Numbers 45 and 47 are medium-grained non-porphyritic diabases whose feldspar forms stout idiomorphic or hypidiomorphic crystals, and whose pyroxene is also to a considerable extent bounded by its own crystal planes. Both are fairly well preserved, although they contain much chlorite, which in number 47 contains highly refractive, spherical bodies. These are isotropic, but their nature could not be determined.

Numbers 20 and 30 are both considerably altered porphyritic diabases, which form transition rocks toward the porphyrites. Their groundmass is an ophitic mass of feldspar and pyroxene, and their phenocrysts mostly, if not altogether, labradorite.

Number 33 is a coarsely amygdaloidal diabase whose vesicles are filled with epidote and calcite.

Among the rocks collected *in situ* near the foot of the Muir glacier by Mr Cushing are five diabases, three of which are distinguished by the presence of brown hornblende. Of these number 5^2 is almost identical with Professor Reid's number 21. Number 9^2 contains large porphyritic crystals of pale pyroxene, which throughout the rock is idiomorphic and seems to have been the earliest product of crystallization. The groundmass is composed of a network of idiomorphic plagioclase laths, connected by interstitial brown hornblende and serpentinized glass-base. This rather unusual sequence of minerals in diabase makes this specimen particularly noteworthy.

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[*] Am. Jour. Sci., 3rd series, vol. xxxix, 1890, p. 356.

[†] Ueber die Eruptivgesteine im Gebiete der schlesisch-mährischen Kreideformation: Tsch. Min. u. Petr. Mitth., vol. 7, 1886, pg. 1. taf. i.

The other three of Mr Cushing's diabase specimens are quite typical representatives of this rock, although they are all considerably altered. They differ mostly in the coarseness of their structure. One contains a little basaltic hornblende and one is slightly amygdaloidal.

PETROGRAPHICAL LABORATORY,
JOHNS HOPKINS UNIVERSITY, *April, 1891.*

SUPPLEMENT III.

MICROSCOPICAL EXAMINATION OF WOOD FROM THE BURIED FOREST, MUIR INLET, ALASKA.

BY

FRANCIS H. HERRICK, PH. D.

The wood which I examined at the request of my friend, Mr Reid, is in a remarkably perfect state of preservation. Weathered portions are somewhat decomposed at the surface and show traces of wood-borers, but the deeper parts are perfectly sound. The wood is of medium weight, fine grained or of medium grain, and compact. It is odorless and light brown in color, the grain being noticeably brownish. This color is due principally to a brown, or slightly reddish-brown, homogeneous deposit in the cells of the medullary rays. As no portions of the bark were obtained, I can speak of the structure of the wood only. This is illustrated by two drawings (figures 4 and 5) of thin sections made in longitudinal, vertical (tangential to the medullary rays), and transverse planes respectively.*

Two elements only are met with in the wood, namely, tracheides, or wood-fibers, and the parenchyma of the medullary rays. The tracheides are characterized by the presence of bordered pits on their walls, a common mark of the wood of coniferæ. The outer border of the pit is about $\frac{1}{64}$ mm in diameter, and the inner border or aperture is $\frac{1}{320}$ mm. The aperture of the canal leading from the cavity of the pit to that of the fiber is frequently slit-like (figure 4, *a p*), and in the preparations this slit is all that can be seen, in most cases, when the fibers are viewed *en face*. The outer border of the pit can, however, be distinctly seen in exceptional cases. The pits shown in figures 4 and 5 were introduced from another part of the section. The dotted lines in the adjoining fiber show the probable outlines of the pits in that cell. The two openings of the pit cavity are shown where the slits apparently intersect. The cavity of the pit is

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* Before sectioning the wood was soaked for about a month in glycerine.

sectioned in many places between adjoining fibers, as in *p*, figure 4; and in figure 5, *x*, it is seen that neighboring cells communicate with each other by a canal or aperture in the center of each wall of the pit. A limiting lamella sometimes, if not always, occurs in the fresh wood of coniferous trees, stretched across the cavity of the pit. This serves as a screen to block the direct

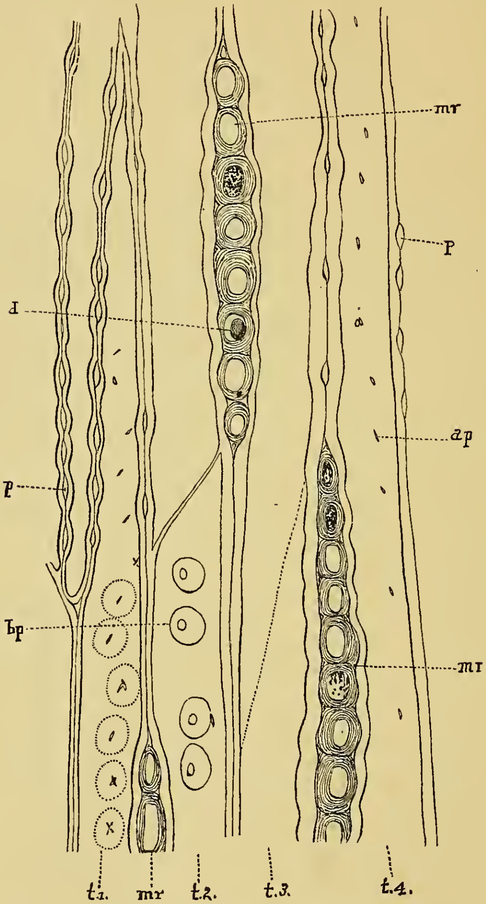

Figure 4—*Longitudinal Section of Wood from the buried Forest.*

m r = Medullary ray; *p* = Pit-cavity; *d* = Deposit in cell of medullary ray; *a p* = Aperture of pit; *b p* = Bordered pit; *t 1, t 2, t 3, t 4* = Tracheides.

communication of fiber with fiber. No such membrane could be detected in the buried forest specimens.

The medullary rays (*m r*) are very minute, narrow and quite uniformly distributed sheets of parenchymatous tissue. There are about 40 rays to the square millimeter of surface (in tangential section). The rays are uniseriate—that is, one cell broad, as in most coniferæ. The breadth of the ray is thus measured by that of the medullary cell, which is about $\frac{1}{64}$ mm. The height of the rays varies from about $\frac{1}{20}$ to $\frac{2}{5}$ mm, and is from three to about seventeen cells deep. The medullary rays exactly fill the meshes between the bundles of wood-fibers. In some cases the cell-walls of the parenchyma have undergone alteration, and contain the brownish deposit (*d*) already noticed.

The transverse section shows parts of two annual rings or layers (figure 5). In one (the later growth—late summer or autumn, *a, g*) the cells are flattened and have very thick walls; in the other (the earlier growth—spring or early summer, *v, g*) the cells are much larger, and the walls are thinner. Pits occur in both

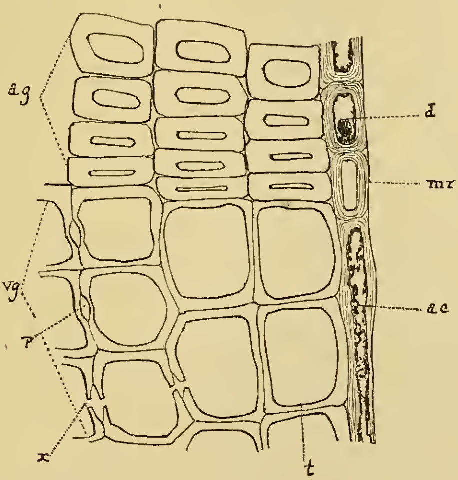

FIGURE 5—*Transverse Section of Wood from the buried Forest.*

a g = Outer portion of annual layer representing later growth; *v g* = Inner portion of succeeding annular layer, representing earlier growth; *d* = Deposit in cell of medullary ray; *m r* = Medullary ray; *a c* = Altered cell wall of parenchymatous tissue; *p* = Pit-cavity; *x* = Internal opening of pit; *t* = Tracheide.

late and early wood, although they are represented in the drawing only in the latter.

A specimen of recently grown spruce was obtained by Mr Reid from Alaska,[*] and I have compared it carefully with the preceding and find that the two agree in every structural detail. Figures of transverse and longitudinal sections of the recent wood are not given, since they would be merely repetitions of figures 4 and 5. The size and shape of the medullary rays are essentially the same, and the average number of rays per square millimeter of section is the same in the two specimens. Resin canals are occasionally seen in the midst of a thickened medullary ray in the modern wood, and while I have not observed them in the buried-forest wood, yet I have no doubt that they would be found by persistent sectioning. Transverse sections of the new wood show the same differentiation between the earlier and later cells of the annular ring. The modern wood is several shades lighter than the old, and the brownish tinge of the grain is due to the color of the medullary tissue. The conclusion would be warranted, upon the evidence above given, that the wood taken from a forest at one time buried under glacial deposits in Alaska and submitted to me for examination by Mr Reid is specifically identical with that of the Alaskan spruce (*Abies sitkensis* or *A. menziesii*) which grows in the neighborhood of the glaciers of Alaska to-day, provided that microscopical examination of the wood alone could be relied upon for the determination of species of coniferous trees. Unfortunately for the student of this subject, the structure of the wood must be supplemented by other characters before the species can definitely be settled. The preceding observations can, however, be said to render quite probable, at least, the conclusion intimated above.

ADELBERT COLLEGE, *March 14, 1891.*

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[*] This was sent to me from Juneau by Reverend Eugene S. Willard. H. F. R.

APPENDICES.

Appendix I.

LIST OF PLANTS COLLECTED NEAR MUIR GLACIER;

DETERMINED BY

W. W. ROWLEE, BOTANICAL DEPARTMENT, CORNELL UNIVERSITY.

Anemone multifida, DC.
A. narcissiflora, L.
Ranunculus repens, L.
Aquilegia formosa, Fisch.
Aconitum napellus, L., var. *delphinifolium*, Seringe.
Arabis (?)
Arabis ambigua, DC. (?)
A. petræa, Lam.
Cardamine hirsuta, L.
Arenaria lateriflora, L.
Honckenya oblongifolia, Gray.
Cerastium alpinum, L.
Geranium erianthum, DC.
Lupinus versicolor, Lindl.
Astragalus frigidus, Gr., var. *americanus*, Wats.
Oxytropis monticola, Gr.
Hedysarum mackenzii, Rich.
Spiræa pectinata, Gr.
Dryas drummondii, Hook.
Geum calthifolium, Smith.
G. strictum, Ait.
Potentilla anserina, L.
Rubus arcticus, L.
Rubus pedatus, Smith.
Saxifraga davurica, Willd.
S. pseudo-burseriana, Fisch.
S. tricuspidata, Retz.
S. æstivalis, Fisch.
Heuchera glabra, Willd.
Parnassia fimbriata, Banks.
P. palustris, L.
Sedum rhodiola, DC.
Epilobium hornemanni, Reichb.
E. affine, Bongard.
E. latifolium, L. (purple).
E. latifolium, L. (white).
E. angustifolium, L.
Conioselinum fischeri, Wimm. and Grab.
Cornus canadensis, L.
Valeriana sitchensis, Bong.
Solidago multiradiata, Ait.
S. humilis, Pursh., var. *nana*, Gr.
Aster foliaceus, Lindl.
A. peregrinus, Pursh.
Erigeron ursinus, Eaton (?)
Erigeron (?)
Senecio (?)
Antennaria dioica, Gaertn. (only female plant).
Anaphalis margaritacea, Benth. and Hook.
Achillea millefolium, L., var. *lanata*, Koch.
Arnica unalaschensis, Less.
A. latifolia, Bong.
Campanula lasiocarpa, Cham.
C. scheuchzeri, Vill., var. *heterodoxa*, Gr.
Pyrola secunda, L., var. *pumila*, Gr.
Bryanthus glanduliflorus, Gr.
B. aleuticus, Gr.
B. empetriformis, Gr.
Trientalis europaea, L., var. *arctica*, Ledeb.
Romanzoffia sitchensis, Bong.
Veronica alpina, L.
Castilleia parviflora, Bong.
C. coccinea, Spreng.
Euphrasia officinalis, L.
Rhinanthus crista-galli, L.
Pedicularis verticillata, L.
Pinguicula vulgaris, L.
Phlox cæspitosa, Nutt.
Gentiana parryi, Engl.
G. arctophila, Griseb.
G. amarella, L., var. *acuta*, Hook. f.
G. prostrata, Haenke.
Polygonum viviparum, L.
Veratrum viride, Ait.
Salix ovalifolia, Traut.
S. sitchensis, Sauson.
S. reticulata, L.
S. arctica, Pallas.
S. speciosa, Hook. and Arn.
Aspidium lonchitis, Swz.
A. spinulosum, Swz. (?)
A. s., Swz., var. *dilatatum*, Hornemann
Asplenium viride, Huds.
Woodsia hyperborea, R. Br.
Cryptogramme acrostichoides, R. Br.
Cystopteris fragilis, Bernh.
Adiantum pedatum, L.

Appendix II.

METEOROLOGICAL OBSERVATIONS.

BY

HARRY FIELDING REID.

A louvred box, open below, was mounted on posts about 6 feet above the ground ; it was about 20 feet behind our tents. In it were placed the wet and dry bulb, the maximum and minimum, and the self-recording thermometers. To one of the supporting posts was fastened a long box with a hinged door in which hung a mercurial barometer (lent by the United States Coast and Geodetic Survey). The rain gauge (lent by the United States Signal Service) was placed on the ground about 30 feet in front of the tent. Readings of these instruments (except the maximum, minimum, and self-recording thermometers) were made three times a day, at 7 a. m., 2 p. m. and 9 p. m. These observations, though made by all members of the party, were under the direct charge of Mr Cushing.*

I append some meteorological data which may be interesting: The difference between the mean temperature at Muir inlet and at Juneau (the latter averaged from 8 a. m. and 8 p. m. readings) will be at once noticed. The observations from the latter place were sent me by the Signal Service.

The dial of the self-recording thermometer showed rapid variations of temperature, amounting sometimes to 5° F. in as many minutes. During our stay at the glacier we had three or four strong southerly gales. The thermometer rose 10° or 15° within an hour, held this high temperature during the gale, which usually lasted six or eight hours, and fell even more suddenly to its usual height. Our highest temperatures were recorded during these gales, even when they occurred at night.

The 2 p. m. barometric mean does not show a depression. This, of course, is partly due to the high latitude, but I do not think that is the whole cause. The difference of temperature between the air over the snow-fields and over the neighboring country is greatest in the early afternoon, resulting in a maximum difference of pressure at that time. The flag at our camp blew more strongly toward the south during the warm part of the day than at other times. For several consecutive days in September it hung quietly all night. Thus the proximity of extensive snow-fields holds the barometer up in the afternoon and interferes with the usual minimum. We have, unfortunately, no observations at a near station with which we can compare our own in order to deduce a quantitative value of the glacier's influence on the barometer.

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*A complete record of these observations has been sent to the United States Signal Service.

Temperature and Rainfall Observations.

	Mean temperature.		Maximum temperature.		Minimum temperature.		Rainfall.	
	Camp Muir.	Juneau.	Camp Muir.	Juneau.	Camp Muir.	Juneau.	Camp Muir.	Juneau.
1890.								
July .	45°.2 F.	56°.9 F.	63°.1 F.	74° F.	35°.4 F.	42° F.	3″.06	5″.51
Aug. .	45.1	55.1	63.9	70	37.2	43	4.88	2.21

Barometer Observations at Camp Muir.

	Mean barometer.			Daily barometer.		
	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.
July, 1890...	30″.113	30″.078	30″.077	30″.089	30″.335	29″.565
Aug., " ...	30.115	30.128	30.125	30.123	30.418	29.787

Number of days on which 0.01 or more of rain fell:

	Camp Muir.	Juneau.
July	12	16
August	10	11
September................................	..	26

Mean humidity at Camp Muir: July, 82.2; August, 83.

APPENDIX III.

MAGNETIC OBSERVATIONS.

BY

HARRY FIELDING REID.

The instruments for this work were supplied by the United States Coast and Geodetic Survey. They were a small magnetometer, known as the Bache Fund magnetometer; a dip circle (number 12) of about 12″ diameter; and a mean time chronometer.

The magnetometer was not adapted for determining the magnetic moment of the needle; and as this was not done until some time after my return, the resulting value of the intensity cannot be considered very accurate. The moment of inertia was, however, determined in the field. *H* is given in c-g-s units (*i. e.*, in centimetre-gramme-seconds).

Special tents were erected for the instruments. The magnetometer was 85 yards and the dip circle 65 yards from our tents. During the observations with the former, the latter was about 100 yards distant.

Date.	Declination.*	Approximate daily range.	Dip.	Horizontal intensity.
Aug. 22, 1890	....	....	....	.150
23, "	....	....	75° 49′.8	.150
Sept. 5, "	....	....	75 51 .7	....
8, "	— 30° 27′.8	0° 6′.9	....	....
9, "	— 30 26 .1	8 .4	....	....
10, "	— 30 24 .1	5 .4	....	....
Mean	— 30 26.	6 .9	75 50 .8	.150

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* The negative sign means that the north end of the needle points to the east of astronomical north.

APPENDIX IV.

SUGGESTIONS TO FUTURE OBSERVERS.

BY

H. F. REID.

The accessibility and growing fame of Muir glacier make it certain that parties will frequently spend two weeks or a month there in future summers. They will have the opportunity of making observations of considerable interest.

The most important is the rate of recession of the ice-front. Much the easiest way of doing this is by taking photographs and comparing them with others taken earlier from the same points. These photographs should show the mountains behind. The following would be useful: A photograph of the northwestern corner of the ice-front taken from the beach close to camp Muir, the northeastern corner taken from the top of the bluff on the western side of the inlet, just south of the mouth of the glacial stream; the whole front taken from *E*, the front taken from *V*. This latter would show better than the others what change has taken place and can be compared directly with plate 13. *V* can be found without much trouble. It is the highest point in its neighborhood (3,000 feet), and lies N. 65° W., magnetic, from the peak of mount Wright. It is most easily reached by the stream between it and *E* (see map, plate 14).

Compass bearings also will serve to determine the position of the ice-front. They should be taken on the corners and on any well-defined points of the ice-front. These bearings had better be taken from *M* and *L*. *M* can easily be found. It is on the projecting point of the bluff on the east side of the inlet near the edge. *L* is just opposite and bears N. 70° W. astronomical or S. 80° W. magnetic. The distance between them is 8,019 yards. From such observation the position of the ice-front can be immediately platted on the map and the recession measured. Neither of these methods will yield very accurate results.

The map which I have made, though accurate so far as it goes, is far from complete. The upper parts of all the tributaries and much of the region between them is left blank. Any one with the proper training would find it very interesting to map these portions. Starting from the points *E* and *D*, his map could readily be fitted to mine (see page 54). For such work I strongly urge the use of a planetable.

These suggestions are not, of course, intended for scientific explorers; but for persons of some scientific knowledge who may wish to add to the general pleasure of a stay at Muir glacier the special interest of a definite object, viz, to increase our knowledge of the region. I may say that a small piece of work done well, such as the mapping of a single tributary—*e. g.*, Dirt glacier, White glacier, or Granite canyon—is more useful than indefinite observations over a wider range.

VOL. IV, PP, 85-100 MARCH 18, 1892

THE

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GEOGRAPHY OF THE AIR

ANNUAL REPORT BY VICE-PRESIDENT

GENERAL A. W. GREELY

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(Presented by title before the Society January 22, 1892.)

If the poet finds retrospection one of the delights of the mind, the investigator finds it to be a useful mental process at certain stages in order the better to determine not only the results certainly attained but also the methods and directions promising most in the future. Such a retrospective study has not infrequently been more valuable to the scientist than would an uninterrupted continuance of his investigations involving double the effort.

The object of these annual reports is to give yearly, for the benefit of the Society, a retrospective glance to appropriate branches of physical sciences or physical research.

I have said physical "research" as well as science, for only the enthusiastic yet class my subject—meteorology—as a science, certainly no one as an exact science. It is of course a matter of opinion as to when the epoch arrives wherein any distinct department of nature can be properly designated as a science, and as being no longer an immense aggregation of facts, theories and assumptions. Within the century the world has seen chemistry, mineralogy, botany, zoology and other now recognized sciences emerge from their previously uncertain and indefinite status. Of meteorology, however, using this term as especially applying to weather and not to climate, which will be referred to later, it may fairly be said that the generalizations are too indefinite in terms and too scanty in number, the ascertained and acknowledged facts too insufficient as well as too disjointed in their relations, to form the indispensable work of fundamental principles whereon is to be woven the regular, graceful curves which nature ever presents to us under the magic wand as waved by the specialist in any science.

The term "science" carries with it in a degree the idea of prevision, so that exemplifications of its principles shall always find expression in foreseen results, whose ultimate variations should not exceed certain narrow limits.

Abercrombie and the writer have published, almost simultaneously, the latest works in English on the weather. My own opinions as to the status of this department of nature were clearly put in "American Weather," 1888. To quote:

> "All skilled meteorologists realize how comparatively local are weather conditions and how impossible it is, at times, to make predictions for a definite period with any feeling of certainty. * * * It is evident that fair-weather conditions are those which are most persistent [i. e., they partake more of climatic conditions than of weather] and from the prediction of which the highest percentages of accuracy will be obtained."

Professor Marvin, a careful, conscientious official, whose duty has included the examination and verification of forecasts, after three years of study, says (referring to verification-percentages not being strictly comparable) in confirmation: "The reasons for this are principally because of the much greater difficulty of successfully forecasting rainy and unsettled than fair weather, together with the seasonal spasmodic variations in their respective occurrences." His illustrations make clear what has been believed by all close observers, namely, that high percentages and satisfactory forecasts are attendant on the persistency of climatic or permanent conditions (such as no summer rain in California) when unbroken by the violent and marked changes which distinguish weather from climate.

It is safe to say that the percentage of successful forecasts of rain twenty-four hours in advance is not one-half, and probably not more than one-third, so successful as forecasts of fine, clear weather for the same period.

The scientific investigator or student who longest applied himself to the study of American weather endeavored a few years since to deduce a practical rule for weather forecasts which might be applied to current and daily work. It is significant that no single application of this rule or theory has ever been made. If the test had been made it is to be feared that the criticism of Strachey would recur, viz, that theory finds not its counterpart in actual values.

It may or may not be indicative of the state of meteorology that the eleven rules for practical predictions laid down by me in "American Weather" in 1888 have received no accretions. Many are willing to indulge in criticism and glittering generalities, but in any scientific work practical and particular applications are demanded. Careful and continued observations have indeed determined the usual paths of storms, but most uncertain and so far indeterminate have been all researches to so determine the cause of storm development and movement that from observed meteorological phenomena can be seen not only the certainty of the storm's approach but also its particular course.

What do experts abroad think? Abercrombie says: "The service of weather forecasting can never be treated mathematically. * * * Many isolated principles have been discovered, but no attempt has been made to lay down the broad principles of the science of the weather as a whole." The terse dictum that "The successive 'changes in the *shape* of isobars * * * indicate the sequence of weather' in any place" is declared to be the fundamental principle of all synoptic meteorology, and we have only to work out the local details connected with the changes of isobars to formulate and connect therewith sequent and appertaining weather changes.

It may well be questioned if any meteorological expert outside of the British office accepts this principle or limitation of Abercrombie's. Statistical methods, he goes on to remark, are practically devoid of physical significance, and through misuse have tended to bring modern meteorology into disrepute. While most meteorologists agree with him in their disapproval of certain statistical methods as applicable to meteorology, yet they endorse others, these or those according to circumstances, as valuable or invaluable aids to successful work in weather forecasting.

Among investigators following statistical methods is M Teisserence de Bort, the very able assistant of Professor Mascart in France. who believes that the recurring weather changes can be reduced to types, and who has devoted his perspicacity, talents and industry to the solution of the problem for France in particular and Europe in general.

While perhaps no scientist of high standing now invokes the moon's phases as potent factors in weather changes, yet the influence of atmospheric electricity is believed by some to possibly dominate the weather, while again others turn to terrestrial or interplanetary magnetism as the essential basis.

Not a few distinguished physicists refer the whole question directly to the radiative energy of the sun, which all, however, necessarily admit as an ultimate and predominating cause. When, however, we come to particularly apply the principle, a distinguished English astronomer claimed that the rainfall of India (which may be said to be the weather of that country) follows in its phases the curve of sunspots. Immediately the meteorological reporter, Mr. Blanford, proved that not only was this not true of the locality directly referred to, but that in India there was no year in which extended areas of country did not present striking contrasts as to precipitation, excesses in some provinces and marked deficiencies in others.

It is significant that in an article of 45 pages in the Encyclopædia Britannica, Buchan gives no law for any meteorological phenomena, and says, referring to the formulas of Ferrel, Mohn, Hann, Everett and others, that in "The development of the law of the relation of the wind's velocity to the barometric gradients," the evident inexactness of the various investigations justify Strachan's criticism that "The theoretical values do not accord with the actual values."

Delauney, in announcing a new theory of storms, says that meteorology has not yet emerged from the domain of observation, is now unprogressive, and, in fact, under present methods has reached its limits as a science. Further progress is only possible by ascertaining the causes of meteorological disturbances and in defining the fixed laws which bring about weather changes. Similar opinions could be drawn from other authorities if time and space permittted.

When the duties of forecasting storms devolved by Congressional joint resolution of February 9, 1870, on the War department, its success was by many considered most doubtful, especially in view of the fact that the efforts of Admiral Fitz Roy in Great Britain had resulted so unsatisfactorily. The problem was to evolve out of unknown and unsatisfactory conditions a system suited to America, or in other words, a system that should ensure to citizens and tax-payers practical results commensurate with expenditures. How the system of weather forecasting was built up in detail, it is neither the province nor purpose of this report to consider. It is, however, not a theory but a fact that under the military administration this service throve wonderfully; though be it understood the military administration is no more indorsed in all its details than is the civilian administration of governmental bureaus in all its details. Bickerings, jealousies, repressions, maladministration and inefficiency are not necessary characteristics of either civilian or military methods, nor can either be absolutely free therefrom. In short, in every bureau the ability, application, energy and all the common-sense characteristics of its chief, be they great or little, find their exaggerated reflex in the work done and the policy followed, in the working out of details and in the accomplishment of results.

The Weather bureau of the United States, however, soon speedily attained a degree of efficiency and success sufficient to commend it not only to the practical American citizen, but yet more to the admiring judgment of foreign scientists, who, inspired by the satisfactory work in the United States, speedily increased the scope of their own duties or persuaded the government to initiate a like system for their own country.

The conference of European meteorologists at Leipsic in 1872 resulted in a national congress at Vienna in 1873; and in an official invitation extended to the government of the United States to take part, it is said—"The wonderful results which have been obtained by meteorological observations on this continent [the United States] renders its participation in the aforesaid congress highly desirable;" and the hope is expressed that this government will, "In the interests of science and the general welfare, unite through its representatives at this congress the experience of its meteorological institutes to the observations of the meteorologists of Europe."

The Universal exhibition at Prussia in 1876, in considering the Signal service exhibit, acknowledged in express terms that no award within the power of the committee would adequately express its appreciation of the merits of the Signal service meteorological exhibit, and consequently sent a special letter. A diploma of honor, the highest award granted, was received from the National exhibition of electricity at Paris; and a letter of distinction, also the highest award, came from the Geographical exhibition congress at Vienna, Austria, for tri-daily weather charts.

Some Americans may deprecate the strong language used in these resolutions, but it should be borne in mind that distance is necessary to give a just perspective to all great undertakings. If it be considered that no nation can justly estimate the tenor and effect, either of its ordinary and average contributions to modern progress or of its greatest achievements, so a just opinion of the ability displayed in the management of any service, or of the results obtained, can rarely, if ever, be given by the scientists of that country. Their mental vision is liable to distortion, perhaps through indifference to or distaste for the work in question; perhaps by a sense of present or fear of possible encroachment on their own lines of research; perhaps by a feeling of scientific jealously, either personal to the staff concerned or general as to the branch of natural science under inquiry. One does not have to go out of the city of Washington to hear disparaging and unprofessional reflections on the scientific standing of persons, the highest in the opinion of the world in their specialties; and as with men, so with bureaus.

Be this as it may, the Weather bureau under military administration has made its indelible impression upon the meteorological societies of all civilized countries from year to year; and even in countries where a lurking suspicion of jealously toward the growing scientific importance of the United States has existed, in these countries as in all others the means and methods employed in the United States are being followed.

It was interesting at the late conference of meteorological chiefs in September, 1891, at Munich, Bavaria, to note from time to time that the military Weather bureau of the United States had been the only office which had endeavored to live up to the scientific meteorological ideals elaborated and endorsed by previous conferences and congresses. Similarly it may be mentioned that the same peculiarity developed at the International polar congress, wherein it appears that the United States, through the Signal service, was the only country which had endeavored to follow the line of obligation agreed on for international use in publication.

If for no other reason, meteorology owes its debt of gratitude to an officer of the army, the late General Myer, from whose mind in August, 1873, proceeded the idea of an exchange of international telegraphic weather reports as widely as possible, and to whose initiative in connection with the congress at Vienna is due the unparalleled, important and successful international meteorological work.

During thirteen years, 1875 to 1887 inclusive, the land observations of this service covered the countries of almost the entire northern hemisphere and a part of the southern hemisphere, and reports were also received from regular naval and merchant marine vessels of the principal countries of the northern hemisphere. More than 150,000 monthly reports, representing upwards of 5,000,000 daily simultaneous observations, were received, collected, and published or charted by the Signal office. The number of vessel reports reached 600, and the foreign land stations increased to a total of 459, exclusive of the international polar stations. The following countries coöperated during a part or a whole of the period 1875 to 1887: Algeria, Australia, Austria-Hungary, Belgium, Brazil, Great Britain, Canada, Cape Colony, Chili, China, Costa Rica, Denmark, Egypt, France, Germany, Greece, Hawaiian islands, India, Italy, Japan, Mauritius, Mexico, the Netherlands, Norway, Russia, Scotland, Spain, Sweden, Switzerland, Turkey. In addition to the reports furnished by the regular services of the several countries, observations were made and forwarded from the islands of the northern Atlantic ocean, of Central America and northern South America, and from Bering island, the Aleutian islands, Alaska, Greenland and Iceland.

The international publications of the Signal service, which commenced with the regular issue of the daily bulletin of simultaneous observations in July, 1875, embodied data whose value cannot be overestimated. The network of stations which covered the northern hemisphere for a period of years furnished a vast number of reliable observations, the study of which has in no small measure contributed to recent discoveries and advances in meteorology, and in future investigations these observations will be invaluable.

These publications and charts are based upon an unparalleled series of observations; they represent graphically the labor of meteorologists throughout the civilized world for a period of thirteen years; they are unique in the annals of meteorology; and their proper presentation, rendered impracticable heretofore owing to insufficiency of funds, is alone needed to class them with the most treasured products of modern meteorology. In completing this work, the Signal office has compiled maps showing the mean pressure of the northern hemisphere as deduced from ten years observations under this system, and the changes in pressure from month to month; and it has also charted the average storm frequency for each month of the year.

In considering these great labors, one may be named who is no longer sensitive to criticism, the late General Albert J. Myer, whose diplomatic skill and wonderful persistency in dealing with the legislative branch of the government and whose judgment in selecting his subordinates ensured ultimately both a financial support for the service in general, and also an excellence of execution in general weather predictions and in detailed work throughout the country which have never been attained by any other meteorological service in the world. Then theoretically equal credit is due to the late Professor Ferrel, whose relations were maintained with the Signal service until he sought his well earned retirement, and from whose intelligent ability and aptitude for research have proceeded the most complete and satisfactory treatises on meteorology from a scientific and mathematical standpoint. The important services rendered by other distinguished professors merit similar praise.

As to the officers and professors forming the general staff of the bureau, it may be remarked that their labors in organizing, developing and operating the meteorological work of this service will never be adequately stated or generally recognized. It is, however, a matter of record that the meteorological system devised by officers of the United States army has proved to be the most successful practical service in the world, and has served as a working model and example for other nations, while its unique exhibits have elicited unparalleled commendation. The records of such officers as have participated in the work of this service for any prolonged period show the native ability and special adaptitude of army officers, when ordered to scientific duty for which they had not been educated and which more than one accepted with reluctance, and proves, if proof were needed, that the holding of a commission does not emasculate intellectual qualities.

As to the Signal service in general, it collects and distributes an enormous amount of weather data. In accuracy of collation, in speed of collection from and distribution to distant points, in extent and in legibility even of its ephemeral publications, the service is not only unrivaled, but is not even approached by any other weather service in the world. In attaining this practical excellence, many peculiar methods of work and a large number of special mechanical devices were essential to the present success, and in this connection the intelligent ability and interest of the enlisted men who served as observers is evidenced by the fact that far the greater part of these improvements in mechanical details and office methods is due to ideas, suggestions, etc, therefrom. The local observers in charge of stations throughout the country have, almost without exception, obtained their entire knowledge of weather predictions and their meteorological information while in this service. More than one-third of the observers in charge of stations have had the benefit of some collegiate training, and the satisfaction of observers with their status is evinced by the fact that their average length of service has been 13 years, while the entire life of the service has only been 20 years. Only a small percentage of the observers have left the Signal service save to benefit themselves by accepting duties of a more responsible and better compensated character, which often have opened up to them through their connection with the Signal service.

The military staff of the Signal service has all these years worked under the greatest possible disadvantages, receiving no additional pay for the performance of weather duty. Their professional standing in the army often suffered from their absence from their corps, and they received scant acknowledgment and honor from other sources. This, too, while serving on such a pay and under such conditions in a large city as to prevent officers from living in accord with their brother officers serving with their regiment or corps. More than one hundred officers have been detailed for signal duty, but not more than a dozen have ever been willing to remain for any length of time, and the number of these was subject to change and depletion by promotion, resignation, or the assumption of better paid duties bringing professional and personal reputation. In other words, the Signal service staff has been poorly compensated, either in money or reputation, has had no definite status, and has worked merely for the love of science, which is indeed the most beautiful and stimulating sentiment animating men of science, but which alone and unsupported, as is well known, does not always lead to the best results either in theoretical or in applied sciences.

As regards detailed studies and scientific theses, it may be well admitted that the meteorologists of other lands have contributed more fully to the literature of the day than the meteorologists of the Signal service, but it should be borne in mind that eight years ago a Congressional commission reported against the continuance of scientific investigations previously fostered by the Signal service, and a clause in an appropriation bill compelled the abandonment of the school of instruction and the discontinuance of theoretical meteorological research, except incidentally. As to the regular publications, reference elsewhere shows that the unequaled Weather Review of the Signal service has been imitated abroad, and as to the more ephemereal publications, it may be pointed out that the example of the Signal service has also been followed out as to daily weather maps and accompanying meteorological data.

In Australasia, by the combined efforts of several states, there is issued each day a weather map; in Belgium, one map is issued; in Austria-Hungary, one; in Algeria, one; in France, one; in Japan, three; in India, one; in Russia, one; and in Switzerland, one.

The intellectual activity of the staff of the Weather bureau may be indicated by the fact that more than four hundred separate articles were mentioned by title in the report of the Chief Signal officer for this year as having emanated from these officials during their connection with the Signal service. Far the greater number pertain directly to meteorological subjects, and a majority of them have been printed without expense to the government.

There has been assertion on the part of ill informed persons that proper attention has not been given under army administration to the collection and discussion of climatic data. As an answer to this, it is only necessary to point to the monthly Weather Review initiated in 1873. which is, and always has been, the most complete repository of climatic data in the world. This publication, for eighteen years, has presented both in tabular and graphic form the salient climatic conditions of the United States so far as could be determined. From a folder the size of ordinary letter paper, with only 37 lines of text and one chart, it has grown to be a large, well printed quarto, averaging 28 pages to the month and having 50 charts annually.

The Review from the very first was largely climatic, two-thirds of the earliest numbers being given to temperature and rainfall, and gradually this proportion in regard to climatic data and discussion has increased until it amounts at length to fully three-fourths.

The single chart of storm-tracks was speedily followed by two others, on which were respectively represented for the United States (1) the monthly rainfall, and (2) the isobars, isotherms and prevailing winds for the individual month. Other appropriate charts have likewise been reproduced, such as mean depth of snowfall, the amount of snow on the ground in the middle or at the end of month, the range of temperature, the movements of high areas, the departures of temperature from the normal, the distribution of thunder-storms in the United States and Canada, etc; and also charts indicating the limits of dangerous ice in the northern Atlantic, and international charts for the northern hemisphere, showing for the month the mean pressure and the mean temperature and prevailing winds at the hour (Greenwich noon) of simultaneous observations. Similar maps for the yearly means have also been issued for Canada and for the United States and the northern hemisphere.

From occasional and widely separated data as to wind, temperature and rainfall on chart or in text of the first Review, the present publication includes observations and means from observers as to maxima temperatures, minima temperatures, mean temperatures and rainfall for each month, exceeding 2,000 in number in the United States; and other data from about 500 more stations in Canada and along the sea-coast of North America have also been discussed, thus making over 2,500 separate monthly reports as to climatic conditions made available in such manner that "he who runs may read."

This summary conveys no adequate idea of the variety and character of the immense and valuable masses of climatic data which the monthly Weather Review of the Signal service has scattered over the world relative to, and in the interest of, the United States.

The great value set on this publication both by skilled meteorologists and by the reading public of this and other countries has been a source of astonishment and gratification to other chiefs and to myself.

As to the opinion of the distinguished meteorologists abroad, recalling the saying that imitation is the sincerest form of flattery, it is to be remarked that monthly publications similar in literary form and substance have been instituted in Canada, Germany, Great Britain, India, Jamaica, Mexico and Victoria.

Among other valuable compilations and graphic representations of climatic data for the United States in general published by the Signal service may be mentioned:

1. Isothermal charts for each month of the year, based (*a*) on observations of ten years, and also (*b*) on observations of eighteen years.
2. Charts of normal temperature at 8 a. m. and 8 p. m. for each decade in the year.
3. Charts of absolute maxima and minima in each decade and also for each year at all Signal service stations (awaiting press).
4. Charts of isotherms and isobars and prevailing winds for each month from January, 1871, to 1873, inclusive.
5. Tables indicating diurnal fluctuations of temperature for each hour and month at 47 typical and representative stations.
6. Charts and tables of average dates of first killing frosts of autumn and last killing frosts of spring.
7. Charts and tables showing the normal rainfall for each month based on record (*a*) of 10 years; (*b*) of 18 years; (*c*) of 20 years (May and June; rest awaiting publication).
8. Charts and tables showing the rainfall for each month from January, 1870, to December, 1873.
9. Excessive precipitation for month, day and hour at all available stations from establishment to 1890.
10. Charts for each month, showing the probability of rain at all Signal service stations as deduced from 18 years' observations.
11. Charts and tables of possible annual evaporation.
12. Charts of average cloudiness for each month of the year.
13. Charts of most frequent wind-direction and average hourly velocities at 65 typical and representative stations at 8 a. m. and 8 p. m.

14. Hourly wind travel at principal and representative stations, 1881–1890.

15. Tables showing the diurnal fluctuations and pressure of the atmosphere for each hour of the day and month of the year at 29 representative stations.

16. Charts with tables of supporting data from 654 separate stations, showing for Arizona, California, Colorado, Idaho, Indian Territory, Nevada, Oregon, New Mexico, Utah and Washington state the average precipitation and the greatest and least quantity of rain for each month of the year.

17. Climatic charts and tabular matter, with discussion relative to temperature, rainfall, sunshine, frost, evaporation, etc, of the states of Nebraska, Oregon, Texas and Washington.

18. Climatic charts, diagrams and tables from 651 stations relative to irrigation and water-storage in Arizona, California, Colorado, Nevada, New Mexico and Utah.

Many other similar climatic publications of less extent and importance might be added; but reference will only be made to the chart of rainfall and temperature for Michigan, and several charts of normal temperature for New York, both prepared at the office of the Chief Signal officer.

The annual reports of the Chief Signal officer have been largely given up to climatic data, which for years were published on so liberal a scale as to induce criticism from members of Congress. For several years the amount of climatic data annually published exceeded five hundred octavo pages, and for the past eighteen years has averaged over three hundred octavo pages.

The climatic work of the Signal service of the army can be summarized by the general statement (which can be verified by any one who wishes) that the climatic characteristics of the United States have been determined and are better known than those of any other equal area on the surface of the earth.

The forecasting of weather was not the only duty imposed by law on the office. The construction, maintenance and operation of about 5,000 miles of telegraph lines on the Indian and Mexican frontiers and along the uninhabited coasts of the Atlantic and Pacific oceans, the performance of military signaling duty, the gauging of the principal rivers of the country and the predicting of floods and low waters therein, have also demanded special application, ability and energy which could not but somewhat impair the interest in the weather work and detract from the success with which it was prosecuted. The high degree of success in these other branches has been recognized by those interested in the practical work involved therein. The accuracy of river and flood forecasts and the ample notice thereof in advance have elicited well deserved encomiums from the inhabitants of the valleys of our great rivers, and the rules for flood forecasts have been laid down with most satisfactory results.

It is not the intent to convey an idea that no further progress in these various branches of work is possible, for knowledge ever goes on from more to more, and improvement is the order of the day.

The spirit toward other scientific branches of investigation, if not so catholic as extremists could wish, has been so liberal as to compare favorably with that of any other governmental bureau. Few realize how difficult it is for any bureau chief to obtain from the legislative branch of the government sufficient appropriations for the liberal support of the special duties of his bureau, but the difficulty is greatly enhanced when it is sought to obtain funds for contingent purposes involving the carrying on or the investigating of subjects relating indefinitely, if indeed at all, to the more specific duties of the bureau. Again, instances are not rare in which individuals or institutions desire to obtain the aid of governmental bureaus in the investigation and support of matters which, although worthy in themselves of encouragement and aid, in their nature partake rather of private and personal schemes than of the more general investigations for the public benefit. In short, it rarely occurs that means and sense of duty permit the diversion of large sums from the narrow scope of official action imposed on a bureau by the limiting provisions of appropriation acts and the perhaps more important restrictions of the auditing officials of the treasury.

Considering limitations of law, restrictions of auditors, and amounts of appropriations, the Signal service has shown great liberality in extending aid to collateral investigations and researches. It has spent for such purposes not simply hundreds or thousands of dollars, but tens of thousands. Among other noteworthy instances involving important or essential aid may be mentioned. International meteorology, Langley's magnificent and unique work at mount Whitney, the contributory observations for the Fish commission, demanding special instruments and sometimes extra observers; extensive and, as Professor Baird said, "indispensable aid during this transition period" in ethnological and other work throughout the extent of all Alaska; coöperation with the Polaris expedition; the Cumberland sound work; the solar total eclipse of 1878; the investigation of the locust plague; the point Barrow and Lady Franklin bay expeditions, which otherwise could never have started; the Labrador expedition; the Death valley investigations; and the western Africa eclipse expedition.

It should be borne in mind that the civilian organization now in operation is due entirely to the military force. The lately lauded system of local forecast officials at the more important cities is simply a continuation of duties initiated several years since, and which, as to name, compensation and scope of work, were planned and carried into execution by officers of the army.

The estimates and proposals for liberal pay to civilians in the reorganized Weather bureau were also the work of an officer, and the pay obtained was not only considered exceedingly liberal by the legislative branch but also by the civilian organization, as evinced by the omission of two professors of highest pay from the estimates of this year.

En résumé, it has been shown that the Signal corps of the United States army has so conducted the meteorological work entrusted to its charge as to develop and advance meteorological investigation to very near the dignity of a science, partly through the high class of work done by the service and partly by the stimulus it has given to this work through its international system and other liberal methods; that the practical application of weather forecasts has attained a degree of perfection unexcelled, if even equalled, by any other nation; that its system of river observations and flood forecasts, taking into consideration the enormous area of the drainage basins and the unparalleled amount of material interests concerned, has reached a stage comparing most favorably with that of any foreign country; and that the graphic and tabular data representing the climatic elements of precipitation, temperature, wind, sunshine, evaporation, humidity, prevalence of cloudiness and probability of rain, have covered the entire United States with a fullness and perfection of detail unknown over any other equally extensive area on the face of the globe.

It is believed that no branch of meteorological or climatic investigation has been neglected by the army administration of the Weather bureau, and the character and reliability of the work thus done is submitted with confidence that it will stand the test of investigation and discussion as well as that of any other department of natural science through a period of equal length in its organization, development and transition upwards.

One broad field opens up to the Weather bureau under its happy organization, freed from the heavy burden of conflicting duties foreign to scientific work, and in this field of the relation of weather and climate to agricultural productions the prospects for great usefulness is possible. This field the army administration made unavailing efforts to cover through coöperation with the department of agriculture, but to a bureau of its own this department will no longer maintain an indifferent attitude such as was displayed toward the army.

In its development in this and in all directions, and in the efforts of its professors and advocates to place meteorology among the acknowledged and exact sciences, the United States Weather bureau has no more interested or friendly sympathizers than the officers of the army who have contributed by their labors to the perfection of the splendid, practical system on which this bureau now rests.

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THE

NATIONAL GEOGRAPHIC MAGAZINE

THE MOTHER MAPS
OF THE
UNITED STATES

HENRY GANNETT

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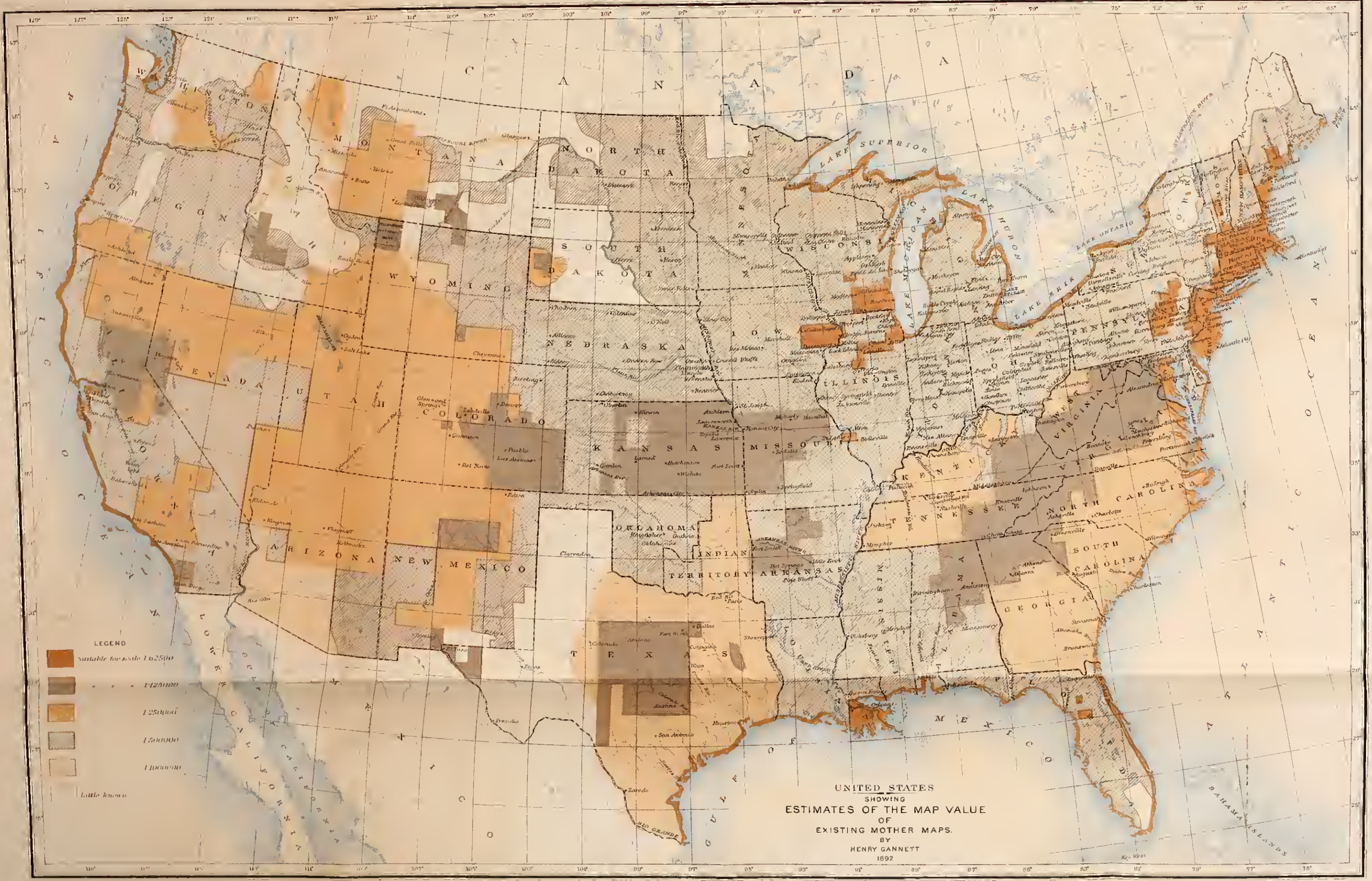

UNITED STATES
SHOWING
ESTIMATES OF THE MAP VALUE
OF
EXISTING MOTHER MAPS.
BY
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THE MOTHER MAPS OF THE UNITED STATES.

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(Presented before the Society January 22, 1892.)

INTRODUCTION.

We read of topographic maps and of geographic maps. Both of these classes of maps represent similar features—the drainage and other bodies of water, the relief of the earth's surface, and the artificial features, such as railroads, roads, towns, houses, etc. The distinctions between them are merely those of scale and of area represented. A map on a small scale and covering a large area is commonly known as a geographic map.

Mother maps are those made from original sources of information. Commonly they are the maps for the production of which a survey was carried on, while compiled maps are secondary productions, being reduced or changed in certain respects from the mother maps. Topographic maps may be mother maps or compiled maps. Geographic maps are in most cases compiled maps.

Most of the countries of Europe have been surveyed under a uniform plan or system and mother maps produced therefrom. In these cases the mother map is everywhere of uniform quality and character. In the United States, on the other hand, many partial surveys have been made under independent authorities and of widely differing degrees of accuracy, and the maps resulting therefrom differ in scale and value.

It is my purpose to sketch the principal of these surveys, characterizing the methods employed and the accuracy and value of the maps which have resulted from them, in order to learn what parts of the country have been well mapped, what parts have been indifferently mapped, and what parts have not been mapped at all. Such surveys have been executed under authority of the general government and of state governments and have been carried on by private enterprise.

SURVEYS OF THE UNITED STATES GOVERNMENT.

The Coast and Geodetic Survey.—The most prominent organization under the general government, and that one which is executing the most accurate work, is the United States Coast and Geodetic survey, which, commencing its actual work in 1832, has continued down to the present time. During this period nearly the entire coast line of the Atlantic, Gulf and Pacific, with the exception of the coast of Alaska, has been mapped, together with a strip of inshore topography ranging from half a mile to five miles in breadth. The area of topographic surveys is not extensive, being at the present date only about 34,000 square miles. In addition to this work, triangulation has been extended inland in various directions for a number of different purposes: It has been extended southwestward along the Appalachian mountains for the purpose of furnishing a suitable control for the work along the southern coast; it has been extended westward from the Atlantic coast in the neighborhood of the 40th parallel of latitude to central Kansas, and from the Pacific coast eastward to eastern Utah for the purpose of ultimately joining together by triangulation the work upon the eastern and western coasts. For assisting in state surveys, triangulation has been done in the interior in many of the states, among which are New Hampshire, Massachusetts, New Jersey, Wisconsin, Indiana, Kentucky and Tennessee. Besides all this triangulation, numerous astronomic determinations have been made in the interior.

The triangulation of this organization is of the highest order of excellence. Topographic details are mapped by the planetable. The planetable sheets are in the main made on a scale of 1 : 10,000, or about 6 inches to 1 mile, and are published on various scales from 1 : 10,000 to 1 : 80,000. Contour lines at vertical intervals of 10 or 20 feet are located on the planetable sheets. The small scale charts are published in hachures, those on the larger scales commonly in contours.

Geological Survey.—The United States Geological survey is the only organization which has ever undertaken to map the United States under a comprehensive and well defined plan, and it has surveyed a greater area than any other organization. It was formed in 1879 upon the discontinuance of the three rival western surveys, namely, the Hayden, Wheeler and Powell surveys. At first it was restricted in its operations to the public domain, but was soon authorized by law to include the entire United States. The work of topographic surveying on a large scale, with a view to mapping the entire country, was commenced in 1882 and has been prosecuted actively since that time.

The work, wherever practicable, is controlled by triangulation, which, though not of geodetic refinement, is suitable for the control of the maps upon the adopted scales. Where it is not practicable to carry on triangulation for control, traverses are run for that purpose with instruments of considerable power and with all possible precaution to prevent the accumulation of sensible error.

Aside from the primary control, location is effected by graphic methods. The planetable is used for secondary triangulation and for traversing. Heights are measured with the spirit level, by vertical angles, and by aneroid. The maps are now published on two scales, one of 1 : 62,500, or about one mile to an inch, the other of 1 : 125,000, or about two miles to an inch. Considerable work has been executed on the scale of 1 : 250,000, but that scale has been abandoned. Relief is expressed by contours, the intervals ranging from 5 feet up to 200, depending upon the scale and upon the degree of relief of the country.

The Geological survey has worked in coöperation with four states, namely, Massachusetts, Rhode Island, Connecticut and New Jersey, and has completed the surveys of these states. It has also surveyed large areas in New York, Pennsylvania, Maryland, Virginia and West Virginia, the southern Appalachian region, Louisiana, Texas, Arkansas, Illinois, Iowa, Wisconsin, Missouri, Kansas, and the western states and territories generally. Altogether an area of 550,000 square miles has been surveyed. The maps are engraved on copper. Three plates are required, the culture, drainage and relief being printed in different colors.

Lake Survey.—The shores of the Great lakes and of the St Lawrence river have been mapped, together with a narrow strip of topography, by the organization known as the United States Lake survey, which was under the control of the Engineer corps of the United States army. Besides mapping the shores of the lakes, this organization carried a belt of triangulation from the head of lake Michigan to that of lake Erie across the southern end of the peninsula of Michigan, and another strip of triangulation through eastern Illinois to the neighborhood of Vincennes, Indiana, and located by astronomic means a large number of points in the lower peninsula of Michigan. All these determinations of positions were connected directly with section corners of the United States Land survey, to be hereafter described.

The work of this organization was of a high order of excellence, comparable in most respects to that of the United States Coast and Geodetic survey.

Engineer Surveys.—In connection with river improvements, the United States Engineer corps has made surveys of many navigable rivers. In many cases these are merely local surveys covering trifling areas, but in the cases of the lower Mississippi and the Missouri river excellent maps, controlled by triangulation, have been produced.

Army Explorations.—The western part of the United States has, ever since its acquisition, been a favorite field for exploration and survey. For a long time the War department monopolized this field. The explorations began with the famous expedition of Lewis and Clarke in the early years of the century, followed by those of Long, Pike and Fremont. Then, in the early fifties, came that remarkable series of explorations known as the Pacific railroad surveys. These were followed by numerous other army expeditions, some of which are of comparatively recent date. Altogether a large number of military parties have traversed the Cordilleran region and each of these expeditions has furnished more or less geographic information.

Their methods of survey were, in nearly all cases, similar: A traverse survey of the route was made, using the compass for directions. Distances were measured by the revolutions of a wheel or by estimates based upon the time of travel. Points off the line were intersected upon and thus located roughly with reference to the line of travel, and, resting upon this rather imperfect skeleton, the topography in sight of the line was sketched, while that out of sight of the line was often added from the statements of hunters, trappers and Indians. These lines were checked at intervals by astronomic determinations, the latitude being determined by altitudes of the sun or a star, the longitude by moon culminations or lunar distances, or by chronometer.

Many such lines were run in various directions over the Cordilleran region. From such as were at that time available, General G. K. Warren constructed in 1857 the first map of the western United States which was in any way worthy of the name of map.

Nearly all of the areas thus explored have since been resurveyed by more accurate and detailed methods.

Survey of the 40th Parallel.—In 1867 Mr Clarence King, a civilian in the employ of the War department, organized a survey for the exploration of a strip of country adjacent to the line of the Union Pacific and Central Pacific railroads, from the longitude of Cheyenne on the east to the eastern boundary of California on the west, and about 100 miles in breadth from north to south. This work, which was completed in 1871, comprises an area of about 87,000 square miles. It was published on a scale of 4 miles to 1 inch in approximate contour lines 300 feet apart. The work was controlled by triangulation; heights were measured by barometer and by vertical angles, and sketching was done in note books, the sketches being adjusted to the locations in the office.

Surveys west of the 100th Meridian.—This was the most extensive of the surveys within the Cordilleran region. It was commenced in 1869, and for several years was carried on by traverse methods similar to those followed by the other explorations under the War department, and the maps produced were published on a scale of 8 miles to an inch, the relief being expressed by hachures. In 1873–'4–'5 the methods of this survey were radically improved. A system of control by triangulation was adopted, the scale of publication was increased from 8 to 4 miles to an inch, and areas, instead of lines of travel, were mapped. This survey was discontinued in 1879. The entire area surveyed is said to have been 361,000 square miles, of which 103,000 square miles was on a scale of 4 miles to an inch, the balance being on that of 8 miles to an inch.

The Hayden Survey.—This organization, which was initially a geologic exploration, was instituted in 1867. No topographic work was done by it until 1871, when certain route surveys were made in Montana, Idaho and Yellowstone park. In 1872 similar surveys were carried on in the same region. Between 1873 and 1876, inclusive, the work of this organization was confined to Colorado and adjacent strips of Arizona, New Mexico and Utah, while in 1877 and 1878 work was done in Wyoming, Idaho, Utah and Yellowstone park. During 1873 and following years the methods of survey were greatly improved. The work was controlled by triangulation originating in measured bases, within which was a secondary triangulation, by means of which nearly all control points were located; traverse being used to locate only minor details of roads, streams, etc. Sketching was done in note books, and the sketching was adjusted to the control in the office. The maps were published on a scale of 4 miles to an inch, in approximate contour lines 200 feet apart. Altogether an area of about 100,000 square miles was surveyed by this organization, which was discontinued in 1879.

Powell Survey.—This survey originated in an exploration of the Colorado river, commenced in 1867. After the completion of this exploration, systematic work was undertaken in the territory of Utah, and up to the time of the discontinuance of the survey in 1879 about 67,000 square miles had been surveyed, comprised in Utah and the northern part of Arizona. The methods of work were quite similar to those of the Hayden survey, but with this notable exception, that the minor control and the sketching were done upon planetables, the sketching being adjusted to the control in the field upon the stations. The maps were published by the present Geological survey on a scale of 1 : 250,000, the relief being expressed by contours 250 feet apart.

Boundary Surveys.—The boundary lines of many of the western states and territories have been run at the expense of the general government, and in connection with these boundary surveys narrow strips of topography have been mapped.

In 1875, when public attention had become drawn to the gold deposits of the Black hills, an exploration of this region was undertaken by the Indian bureau under the authority of the general government. This exploration included both the preparation of a topographic map and a geologic examination. The map was produced on a scale of 4 miles to an inch in approximate contour lines.

Public Land Surveys.—In the latter part of the last century a system was devised for the subdivision of the public lands held by the United States, for the purpose of cutting them up into convenient parcels for sale or other mode of disposal. The system then devised has been extended with little modification over all the states, with the exception of the thirteen original colonies, together with Maine, Vermont, Kentucky, Tennessee and Texas. Many of the states have been surveyed entirely under this system, while the others have been in greater part surveyed.

The method of subdivision is a very simple one, and is learned by every western child in connection with the alphabet. An initial point is selected from which a base line is run east and west and a principal meridian is run north. At intervals upon this base line, ranging from twenty-four miles upward, other lines are run north, known as guide meridians, and at similar intervals on the principal meridian secondary east-and-west lines are run, known as correction lines. The blocks of country thus laid out into approximately rectangular shape are subdivided into approximate squares by running lines northward, eastward, and westward at intervals of six miles, forming what are known as townships. Each township is then subdivided by means of lines run at every mile in both directions, forming sections, each section being approximately a mile square. The north lines are theoretically run on true meridians and therefore converge, the convergence increasing from the base line northward until a correction line is reached. Upon the correction line a new start is made, the townships and sections resuming their former bases of six miles and one mile respectively.

The principal and guide meridians, the base lines and correction lines, as well as all other township lines in this work, are run by solar compass, and distances are measured by chain with considerable care. The subdivision of townships into sections is generally done with a compass, and the chaining is executed with less care. The accumulated errors in the survey of a township are thrown into the northern and western tiers of sections, culminating in the northwestern corner.

In the prosecution of these surveys no attention has been paid to geographic positions. The initial points have been selected arbitrarily, and it is only by connecting these surveys with positions determined independently that they have been located. Such determinations have been made in abundance by one means or another, and they are well distributed; so that for maps on small scales there is no difficulty in locating these surveys.

As these surveys have been made merely for the purpose of subdividing the land, little attention has been directed toward making them available for the production of maps. The instructions under which they have been made, however, require that the points of crossing of all streams by the lines of survey be noted, together with the directions of the streams; that all streams above a certain breadth, as well as the borders of all lakes and ponds, be traversed; and that the limits of all swamps and marshes and timbered lands be noted. Had these instructions been everywhere carried out a large amount of geographic information would have been gathered; but unfortunately they have not been fully carried out, and hence the township plats differ greatly in the amount of information which they present. These plats are made on a scale of 2 inches to a mile, a scale many times greater than the degree of detail upon them requires. From these plats, with the addition of information from other sources, the General Land office prepares and publishes a series of very useful state and territorial maps on scales ranging from ten to eighteen miles to an inch, and a map of the United States upon a scale of about 40 miles to an inch.

There is another group of maps published by the general government, the material of which is, in the main, compiled, but which contains certain elements of originality. These are the postal-route maps which are prepared by the Post-office department for illustrating the location of post-offices and the lines of transportation of mails. The natural features of these maps are of course compiled. The boundary lines of counties, on the contrary, are in the main laid down directly in accordance with statute. The location of railroads is effected mainly by means of plats furnished directly from the railroad surveys, and the location of post-offices is in a corresponding measure derived from similar sources.

With the exception of a few minor matters, the above list covers the survey works and the sources of geographic information furnished by the general government. We turn next to the work done by the various state governments.

STATE SURVEYS.

New Hampshire.—This state supported recently a geologic survey, which undertook the preparation of a topographic map, a work which was effected mainly, however, by compilation, little original work being done. A number of positions in the state were obtained from the United States Coast and Geodetic survey and to these were fitted traverses of roads which had previously been surveyed by private enterprise. Upon this skeleton a somewhat pretentious contour map was produced by using for heights the profiles of the railroads of the state, supplemented by numerous aneroid measurements made by the geologic survey. This map was printed on a scale of 2½ miles to an inch with a contour interval of 100 feet. It was issued in 1878.

New York.—From 1877 to 1884 the state of New York maintained a survey under Mr J. T. Gardiner. By this survey much triangulation of a high degree of accuracy was carried on, but no topographic work was executed. This state also maintained for many years an organization known as the Adirondack survey, which was instituted for the purpose of mapping the Adirondack region. No results, however, have been published beyond the positions of a few geodetic points and a large number of measurements of altitude.

Pennsylvania.—In Pennsylvania considerable money has been expended in topographic surveys for special purposes, but these have been on so large a scale and are so detailed in character that, areally, they are of slight importance. Most of them are on the scale of 1,600 feet to an inch, in contours 10 or 20 feet apart.

Wisconsin.—In Wisconsin some work was done in the southwestern part of the state by the state geologic survey. This work was based on the triangulation of the United States Coast and Geodetic survey. The Land office plats were utilized and the relief was expressed by 50-foot contours.

Minnesota.—Most of the area of Minnesota has been mapped by the state geologic survey on a scale of 4 miles to an inch, in 50-foot contours. The horizontal element of this map was furnished by the surveys of the General Land office, the vertical element being supplied from the profiles of railroads, supplemented by aneroid measurements.

Kentucky.—Drainage maps of many of the counties of Kentucky have been prepared from traverses of the roads. These maps, which make no attempt to show the relief, are published on a scale of 2 miles to an inch.

California.—Between 1860 and 1870 the state of California maintained a geologic survey, which, like all other well regulated geologic surveys, found it necessary to devote much of its means to making topographic maps. By this organization a large part of central California was mapped, the greater part being on a scale of 6 miles to an inch, while a small area about the bay of San Francisco was on a scale of 2 miles to an inch, the relief in both series of maps being expressed by hachures.

New Jersey.—The only state which thus far has devised and put into operation a reasonable and economical plan for mapping its area is New Jersey. In 1877 this state commenced surveys for a map in connection with its geologic survey upon a plan and by methods very similar to those subsequently adopted in the geologic survey of the United States. The work was controlled by triangulation, in the main executed by the United States Coast and Geodetic survey and supplemented by the state survey. Minor control was furnished by means of traverse lines, and elevations were measured by spirit level and vertical angles. The resulting maps were published on a scale of one mile to an inch, in contours of 10 and 20 feet. When the state was about half surveyed the United States Geological survey undertook and carried the work through to completion upon the same plan and by the same methods which the state had originated.

PRIVATE SURVEYS.

In consequence of the neglect of the government in the matter of mapping this country, a wide field has been left open for private enterprise, and this field has been worked actively, but with curious results. Maps have been produced by private parties of practically every county in the northern states and of some counties of the southern states. The material for these maps has been obtained by traverse surveys along the roads. These maps are generically similar, and can be characterized in a very few words. They are essentially diagrams of roads. The houses along the roads are generally represented, together with the names of the owners, as it is found that this aids in the sale of the maps. Streams are but feebly represented, and relief is rarely shown.

Most of the railroads of the country have prepared maps of their lines showing at least the alignment of the road and in many cases the adjacent topography. They have prepared also profiles of their lines, and as this is an important element from the railroad point of view, much more attention has been given to this than to alignment.

There is one railroad company which has done more than this. The Northern Pacific railroad organized in 1882, and supported for three years, a survey of the country adjacent to its line. During these three years an area of 43,000 square miles was mapped in Montana and Washington. The methods used were similar to those of the Hayden survey, and the maps were designed for publication on a scale of 4 miles to an inch, in 200-foot contours. A part of this area has been published by the United States Geological survey.

Large areas of the eastern and most densely settled portion of the country are dependent entirely for their maps upon these road diagrams of counties and upon railroad maps and profiles. Such is the condition of all in which no public land surveys have been carried on, excepting the areas surveyed by the organizations above described. Thus, New York has no other maps besides these road diagrams, excepting some 2,000 square miles mapped by the United States Geological survey and some trifling additions by the United States Coast and Geodetic survey, while Pennsylvania is almost as poor in information regarding its topography.

The foregoing is a summary of the principal sources of geographic information concerning this country. It comprises practically all the material which is available for the compilation of a map of the United States. Of course, it is understood that in numerous cases the same area has been mapped by two or more organizations, thus affording opportunity for selection between them. In such cases, generally speaking, the later survey is the better, but in certain cases one piece of work is better for one purpose, and another for another purpose; one for one class of features, another for another class.

RELATIVE VALUES OF THE MAPS.

I propose to classify the body of diversified material in accordance with my estimate of its map value as expressed by the scale upon which it is worthy of being represented, and thus to make an estimate of the area of the country which can be mapped from existing material upon each of several different scales.

The scales which I shall consider are 1, 2, 4, 8 and 16 miles to an inch. I exclude from consideration, for the present, the territory of Alaska.

On a scale of 1 mile to an inch, I find that only 100,000 square miles can be mapped, or about one-thirtieth of the area of the country (that area being a trifle over 3,000,000 square miles). This area possible to map includes the states of Massachusetts, Rhode Island, Connecticut and New Jersey and parts of numerous other states, mainly in the north. It includes a narrow strip of topography along the sea and lake coasts and the Mississippi and Missouri rivers. Two-thirds of this area is the work of the United States Geological survey, the balance being mainly that of the United States Coast and Geodetic survey.

On the scale of two miles to one inch, an area of 360,000 square miles has been surveyed by the Geological survey. No work adapted to representation upon that scale has ever been surveyed by other organizations. This area is widely scattered over the country. On this scale, therefore, an area of 460,000 square miles, or between one-fifth and one-sixth of the area of the country, can be mapped.

On a scale of 4 miles to one inch, the work of several organizations is included, viz, the exploration of the 40th parallel, the Hayden, Powell and Northern Transcontinental surveys, the Black hills survey, the 4-mile work of the Wheeler survey, and the 4-mile work of the United States Geological survey. The work of these organizations foots up, after deducting the overlapping areas, 460,000 square miles. All this area is in the Cordilleran region.

The area in the United States which can be mapped on a scale of 4 miles to one inch is, therefore, 920,000 square miles, or between one-third and one-fourth of the area of the country.

The original maps of this area are all of such character as to furnish material for representing all the three elements of a topographic map—the hydrography, the culture and the relief. They include most of those parts of the country which present high relief, including the southern Appalachians and most of the Cordilleran region. With the exception of 60,000 square miles furnished by the Wheeler survey, the relief of this area can be expressed quantitatively by contours.

The additional material which is adapted for smaller scales than those mentioned above shows, in the main, only hydrography and culture. Except for certain comparatively small areas, relief is not expressed at all. Still, the fact should not be overlooked that by far the greater proportion of the areas of high relief have been mapped upon the larger scales. In the remaining areas the relief element is not of so great importance.

On the scale of 8 miles to one inch, 1,530,000 square miles in addition to the areas above enumerated can be mapped. Of this area, 1,200,000 square miles are furnished by the maps of the General Land office and 100,000 square miles by county maps of the New England states, both of which classes of maps show no relief. 100,000 square miles are included from the 8-mile work of the Wheeler survey, which shows relief by hachures. The remainder comes in small areas from various sources. On this scale, therefore, a map including 2,450,000 square miles, or nearly five-sixths of the country, can be prepared, showing hydrography and culture.

A reduction of the scale to 16 miles to one inch, or about 1 : 1,000,000, increases but little the area possible to map. It adds only such parts of the southeastern states as are not already included, a portion of Texas, and some trifling areas in the Cordilleran region. The southeastern states can be represented on this scale by the aid of compilations of railroad maps, war maps, etc, notably the compilations made by the United States Coast and Geodetic survey during the civil war, the compilation of North Carolina made by Professor W. C. Kerr, and others.

A compilation from railroad surveys has been made of Texas, which, excepting for the western part of the state, will answer for this scale. In the Cordilleran region some small areas not included in later maps have been run over so closely by army expeditions and exploring parties as to be worthy of a place in this category.

Altogether, an area of about 2,800,000 square miles can be mapped on this scale. This leaves, besides Alaska, about 225,000 square miles which is too little known to be represented on a scale of 16 miles to one inch.

Much of this material is measurably deficient in the culture element, inasmuch as the surveys were executed many years ago and, in the interval which has elapsed, this element has changed greatly. This is particularly the case in the west, where most of the present stage of development has been produced since the work of the Hayden, Wheeler, King and Powell surveys was done.

To bring this culture element up to date on maps of the two last-mentioned scales, viz, 8 and 16 miles to one inch, the postal-route maps are of great service—are, indeed, well-nigh invaluable.

SUMMARY.

About 76 per cent of the area of the United States, exclusive of Alaska, has been surveyed by the general government on various scales, and fully 16 per cent more has been surveyed by other organizations or private parties in such manner as to yield useful maps, leaving barely 8 per cent of our territory unsurveyed. The mother maps of the country are based upon these surveys.

The areas represented on the various mother maps of the United States and available for compilation, classified by the scales on which they are worthy of reproduction, are summarized in the appended table. They are also shown graphically in the accompanying map of the United States forming plate 17.

The scale of 1 : 1,000,000, or nearly 16 miles to one inch, has been adopted by the Geographic congress for mapping the earth, and it is therefore of interest to know how much of this country can be mapped on this scale, and where the areas are located concerning which our information is too scanty to warrant such representation. These areas may briefly be enumerated. They are:

Northern Maine.
Adirondack plateau of New York.
Southern Florida.
Most of Idaho and much of Montana.
The Cascade and Coast ranges of Oregon and Washington.
Western North Dakota and South Dakota.
Western Texas and southeastern New Mexico.

Areas represented on the various Mother Maps of the United States and available for Compilation on certain selected Scales.

Scale (miles to one inch).	Surveyed by—	Area in square miles.	Total area on scale.	Total available for scale.	Remarks.
1.	Coast and Geodetic survey......	34,000	100,000	100,000	All in contours.
	Geological survey..............	66,000			
2.	Geological survey..............	360,000	360,000	460,000	All in contours.
4.	Geological survey..............	120,000	460,000	920,000	All but 60,000 in contours.
	Powell survey................	67,000			
	Hayden survey................	86,000			
	Northern Transcontinental surv.	40,000			
	King survey..................	87,000			
	Wheeler survey...............	60,000			
8.	Wheeler survey......	100,000	1,530,000	2,450,000	860,000 in contours; 160,000 in hachures; remainder show no relief.
	Land Office surveys...........	1,200,000			
	Private surveys...............	100,000			
	Miscellaneous surveys..........	30,000			
16.	Miscellaneous surveys..........	350,000	350,000	2,800,000	Same as above.

The territory of Alaska is still in the exploration stage. Its condition, as regards our geographic knowledge of its area, is quite similar to that of the Cordilleran region half a century ago. The shore line has been explored and laid down upon charts in its approximate position, and a part of the intricate shore line of southeastern Alaska has been mapped with some accuracy. The interior of the territory has been traversed by a number of expeditions, and thus a few routes have been surveyed; but far the greater part of the interior is still utterly unknown.

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THE
NATIONAL GEOGRAPHIC MAGAZINE

AN EXPEDITION

THROUGH

THE YUKON DISTRICT

CHARLES WILLARD HAYES

WASHINGTON
PUBLISHED BY THE NATIONAL GEOGRAPHIC SOCIETY

Price, 50 cents.

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AN EXPEDITION THROUGH THE YUKON DISTRICT.

BY CHARLES WILLARD HAYES.

(Presented before the Society February 5, 1892.)

CONTENTS.

INTRODUCTION.

An expedition in the interest of a syndicate of newspapers was organized in the spring of 1891 by Mr Frederick Schwatka for exploring portions of the Yukon basin in the British Northwest Territory and Alaska, particularly the region lying north of the St Elias mountains. A request was made to the director of the United States Geological survey for a geologist to accompany the expedition, and it was the good fortune of the writer to be detailed for that duty.

Under the conditions of travel only a hasty reconnaissance of the region traversed was possible, but so little has been known of it geologically or otherwise that such observations as were made possess a value out of proportion to their completeness. It is the object of this paper to give in systematic form the main facts of scientific interest observed during the journey. A full account of the journey itself, which is not without interest, cannot be given here, but will appear elsewhere through its appropriate channels. Enough of the narrative will be included, however, to indicate the route and means of travel and something of the conditions under which the scientific observations were made.

Mr Schwatka's original plan was to go over Chilkoot pass and down the Lewes, following the regular miners' route to the interior; but on reaching Juneau, at the request of the citizens, backed up by their substantial assistance, it was decided to go in by way of Taku river, with a view to determining whether a trail for pack-animals could be constructed over that route.

Considerable information of an indefinite sort was available concerning the country to be traversed before reaching Lewes river. The pioneers of the Western Union Telegraph company crossed the upper portion of the Taku basin in passing from the Stikine to the Lewes, but the map which resulted from their explorations is only a very crude approximation to the topographic facts, and must have been drawn largely from memory.

Dr Dawson obtained from a prospector named Boswell some information concerning Teslin river and lake Ahklen which he embodied in the map accompanying his report on the Yukon district. The location and form of the lake proved to be remarkably accurate, though the regularity of the topographic features of the region is such that a clear idea of their relations is easily obtained even without instruments.

The whole of the route from Taku inlet to the Lewes was traversed in the spring and summer of 1890 by a party of eight miners, among whom Mark Russell, a member of our party, was a leading spirit. They started from Juneau before the ice was out of the river, hauling their outfit on hand-sleds so long as the snow lasted, and then packing them. It required eighty days to reach the lake, where the party built a number of boats. After prospecting the Nisutlin and other streams on the eastern side of Ahklen valley they went down the Teslin and back to the coast by Lewes river and Chilkoot pass. This is an example of the many unheralded expeditions which the Alaskan prospectors have carried out, facing dangers and privations which appear incredible to one who is not familiar with the men themselves. Less arduous or novel expeditions have brought fame to explorers better versed in the art of advertising than these unassuming miners. Unfortunately, however, geography is but slightly the gainer from the work of the prospector, since he usually has neither the training nor the inclination to use instruments even if he should be supplied with them, which is rarely the case, and ordinarily the map which he draws from memory, unassisted by notes of any sort, is not a model of accuracy.

At the head of Taku inlet a "track survey" was begun and carried continuously to the mouth of Teslin river, where it connected with the line surveyed by Mr Ogilvie in 1886. The instruments used were a prismatic compass for determining direction, and a sextant for latitude. Distance was obtained during the boat journey on the Taku, lake Ahklen, and Teslin river by time and eye estimates, and on the portage between Taku river and the lake by pacing. Altitudes were determined from the mean of four aneroids with synchronous readings of a base barometer at Juneau, for which we are indebted to the kindness of Mr E. S. Willard. The route was plotted in the note book and relief indicated by sketch contours; all prominent points within sight along the line of travel being approximately located by compass bearings. While such a survey does not, of course, possess the precision of an instrumentally measured line, still, when carefully executed, it represents the character and relations of the topographic features of a country with a fair degree of accuracy.

Between Yukon river and the St Elias mountains lies a large area, embracing the whole of White river and its tributaries, as well as the headwaters of the Copper and Tananah, which has been geographically a blank. So far as can be learned it had never been penetrated by a white man, and the lakes, rivers and mountains which appear on many maps are products of the geographer's imagination. Across this unknown region a track survey was made similar to the one already described. Excepting about fifty miles traversed by water, the whole distance of 330 miles from Selkirk on the Yukon to the junction of Chittenah and Nizzenah rivers was carefully paced; and the two ends of the line being located by astronomic observations, the former by Ogilvie and the latter by Allen, the location of intermediate points cannot be far out of the way.

The portion of our route between the mouth of the Teslin and Selkirk, at the junction of the Lewes and Pelly, had already been twice surveyed, first by C. A. Homan, the topographer of Schwatka's party in 1883, and more accurately by Ogilvie in 1887. Chittenah and Copper rivers had been surveyed by Allen in 1885, so that no continuous survey of these rivers was undertaken though numerous observations were made to supplement those embodied in Allen's map.

Narrative of the Expedition.

Our party consisted at the start of three white men—Mr. Schwatka, the prospector Mark Russell, and the writer—with seven Indians engaged as boatmen and packers for the first stage of the journey. After a few days spent in completing the outfit and waiting for the river to become free of ice, we left Juneau May 25, 1891.

The large two-ton dugout canoe in which we embarked was well adapted for navigating the deep waters of the inlet, but we found it poorly suited to the swift and shallow river. When the wind blew up stream rapid progress was made in spite of the current by spreading two large sails wing and wing, but when the wind failed our progress, by poling or tracking wherever the banks permitted, was painfully slow. Seven days were spent in reaching the head of canoe navigation, eight miles above the South fork and about eighty from Juneau. During this part of the journey little opportunity was afforded for studying the geology of the region traversed, since the boatmen generally kept to the middle of the valley and we usually made camp at night on one of the small islands which separate the river into many channels.

While Taku river is far from being an ideal highway to the interior, still a flat-bottomed steamer of light draft and good power would probably have no serious difficulty in reaching the mouth of the South fork, less than a hundred miles from a point on lake Ahklen which could be reached by steamer from the mouth of the Yukon. The country intervening between these points is practicable for pack-animals with the expenditure of comparatively little labor in constructing a trail. It is probably only a question of time when some better way of reaching the upper Yukon basin than Chilkoot pass will be demanded, and the Taku route is, so far as yet known, the least objectionable.

At the head of canoe navigation our outfit was made up into twelve packs of about one hundred pounds each for the portage of eighty-five miles to the head of lake Ahklen. As there were but six packers, each was obliged to make two trips; so that our progress was extremely slow. The first twenty miles of the portage are in the narrow canyon-like valley of an eastern branch of the river, and the next fifty in broad valleys of the upper Taku basin, from 3,500 to 5,000 feet above sea level. The last fifteen miles are in the densely wooded Ahklen valley among innumerable small lakes and ponds. We reached lake Ahklen June 16, and from this point the Indians were sent back to the coast. It was with a feeling of great relief that we watched them disappear on their homeward journey and knew that we were no longer dependent on their caprice.

Setting up the two portable canvas canoes which had been packed in from the coast, we continued our journey toward the northwest, down lake Ahklen and Teslin river, which forms its outlet. The Lewes was reached June 24 and Selkirk, at the junction of the Lewes and Pelly, four days later. The original plan had been to continue down the Yukon to the mouth of White river and up that stream so far as possible by boat, but the Indians whom we found at Selkirk told us the easier route to the head of White river was overland, keeping southeast of the main river valley; and this route we decided to follow.

A store has recently been established on the site of old fort Selkirk, the Hudson Bay company's post, which was burned by the coast Indians in 1848. The trader, Mr Harper, was down the river and we found only a couple of Indians whom he had left in charge. These were dispatched up the Pelly to collect the natives in the vicinity and we soon had about forty of them camped around us. Only a few of them, however, were able-bodied men, and it was extremely difficult to persuade these to go with us; and when they had promised it was only to back out the next day. After laboring with them for over a week it seemed that the attempt to secure the necessary packers was hopeless, and we were preparing to go down to the mouth of White river and try the ascent by boat, when the tide was turned by the opportune arrival of a prospector, Frank Bowker. He had come up the river from Forty-mile creek, intending to spend the summer prospecting in White River basin. With him were two natives from further down the river, muscular and willing fellows, very different from the wretched specimens from Pelly river. Bowker's arrival, as he came with authority from Mr Harper, who has great influence over the natives, put new backbone into our enterprise. Five packers were soon secured, who promised to go with us to the country of Scolai, beyond the mountains. Dogs were obtained to carry the remainder of the outfit, from twenty-five to forty pounds being packed upon each in panniers of birch bark or moose skin.

On July 9 our combined party of four white men, eight Indians, and eleven dogs left Selkirk. Our course lay toward the southwest, over the great interior plateau which stretches from the Yukon to the St Elias mountains. The headwaters of Selwyn river were crossed and several eastern tributaries of White river.

The country is very scantily peopled, and although we probably saw most of the natives inhabiting the White River basin they only numbered alogether between fifty and sixty persons. The first party, consisting of six families, was camped on the Nisling, making a fish trap in anticipation of arrival of the salmon, which was anxiously looked for. These Indians are closely related to those living on the Pelly. They are similar in appearance and mode of life, and apparently speak the same language. They have no permanent dwellings, but several substantial log caches were seen, which they use for storing their winter's supply of dried fish and moose meat. The country seems to be fairly well supplied with game, goats on the highest rocky summits, moose and bear in the river valleys, and reindeer or barren-grounds caribou on the plateau above timber line. Several of the latter were killed by members of our party, and our supply of provisions was also helped out by the dried meat which we obtained from the natives. On the Kluantu was found a second party of Indians, most of whom had never before seen a white man. Obtaining a number of rafts from these natives we descended the river about fourteen miles to its confluence with the Donjek, since both the Kluantu and Donjek were too deep and rapid to ford. The Klutlan was also found to be unfordable, and we were compelled to go around its head and cross upon the glacier from which it flows. Although this was not attended by any special danger it caused great dismay among the Indians, who regard a glacier with superstitious terror.

About twelve miles beyond Klutlan glacier we reached a small stream called the Klet-san-dek, or Copper creek, coming from a narrow gorge in the mountains. This is where the Yukon Indians have been accustomed to come for supplies of native copper. It was as far as any of our packers had ever been from home and they knew of the country beyond only by report. They refused to go with us further, assuring us that it was quite impossible to get through the mountains at that season since the pass was only traveled by Indians in the winter on snow-shoes. Bowker had already come further than he originally intended, so that he turned back with the Indians. It was something over two hundred miles back to Selkirk, and although through an unknown country a considerably shorter distance to an Indian village on the other side of the mountains. Trusting in our ability to reach the latter inside of two weeks, a period for which we had provisions, we decided to push forward. Discarding everything not absolutely essential our packs still amounted to seventy-five or eighty pounds apiece, so that progress was necessarily slow. The weather since leaving the coast in May had been very warm, with little rain except local thunder showers, but from this time until we again reached the coast rain was falling most of the time. As we had no tent, this added greatly to our discomfort.

Leaving the Kletsan, our party now reduced to three, we continued toward the northwest through the densely wooded valley, with the White river on our right and the steep mountain face on the left. At the end of the third day we came out upon

White river, flowing from the south in a deep narrow valley. This we concluded must be the pass of which the Indians had told us, and our belief was strengthened by meeting a high wind, amounting almost to a gale, blowing through from the south. A couple of miles back from its mouth a wall of moraine-covered ice stretched across the valley, the river emerging from a tunnel on the extreme western side. This was undoubtedly the ice which the Indians said it would take us at least four days to cross. As usual, however, their statement was wide of the truth. Crossing a couple of miles of rough moraine-covered glacier with a gradual ascent toward the south, we came to a long stretch of firm white ice upon which walking was a positive luxury after our days of floundering in the deep moss and alder thickets of White River valley. We continued to ascend gradually for about ten miles, directing our course toward a low saddle in the mountains on the south which we supposed to be the pass. Toward evening, however, we were surprised to find the surface of the glacier descending and a little later discovered a deep narrow gorge turning off to the right almost at right angles with our former course. We had crossed the divide, and in a short time were off the ice and camped on a stream flowing into the Pacific. This was the Nizzenah, a tributary of the Chittenah, or eastern branch of Copper river.

The next four days we continued our journey down the narrow canyon which this stream has cut through the mountain range and encountered the most difficult traveling we had yet found. The vegetation on the southern side of this range rivals in luxuriance that of the coast. Forcing our way through the dense growth of alder and spruce which covers the steep slopes at the base of canyon walls was extremely slow and painful work. A mile in four or five hours was counted fair progress.

At length, after having been compelled to ford the river several times, we reached a point at which it appeared not wholly impracticable for boating, and it was decided to stop and build a boat. Our tools consisted of a very dull axe and our pocket knives, but with these we hewed out a keel and gunwales from spruce saplings and fashioned ribs from willow poles, lashing the structure together with twine ravelled from our pack ropes. Over this frame was stretched the canvas in which our bedding had been wrapped and finally the covering was smeared liberally with spruce gum. In this craft our progress was more rapid and not without excitement. The river has a fall of about twenty feet to the mile, so that it is practically a continuous rapid from the point where we embarked thirty-five miles down to its confluence with the Chittenah. For seven miles above the confluence the river flows through a canyon with rocky walls from 350 to 500 feet high. It is extremely narrow and crooked; the water, which above the canyon frequently spreads out half a mile or more in breadth, being compressed into a channel in places only a few yards across.

We were presumably on a part of the river descended by Lieutenant Allen in 1886 with a crew of natives, but thus far had been unable to make the country fit his map and were in doubt until we reached the lower end of the canyon, when it was of less interest to know that another had been through than it would have been before we started in. After endeavoring with poor success to learn something of the character of the canyon from the top of the bluffs, we decided to attempt its passage. Our boat was tossed from side to side like a shuttlecock, whirled around sharp projecting points of rock and through narrow chutes with a velocity that fairly took our breath. Twice more the canyon wall was scaled, but the river could be seen only a short distance ahead. Several times we came uncomfortably near disaster, and that we got through in safety is largely due to the coolness and skill with which Mark Russell navigated our craft.

Continuing down the Chittenah about forty miles to its confluence with Copper river, we reached Taral, a few miles below the confluence, August 12, just fourteen days after the natives left us on White river. We had come through exactly on schedule time, with three pounds of flour and a handful of tea remaining of the provisions with which we left Selkirk.

At Taral we found Nicolai, or "Scolai," as the Yukon Indians call him, the autocrat of the Copper river country. He gave us a most hospitable reception and supplied us with provisions so far as his limited stores permitted. Salmon, both fresh and dried, were abundant, so that we had no further apprehension of famine. The Copper river Indians have an unenviable reputation for treachery and hostility to the whites; but we saw nothing to justify it. They are greatly superior to the Yukon natives, physically at least, and have a much more elaborate family and tribal organization.

We were so fortunate as to reach Taral just as Nicolai was preparing for his annual visit to the coast, and after a delay of four days we embarked in a large skin boat manned by ten of his vassals. A couple of days brought us down to Miles glacier, where the river tumbles over a dam of huge moraine bowlders. It is necessary to make a portage here sometimes across both moraine and glacier. Crossing about two miles of moraine covered with a dense alder thicket, we came out upon a high ridge of freshly deposited bowlders. Immediately in front was a broad expansion of the river in front of the glacier, which formed an ice cliff along one side nearly four hundred feet in height. Bergs were almost constantly falling, with reports like thunder, dashing the spray high above the top of the cliff. The current of the river sets across the lake toward the front of the glacier, and where it meets the swell produced by a falling mass of ice the water is thrown into enormous breakers which, with the grinding icebergs, would swamp a boat instantly. Nicolai decided that we might get past by waiting for a lull in the falling of the ice and for a wind from the right direction to open a passage through the floating bergs. The right moment came after a wait of nearly a day, and tumbling things into the boat we were soon past the dangerous spot, to the evident relief of Nicolai and his crew. A short distance below we passed the front of Childs glacier, running within a stone's throw of the lofty wall of ice, and found ourselves at the head of the river delta, with the blue Pacific in sight far to the southward. It lacked a few days of being three months since we had left the coast at Juneau, and in that time we had travelled almost exactly a thousand miles, nearly half the distance being on foot.

Nicolai intended going to Eyak, where two salmon canneries are located on a narrow neck of the peninsula between the Copper River delta and Prince William sound. When within a few miles of that place we were met by a native with the report that the Eyak canneries had closed and the traders had left. This report, which we afterward found to be the invention of a rival trader, turned us back to the head of the delta and down one of the eastern channels fifty miles out of our way and delayed our arrival at Eyak about four days. On account of this delay we missed the August mail steamer from the sound by twelve hours and were obliged to wait there a month for the

September steamer. Thanks to the abundant hospitality of Captain Humphrey, superintendent of the Pacific Steam Whaling company's cannery, our detention there was rendered far from unpleasant, and the opportunity was afforded of examining this little known region. Taking passage September 21, on the mail steamer *Elsie*, from Nutchek, we reached Sitka four days later, connecting there with the steamer *Mexico* for Puget sound.

TOPOGRAPHY.

Cartographic Data.

The topographic data embodied in the accompanying map sheets (plates 19 and 20) are from the following sources:

On sheet i the region from the head of Taku inlet to the mouth of the Teslin, embracing Taku river, lake Ahklen, and Teslin river, is mapped from my track survey made in 1891, which I have already briefly described. The relief is indicated by sketch contours with an approximate vertical interval of 250 feet.

The portions of Pelly river shown on sheets i and ii are from the track survey made in 1887 by Dr Dawson. The region from the mouth of the Lewes, shown on sheet ii, across Chilkoot pass to Pyramid harbor, at the head of Lynn canal, is from the instrumental traverse made by Mr W. Ogilvie in 1887 and embodied, together with Dawson's track surveys, in the map of a portion of the Yukon district which accompanies the report on an expedition to the Yukon district, Northwest Territory, and adjacent northern portion of British Columbia, in 1887, by Dr George M. Dawson.*

The region embracing the head of Lynn canal. Chilkat river, and the sources of Altsek and Tahkeena rivers is from the Karte des Tschilkat-Gebietes mit dem Pässen zum Yukon.† Lake Arkell and Tahkeena river are from data furnished to the Census office by Mr E. J. Glave from surveys made by him in 1891. Muir glacier is from a planetable survey made by Professor Harry Fielding Ried in 1890, embodied in the map accompanying a paper entitled Studies of Muir glacier, Alaska.‡

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* Ann. Rep. Geol. Survey Canada, pt. B, Montreal, 1888.

† Nach eigenen Aufnahmen im Jahre 1882 von Dr Arthur Krause, Berlin, 1883.

‡ Nat. Geog. Mag., vol. iv, 1892. pl. 14.

The coast from Taku inlet to cape Spencer, and also from Icy bay to the western edge of sheet ii, is from the general chart of Alaska, number 900, issued by the United States Coast and Geodetic survey, Washington, 1891. The topography of the region shown on sheet ii between Selkirk, at the confluence of the Pelly and Lewes rivers, and the mouth of the Nizzenah is from my track survey, the greater part of which was a paced traverse.

The Yukon from Selkirk to the edge of sheet ii is from the sketch survey by Charles A. Homan, published as sheet 5 of map accompanying the report of a military reconnoissance in Alaska, made in 1883 by Lieutenant Frederick Schwatka (Washington, 1885).

Chittenah river and the mount Wrangell region are from the survey made by Allen in 1885; sheet 2 of map accompanying the report of an expedition to the Copper, Tananá and Koyukuk rivers, in the territory of Alaska, in the year 1885 by Lieutenant Henry T. Allen (Washington, 1887).

The coast from Icy bay to Yakutat bay, with the region toward the north including mount St Elias, is from the surveys of Kerr in 1890 and Russell in 1891, embodied in the map of the mount St Elias region accompanying a recent paper on mount St Elias and its glaciers by Israel C. Russell.*

Orographic Features.

From the vicinity of Frazer river, in southern British Columbia, the western mainland range of the Cordilleran mountain system follows the coast toward the northwest as far as the head of Lynn canal. Here it becomes an interior range, while to the westward its place next the coast is taken by the St Elias range. The southern Alaskan coast mountains form a broad elevated belt with many scattered peaks, of which none perhaps have an altitude of more than 8,000 or 9,000 feet, while there is no dominant chain. The southwestern front of the range rises abruptly from the waters of the inland passage, forming a rugged barrier to the interior. A few rivers have cut their channels through the range, and it is penetrated varying distances by numerous deep fiords. From the head of Lynn canal northwestward the range decreases in altitude and probably spreads out and merges in the broken

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* Am. Jour. Sci., 3d series, vol. xliii, 1892, pl. iv.

plateau which occupies the eastern part of White River basin. This region is practically unknown, however, and the precise relation of the Coast range to the St Elias range has not yet been determined. Where the former range is cut through by Taku river its northeastern face, like its northwestern termination, is not sharply defined, but the mountain range merges with the high plateau lying to the eastward between the Coast range and the Rocky mountains.

The St Elias range appears to be due to a separate and more recent uplift. Its continuation southward is partially submerged and forms the islands of the Alexander archipelago. Still further southward, in Queen Charlotte and Vancouver islands, it has been called by Dawson the Vancouver range, the westernmost member of the Cordilleran system. Like the southern coast range, it is a broad elevated belt with numerous peaks and short ridges, probably the highest being along its southern border, culminating in mount St Elias. Westward from this peak the range is separated into two divergent ranges by the valley of Chittenah river. The one continuing toward the northwest contains the high volcanic peaks of the Wrangell group. The southern divergent range follows the coast toward the west and, bending round Prince William sound, continues toward the southwest in the Kenai peninsula and perhaps Kadiak island.

The eastern limit of the Coast range may be fixed approximately at the junction of the northern and southern forks of the Taku, the region east of this being a high plateau which extends to the Cassiar range, the northern representative of the Gold ranges of British Columbia. The elevation of the interior plateau, where it is crossed in passing from the Taku to lake Ahklen, is about 5,000 feet above sea level. From this point it descends gradually toward the northwest, its altitude at the junction of Lewes and Pelly rivers being less than 3,000 feet. Southwest of Selkirk the same plateau extends with gradually increasing altitude to the base of the St Elias mountains. It is only in a general way, however, that these areas are to be regarded as plateaus. When considered in detail the surface is extremely rough and broken. The river valleys lie from 2,000 to 2,500 feet below the general plateau level, while broad and rounded domelike summits and a few sharp peaks rise from 700 to 1,200 feet above it; but there appear to be no well defined ridges or chains of peaks. For about 150 miles southwest of Selkirk the contours are generally smooth and flowing, and the surface, except in the southern and glaciated portion of the region, shows the effect of long continued exposure to the action of subaërial agencies. While rock decay has made little progress, so that the surface is practically free from soil, rock disintegration has been extremely active and the country is thickly mantled with rock débris of varying degrees of coarseness. Projecting through this mantle of débris, above smooth gentle slopes, are many isolated pinnacles and towers of rock rendered especially conspicuous by contrast with their moss-covered talus slopes. Surface degradation is greatly retarded by the luxuriant growth of moss which covers practically the entire surface of the country. The annual precipitation is largely confined to the winter months, and the water from the melting snow is held by the sponge-like moss, which remains saturated throughout the short but hot and dry summer. Thus, with a rainfall which in lower latitudes would condition an arid region, a large part of the surface is swampy, quite irrespective of slope; that is, wherever the material composing it is sufficiently compact to become impervious to water by freezing. On account of this slow and imperfect surface drainage the slopes are not cut into the ravines and arroyas so characteristic of arid regions. The plateau extends west of White river, though it is there rather more diversified than toward the east by a number of high sharp peaks, probably of volcanic origin.

Approaching the northern base of the St Elias range the plateau character is almost wholly lost, giving way to steep and rugged though not lofty mountains separated by rather wide river valleys. There is, however, no merging of the plateau in the St Elias mountains, but south of a well marked limit the whole character of the topography suffers a complete change. Between the southern limit of the interior plateau and the northern base of the St Elias mountains is a depression running parallel with the mountain range and having an altitude of about 4,000 feet. It contains the upper part of White river for a distance of about thirty miles, and probably also in its northwestern continuation the headwaters of the Tananah. Southward across this depression was seen the abrupt northern face of the St Elias mountains, with many sharp and rugged peaks rising to altitudes of 10,000 to 12,000 feet. Only the steepest slopes were free from snow, and the region presented a striking contrast to the green moss-covered plateau country toward the north. The range here occupies a belt about eighty miles in width from north to south. Mr Russell saw the same region from the eastern flanks of mount St Elias, and he describes it as "A vast snow-covered region, limitless in its expanse, through which hundreds and probably thousands of barren, angular mountain peaks project. There was not a stream, not a lake, not a vestige of vegetation in sight. A more desolate or a more utterly lifeless land one never beheld. Vast, smooth snow surfaces, without crevasses or breaks, stretched away to seemingly limitless distances, diversified only by jagged and angular mountain peaks."*

Drainage.

The Taku, like the Stikine and other rivers toward the south, is flowing in a deeply buried channel excavated when the land stood relatively much higher than at present. Its valley, which is a continuation of Taku inlet, is from one to two miles wide with steep sides rising in many places almost vertically from 3,000 to 5,000 feet. The river, interrupted by many sand bars and low, wooded islands, meanders over a gravel floodplain between the high walls of the valley. Its current is rapid and it is transporting to the inlet great quantities of sediment from its upper course. Beyond the junction of the northern and southern forks, which may be regarded as approximately at the eastern limit of the Coast range, the valley sides are rather steep to an elevation of about 1,500 feet from the river, while above that elevation the slopes are gentle to broad, rounded summits of the interior plateau. The upper branches of the Taku flow in open valleys from 3,000 to 4,000 feet above sea level, indicating a long period of erosion during which the land stood at a much lower level than at present. Similar broad valleys at the upper courses of many rivers in British Columbia have been referred by Dr Dawson † to long-continued erosion in middle Tertiary time; and it is probable that the same conditions prevailed far to the north-

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*Mount St. Elias and its Glaciers: Am. Jour. Sci., 3d series, vol. xliii, 1892, p. 171.

† On the later Physiographical Geology of the Rocky Mountain Region in Canada, with special reference to changes in elevation and to the history of the Glacial Period: Trans. Roy. Soc. Can., vol. viii, sec. iv, 1890, pp. 17–21.

ward, producing the broad valleys of the upper Taku tributaries. The deep canyon-like valleys in the lower portion of the river basin represent a part of the erosion due to uplift in late Tertiary and Pleistocene time.

The divide between the Taku and Yukon drainage basins is on the edge of an escarpment by which the surface drops from the high plateau 2,600 feet to the level of Ahklen valley. The altitude of the pass is 5,100 feet, which corresponds very nearly with the average altitude of the interior plateau at this point. The valley is from twelve to twenty miles broad, and on its eastern side is the steep edge of a plateau corresponding to the one on the west and extending eastward to the base of the Cassiar range, forty or fifty miles beyond. Bounded by these approximately parallel plateau escarpments, the valley extends in an almost perfectly straight line for at least 250 miles in a northwest-southeast direction. The upper, that is, the southeastern, half of the valley is occupied by lakes. From one point on the escarpment, affording only a partial view of the valley, fifty-four were counted. Of these lakes, Ahklen* is the northernmost and by far the largest. This lake is ninety-five miles in length and from six to ten in breadth. Several small streams enter the upper end, but its main feeder comes in from the northeast about midway between the head of the lake and its outlet. This stream, the Nisutlin, enters the head of an inlet about ten miles in length which extends at right angles to the direction of the lake. According to Mark Russell, who has prospected the stream, its current is very sluggish for seventy-five or one hundred miles above the head of the inlet.

Beyond the lake the valley continues with little change, except that the bounding escarpments draw somewhat closer together and decrease in height with the decreasing altitude of the plateau toward the north.

A consideration of the name to be applied to the river which

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*Among the various names which have been applied to the lake, *Ahklen* is undoubtedly the one which should be retained. It is the name in common use among the Taku Indians. One branch of this tribe claims the country about the southern end of the lake, spending a part of the year there and coming out to the coast during the salmon season. The name is a T'linket word, meaning "big water." I have changed the spelling of the word from "Aklene," as it appears on some maps, to Ahklen, which more nearly represents the native pronunciation.

forms the outlet of lake Ahklen brings up the whole subject of the nomenclature of the Yukon and its tributaries. The subject has received very thorough treatment by Dall, Dawson, and Russell, so that the history of discovery in the Yukon basin and the origin of the names applied to the Yukon tributaries need not be discussed here. From a consideration of the physiography of the basin, its main axis must be regarded as coinciding with the Ahklen valley; but I can hardly agree with Russell that this is sufficient ground for disregarding well established usage, as he has done in continuing the name Yukon up to the lake.* Inasmuch as the rivers in question lie almost wholly within Canadian territory, the final authority upon the nomenclature must be the Canadian board of geographic names, and as Dr Dawson has given the subject the most thorough consideration I have followed him,† with a few minor changes in the most of which he has signified his concurrence. The name *Yukon* is applied to the river from its mouth to Selkirk. The name *Pelly* is confined to what has been called the "Upper Pelly," *i. e.*, from Selkirk to its head. The name *Lewes* is applied to the river from Selkirk to lake Lindemann, called the "Yukon" by Schwatka. Finally the river flowing from lake Ahklen is called the *Teslin*, that being the native name as determined by Schwatka and Dawson, with the generic portion dropped. Thus Schwatka ‡ gives "Tesel-hina" (more probably Tes-el-in-hina) and Dawson, "Teslin-too;" but "hina" and "too" are generic terms for river, so it is properly Teslin river. The name *Newberry*, applied to the river by Schwatka in 1883, has never come into general use, and the name *Hotalinqua*, which is commonly used by the miners, was, as Dawson has shown, transferred through misapprehension from another tributary of the Lewes.

The floodplain of Teslin river is something over a mile in width, between high bluffs of silt and gravel which will be more fully described under the head of glacial phenomena.

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*Notes on the Surface Geology of Alaska: Bull. Geol. Soc. Am., vol. 1, 1889, p. 107.

† Report on an Exploration in the Yukon district, N. W. Territory, and adjacent northern portion of British Columbia, in 1887: Ann. Rep. Geol. Surv. of Canada for 1887–88, vol. 3, pt. i, 1889, pp. 14B–18B.

‡ Report of a Military Reconnoissance in Alaska made in 1883, Washington, 1885, map (pt. i, sheet 4).

The current is from four to six miles per hour and, except for a few sluggish expansions near the lake, is quite uniform throughout. The water was exceptionally high in the spring of 1891, however, and this would tend to increase the uniformity and velocity of the current. There are no shoals or rapids which would prevent the passage of a river steamer from its mouth to the head of the lake.

The course of White river, except for a short distance near its mouth, has hitherto been entirely unknown. Some miners are said to have spent a winter at the first fork, about sixty miles from the Yukon, but beyond this they have failed to penetrate, probably because of the unpromising character of the stream, for it is difficult to conceive physical obstacles sufficiently formidable to turn back these hardy explorers.

The White River basin was entered by the writer fifty miles southwest of Selkirk. From the high land between the Nisling* and Donjek the main valley could be seen for a long distance north and south, with the river pursuing its extremely tortuous course among innumerable low islands and bars. At one point above the mouth of the Nisling the river passes through the point of a mountain spur by a narrow canyon, probably a case of superposed drainage due to the occupation of the valley by ice. Further northward it turns sharply toward the west and enters a deep narrow valley, in which, by native report, there are many dangerous rapids.

For the first seventy miles in the White River basin only clear tributaries were crossed. The largest of these, the Nisling, probably drains the greater part of the large area bounded on the east by the Tahkeena and Lewes, occupying very nearly the position which Dawson has assigned for the main White river, but receiving no part of its waters from the high Coast range. Evidently the greater part of the northward-flowing drainage of the St Elias mountains is carried off by other tributaries of the White river, which show ample evidence of glacial origin in their extreme turbidity. The Donjek is the largest eastern tribu-

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*In naming the tributaries of White river I have followed usage among the native Indians so far as possible. Some of the names required slight modification to render them pronounceable, and in most cases the generic part of the name has been dropped, as "too," meaning river, and "dek," creek. The names, however, are near enough to their indigenous forms to be recognized by the natives themselves.

tary, and receives the northward drainage from the greater part of the St Elias mountains east of the 141st meridian. There was some question as to which branch should be regarded as the main river and which the tributary, but the western is more nearly in the axis of the main valley and is probably also somewhat larger than the Donjek, although no satisfactory comparison could be made as the confluence was not seen. The western branch rises in Scolai pass from the northward-flowing lobe of Russell glacier. In the fifty miles of its course lying west of the international boundary it receives a number of tributaries from the south, all of which flow from glaciers. This part of the river is in unstable condition. It flows in many channels, constantly shifting its position upon a wide gravel plain which is being built up by contributions of coarse sediment from the overloaded stream.

Scolai* pass is a low gap cut through the range which extends northwestward to the Wrangell group. Russell glacier, from the southeast, flows into the pass against the steep western wall, which turns a part of the stream northward into White river basin and turns a smaller lobe toward the south, so that for about ten miles the pass is filled with ice at least several hundred feet in depth. The altitude of the divide, which is near the northern edge of the range, is 5,040 feet, or about 1,000 feet higher than the upper White River valley. The southern lobe of the glacier gives rise to the Nizzenah river, which flows at first westward through a deep canyon-like valley for fifteen miles, and then nearly southward about twenty miles, emerging into the valley between the two divergent mountain ranges already described. At the point where the river makes its sharp bend toward the south, a glacier coming into the valley from the northwest has dammed its waters so as to form a lake several miles in length. Pushed out of its old channel by the ice, the stream flows a short distance across a rocky point and then plunges into a tunnel in the ice from which it emerges half a mile below. After leaving the mountains it flows nearly westward for thirty miles, to its confluence with the Chittenah, and the latter stream continues in the same course about fifty miles further to Copper river. These eighty miles are in a rather broad, open valley,

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* "Scolai" is the name by which the Copper river chief, Nicolai, is known among all the Yukon natives.

though the floodplain is bordered by gravel bluffs about a mile apart and from 200 to 400 feet high.

The course of Copper river from the mouth of the Chittenah to the coast is nearly due south. The river has cut through the Coast range a valley which closely resembles that of the lower Taku. Its walls are high and rugged, and the stream meanders from side to side over a floodplain of coarse gravel.

Miles glacier, which is the largest of several ice streams tributary to Copper river along its lower course, has pushed across the valley, forming slack water several miles up the river. The glacier is now retreating, but its northern lateral moraine remains as a dam, over which the river tumbles in a series of rapids. The lake formed by this dam is almost entirely filled with gravel in its upper portion and with fine sand and mud below, so that the water is for the most part only a few inches in depth.

A short distance below Miles glacier is the head of the delta, which reaches thirty miles southward to the line of bars or keys at the edge of deep water. Excepting a few sand dunes, the delta consists of broad, level meadows and still more extensive mud flats exposed at low tide. Deposition is going on at a rapid rate over this considerable area, and it is interesting to note that subsidence also is taking place. There are no trees growing upon the delta now, but the remains of many large spruce trees were observed standing several feet below tide-water.

VEGETATION.

The vegetation of the Yukon basin presents a marked contrast to that of the coast, the luxuriance of which is too well known to require description. This contrast consists more in the amount of vegetation than in the difference of species. Cut off by high mountains from the abundant supplies of moisture which the coast enjoys, the interior supports a comparatively scanty growth, especially of arboreal vegetation, while some of the moisture-loving species of the coast are absent. Excepting surfaces covered by snow or ice throughout the year and the steepest rocky cliffs and screes, practically the whole Yukon basin, as well as the Alaskan coast strip, is covered by a more or less luxuriant growth of moss. Meadows of coarse grass were seen in a few of the interior valleys and some of the gravel terraces along Teslin and Lewes rivers are covered with sage brush, but these areas are wholly insignificant when compared with those which are covered with moss. The black alder, so abundant on the coast, is also very common in the interior, but in a dwarfed form, decreasing in size with increasing altitudes from ten or twelve feet in the valleys to a few inches on the higher parts of the plateau. The upper limit of the spruce forests is reached along the coast at an altitude of about 1,800 feet, but this limit, along with the snow line, gradually ascends toward the interior. The high valleys of the Taku tributaries have considerable spruce timber, although the trees are not close together and the largest are seldom over a foot in diameter. Taku pass, with an altitude of 5,100 feet, is approximately at the timber line and only a few stunted trees manage to exist there.

Ahklen valley is quite heavily timbered, and some trees eighteen inches in diameter, the largest seen anywhere in the interior, were among the drift from Nisutlin river.

In the White River basin only the valleys are wooded, the timber extending less than a thousand feet up their sides, while the greater part of the plateau surface is practically treeless. The timber line on the northern side of the St Elias mountains has an altitude of about 4,500 feet.

The Chittenah and Copper river valleys feel the influence of the coast climate, and their vegetation is consequently much more luxuriant than in the valleys of White River basin.

HARD GEOLOGY.

Character of the Observations.—Any attempt to solve the many difficult problems connected with the geology of the region traversed would necessitate detailed study of large areas. The opportunities afforded by a hasty reconnaissance along a single line of travel are obviously inadequate to the solution of these problems, particularly when the greater part of the geologist's energy is absorbed in overcoming the physical obstacles to his progress and in making even the crudest topographic map to which to refer his observations.

The most satisfactory information on the hard geology of any portion of this region is contained in Dawson's report, already cited, on the geology of the Yukon district. Dr Dawson had the great advantage of familiarity with similar rocks and geologic problems from previous study in British Columbia. He was also in a position to control the movements of his party, and so was able to give more than a passing glance to points of special importance. Since the writer was without previous acquaintance with the rocks of the Cordilleran system and had no opportunity for observation, except as it was afforded along the route or at stops selected without reference to the geology, the information obtained is offered only as supplementary to the observations made by others and as preliminary to the more thorough study of those who may hereafter visit the region.

Rocks of Taku Valley.—The section afforded by Taku river as it cuts through the Coast range is quite similar to those described by Dawson on Stikine river and Chilkoot pass. After leaving the argillites of the coast, which extend to near the head of Taku inlet, a broad belt of gray hornblende granite is crossed; this is called the Coast Range granite by Dawson. The belt is about forty miles in width, extending nearly to the South fork of the Taku. In addition to the granites, this belt also contains altered eruptive rocks in horizontal or undulating and sometimes highly contorted beds.

Rocks of the interior Plateau.—Forming the high plateau between the Coast range and Ahklen valley is a somewhat broader belt, containing a great variety of rocks, both eruptive and sedimentary but all highly altered. The sedimentary rocks consist of limestones and marbles, shales and slates with conglomerates, sandstones and quartzites. The least altered members of this series are along the western side of the belt. At the junction of the North and South forks of the Taku, near the eastern limit of the Coast Range granites, there are black slaty shales and, apparently overlying them with a dip of from 25° to 50° northeastward, are compact bluish limestones. Still farther eastward there are siliceous shales with large conglomeratic pebbles of the underlying limestone. The pebbles contain some obscure fossils, probably Carboniferous, which would indicate a Mesozoic or later age for the shales. These slightly altered rocks occupy a belt about eight miles wide, east of which lies a region traversed by many dikes that have converted probably similar shales and limestones into talcose slate and highly crystalline marble.

Among the non-sedimentary rocks of this plateau belt there are many basic eruptives largely altered to serpentine, and also considerable areas of granite. A portion at least of the granite is older than the sediments as indicated by basal conglomerates at the contacts. The basic eruptives are confined to a narrow strip less than a quarter of the width of the plateau belt and lying along its western side. The sequence of these rocks, as well as their relation to the Coast Range granite, is extremely involved, and much further study will be required in order fully to determine these relations. Their age is probably upper Paleozoic and Mesozoic, though very few fossils were found and none except in the less altered western portion of the belt.

East of Ahklen valley there is another belt of granite, quite distinct in character from that of the Coast range. It is free from hornblende and contains a large amount of pink feldspar, giving a decided red color to the rock in mass. The granite has in some places a well developed gneissoid structure, the cleavage being approximately parallel with the direction of the lake. Teslin river flows in a valley deeply filled with silt and gravel, so that not more than two or three rock exposures occur throughout its whole length; but so far as could be determined at a distance the escarpments on both sides of the valley are composed of rocks similar to those forming the plateau west of the lake. About thirty miles above the mouth of the river the hills toward the northeast are composed of bright red sandstones with yellow and gray shales, probably less altered and perhaps younger than any of the sandstones above described.

The extensive plateau region between the Yukon river and the northern base of the St Elias mountains is composed of various kinds of crystalline rocks with small areas of highly altered sediments. Gray hornblende granite similar to that forming the Coast range of southern Alaska occurs in a somewhat narrow belt just north of the St Elias mountains. The prevailing rock of the greater part of the region north of this belt is a reddish granite quite free from hornblende and frequently containing large porphyritic crystals of feldspar. Both kinds of granite are cut by numerous dikes or covered by sheets of eruptive rocks, from the most recent vesicular basaltic lavas to highly altered diabase. The red granites, at least, appear to be Archean, deposited upon which are small areas of sedimentary rocks that have been infolded with the granite and penetrated by the basic dikes and thus so completely changed from their original condition that no clue is afforded as to their age. They consist of arkose-conglomerates, slates and marbles. North of the Kluantu valley the only clastic rocks seen were a few exposures of conglomerate and schist. The district between the Donjek and Koidern rivers is composed almost entirely of white marble and talcose schist, and is the largest observed area of sedimentary rocks between the St Elias mountains and the Yukon.

Rocks of Scolai Pass.—As already described, two slightly divergent ranges, separated by the Chittenah valley, extend toward the west and northwest from mount St Elias. The geology of the northern range is simple. In the walls of Scolai pass, by which the range was crossed, its stratigraphy and structure are magnificently displayed. The rocks are comparatively recent, for the most part Carboniferous, Triassic, and Cretaceous. A bed of limestone about 500 feet thick contains many crinoids and corals, probably of Carboniferous age. Above it are red sandstone and jasper and a great thickness of black shale. Collections of fossils from the limestone and the black shale were made, but before reaching the coast they unfortunately were lost, with the exception of a single small piece of shale; this, however, contained several tolerably perfect impressions and was submitted to Professor Alpheus Hyatt for identification. He says: "The fossils in the shale are clearly the remains of a *Monotis* of a Triassic type, allied to *M. subcircularis*, Gabb, a characteristic Triassic form in California. This one seems to be distinct specifically, but is evidently of the same age."

Interbedded with these sedimentary rocks and penetrating them as dikes are fine-grained, greenish amygdaloid lavas forming perhaps half of the whole rock-mass. The structure of the range consists essentially of a broad, gentle synclinal, with a highly contorted belt on either side.

Excellent examples of typical fan structure were seen in the intensely plicated rocks which form the abrupt northern face of the range. This structure is remarkably well shown in the sides of the gorge from which Kletsan creek issues. The 500-foot stratum of white limestone above referred to is folded in with dark greenish-black eruptive rocks so as to form a double V; the overturned southern synclinal limbs dip southward about 30° and 45°, while the normal northern limbs are nearly horizontal.

This plicated belt on the northern side of the mountains is about six miles wide, and south of it the synclinal in which the beds are practically horizontal (coinciding with the axis of the range) occupies a belt from twenty-five to thirty miles in width.

On the southern side of the range there is a region of disturbed rocks similar to that on the north, but somewhat wider and less minutely plicated. The structure is well shown in the lower portion of the Nizzenah canyon, whose walls rise from 2,000 to 3,000 feet vertically above the river. One excellent example of faulting was observed. A bed of white limestone about 500 feet in thickness, probably a continuation of the one in which the fan structure was observed on the northern side of the range, has been broken across and thrust over upon itself a distance of half a mile. Within this space there appear to be two conformable beds of limestone in place of one. The diagramatic form in which the fault is displayed on the canyon wall confirms certain theories as to the mechanism of such faults derived from much more obscure phenomena in other regions. Evidently folding, due to lateral compression, had been only slightly developed when a shearing fracture took place across the rigid bed. The fracture did not extend far on either side of the limestone, but the thin-bedded black shales above and below are intensely plicated, having taken up the lateral compression by folding instead of faulting. Apparently the conditions which determined the formation of a fault rather than a series of folds in the limestone were, first, the great difference in rigidity between that bed and the adjacent shales and, second, the absence of a heavy load upon the beds during the compression.

Nizzenah river, for about seven miles above its confluence with the Chittenah, flows in a narrow canyon with rocky walls from 400 to 500 feet high. For a short distance above the canyon the gravel bluffs are replaced by cliffs of calcareous black shale apparently very recent and only slightly affected by the compression which has disturbed the rocks lying on the north. At the upper end of the canyon the black shale contains beds of extremely coarse conglomerate, and is succeeded by black slate and mica schist, the latter containing many small quartz veins. An east-and-west line through the upper part of this canyon appears to be the approximate limit of the little altered rocks forming the northern range.

Rocks of Copper River Valley.—Several massive dikes intersect the course of the Chittenah a few miles above its junction with the Copper, forming high cliffs, and a number of rocky islands in the river channel. The dikes are composed of a very compact greenish-black rock, traversed by many streaks of lighter green serpentine and white veins apparently of calcite. The rocks of the southern range which extends westward from St Elias differ widely from those exposed in Scolai pass. About Taral they consist for the most part of siliceous talcose schist with gray hornblende granite, which is apparently eruptive. Between Taral and the coast the prevailing rocks are bluish-gray quartzite or quartzite-schist. The moraines of glaciers along the lower course of Copper river flowing from the eastward are composed largely of eruptive granites and granitoid gneiss containing inclusions of black slate and schist. All the sedimentary rocks between the Chittenah and the coast have been so thoroughly metamorphosed that their original bedding is wholly obliterated, and no statement can yet be made as to their probable age.

Rocks of Prince William Sound.—Forming the shores about Prince William sound there is a series of black shales and thin-bedded dark-brown sandstones. They are highly contorted and somewhat altered, especially the shales. The strike, wherever any regularity can be detected, is about north-and-south, and the dips are generally steep, often vertical. They bear a strong resemblance to the rocks of the Yakutat series described by Russell,* and it is not improbable that they are the continution westward of that series. Fossil plants are reported to occur in these rocks at some points on Prince William sound, but none have yet been collected. While the series is perhaps all Mesozoic or younger, any statement as to its age made at the present time must be regarded as purely hypothetic.

MINERAL RESOURCES.

Gold.—Placer gold occurs widely disseminated throughout the Yukon basin, though only in a few places has it been found in sufficient quantity to make profitable working. The most important of these are bars along the Lewes between Teslin and Little Salmon rivers and on Forty-mile creek, a southern tributary of the Yukon emptying near the 141st meridian. Ten men were located on the bars of the Lewes, and, although the water

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* An Expedition to Mount St Elias, Alaska: Nat. Geog. Mag., vol. iii, 1891, p. 167.

was very high when we went down, they are said to have done well in the latter part of the season.

One member of our party, Mark Russell, was equipped with long experience in prospecting both for placer and vein gold, and while the necessity for getting through the country as rapidly as possible prevented anything like an exhaustive examination, still enough was done to give a fair idea of the resources of the region traversed. While in White River basin we also had the benefit of Mr Bowker's experience. A few "colors" were found on most of the branches of White river which we crossed, but it was all fine gold and afforded nothing which could be regarded as a good prospect. The indications of gold-bearing quartz were even less encouraging. Practically no vein quartz was seen between Selkirk and Scolai pass, either in place or among the stream gravels. Along the lower portion of the Nizzenah and thence southward to near the mouth of Copper river considerable quartz occurs in small stringers through the schist, so that there is a possibility of this region containing gold-bearing veins.

Copper.—Native copper has long been known to exist in the Copper River basin, but exactly where or in what quantity has never been ascertained through actual examination by a competent observer. Its occurrence in White River basin also has been suspected from the presence of native copper among the Yukon Indians, although they were known to trade with those living on Copper river from whom they might have obtained the metal. The Pelly Indians whom we secured at Selkirk for packers promised to show us the source from which in the past they had secured copper for making arrow-heads and more recently for making bullets, which are still used to some extent when lead cannot be obtained. While still at Selkirk they told us of great masses of copper as large as houses on a stream called the Klet-san-dek, or Copper creek, flowing into White river near its source. As we approached this locality, however, the masses of copper rapidly decreased in size, first to pieces as big as a man and then to bowlders of such size that they could be lifted by prying with a stout stick, and finally what they actually showed us consisted of small nuggets, the largest only a few ounces in weight.

Kletsan creek issues from a narrow gorge in the steep northern face of the St Elias mountains, flowing from numerous small glaciers a mile or two back from and several thousand feet above the valley of White river. At a former stage, probably when the glaciers descended to a much lower level, the stream deposited a broad alluvial cone about the mouth of the gorge. This deposit of gravel is now being cut away and in its lower portions or in crevices of the bed rock numerous small nuggets of native copper are found. This seemed to be the only locality for the metal known to the Indians who were with us, though pieces which had been cut from a larger mass were shown us by those whom we met on Kluantu river. It is not probable, however, that any of the Yukon basin Indians are acquainted with extensive deposits of native copper, since they have very little of the metal in their possession and hold a greatly exaggerated idea of its value. Some time was spent in searching for the source of the copper on Kletsan creek but without success as we soon reached the snow line, beyond which, of course, further search was impracticable. It appears to have been brought by glaciers from the region toward the south which is still covered by snow and ice. It is associated with greenish-black amygdaloid lava and red sandstone and jasper, rocks which resemble, superficially at least, those of the copper-bearing series of the lake Superior region.

A small quantity of what appeared to be azurite, pulverized and used as a pigment, was shown us by the Yukon Indians. They said it came from the country beyond Scolai pass, but we were unable to learn its exact source or how they obtained it.

According to Allen's account, the chief of the Copper river Indians told him of the existence of native copper and also of copper ores in the upper Chittenah valley between the two main streams, but he did not visit the locality. We expected to find Indians on the Nizzenah near the point where it emerges from the mountain pass and to be able to examine the copper of this region, but unfortunately Nicolai and his tribe were at their summer fishing station, Taral, and it was too late in the season to return to the copper region which we had passed.

Doubtless this interesting region on both sides of Scolai pass will be found on careful examination to contain considerable mineral wealth, but the extreme difficulty of access together with the unfavorable climatic conditions will greatly retard, if not wholly prevent, the development of its resources.

VOLCANIC PHENOMENA.

Active Volcanoes.

Volcanic activity in the United States within historical times has been confined wholly to Alaska, and, excepting somewhat mythical eruptions of mount Calder on Prince of Wales island in 1775, and of mount Edgecumbe in 1796 it has been confined to the southwestern extremity of the territory. The most easterly known crater which shows any activity at present is mount Wrangell. This was observed for several days during August, 1891, from Taral, at the confluence of Chittenah and Copper rivers. It lies about fifty-five miles nearly north of Taral, and only the top of the mountain, a sharp black cone, appears above the intervening broad snow-covered dome of mount Blackburn. From this cone masses of densely black vapor were constantly rising. At intervals of about half a minute a cloudy pillar would rear itself to a height of several thousand feet and, floating off toward the east, quickly disappear, to be replaced by another burst of vapor from the crater. No illumination of the vapor was noticed at night and, so far as I could learn from the chief Nicolai, no appearance of fire was ever seen. According to the diary of John Brenner,* a miner, who spent the winter of 1884-'85 at Taral, the volcano was at that time in a state of somewhat violent eruption. He says:

> "The volcano has been very quiet a good while, but today it is sending out a vast column of smoke and hurling immense stones hundreds of feet high in the air. The masses it is throwing up must be very large to be seen here. * * * It has made no loud reports, only a sort of rumbling noise."

It is possible that an active volcano may exist east of mount Wrangell in the upper White river basin, but our information as to its existence depends on the vague and unreliable statements of the Yukon natives—statements that may refer to mount Wrangell. Some sharp cones were seen northwest of lake Wellesley and also some in the St Elias mountains between Klutlan glacier and Scolai pass. Their volcanic origin, however, could only be inferred, and any present activity would

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*The Shores and Alps of Alaska, H. W. Seton Karr: London, 1887, p. 219.

have been concealed from us by the clouds which hung about their summits.

Recent volcanic Activity.

The most striking effect of recent volcanic activity in this region is the wide-spread deposit of volcanic ash, or tufa, which covers the southeastern portion of the Yukon basin. This deposit was first noted by Schwatka in his reconnaissance of 1883. It was more fully described as it occurs on the Pelly and Lewes by Dawson in his report of the Yukon expedition of 1886, and was noted by McConnell in 1887 and Russell in 1889 on the Yukon and Lewes.

It was first seen by our party on Teslin river shortly after leaving lake Ahklen, and from this point northward it forms a conspicuous and nearly continuous white band in cut banks of the river nearly down to Selkirk, at the confluence of the Lewes and Pelly. Where first seen the layer of tufa was less than an inch in thickness, and from this increased to a maximum of nearly a foot near the mouth of the Teslin, with some local accumulations of two or three feet. The alluvium which has accumulated upon the layer of tufa is generally about a foot in depth, but it occasionally varies from nothing to three or four feet. A foot, however, probably represents the normal accumulation of soil under the prevailing conditions since the deposit of the tufa.

The first point at which the tufa was noticed in the White River basin was about one hundred miles southwest of Selkirk, on the divide between the Nisling and Donjek, eastern tributaries of White river. It is altogether probable that the deposit was continuous over the whole of this country, but no localities favorable for its preservation and display were seen on the high land traversed. A layer much heavier than that appearing on the Lewes would in a short time be wholly lost on a surface almost entirely destitute of soil and composed of rock fragments of varying degrees of coarseness.

In the banks of the Kluantu and Donjek the tufa does not form a distinct layer as along the Lewes, but is probably represented by certain stratified beds of white sand, which were regarded at the time as lake deposits. They are indistinguishable from the sediments carried and deposited by the river at the present time, except in being somewhat coarser.

The original thickness west of the Donjek must have been at least several feet, and the increase is very marked toward the southwest. The white tufa is washed down from the steep slopes and forms considerable alluvial fans at the mouths of the ravines closely resembling the cones of snow which form in similar position. After passing the Koidern the narrow valleys were found deeply filled with tufa which had accumulated from the steep mountain slopes. From the divide the upper White River valley was seen stretching forty miles to the westward, and appeared almost completely covered with drifts of snow. On reaching the valley the drifts proved to be tufa, which forms a deep mantle over the country north of the St Elias mountains, and for twenty miles west of the Klutlan forms a desert of drifting snow-white sand into which one sinks from four to twelve inches in walking. A scanty growth of dwarf alder and blueberry bushes has gained a precarious foothold in some places, and a few stunted spruce trees grow in protected spots along the streams. The tufa extends up the mountain sides on the south, covering every surface where the slope is not too steep for it to lie and finally merging with the névé snow, which begins about 1,500 feet above the valley or 6,000 feet above sea level. The valley was covered with a sheet of glacial drift before the deposition of the tufa, and in consequence the drainage is very imperfect. Many small lakes and ponds, usually without outlet, occur scattered over the surface.

The greatest observed thickness to which the tufa deposit attains is between 75 and 100 feet. This was seen on the western bank of the Klutlan, where there is no reason to suppose that its original thickness has been increased at the expense of surrounding regions except, perhaps, by wind drift.

Toward the upper end of the valley the thickness of the deposit decreases very rapidly, and at the entrance to Scolai pass, less than forty miles from its maximum, it appears as a narrow white streak in the freshly cut river banks, exactly as it does along the Lewes and Pelly, 300 miles to the eastward. The deposit also appears to decrease in thickness rapidly toward the north, and there is no indication of any considerable accumulation on the gentle slopes of the valley or on the mesas north of White river.

The gradual increase in thickness of the deposit from east to west is accompanied by an increase in the size of the fragments.

As described by Dawson* from the Yukon, "It is a fine, white, sandy material * * * consisting chiefly of volcanic glass, * * * the greater portion of which has been drawn out into elongated shreds, frequently resembling the substance known as 'Pele's hair.'" Where first noticed between the Nisling and Kluantu it had the appearance of sand which results from the disintegration of a rather coarsely crystalline marble, the individual fragments being from 0.5 mm to 1 mm in diameter. The average dimensions increase to the westward, and in the Klutlan valley the deposit contains many fragments of white vesicular pumice from two to ten centimeters in diameter, though the greater part is much finer, perhaps from 1 mm to 5 mm in diameter. Nothing in the nature of true volcanic bombs was seen in the tufa, though their presence may have been overlooked.

Taking the approximate limits of the deposit, as observed on the Yukon by McConnell, on the Pelly and Lewes by Dawson, and on the Teslin and at Scolai pass by the writer, it will be seen to cover an oval area, with the maximum thickness near the western extremity. The oval area (which is depicted on plate 18) is about 370 miles from east to west and 220 from north to south, or about 52,280 square miles. Assuming the deposit to be in the form of a flat cone with the above base and a vertical height of but fifty feet, its volume amounts to 165 cubic miles of material.

From the facts of distribution, as above stated, a fairly safe inference may be drawn as to the source of the deposit. The explosive eruption which produced the tufa probably occurred in the northern part of the St Elias mountains, near the source of Klutlan glacier. As already stated, it was impossible to tell whether there is any present volcanic activity in this region. One conspicuous peak, of which the top remained hidden by clouds, was pointed out by the natives as having some unusual characteristics of which they seemed to stand much in awe. The name by which they called the mountain was Nat-azh-at, meaning, as near as I could make out, "shape of a man;" but, owing to native reticence and lack of an interpreter, it was impossible to obtain any satisfactory information concerning the mountain. Mount Wrangell has been suggested as the source of the tufa,

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*Report of an exploration in the Yukon district, N. W. T., and adjacent northern portions of British Columbia, 1887; Ann. Rep. Geol. Surv. Canada, Montreal, 1889, p. 46B.

but this is clearly impossible, as it lies wholly beyond the area covered by the deposit.

The strong winds prevailing in the upper White River valley during August, 1891, were from the west and were evidently in the same direction during the great eruption. It would be interesting to fix the date of the eruption, but it is impossible to do so with any degree of certainty. From a study of the relations of the tufa bed on the Pelly and Lewes Dr Dawson says: "While the eruption must have happened several hundred years ago, it can scarcely be supposed to have taken place more than a thousand years before the present time." A similar conclusion is reached from a study of the deposit in the White River basin. As already stated, for ten miles on either side of the maximum thickness the surface tufa is unconsolidated and supports only a very scanty vegetation; but the tundra moss covers with great readiness even the most barren surfaces, wholly independent of soil, so that it seems impossible this should have remained bare for any great length of time.

From its position near the greatest thickness of the deposit a vast quantity of the tufa must have fallen on the surface of the Klutlan glacier as well as on the névé fields at its source. The fact that this has nearly all been deposited in the terminal moraine and remains only on the surface of the stagnant ice a short distance back from its front indicates an interval since the eruption sufficiently long for ice which then formed the névé to flow the whole length of the glacier and deposit its burden in the terminal moraine. Neither the length of the glacier nor the rate of motion of its different parts is known, but the time required for the transfer of material on the névé fields to the terminal moraine must be at least several hundred years. The time since the eruption has also been sufficient to permit the recession of the glacier front about three miles.

The color of the waters of White river has been noted by all travelers on the Yukon who have passed its mouth. Schwatka* describes it as resembling "a river of liquid mud of almost white hue," and McConnell† says: "The turbid character of the White river is famous, and sufficient sediment is brought down to change the color of the whole Pelly-Yukon flood from a pale

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* Along Alaska's Great River: New York, 1885, p. 240.

† Report of an exploration in the Yukon and Mackenzie basins, N. W. T.: Ann. Report Geol. Surv. Canada, Montreal, 1891, p. 144D.

green to a milky white." This turbidity has been attributed to the glacial source of the river, but glaciers could scarcely supply such an enormous quantity of mud unless acting under peculiar conditions. The presence of this great deposit of unconsolidated material, which is being ground up by the ice and removed by the englacial streams, affords a ready explanation of the turbidity of the water. The highly vesicular character of the tufa permits a much larger amount of it to be held in suspension than of sediment derived from compact rocks.

Tertiary volcanic Activity.

Evidence of volcanic activity, geologically recent though very much more remote than the eruption of the tufa deposit, is somewhat abundant. Perhaps the most striking example of such activity is seen in the basaltic mesa at the junction of Pelly and Lewes rivers. This lava flow took place after the river valleys had been eroded perhaps below their present levels and extended entirely across the valley. The river has since cut through the barrier, leaving only a few fragments of the basalt resting on the granite on the western side of the channel. This lava flow probably came from two or more vents; one about ten miles north of Selkirk still retains the form of a symmetrical cone, and according to the native accounts has a small lake upon its summit, probably occupying the crater. A second vent was the high hill on the western side of the Yukon, about four miles northwest of Selkirk. Between the Yukon and St Elias mountains black vesicular lava was seen at a number of localities, and north of the upper part of White river are broad mesas which appear to be formed of black lava. These are all probably of Tertiary age.

GLACIAL PHENOMENA.

Existing Glaciers.

So far as known the existing glaciers of Alaska are confined to a narrow belt along the southwestern coast. Although the highest land lies in the coast belt, this is not the sole or chief reason for the notable absence of glaciers in the interior, except in so far as climatic conditions are thereby modified. There are numerous points in the Yukon basin from which practically all snow disappears in summer, although they have an altitude of from 6,000 to 7,000 feet and a mean temperature much lower than any portion of the southern coast. The explanation must be found in the very much greater precipitation and prevalence of clouds along the coast than in the interior.

The glaciers farthest removed from the coast are those flowing from the mountains of the Wrangell group, where the moisture-laden winds of the north Pacific are able to pass up the Copper River valley and across the coast range, which is here much lower than toward the east.

Four considerable glaciers descend to or nearly to tide level on Taku inlet and river, though only Taku glacier, entering the head of the inlet, discharges bergs. A few miles up from the mouth of the river are two glaciers which come down into the valley nearly opposite to each other. Neither quite reaches the river, but, like the Norris* glacier on the inlet, they spread out into fan-shaped expansions with low wooded deltas of moraine material in front. Along the steep sides of the river valley above these glaciers a slight but distinct terrace has been cut about 150 feet above the river. It is probable that Wright† glacier, pushing across the valley to its northern side, dammed the stream for a short time after the main valley was clear of ice. Above Wright glacier only a few small masses of ice or glacierets occur in the Taku basin in cirques about the higher mountain summits. No parts of the high interior plateau, either in the Taku or Yukon basins, carry glaciers, and probably very little, if any, snow remains throughout the year between the Coast and Cassiar ranges, though much of the surface is fully 3,000 feet above the snow line at the coast. The reason for this rapid rise of the snow line toward the interior is the dry climate, with short but hot summers prevailing throughout this region. In like manner the high plateau east of White river is wholly free from summer snow, and the first glaciers seen in the Yukon basin were those flowing northward from the St Elias range. Kluantu and Donjek rivers undoubtedly head in glaciers, but these were not seen, since they lay too far east of the route traveled. Three large glaciers flow into the White River basin west of the Alaskan boundary, and numerous streams crossed while following the southern bank of the upper White river

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* Named in 1886 for Dr Basil Norris, surgeon United States Navy.

† Named by the writer for Professor G. F. Wright of Oberlin college.

rise in small glaciers which do not descend to the level of the valley.

The largest glacier known to discharge wholly in the Yukon basin is one which lies approximately on the 141st meridian, called the Klutlan from the native name of the river to which it gives rise. Its source is in the great snow fields between mount St Elias and the high peak on the northern border of the range called Nat-azh-at by the natives. It extends several miles beyond the foot of the range, though it is rapidly receding at the present time, and is between four and five miles broad where it enters the valley. The stagnant ice at the front of the retreating glacier is buried under a great accumulation of moraine material continuous with the terminal moraine, so that it is impossible to determine the exact limits of the ice. The heavy mantle of vegetation which covers the terminal moraine continues a mile or more beyond the outer edge of the ice, becoming gradually less abundant as the active portion of the glacier is approached.

The moraine in front of the Klutlan is the largest accumulated by any of the interior glaciers. It is composed very largely of the white volcanic tufa already described, but with this are mingled many angular fragments of amygdaloid lavas and a few of granite and gneiss. Much of the moraine has been removed by streams flowing from the glacier, but remnants 200 feet or more in thickness extend nearly across to the high land north of the valley.

The second of the White river glaciers is about midway between the Klutlan and Scolai pass. It is much smaller than the Klutlan and does not push out into the valley, but its front forms a wall of ice something over a mile in length from side to side of the narrow valley in which it lies.

The third and largest of the interior glaciers flows from the high mountains northwest of St Elias down into Scolai pass, and from the divide sends a lobe of ice toward White river and a smaller one toward Copper River basin. This was named in honor of Mr I. C. Russell, whose exploration and study of the St Elias region during the past two years have added very largely to our knowledge of Alaskan glaciers and to the science of glaciology. The northern or White river lobe of Russell glacier is buried under a heavy accumulation of moraine, bearing some vegetation, while the southern lobe is almost wholly free from moraine material and the exposed ice has melted down to the smooth convex surface and feather edge characteristics of stagnant ice at the front of a retreating glacier.

Taken altogether, the ice flowing northward from the St Elias mountains is insignificant in amount when compared with that flowing southward. The Seward glacier alone probably contains a greater volume than all of those flowing into the White river basin combined. The great difference in climatic conditions, on which the formation of glaciers depend, is indicated by the difference in altitude of the lower limit of the névé snow on the north and south. According to Russell's observations about Yakutat bay and my own on Prince William sound. that limit on the seaward side of the mountains is at an altitude of about 2,000 feet, while on the north the altitude of the lowest névé observed was 6,300 feet. This rise in the snow line toward the north, over 4,000 feet in a distance of about eighty miles, is an important fact in the consideration of the causes of glaciation, either local or general.

The Nizzenah river rises from one lobe of Russell glacier and in the upper part of its course is fed by a number of glaciers coming in from the high mountains on either side of Scolai pass. One of these, the Frederika, possesses a peculiar interest in that it appears to be the only well marked case among Alaskan glaciers of active advance at the present time. Flowing southward in a lateral valley which joins that of the Nizzenah at right angles, its front is parallel with the river and about three-quarters of a mile distant, the intervening space being a smooth gravel plain. The glacier terminates in a nearly vertical ice cliff stretching across the lateral valley a mile in length and about 250 feet high. Its surface is free from moraine, but is extremely rough and broken, wholly unlike the surface of stagnant ice at the end of a retreating glacier. At the foot of the cliff there is a small accumulation of gravel and ice fragments, apparently being pushed along by the advancing mass.

Since the same climatic changes must affect all the glaciers of the region alike, the cause of this anomalous advance must be sought in some peculiar local condition affecting this glacier alone. A simple explanation is suggested, though it must be regarded merely as a suggestion since no means of verification are at hand. Ten miles to the westward of the Frederika another and much larger glacier flows into the valley of the Nizzenah. This is formed by the union of three separate streams, and of these the eastern appears to be retreating much more rapidly than either of the others; but this eastern branch probably has its source in the same basin as the Frederika glacier, and it seems not improbable that by some means the drainage of the basin has been diverted from the western to the eastern outlet, thus causing the rapid retreat in the former glacier and advance in the latter.

The large triple glacier above referred to flows from the high mountains forming the eastern members of the Wrangell group. After the union of its three branches the combined stream occupies the valley of the Nizzenah for about six miles, crowding the river out of its channel and forming a berg-filled lake above the ice barrier. Its great volume, together with the distance which this glacier pushes down into the valley, indicate an increased precipitation, due to proximity to the Copper River valley through which pass the warm winds from the ocean.

No glaciers flow into the Chittenah valley from the ranges on either side, though all the upper portions of the Wrangell group are snow-covered and doubtless the high ravines are filled with ice. Several large glaciers flow into the Copper River valley from the Coast range, although its altitude is not so great as that of many portions of the interior plateau, which is entirely free from summer snow. The largest of these Coast range tributaries of Copper river are Miles and Childs glaciers, named by Lieutenant Allen in 1885. Several others of considerable size higher up the river do not appear on Allen's map, probably because he passed up the river while the surface was still covered with snow. Miles glacier is quite comparable in size with those of the St Elias region and is formed under essentially the same climatic conditions. It is evidently retreating at present, and the river spreads out in a lake-like expansion along its front in a part of the glacial channel from which the ice has receded. This expansion of the river is about a mile in width and one side is formed by the glacier front, a cliff of ice 350 feet above the water and over five miles in length. Although the ice no longer reaches entirely across the valley, there remains a heavy lateral moraine, indicating its former position and damming back the river as already described. The fact that the river has cut only part way through the moraine indicates a very recent recession of the glacier.

Former Glaciation.

In common with other parts of the coast region, the Taku basin shows signs of intense glaciation from the westward-moving portion of the Cordilleran ice sheet. Evidence of this in the way of glacial deposits is wanting along the lower portion of the river, while the polished and striated rock surfaces so abundant there may be due to the action of a glacier occupying simply the river valley. The evidence of an ice sheet becomes more abundant, however, toward the upper part of the basin. Thus, on a spur of the high plateau east of the forks of Taku river, bowlder clay and stratified gravels were seen 3,100 feet above the river. The movement of the ice in the greater portion of the Taku basin was apparently in the same direction as the present drainage. The high broad valleys of the upper Taku branches are deeply filled with a mantle of bowlder clay and gravel. In most cases this is spread out in a comparatively even layer over the surface, but also many narrow ridges occur from ten to fifty feet in height, with the longer axes in the direction of the present valleys. These, however, probably mark a phase of deposition by a greatly diminished and waning ice sheet, so that they afford little if any indication of the direction of ice movement during the maximum glaciation. A much better indication is afforded by the transportation of bowlders. From the head of canoe navigation on the Taku to a point nearly half way across to Ahklen valley, increasing numbers of bowlders were observed composed of a peculiar granite containing large porphyritic crystals of black hornblende. At this point their source was found in a range of hills composed of the same granite, and no bowlders of this rock were seen to the northeastward. At the summit of the divide but little evidence was seen which would indicate the direction of the ice movement, though it seems probable that it was toward the northwest, as it certainly was in Ahklen valley.

Some deposits of true bowlder clay occur at various points along the lake, and a single occurrence was noted on the Teslin river about five miles from its mouth. Among the many lakes in the upper part of the valley are ridges and mounds of rounded bowlders and gravel, which, with terraces of the same material about the head of Ahklen, were evidently deposited by a rapidly retreating glacier and the streams to which it gave rise. These gravels are younger than the bowlder clay which they overlie and also younger than the silt of the river bluffs toward the north.

Among the most interesting deposits associated with the second period of glaciation in the northwest are those forming the river bluffs along the Teslin and other tributaries of the Yukon. Bluffs are continuous throughout the whole length of the Teslin river, increasing slightly in height from about 100 feet at the lake to 150 feet at the mouth, and frequently cut into a number of terraces. The materials of which they consist are light colored silts or fine sand interbedded with layers, one to three inches in thickness, of tough bluish clay. The layers of sand are often cross-bedded and contain sufficient clay to give the material considerable tenacity. At some places intermediate beds are highly contorted, while those above and below are undisturbed. Although the deposit differs widely from the true bowlder clay which it was seen to overlie, yet it contains occasional large angular bowlders, evidently brought to their present position by floating ice. The bluffs are usually capped by a bed of coarse gravel, ten feet or more in thickness, but sharply separated from the underlying silt formation. More rarely, layers of coarse sand and gravel a few feet thick occur, interbedded with the silt, usually toward the top.

This deposit undoubtedly belongs to the wide-spread "white silt" formation which Dr Dawson has described as occurring at many localities in British Columbia and the upper Yukon basin. He regards the white silt as a deposit laid down in estuaries by waters containing glacial mud supplied by streams from the retreating or stationary ice front. The altitude of Ahklen is 2,500 feet, and hence the upper limit of the silt in the bluffs at the lower end of the lake is about 2,600 feet. The upper limit of the white silt, as observed by Dawson at various points in British Columbia and the Yukon basin, is between 2,400 and 2,700 feet, indicating a subsidence to that extent for a considerable period toward the close of the second epoch of glaciation. During this period of subsidence the present lake basin was doubtless occupied by a lobe of the retreating glacier which prevented the silting up of the portion of the valley so occupied. On its withdrawal at the close of the stationary period, the lake was left much as it appears at present, only somewhat larger, its waters being held by the dam of silt which had been laid down in front of the ice.

Having in mind the conclusions of Dawson, McConnell and Russell as to the northern limit of glaciation in the Yukon basin, evidence on that point was carefully sought in the plateau region southwest of Selkirk. For the first one hundred and twenty-five miles the evidence was wholly negative. No sign of glaciation was seen, and this too in a country well calculated to retain the marks of ice action. The stream gravels consist of a very small number of rock species, and on following a stream to its head the source of each was usually found, showing that no foreign material had been brought into their basins. While in general the surface contours are smooth and flowing, this is the result of long-continued subaërial rock disintegration, and generally the surface rock is deeply buried beneath great accumulations of fragmental débris, though occasional sharp pinnacles and towers of rock project from the smooth talus slopes. Had this region been subjected to the action of an ice sheet during the glacial epoch, not only would the greater part of the rock débris have been removed but the projecting pinnacles would have been planed down to rounded knobs which would still retain polished and striated surfaces.

Where Nisling river was crossed its broad valley is filled with a deposit of coarse gravel and bowlders, and from their great quantity and variety it was inferred that the stream had its source in a drift-covered region. The first undoubted evidence of ice, however, was found on the divide between Nisling and Kluantu rivers, where the northern edge of a sheet of bowlder clay was passed. From this point southward the character of the surface suffers a marked change. It is no longer composed of the fragments of one or two kinds of rock occurring in place near at hand, but rather of many varieties confusedly mingled with clay and sand. The drainage system is imperfectly adjusted to the topographic surface, so that wide valleys carry small streams, and large streams like the Kluantu and Donjek flow, for considerable distances at least, through narrow valleys.

The ice which has left its records in this sheet of bowlder clay was probably a confluent glacier formed by streams coming from the south through narrow valleys now occupied by Kluantu and Donjek rivers. These valleys do not appear to have been glaciated high up their sides, and it is probable that those detached southern portions of the interior plateau already described were not wholly covered by ice, even when the Cordilleran glacier had its greatest extension. The absence of a terminal moraine along the northern limit of the glaciated area would indicate that the Kluantu valley was filled by ice from comparatively small streams bearing little moraine material.

Southward from the Kluantu valley, records of former ice action continued to the coast, but the glaciation was by no means so intense as one might be inclined to expect from the high latitude of the region and the great altitude of the neighboring mountains. The marks of this former general glaciation have been removed from many of the river valleys, or at least greatly obscured by more recent glaciers which have but lately withdrawn from the valleys.

It seems probable that at the period of maximum glaciation the relative amounts of precipitation on the northern and southern sides of the St Elias mountains were much the same as at present, and then as now by far the greater ice drainage was toward the south. Some measure of the relative volume of the ice streams flowing in the two directions may be obtained from the relative amounts of moraine material which they have left. On the north, as already stated, there is no terminal moraine—only a comparatively thin sheet of bowlder clay. South of the mountains, on the other hand, a deposit of morainal material at least several thousand feet in thickness was accumulated on the sea bottom in front of the glacier and is now shown, according to Russell, in the recent uplift forming the Chaix hills.

Connecting upon the map the points which have been determined by various observers as the northern limit of the glaciated area in the Yukon basin, the position of the Cordilleran ice sheet at the period of its greatest extension is approximately outlined. Striated rock surfaces were observed by Dawson on the Pelly down to the point at which it crosses the 136th meridian and on the Lewes as far north as 61° 40′. Although he does not regard these as strictly limiting points, still, in the light of facts observed on the plateau southwest of the Pelly-Lewes confluence, the former at least may safely be regarded as such. McConnell and Russell considered the limit of glaciation on the Lewes to be near the mouth of Little Salmon river, and my own observations led me to think it is at least as far north as that. The point to which glaciation extends in the White river basin has already been indicated, with the evidence on which the conclusion is based. The extension of the line west of White river is less satisfactorily fixed than its eastern portion, depending on a statement of Lieutenant Allen that he saw no drift north of the Alaskan mountains, as he called the Tananah-Copper river divide. The ice sheet, a part of whose northern limit is thus approximately outlined, had its principal center of dispersion in the high plateau of British Columbia, between the Coast and Rocky mountains. From this center two subordinate lines of dispersion diverged toward the north and northwest, following the axes respectively of the Rocky mountains and the St Elias range, while the non-glaciated area formed a deep embayment in the Yukon basin between these divergent lines. The northern limit of glaciation is shown approximately on plate 18.

It is probable, however, that many lobes from the main glacier extended down the valleys beyond the limit above indicated, while the confluent ice sheet was not sufficiently thick toward its northern border to override the greater inequalities of the surface. Thus the White River valley, at least, must have been occupied by ice well north of the general glacier front even after a considerable amount of recession had taken place. The altitude of the valley at the mouth of the Nisling is about 2,400 feet; so that it must have formed an estuary during the period of subsidence marked by the white silt deposits, and the formation of lake Wellesley is probably analogous to that of lake Ahklen.

APPENDIX.

CRYPTOGAMS COLLECTED BY DR C. WILLARD HAYES IN ALASKA, 1891.

BY CLARA E. CUMMINGS.

LYCOPODIACEÆ.

Lycopodium complanatum, L. Taku, June. A small form without fruit.

MOSSES.

Sphagnum acutifolium, Ehrh. Prince William sound, September.

Sphagnum acutifolium, Ehrh., var. *purpurem*, Schimp. Taku, June. A stunted form.

Dicranum fuscescens, Turn. Prince William sound, September. On decayed wood.

Dicranum scoparium, Hedw. Prince William sound, September.

Dicranum majus?, Turn. Prince William sound, September. Sterile.

Tetraphis pellucida, Hedw. Prince William sound, September. Male plants, on wood.

Mnium punctatum, Hedw. Prince William sound, September. Sterile.

Aulacomnium palustre, Schwaegr. Taku, June.

Polytrichum commune, L. Prince William sound.

Polytrichum juniperinum, Willd. Taku, June. Male plant.

Hypnum (*Plagiothecium*) *undulatum*, L. Prince William sound, September. Sterile.

Hypnum circinale, Hook. Prince William sound. Sterile.

Hypnum (*Pleurozium*) *splendens*, Hedw. Prince William sound. Sterile.

Hypnum (*Hylocomium*) *loreum*, L. Prince William sound. Sterile.

HEPATICÆ.

Frullania (probably a new species). Prince William sound, September.

Bassania deflexa, Br. Gr. Prince William sound, September.

Lepidiosa reptans, L. Dum. Prince William sound, September.

Scapania albescens, Stephani. Prince William sound, September. A species not before contained in any American collection.

Mylia taylori, S. F. Gray. Prince William sound, September.

LICHENS.

Cetraria artica, Hook. Taku, June. Represented by young and mature conditions.

Cetraria islandica, (L.) Ach. Taku, June. Sterile.

Cetraria cucullata, (Bell) Ach. Taku, June. Sterile.

Cetraria nivalis, (L.) Ach. Taku, June. Sterile; represented by a slender, light colored form.

Cetraria lacunosa, Ach. Prince William sound, September. Sterile.

Cetraria glauca, (L.) Ach. Prince William sound, September. Sterile.

Cetraria glauca, (L.) Ach., b *stenophylla*, Tuck. Prince William sound, September. Sterile.

Alectoria ochroleuca, (Ehrh.) Nyl., a *rigida*. Taku, June. Sterile.

Alectoria ochroleuca, (Ehrh.) Nyl., c *sarmentosa*, Nyl. Prince William sound, September. Sterile.

Nephroma articum, (L.) Fr. Taku, June. Sterile; growing on *Dicranum*.

Peltigera aphthosa, (L.) Hoffm. Taku, June. Sterile.

Peltigera horizontalis, (L.) Hoffm. Prince William sound, September.

Peltigera canina? (L.) Hoffm. Taku, June.

Lecanora frustulosa? (Dicks.). Taku, June. Mass.

Cladonia alcicornis, (Lightf.) Floerk. Taku, June.

Cladonia fimbriata, (L.) Fr. Prince William sound, September. Sterile.

Cladonia fimbriata, (L.) Fr., b *tubæformis*, Fr. Prince William sound, September.

Cladonia cornucopioides, (L.) Fr. Takn, June.

Cladonia bellidiflora, (Ach.) Schaer. Prince William sound, September.

Cladonia deformis, (L.) Hoffm. Taku, June. Sterile.

Thamnolia vermicularis, (Sw.) Schaer. Taku, June. Sterile.

Bæomyces æruginosus, Scop. D. C. Prince William sound, September. On wood.

Buellia parasema, (Ach.) Th. Fr. Prince William sound, September. On dead wood.

Sphearophorus globiferus, (L.) D. C. Prince William sound, September. On earth.

In examining the geographic distribution of the species represented in this list it is interesting to note that the only *Lycopodium* is a common and widely distributed species.

Of the mosses, three are from the upper Taku basin, a locality inside the Coast range, while eleven are from Prince William sound, on the coast. Four of the fourteen species are confined to the western coast. These were all found at Prince William sound. Only one species is alpine or subalpine.

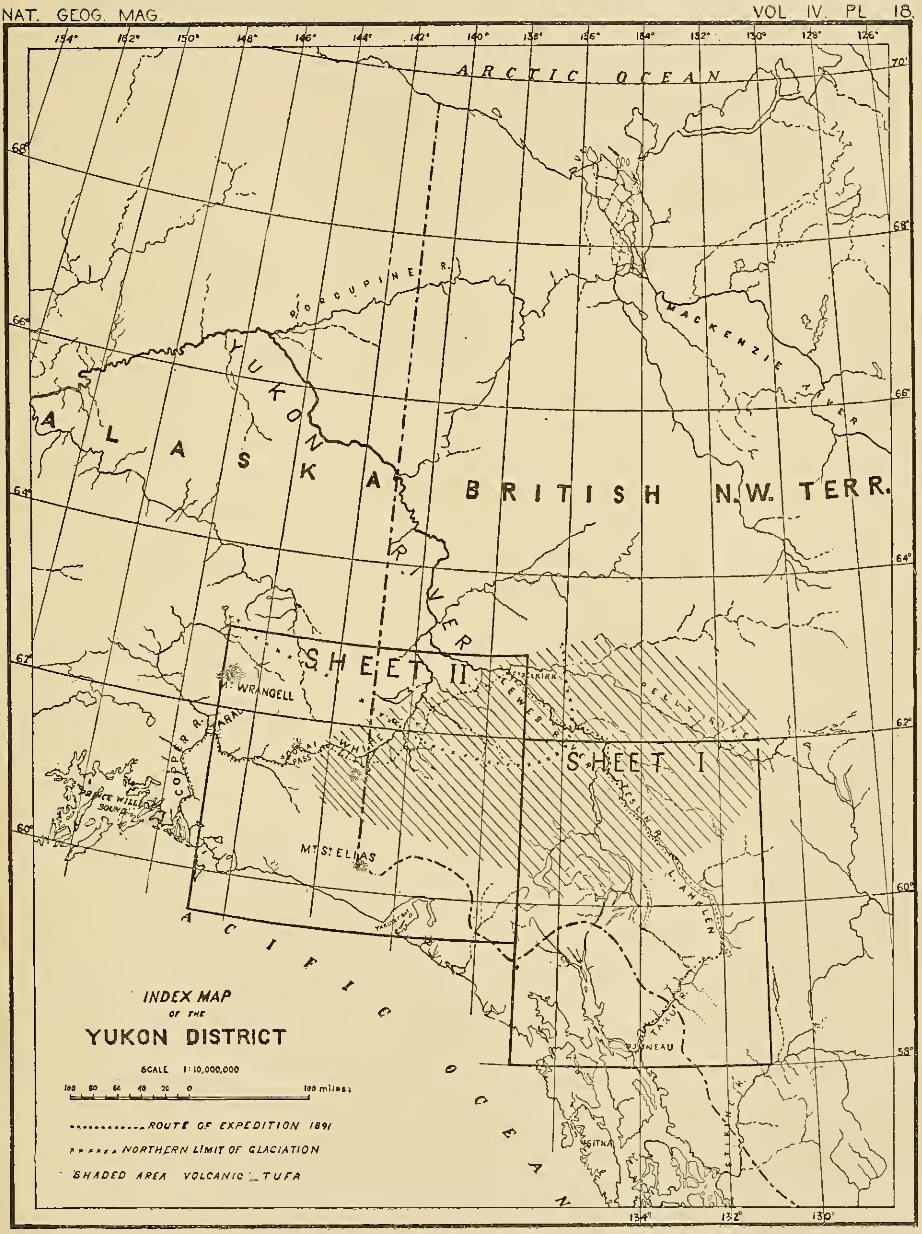
Of the *Hepaticæ*, one has not before been reported from this country, while one is probably an undescribed species.

Eleven lichens are arctic or alpine, while several others reach their best development in mountainous regions. Of the arctic and alpine forms, seven are from Taku and four from Prince William sound. The total number of species from Taku is twelve, while eleven were obtained at Prince William sound. It is thus seen that the percentage of arctic and alpine forms from Taku is considerably the larger. Only one of the lichens is confined to the western coast.

It is greatly to be regretted that all the valuable collections which Dr Hayes made in the interior had to be abandoned because of lack of means of transportation.

In the determination of these plants I have been indebted for aid to Professor L. M. Underwood, who examined some of the *Hepaticæ*, and to Professor A. B. Seymour, who compared several of the lichens with the collections in the Tuckerman herbarium.

Wellesley College, *April* 21, 1892.


INDEX MAP
OF THE
YUKON DISTRICT
SCALE 1:10,000,000
100 80 60 40 20 0 100 miles
ROUTE OF EXPEDITION 1891
NORTHERN LIMIT OF GLACIATION
SHADED AREA VOLCANIC TUFA
ARCTIC OCEAN
PACIFIC OCEAN
ALASKA
BRITISH N.W. TERR.
YUKON RIVER
PORCUPINE R.
MACKENZIE RIVER
SHEET I
SHEET II
MT. WRANGELL
MT. ST. ELIAS
COPPER R.
PRINCE WILLIAM SOUND
WHITE R.
PELLY R.
LEWES R.
SELKIRK
TESLIN R.
L. AHKLEN
TAKU R.
JUNEAU
SITKA
STIKINE R.
YAKUTAT BAY
SCOLAI PASS
154° 152° 150° 148° 146° 144° 142° 140° 138° 136° 134° 132° 130° 128° 126°
70° 68° 66° 64° 62° 60° 58°
134° 132° 130°

YUKON DISTRICT—SHEET 1.

ESCARPMENT
Lake Ruth
TAKU RIVER
South Fork
Tahltan River
Taku Gl.
Norris Gl.
Wright Gl.
Juneau
TAKU INLET
Chilkoot Pass
Chilkat River
Muir Glacier
Lynn Canal
GLACIER BAY
ICY STRAIT
Cape Spencer
CROSS SOUND
59°
58°
137°
136°
135°
134°
133°
132°
131°
SCALE 1:1,900,000.
0
10
20
30
40
50 miles.
JULIUS BIEN & CO. PHOTO LITH N.Y.

YUKON DISTRICT—SHEET 1.

JULIUS BIEN & CO. PHOTO LITH. N.Y.

YUKON DIST


63°
145°
144°
143°
142°
62°
61°
60°
59°
Copper River
Northern Limit
Tananah River
Mt. Wrangell
CHITTYNAH RIVER
NIZZENAH RIVER
GLACIER
Mt. NATAZHAT
MALASPI
PACIFIC OCEAN
SCALE
0
10
20

T—SHEET 2.

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YUKON DISTRICT—SHEET 2.

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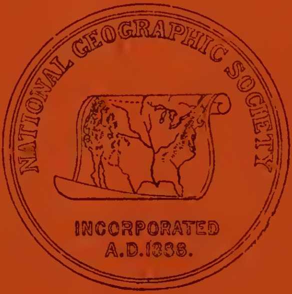

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THE NORTH AMERICAN DESERTS

BY

HERR PROFESSOR DR JOHANNES WALTHER

(*Separate from Verhandl. d. Gesellsch. f. Erdkunde zu Berlin; 1892, Heft 1. Translated by Robert Stein*)

Four years ago I had the honor to report to you on the observations which I made with Professor Schweinfurth in the Egyptian deserts. Since that time I have been again in Egypt, have touched the desert of northern India, and have been much occupied with the literature of deserts; and last autumn I seized the opportunity offered by the fifth International Geologic Congress at Washington to look at the American deserts.

The great geologic excursion through North America, under the professional guidance of our American colleagues, passed for some days through deserts and gave me opportunity for several side trips into neighboring deserts; afterward, in company with Dr von dem Borne, I spent two weeks in traveling through the deserts of Arizona, California and Texas, and met with a hospitable reception in the tent camp of Professor Streeruwitz, of the geological survey of Texas. Through his kind leadership I was enabled in a few days to visit the most interesting points in western Texas, in the Sierra de los Dolores, and in the Sierra del Diablo.

Our first acquaintance with a desert-like region was made in the "Bad Lands" of Dakota. When we awoke on the morning of September 5 our train was on the prairie. A gently undulating plain allowed our eyes to roam to the distant horizon. The gray moraine soil was covered with a dense nap of grass, now sulphur-yellow, now rust-brown. Over it extended, gossamer-like, a silvery gray veil, formed of countless delicate ears of grass. Wherever a depression gave rise to an accumulation of water there appeared a dark-green swamp carpet, overgrown with reeds and rushes, and where the dry prairie grass had been lit by sparks there were seen black bare spots with jagged fire-eaten edges and studded with small, blackened drift bowlders. Inquisitive prairie-dogs sat upright on their hills, a few butterflies were on the wing, one small bird soared in the clear air; on all the wide plain there was nothing else to strike the eye.

In the afternoon there emerged on the horizon sharply outlined table mountains, and at Kurtz station we found ourselves in a landscape full of "Zeugenberge" and mesas. The Americans call the "Zeugenberge" very appropriately "sentinel buttes;" and for the blind-pouchlike wadi valleys penetrating into the table mountains the cowboys use the expression "rimrock." The rimrock valleys are of great value to the cowboys, because they can drive their great herds into them without danger of losing a single head; for the steep slopes from the gateway to the innermost recesses of these valleys prevent all possibility of escape. Quite similar "sentinel" landscapes were seen by us again in Utah, Colorado and Arizona.

At Ogden, a Mormon town at the northeastern end of Great Salt lake, I left the train in company with Professor Krassnoff of Kharkof. We traversed the tree-lined streets of the pleasant little town and ascended the slope of the Wasatch mountains. Fields of *Helianthus* covered the plain, low oak brush grew along the granite mountains, and scattered opuntias and artemisias proclaimed the dryness of the climate. Finally we reached a gravel terrace 100 paces broad, which could be traced as a horizontal band along all the mountain slopes, 120 meters above the bottom of the valley; this was accompanied by similar parallel lines which might be observed along the rocks to a height of 300 meters.

A superb picture here offered itself to our gaze. At our feet, surrounded by fertile fields and orchards, lay the town of Ogden. An ingenious system of canals irrigated the land and caused a verdant oasis to rise in the midst of the salt steppe. Next we surveyed the bright blue mirror of the saline lake, from which jagged islands emerged in picturesque beauty; toward the west there followed a white lustrous plain bounded on the far horizon by violet mountain silhouettes.

At present the lake has an average depth of 4 meters; but there was a time when the wide valley basin, 4,500 square kilometers in extent, was covered by a lake 300 meters deep. At that period the breakers cut a terrace in the rocks of the lake shore, and while the lake water evaporated and its level gradually sank, there were formed the various shorelines which now may be traced as horizontal bands in parallel course along all the mountain slopes. Great Salt lake is the last scanty remnant of old "Lake Bonneville," and the salt desert is a dried lake bottom.

In yellow radiance the sun's disk sank behind the mountain crags when on the Southern Pacific railway we traversed part of the salt desert; the night fell quickly, and soon the desert gleamed in the moonshine like glistening hoar-frost.

When we set out next morning from the lonely station of Terrace on a ramble over the desert our expectations were raised to the highest pitch. Krassnoff recalled his travels in Turkestan; I remembered the Arabian desert; and we looked around anxiously, scanning with care each pebble, each sandhill, each sage bush and each rock, in order to compare them with our experiences in Africa and Asia. While Krassnoff quickly felt at home and everywhere discovered resemblances to the steppes of inner Asia, I marveled to see a desert picture unwonted and strange to me. Wherever my eye might stray, it rested on the yellow bloom of *Halophyta*, the silver-grey bushes of *Artemisia*, and spiny cactuses. Among creeping opuntias I saw a few small moss cushions, and at the foot of the granite hills grew juniper trees two meters high with stems a foot in thickness. We walked in short serpentine windings among bushes a foot in height; some scattered spots were covered with brown pebbles; small sandy water-courses wound, with many a loop, to end on the dazzling white salt plain. As we approached that plain the scrub became scantier, rising island-like from the flat surface, and finally there lay before us the floor-like horizontal plain of saline clay, entirely devoid of plants. The salt formed a coat of fine powder over the gray clay, and the small crystals glistened and sparkled in the sun like fresh-fallen snow. The ground was honeycombed with polygonal heat cracks, and reflected a glare so intense and dazzling that one could look about only with half-shut eyes.

Krassnoff told me that this landscape agreed in many points with the deserts and takyrs of inner Asia, but I found myself face to face with an entirely new type of desert. I was wont, after several hours' ride over gravel-covered serir or brown hamada, to come to a wadi distinguishable, even from afar, from its plantless surroundings as a green band; I had often been engaged with my bedouin for an hour in gathering dry scrub in order to have the fuel necessary for the fire. Here in the American desert there were plants in abundance, and only the increasing salinity of the soil checked vegetation. Apart from the salt-covered lowlands, I received everywhere the impression of an Egyptian wadi vegetation. Bush stood beside bush, and between them was plantless soil; but on looking over the region from an elevated point, everything seemed sprinkled with blooming green bushes. Now this phyto-geographic habit, or, if I may so term it, the "wadi character" of the whole desert, is not confined to Salt Lake desert, but a similar abundance of plants was found by me in the Mohave desert, the Gila desert, and the deserts of western Texas.

It may often have called forth a smile on the part of my companions to hear me complain again and again of the many plants in the North American deserts; but I cannot sufficiently emphasize the difference as compared with northern Africa. The salt-covered tracts on the shore of Great Salt lake, the bottom of the ancient lake Bonneville, are indeed absolutely plantless, and in this respect delight the heart of the desert traveler; but it must be remembered that in this case it is merely the increasing salinity of the soil that kills vegetation. And when we recall that we here tread on the bottom of a drainless, desiccated diluvial lake, the theory of a Saharan sea, which in the case of northern Africa may well be assumed to have been definitively refuted, might seem to find complete confirmation in Great Salt lake of Utah. There we have a desert whose poverty in vegetation is an effect of evaporated salt water.

I supposed at first that this great wealth of plants in the desert of Utah and Colorado is a consequence of the great topographic altitude, for these deserts have an altitude of more than 1,500 meters. The plateau of the southern Galala in the Arabian desert in fact is also much richer in plants than the lowlands of the wadi Arabah. But in the low-lying deserts of southern California I soon convinced myself that this conjecture was incorrect. The depression of the Coahuila desert, 260 feet below tide, was unfortunately traversed by me at night, from Indio to Tortuga; but the picture of the landscape which presented itself early next morning at Aztec was almost as rich in vegetation as the Vanhorne desert in western Texas, although Aztec lies at an altitude of 500 feet, Vanhorne at 4,500 feet. It is apparent from this that topographic altitude is not the cause of the wealth of vegetation in American deserts. It seems, on the contrary, either that the average precipitation in American deserts is greater, or that American desert plants are better adapted to dry air. According to Mr Marcus E. Jones of Salt Lake city, that place has an annual rainfall of about 15–16 inches; Salt Lake desert about 6–10 inches.

The conductor of the Southern Pacific railway, who has traveled through Gila desert daily for many years, told me that there is a rainy season in that desert in July and August. The desert sky, at other times so clear, is then clouded; there are occasional thunder-storms in the afternoon; and irregular rain showers fall, their area being so limited that at times the strip receiving rain is only 5 kilometers broad, though the water there covers the ground to a depth of a foot. For the deserts of Texas, according to von Streeruwitz, a mean annual amount of rain cannot be given at all; for in some cases it does not rain for two years, and again there is a rainfall of two inches in two hours.

The plants of the American deserts attain no inconsiderable dimensions. In southern Arizona we rode for three hours through a desert in which columnar cactuses half a meter in diameter and 7 meters in height were to be seen by the thousand. Never have I witnessed so curious a sight as these huge specimens of *Cereus giganteus* in such multitudes. The salsulaceas and artemisias form bushes a meter in height, and their branches are of an arm's thickness; and, while in the Arabian desert one finds but slight protection against the sun's rays under acacias and tamarisks, in Utah the upper slopes bear shade-giving juniper trees.

While there exist thus in the conditions of vegetation wide differences, on the other hand there are a series of important and characteristic desert phenomena in North America and Africa that present surprising resemblances. In the beginning of October I rode from The Needles through the Mohave desert. On both sides of the railway extended an almost horizontal plain, gently rising toward the granitic and volcanic mountains. So far as the eye could reach, I saw everything covered with scattered desert shrubbery, sprinkling even the slopes of distant mountains in the form of small green points. All mountains, mostly volcanic rocks, dikes and ash-cones, rose island-like from level desert land. The horizontal plain and the steep mountain slopes were not linked together by a débris-covered foothill, but plain and mountain slope intersected without any transition. It is surprising to see steep mountainous islands rise from a sea of débris, and yet this phenomenon is characteristic of all deserts that I have seen in Africa, India and North America. Just as the granite mountains of Sinai or of the Gharib rise island-like from the débris plain in imposing dimensions, and as the plains rise toward the base of the mountains so slowly as hardly to be perceptible until the craggy granite colossus rears its head like our own mountains of massive dolomite, so in the Sierra del Diablo do the plateaus of the Carboniferous limestone rise steeply from a boundless plain, of whose accumulated débris masses one may form an idea on learning that near Torbert at the foot of the Sierra Vanhorne a well was dug 1,050 feet deep in débris. The phenomenon becomes especially striking, because it is noticed that there are no débris deltas at the mouths of valleys 1,000 feet deep; there, too, the horizontal plain is seen to abut directly against the steep slopes of the mountains.

If we conceive each landscape picture as the result of definite processes of denudation, the relation of such a desert plain to its rocky cliffs will at once indicate that denudation in the deserts acts differently from what it does in Europe. But this horizontality of the surfaces of denudation has a further claim on our interest from another point of view.

In the geologic exposures that exhibit to us sections through parts of the earth's crust it is found very frequently that the rock is parted by horizontal planes into layers lying above each other. This structure is called stratification. Now that which in the cross-section of a block of strata appears as a horizontal plane is merely the expression of the fact that at a certain time in the formation of that body of strata the freshly formed sedimentary surface had the character of a widely extended and approximately horizontal plain. If we now look around on the earth's present surface for regions in which the freshly formed deposits with horizontal planes are being formed, we find them, in the first place, at the bottoms of seas and large inland lakes. In them are formed deposits with horizontal surfaces—that is to say, stratified deposits.

Now, it is very important to note that besides the sea bottom there exists another class of regions of the earth's surface on which the products of denudation are spread with great regularity over wide horizontal areas. These are the deserts and steppes. Both therefore are areas which must not be left out of view in the discussion of the origin of stratified deposits. Stratification does not all originate under water.

The activity of denudation is a double one. It destroys the rocks of the earth's surface and transports the comminuted material from its place of origin. In our regions it is water that destroys the rocks; it dissolves them chemically and frost fissuring comminutes them mechnically. Water is also in our latitudes the most important transporting agency. In the desert it rains but seldom. The time in which water may there destroy rocks and transport débris is at most 65 days in the year. It has been thought that during the remaining 300 days denudation in the desert is at a standstill; yet careful, unbiased study teaches that in these 300 dry days denudation is intense. A burning sun beats down on the rock surface, unprotected by any plant cover. In Texas daily variations in temperature of 40° C. are not at all rare; and large and small stones are cracked by the heat. Often have I picked up the halves of such cracked pebbles still fitting together. In Texas I saw granite blocks as high as houses divided by wide cracks, and Mr von Streeruwitz told me that he had seen and heard the cracking of such blocks. The variously colored constituents of the granite become heated to different degrees and fall apart in the form of coarse gravel. In a valley of the Sierra de los Dolores a rainfall had filled the rocky bottom of the valley with granite gravel to a depth of 3 feet; this gravel had been formed by insolation on the granite rocks in the course of years. Deep caves weather out of the granite wherever the water remains longer, and these increase the mass of the products of denudation.

Thus rocks are destroyed by dry heat at a time when denudation by water sinks to a minimum. On the 300 dry days of the year the process of rock destruction continues uninterruptedly. On rainy days, of course, the loosened rock material is carried off by running water. That such a desert rain-storm, falling like a cloud-burst, may carry off immense masses of débris needs no proof. The question is merely this: Is the transportation of the products of denudation at a standstill in the desert during the 300 dry days? To this question also we must reply in the negative. Almost daily I saw columns of dust traveling slowly over the plain. These raise great quantities of loose material high in the air; there this material is caught by horizontal air currents and carried farther away. I also saw in Colorado how within one-quarter of an hour the desert plain was wrapped in clouds of dust so dense that one could hardly see two kilometers away, while previously the eye might discern everything within a radius of many miles.

Thus we see that even when it does not rain there exists in the desert a transporting force, and that on the 300 dry days neither the destruction of rock nor the transportation of the products of destruction is at rest. We also recognize that this "dry denudation," as it has been called by an English reviewer, is of intense power and may well be compared qualitatively, though not quantitatively, with the denuding effect of water. It will be exceedingly difficult, however, to find a scale by which erosion, that is, denudation by water, can be compared with deflation, that is, denudation by wind; and so long as such a scale is wanting, all conclusions regarding their relative activity must rest on subjective estimates.

Many rocks and rocky surfaces of the African deserts are covered with a peculiar coating, which may be designated as "brown protective coat" or "desert varnish." This coating is also found widely distributed in the deserts of North America, and if I did not succeed in forming a definitive judgment concerning the origin of this product in Egypt, I have now in America made observations which promise to bring the problem nearer to its solution. Mr von Streeruwitz in the beginning of September had made excursions to several parts of the Sierra del Diablo, observing instances of the protective coat, which he intended afterward to show me. Toward the end of September cloud-bursts descended there, and when in the beginning of October we entered the valleys of the Sierra, we found to our astonishment that the protective coat had everywhere been torn away, and only a few shreds of it hung against some of the walls. Even where there had merely been a pool of water in a depression, and where therefore the chemical rather than the mechanical force of the water had been active, we found the desert varnish removed. From this appears with certainty what previously I could express only as conjecture:

(1) That the brown protective coat is not formed by the aid of water, and—

(2) That it is torn off and removed wherever rainwater has access.

Now, the latter fact also throws some light on a phenomenon which was previously a perfect enigma. In the African deserts, sandstones or limestones, more rarely granite, are found weathered in such manner that the face of a rock wall is broken by niches or crannies 10 to 100 centimeters high, 5 to 50 centimeters broad, separated by columns reaching a meter in height. Behind these columns—that is to say, in the interior of the rock wall—runs a passageway, at times large enough to allow a man to crawl along it. Both Professor Schweinfurth and myself were convinced that in the formation of these columned passages rainwater had played a part; our views diverged only on the question whether the columns had at one time been washed by descending rain rills or whether that had been the case with the holes between them. By the recent observations it is placed beyond doubt that only the holes can have been formed by water.

Professor Sickenberger of Cairo has been engaged for a year on investigations on the chemical processes involved in the formation of desert varnish, and important results are to be expected from him, confirming the views here set forth.

I attach great importance to a letter I received from Professor von Streeruwitz, who, in his laboratory at Austin, "Kept a protective coat, absolutely free from manganese, in an ozonized atmosphere for two weeks. It rapidly grew darker, and in the course of a few months assumed the color which those rocks had before the cloud-burst." This fact shows how correct is G. Rohlfs in calling attention, as he did again recently, to the significance of electricity in deserts, and how important would be the institution of exact determinations of electricity in some desert.

From what has thus far been stated, it is evident that the North American deserts agree with the Egyptian deserts in all essential and characteristic points. There are striking differences in plant geography, it is true, in that the American deserts on the whole are much richer in vegetation, probably by reason of greater precipitation. It is probably for this reason that erosion plays a larger and more important part than in Egypt. But the topographic character is the same: the prevalence of horizontal plains with island-like mountains rising from them; the frequency of isolated "Zeugenberge," or island mountains and of amphitheaters in the valleys; the intense energy of insolation, cracking bowlders and pebbles and causing varicolored granite to crumble into loose gravel; the appearance of mushroom rocks and columned galleries; and the wide distribution of the desert varnish, a phenomenon which must be regarded as a specific effect of dry climate and scarcity of rain. The denuding effect of wind is apparent not only in the characters of the surface forms just named, which are essentially different from the forms of erosion, but it may also be observed directly when dust storms career over the desert. As in northern Africa, so in North America there are found four types of denudation products or sediments: gravel deposits, sand dunes, clay tracts and salt deposits.

In view of such agreement in the primary and secondary geologic phenomena of the deserts, geographically so far apart, of northern Africa and North America, despite the different conditions of vegetation, one is justified in regarding the phenomenon of desert formation as one of the great telluric processes, a process having its own laws just as much as the glacial phenomena of the polar zone or the cumulative weathering of the tropics. Transferring this principle to the domain of earth history, there arises the problem of searching for the remains of fossil deserts in the strata of the earth's crust with the same care with which in recent time fossil glacial periods are reconstructed.

But the study of deserts has another important consequence. The desert is an extreme of climatologic conditions. Dry air and dry heat, which in our temperate climate make their appearance on a few days only in the year, are active in the desert for the larger part of the year. Their effect in the desert is prominent; in our regions it occupies a very modest place; but it would be unfair to deny their denuding agency even in our regions. There are so many phenomena near us which can hardly be explained as effects of water and ice, but which become easily intelligible as soon as we recognize dry air in motion as a geologic force. There is perhaps not a spot on earth that bears no trace of erosion; neither, on the other hand, is there a spot where the activity of wind denudation or deflation is entirely absent. It is only a question of unbiased observation of nature, and of not attributing to water things which it cannot accomplish.

How close together and in how intimate union erosion and deflation act is shown by an eloquent example, the famous Colorado canyon in Arizona. Most of the members of the great excursion expected that our way from the railway at Flagstaff to the Colorado canyon would lead through a desert. What was our surprise, therefore, when we found that it led for 120 kilometers over a plateau more than 2,000 meters high, with prairies and beautiful pine woods. The shady growth of *Pinus ponderosa* extended to the very edge of the canyon gorge, and as we climbed the last steep slope we were able to come within two steps of the canyon without imagining how close we were to the coveted goal. One step, and we stood on the verge of a gorge 2,000 meters deep, and only at a distance of 20 kilometers did we see the steep verge of the other shore. A magic twilight as yet reigned in the purple depth; only the topmost crags of some rocky towers burned with the rosy glow of the rising sun. Our eyes swept along the horizon, and as far as they could reach there appeared an uninterrupted mantle of forest; only toward the southeast the snow-covered peak of mount San Francisco emerged like another Etna, while toward the north, more than 200 kilometers away in an air-line, arose the gourd-like mount Navajo. Again we looked down into the fathomless depth, gradually illumined by reflection from the upper peaks glittering in the sunlight. The rock walls seemed to glow as with transparent light, and only with difficulty could the eye distinguish details. Little by little the purple glow and the deep blue shadows of the abyss disappeared, and as the sun rose higher and higher, the shadows grew shorter. Like jutting battlements and fairy-like palaces, one rock structure after another disclosed itself. At last we were able to scan the steep walls, to recognize with complete distinctness the Cambrian unconformity, and even at one point to see the river rushing along.

The relation of the bed of the Colorado to the canyon can be better recognized, however, if, proceeding along the upper edge eastward, one finally reaches the point seen and described for the first time by the Spanish commander Coronado in 1542. Spanish point lies at the extremity of one of those wooded tongues of land which project so far toward the middle of the gorge that one is able to survey the river for a considerable distance along its middle line. It has already been pointed out by Dutton, and the view from Spanish point easily shows it, that the canyon is divided into two parts. At the bottom the river is seen rushing along in a narrow gorge cut in gneiss, and our ears catch the muffled roar of the mighty stream that rolls its brown-red flood over rapids and reefs. The bed at times is so narrow that the rocks rise perpendicularly 400 meters from the water, and only on turning northward, where the Little Colorado breaks forth from its narrow gateway of rock, do we see the river bed widening and even bordered by a green fringe of low bushes.

That this trench traversed by the Colorado and mostly of gorge-like narrowness is an effect of erosion, that it was cut by the river and is still being deepened, is not open to the least doubt; but when we turn our eyes to the edge of this interior groove of erosion we see at once a different landscape. The strata referred to the Silurian and Devonian represent a shelf several kilometers in breadth, designated by Dutton as the "esplanade." The edges of the strata appear distinctly as delicate isohypsal lines, and the valley widens with very gentle slope, to be succeeded again by escarpments 1,000 meters high. But the widening above the esplanade is not uniform; for the promontory of Spanish point forms a sheer wall only a few kilometers distant from the river, while alongside it deep, semi circular kettles enter 5 to 8 kilometers into the plateau, and thereby carry back the edge of the canyon gorge as far as 10 kilometers from the erosion groove of the river.

Were we to cast a birdseye view on the whole valley system we should see in the middle a uniform, steeply carved groove, which at a certain point of its depth all at once widens greatly and appears fringed with deep, semicircular bays. If from Spanish point we look westward, we gaze into such an amphitheater. With sheer walls 800 meters high, it rises from the esplanade; nowhere could the bold foot of a mountain-climber find a hold; with dull rumbling the blocks loosened by our feet from the edge of the abyss tumble down into the vast depth. The upper edge is cut sharp as with a knife; nowhere do we see a rivulet descending; nay, the plane of the plateau slopes so steeply away from the edge that even in heavy rainfall no torrent could tumble over it—the whole region is drained toward the land, away from the gorge.

Like an enigma these amphitheaters now appear to us; all the more so when we learn from Major Powell, the famous explorer of the canyon, how rarely it rains here. Major Powell had not thought it necessary to take along tents for us, and when in one bad, stormy night we lay shivering around the smoky fire, unprotected against the hail and the streaming rain, not a few of us must have received the impression that we were in a region of large precipitation; and yet that storm was an unforeseen exception. But even if rain were more frequent than it is, still on account of the topographic conditions of drainage the amphitheaters would be affected only by the erosion of that water which falls on their surface. Bursts of rain from thunder-storms generated within the canyon, such as were graphically described to us by Major Powell, may indeed wash down all the débris which has become loosened in the course of the rainless period, but nevertheless the denuding effect of water can there be only secondary.

But where is the force that carved such amphitheaters? Where is the cause of so singular forms of denudation? Again we stand face to face with the question whether in these kettles denudation is at rest during the 300 rainless days. If we observe with unbiased minds what are the forces that act during these 300 rainless days, we see dry air and dry heat exerting their destructive influence on the rocks. The eye trained for such processes recognizes that the heat of the day, alternating with the cold of the night, may produce the same effect as fissure-frost in our latitudes. We ourselves experienced variations of temperature of 30° C. within the canyon. Thus insolation and weathering penetrate into the rocks and break them, and the wind carries off the light powder of the weathering. The harder ledges of rock are undermined without the aid of eroding water, hang over, and await the first rain-storm. Now comes one of those rare cloud-bursts. The water everywhere finds loose débris and shaky blocks. Thus the relatively small amount of water is able to detach and sweep down a much larger amount of débris which afterward the Colorado carries out into the gulf of California.

Thus we see in the canyon of the Colorado an interesting example of the combined action of erosion and deflation. We recognize in the inner gorge a simple channel of erosion; we observe that the upper amphitheaters owe their existence to the coöperation of erosion and deflation.

Now, what we here see in the Colorado, that we see everywhere on earth where the soil is not covered by a mantle of water, snow or vegetation. There is no need of traveling into the deserts in order to recognize the denuding activity of wind; and in the driest desert the traces of erosion may be observed. There is no region absolutely devoid of precipitation, and, on the other hand, deflation may be observed in the rainiest climate. When on a dry autumn day you walk along the highway and are annoyed by whirling clouds of dust, you are witnessing the denuding effect of wind. Every sand dune is the result of the same force. Every clay bed ("Lehmlager") teaches how vast deposits are produced by wind, and the loess beds of China are supposed to be merely a product of deflation. We say of the wind that it "sweeps" over the ground; for this word means nothing else than that the wind cleans the ground of all loose particles that cover it. Translated into technical geologic language, it is called "deflation," but that means nothing else than the every-day word "sweep."

One must learn to recognize the sweeping activity of the wind not only in the desert but everywhere, and in so doing to detect in its very beginning the process whose final product von Richthofen sees in the loess.

THE ALASKAN BOUNDARY SURVEY

I—INTRODUCTION

BY

DR T. C. MENDENHALL

(Presented before the Society March 4, 1892)

As an introduction to what Mr McGrath and Mr Turner will have to say to you to-night, I have been requested to say something with regard to the origin of the expedition from which they have so recently returned. Everybody present is doubtless familiar with the fact that in 1867 the United States government purchased from Russia that which was then known as Russian America and is now known as Alaska, paying for the same the sum of $7,200,000. There can be no doubt that this was a wise and profitable investment at the time, as it can readily be shown that the territory has returned to the United States in cash more than it cost, and we are just beginning to measure and to understand the real resources which will some time in the future be available. It was perhaps not generally expected at the time, if indeed it was expected at all, that in the purchase of the territory we were also coming into possession of two or three interesting and somewhat provoking controversies. One of these is with regard to the boundary line which separates Alaska from the possessions of Great Britain in North America. This boundary line was originally defined in a treaty between Great Britain and Russia in the year 1825; and in purchasing Alaska from Russia we acquired an interest in the boundary line as defined in that treaty.

Although it was doubtless thought at first that the boundary line was well and satisfactorily defined, it has since come to be generally recognized that the definition is very unsatisfactory, by reason of the fact that it was based upon the very meager information available at the time the treaty was made. I may remind you briefly that the treaty defines the line as beginning at the southernmost extremity of Prince of Wales island, which point was supposed to lie on the parallel 54° 40′ north latitude; thence, "It shall ascend along the Portland canal until the 50th parallel of north latitude is reached." From this point, in accordance with the treaty, it shall follow the line marked by the summits of the range of mountains parallel to the coast until such line meets with the 141st degree of longitude west of Greenwich. From this point it shall proceed along the 141st meridian west of Greenwich until the Arctic ocean, or the "frozen ocean," which is the term used in the treaty, is reached. In a supplementary paragraph it was agreed that all of the island known as the island of the Prince of Wales should belong to Russia, and hence, in virtue of our purchase, to the United States; and also that whenever the summit of the range of mountains referred to before shall be at a greater distance from the coast than ten marine leagues, the limit of the possessions of Russia shall be formed by a line parallel to the windings of the coast and never more than ten marine leagues from the shore.

It will thus be seen that the boundary line is divided into two parts which differ materially from each other. One of these is that line which proceeds from a point near mount Saint Elias—that is to say, the 141st meridian of longitude west from Greenwich—and runs directly north to the frozen ocean. This, being an astronomical line, can readily be located by astronomical methods and should give rise to no controversy. That part of the line, however, which separates what is known as southeastern Alaska from the British possessions is by no means simple and easily determined. At the time the treaty was made between Russia and Great Britain the best information available was that contained in Vancouver's map, which was, and in some respects is still, the best available representation of Bering sea and that part of North America. It seems tolerably certain, however, at the present time that the range of mountains which was assumed to run parallel to the coast has no real existence, and that it is therefore necessary to fall back upon the second definition of the boundary line—that is, the line which is to run parallel to the windings of the shore and be nowhere more than ten marine leagues from the same.

Experience has shown that the longer a question concerning the location of the boundary between two great nations is left unsettled the more difficult it becomes to decide it in a manner satisfactory to both. In a region which is sparsely settled and where there are and can be few interests, either public or private, that conflict in any way, it is not difficult to determine a boundary line without dispute. The postponement of the question, however, may leave it undetermined until the population is greatly increased, property becomes more valuable, and mineral or other resources have been discovered which make it important to each contending side that every foot of territory shall be contested for.

A very few years after the Alaska purchase (in 1872) General Grant, then President of the United States, recognizing the difficulties attending the settlement of this question, and especially the difficulties which might arise from its further postponement, recommended in his annual message to Congress the appointment of a commission for settling the boundary line between Alaska and the possessions of Great Britain. The country being practically unsurveyed, it became necessary to consider a method for a suitable survey of the country adjacent to the boundary line in order that it might be correctly defined, and various estimates of the cost of such an operation and the length of time required for its execution were made at that time. The matter was then allowed to drop, however, and nothing further was done until nearly fifteen years later, when President Cleveland again brought the subject forward by referring to it in his message to Congress.

In the estimates submitted for the year 1888 an item of $100,000 was inserted by the Department of State for a preliminary survey of this boundary. No action was taken upon this item, however, but in the following year an appropriation of $20,000 was made, the survey to be conducted by the United States Coast and Geodetic Survey in accordance with plans or projects approved by the Secretary of State. In drawing up the plan for the work it was agreed to begin the operations by the establishment of points upon the 141st meridian west of Greenwich. In order to accomplish this it was necessary to send observers into the interior, and for this purpose in the spring of 1889 two parties were organized to ascend the Yukon river and its branch, the Porcupine, in order to establish camps as near as possible to the 141st meridian for the purpose of making the necessary astronomical observations for the determination of its location. They were also instructed to execute such triangulation and topography as would be necessary for the identification of the locations of the observing camps, and to establish permanent monuments as nearly as may be upon the meridian line.

These two parties, one to occupy a camp on the Yukon river as nearly as possible where it is intersected by the 141st meridian and the other on the Porcupine, were directed respectively by Mr McGrath and Mr Turner, whose observations are summarized in the following papers.

It was estimated that one year would be sufficient for the accomplishment of the work, and this estimate was a liberal one, provided ordinary weather conditions had prevailed in that part of the country. It was found, however, that these conditions were extremely unfavorable, especially for astronomical work, on account of the continued cloudiness, rendering observations for a long time absolutely impossible. The extreme low temperature also rendered work difficult, and this of itself would have stood in the way of an early completion of the task had it been possible to carry on the astronomical observations. It thus happened that, notwithstanding the rigor of the climate and the difficulty, if not impossibility, of obtaining supplies from outside sources, these parties were obliged to remain in the interior of Alaska during two years. Notwithstanding the unfavorable conditions under which they existed during this time, every individual of both parties returned in good health and in good condition. Indeed, there was scarcely a case of even ordinary illness during the entire campaign, a fact which must reflect great credit upon those charged with the management of the parties.

So far as we have been able to ascertain by recollections and comparisons made up to this date, the work with which Messrs McGrath and Turner were charged has been done in a manner entirely satisfactory and so as to reflect great credit upon these gentlemen. I am sure they have very much to tell you which is of interest in relation to their experiences in this almost unknown and unexplored region, and I will not longer stand in the way of their doing so.

II—THE BOUNDARY SOUTH OF FORT YUKON

BY

J. E. McGRATH

The address of Dr Mendenhall having satisfactorily described the duties which called our party into the interior of Alaska, I shall confine myself to a plain statement of the most prominent points of interest connected with the people and country that came under my observation during a two years' stay in our great northwestern possession. It may not be amiss to call attention to a few salient facts about this vast territory, whose remoteness from the rest of the country has caused but little attention to be paid to its possibilities and character by the people at large until the rights of certain of its old-time inhabitants to peaceful occupation of some favorite summer resorts of theirs on a few small islands off its coast had been rudely interfered with.

Alaska has an area of nearly 580,000 square miles. Its shore line exceeds in length the combined lengths of the Atlantic, Pacific and Gulf coasts belonging to the United States by 7,239 miles. The ocean that freezes along its northern coast is the resort of the greatest whaling fleet in the world. Its islands of Saint Paul and Saint George are the breeding places of the fur seal, for hunting which a company pay the United States government a royalty which equals (when the maximum catch is allowed) about ten per cent on the cost of the whole of Alaska; in the archipelago which extends about the national domain and nearly 8° of longitude into the eastern hemisphere are the haunts of one of the most highly prized of all fur-bearing animals, the sea otter; on the banks off the Alaskan peninsula the Fish Commission steamer *Albatross* has found those very valuable food fishes, the cod and halibut, in such numbers as to make these seas compare favorably with the rich fishing banks of Newfoundland; along the southeastern coast a large mining population is profitably employed, and at the great Treadwell mine on Douglas island (near Juneau) the largest stamp mill in the world is engaged in crushing Alaskan ores; along every favorable bay and stream on the southern coast salmon canneries are to be found, and the importance of this industry may be appreciated when it is considered that the season's pack for 1889 amounted to 703,000 cases. In the interior gold, copper and coal have been found, but as yet the most valuable exports are the many rich furs for which Alaska has long been noted.

No feature of Alaska is more remarkable and noteworthy, geographically, than its great river, the Yukon. This mighty stream, rising within twenty miles of the Pacific ocean (estimated from the head of Lynn canal), flows for about 1,000 miles northwesterly, passing inside the arctic circle, near fort Yukon, and then, bending its course south-southwestward, flows on for another 1,000 miles until it reaches Bering sea.

The Russians during their domination in Alaska did but little in the way of exploring the interior, and it remained for the hardy pioneers of the Western Union Telegraph expedition, who were occupied during 1866 and 1867 in selecting a route for a telegraph line to connect Europe and America by way of Siberia, established the identity of the river known to the British as the Lewes and to the Russians as the Kwikpak or Yukon.

In the early days the trade of the river was divided between the two peoples just mentioned. The Hudson Bay company had established a post at fort Yukon, and the servants of this company received their goods by dog trains from the Mackenzie River district, extending their operations as far down the river as Nuklukayet, near the mouth of Tanana river, and so securing the trade which at the present day is considered the best in the Yukon district. The Russians had to bring their supplies up the Yukon in sailing vessels, and with this slow means of transportation found Nulato far enough in the interior for their trading post. The English occupation of the site of fort Yukon continued until 1869. In that year Captain Raymond, of the United States Engineers, was sent up the river to determine the location of the post. A total eclipse of the sun afforded him an admirable opportunity to determine his longitude. This being supplemented by observations of the moon and moon-culminating stars, a latitude was observed; and then, as it was placed beyond doubt that the station was in the United States territory, the Hudson Bay company retired up Porcupine river to a point that the factor, Mr McDougall, thought was well within the British possessions. Captain Raymond also mapped the river between fort Yukon and its mouth, and when Lieutenant Schwatka made his famous raft journey down the river (from its head) in 1883 he supplemented Raymond's work, and for the first time a fair idea of the course of Yukon river was given to the world.

Captain Everett Smith, of the Western Union Telegraph expedition, made a reconnaissance of the delta, and the present maps nearly all use the chart made by him of the mouth of the river. The great reward for the pioneers in the salmon canning trade on this river has made the agents of the Alaska Commercial company at Saint Michael very anxious to discover a channel in the river up which ocean-going vessels might be taken. At present all stores intended for the Yukon river valley must be taken to Saint Michael and there transferred to small, light-draught river steamboats, which then have a risky outside sea voyage of eighty miles before they can find safety in the most northerly of the outlets of the river, which is the Aphoon mouth. Its great volume of water is poured out through so many different channels that in no one can a sufficient depth be found to allow of admittance into the river of sea-going vessels. Tempted by the prize which is in store for the first ones to establish salmon canneries on the river, the Alaska company's agents have spent much time in searching for a deep-water channel. In this quest they can secure no help from the natives, who appreciate what the consequences will be for themselves if the white man can bring his ships in, and hitherto the search has been a failure.

The inhabitants of the lower Yukon were the most miserable, foul and degraded beings that we saw in Alaska. Of personal cleanliness they seem to have no conception, and it was distressing to note the terrible diseases under which some of them seemed to be wasting away. The chief reason for their dreadful personal condition is their partiality for seal oil under all conditions and circumstances. They seemed to steep themselves in it. It never has an odor which would make it acceptable to civilized people, and coat after coat of this stuff, laid on from childhood to old age, results in making the person so treated a very unwelcome object for notice for either nose or eye of the white man. The lower part of the delta is regularly submerged each spring, and often the miserable dwellers therein have to seek refuge in their boats; but just so soon as the waters subside the people return to their damp and sodden hovels, which really never dry out entirely, on account of the excessive rain that characterizes the lower river. This condition of person and dwelling, together with an almost exclusive fish diet for one-half the year, results in some terrible forms of diseases among the Maklemuts, and at various points we saw poor miserable creatures whose condition was more hideous than anything I ever read of the worst effects of plague or leprosy.

In spring, summer and fall this section is the home for innumerable geese, swans and ducks. The Maklemut then lives well, and we were told wonderful stories of the number of birds killed by single hunters in a day's hunting. Two wild geese could be bought in some places for a head of tobacco, and a miner told us that the ruling rate for wild-goose eggs at the trader's store near cape Romannoff was a head of tobacco, or one-third of a pound of lead for 150 eggs. It is needless to say that the native inhabitants of this section are not very particular about the quality or condition of the food they eat. There are no fastidious scruples about the cause of the death of their game. A white whale or seal that drifts ashore is taken with thanks, and if it is evident that the creature has been dead for some time there is the compensating advantage that the flesh is more tender.

The Yukon river does not lack for settlements, but their size and condition hardly satisfied the ideas we had formed of them before they greeted our view. Kotlik is the home for a single white man, the old Russian trader and his family. Andreafski is only a name; a portion of the old storehouse here came in very handy for wood supplies when we passed it going up river. Ikogumut has some importance because it is the home of the Russian priest who has spiritual charge of most of the natives of the lower river. Kozerehhski is a few miles above the large Catholic mission of the Holy Cross. White Anvik affords a home to the bishop elect of the Episcopal diocese of interior Alaska. Next above Anvik is Nulato, once the outpost of the Russian Trading company and noted for being the scene (so graphically described by Professor Dall in his work on Alaska) of the only massacre perpetrated by the Indians on white people in the Yukon valley. The next station of note after passing Nulato is Nuklukayet, the emporium for the trade of Tanana river and the most productive trading post on the Yukon. About 100 miles above Nuklukayet the Yukon begins to spread out into the great lake-like section which is locally known as the "flats." In this portion of its course the stream is dotted with myriads of islands The great width of the river and the constant changes in the shallow channels leading to every point of the compass make this the most dreaded part of the river for the steamboat-men. Near fort Yukon the river is said to be seven miles wide.

Probably no point on the Yukon is better known by name to people who have not visited the interior of Alaska than fort Yukon. Here once was the largest and best-equipped trading station on the river. It was the most westerly of the Hudson Bay company's posts, and until Captain Raymond determined that the site was within the territory of the United States, it controlled all the trade of the upper river. Now a broken chimney, several mounds of ashes, and a few graves are all the evidences that remain to show where the great station once was.

Above fort Yukon the names of a number of places appear on our maps, but in reality only two locations are permanently occupied on the whole upper half of the river. These are at the mouth of Forty Mile creek and at the site of old fort Selkirk. The scenery along Yukon river will compare favorably with any views I have ever beheld myself or seen reproductions of from any river in our country. Our summer trip up the stream was one continued succession of pleasant surprises. The hills were heavily wooded with spruce, birch and aspen; on shore we found flowers on every side, while birds and insects were as plentiful as we ever saw them in the northern states. At fort Yukon, which is little over a mile inside the arctic circle, the heat was almost insufferable, both in August and July; and the only warning given us of what we might expect a little later on was afforded at Nulato, where we saw a well being sunk which had already been driven through twenty-five feet of frozen ground. In spite of our pleasant summer, as we were all ignorant of what might be the rigors of an arctic winter, there was much anxiety about what the future would have in store for us. All the traders at Saint Michael were certain that the coming winter would be a severe one, because the one just passed had been very mild. Rain had fallen on Forty Mile creek on January 1, 1889, and, according to all the laws of Alaskan weather, the approaching winter would have to make up for the mildness of the preceding one. Mr McGuesten told us of the winter of 1886, when the signal service thermometer at his station recorded —70°, and his face was frozen while going about fifty feet from his house to call some miners who lived in a cabin near by to see how low the temperature was. Mr Mayo was certain that a later winter was still colder, but unfortunately he had no spirit thermometer that year, and so he had to judge entirely by his sensations. With all this expert testimony we began to anticipate trouble.

A careful estimate was made of what wood we would need for our three fires, and it was with much foreboding of its inadequacy that we saw the winter start in while we had only enough wood on hand to last, as it afterwards turned out, for two years, and then have enough left over to give the steamboat *Arctic* four or five cords when we abandoned the camp in 1891.

During the first winter the temperature fell to — 59°, while the second season gave us a still lower minimum, or — 60.5°. We had a long spell in January and February, 1890, when the temperature did not get above 82° below the freezing-point (— 50°), but at no time did this cause any suffering. Our systems became gradually inured to the cold and, without any such amount of extra clothing as would excite comment in the middle states in winter, we were able to go about attending to our regular duties, and taking the indoor exercise that was necessary for our keeping in good health. Fur garments were worn only when the members of the party went on journeys, and then they were taken for use at night, as we used no tents in any of our trips. In the quarters fires were not kept up beyond our time for retiring, except when observations kept us up all night; but, in spite of this, water never froze in the room the men occupied, and in the roof of the officers' room an opening eighteen inches square was kept open summer and winter for ventilating purposes. I suppose our capacity for assimilating fats was very much increased from a little discovery I made last March. One day, while looking over the report of the provisions used by the party, I noticed an extraordinarily large amount of lard charged. As it showed that the man who was acting as cook was using monthly twice as much of this article as his predecessor in office (who was allowed to return home in the previous August) had used in six months, I called on him for an explanation. He claimed that he was using it in a regular and proper way, and when asked for what purposes it went, he said that, for one thing, he always put a pound of it in the soup every day. No one had developed any attack of dyspepsia during the season, and I suppose we must thank our climatic surroundings for being saved from the natural consequences of this practice.

During the intense cold the mercury froze, of course. On Forty Mile creek one experimenter made bullets of this metal, which he fitted into cartridges and fired from his rifle. We amused ourselves with making mercury discs which we would break to see the fracture. Coal-oil and California brandy were also experimented with and solidified in a very short time.

The principal sources of worry and suffering at an arctic station are to be found in the short, dark days of winter and the long, bright days of summer. Our first winter was made rather worse than usual because of the small amount of oil we had to carry us through. For twenty hours each day during the months of December and January no reading or writing could be done in quarters without the aid of artificial light, and as we only had enough oil on hand to allow us to keep a lamp going for four hours per day, we had many a dark hour to endure, and those two months appeared almost endless. The long day of the summer seems to affect some people even more than the long night of winter; they appear to become nervous, and on the whaling fleet it is not unusual for men to become insane, and some are driven to suicide. At camp Davidson we were not inside the arctic circle, but nevertheless no stars were visible to the naked eye from about April 25 to August 15, and in June at midnight diamond print could be read by natural light out of doors. Some members of the party suffered severly from insomnia during the summer, and it did not seem to help them in any way when the heaviest cloths were used to curtain their cots.

Although 1,400 miles in the interior and certain of a mail only once a year, we could not complain of loneliness while the Indians were near us, and very few indeed were the days that some of those social people omitted calling and breakfasting, dining or supping with us. Taken as a whole, the Indians in our vicinity were clean, honest, gentle and virtuous. Never have they occasioned the white men who came among them any trouble, and hitherto the mutual relations of the two races have been of the most cordial and pleasant character.

The miners early recognized the necessity of seeing that none of their number should do the Indians injustice, and rigid laws have been adopted to enforce due consideration of Indian rights. Whatever work an Indian does for a miner or whatever he sells one is paid for, generally at a high price. Indians working in mining claims receive three to four dollars per day, which is relatively higher than the eight dollars paid to white men.

What the outcome of the Alaskan placer mines will be is beyond any one's power to estimate now. The miners have prospected on nearly every stream in the country; even the Arctic portions of the territory have not proven inaccessible to those solitary searchers for the precious metal, and everywhere they have found "color," but up to the present time no place has paid steadily and well, except the small river called by the natives Chitandipeh, and by the whites Forty Mile creek. Here last season there were about 150 white men, and when we left camp Davidson in June, 1891, it was the only river below Pelly, except the Kuyukuk, on which mines were worked. The lower part of the Forty Mile is abandoned now, but the richest ground is in the gulches near the head of the creek, and it is estimated that it will be several years before their treasures are all extracted. Mayo and McGuesten are the traders who supply these men with stores, and they told me that their shipments of gold dust for the past year amounted to $40,000, and this, they estimated, was a little less than one-half of the total output of the creek. The regular mining season lasts for only about three months, but some men do a little winter mining, which is extremely laborious. It necessitates first chopping a great quantity of cord-wood, which then has to be hauled to the bar that is being worked. Here it is heaped up in piles and fired, and then the thawed ground is dug out and piled on some bank above high water, and when summer comes and the ice goes it is taken down and washed out. In the winter of 1889–1890 three men took out 23,000 buckets of dirt, which netted them $1,000 apiece for their three months of the hardest kind of mining work known. The largest nuggets ever found in Alaska have been found on Forty Mile creek; one was shown us which was worth $56, and in last July a man named Nelson took out a nugget worth $260. The evidences that Alaska gives on all sides of the existence of gold will always tempt men to go there, but real exhaustive examinations of her streams will not be made until the miners feel sure that when they return to the trading posts after a long season's prospecting they can depend upon finding food there. As affairs are managed now, they must return to the stations in the middle of their short working season to see what the steamboat has brought, and no one can tell when some accident will happen to the one steamer that connects the interior with Saint Michael, and force all hands to leave the country or else face the possibility of starvation, as was the case in the fall of 1889. It is a very risky venture trying to live on the country in the interior of Alaska.

III—THE BOUNDARY NORTH OF FORT YUKON

BY

J. HENRY TURNER

There is perhaps no portion of the vast territory of Alaska so little known as the country stretching northward from fort Yukon to the Arctic ocean, eastward to the international boundary, and westward to the headwaters of Koyukuk river. Simpson and Franklin skirted its northern shore, Allen penetrated into it a short distance, and Stoney proved the existence of a mountain range trending to the eastward. Notwithstanding the fact that the summits of lofty mountains are visible in the horizon to the north of fort Yukon, the impression has long prevailed that the river plains extend to the shores of the frozen ocean. This idea has even been advanced by an explorer of note within the last few years. Travelers have sedulously avoided this region for the obvious reason that the supposed absence of navigable rivers and remoteness of trading posts and other means of communication with the outer world would render it peculiarly unsuited for summer exploration.

It is believed that certain discoveries made during a journey northward from camp Colonna in the spring of 1890 will throw considerable light on the geography of this *terra incognita.* I shall take occasion to revert to this question in closing my remarks.

Mr McGrath has already described the river from its mouth to old fort Yukon, at which point the two parties separated. On August 3 the steamer *Yukon*, with the Porcupine River party and its supplies aboard, left fort Yukon and three days thereafter reached camp Tittmann, the then head of navigation, distant 158 miles from the mouth of the river. The time of arrival was unavoidably ill chosen, as the July droughts had reduced the stream to its lowest summer ebb.

Observations placed camp Tittman 39 miles west of the boundary. Captain Peterson refused to tarry, since the river was still falling, as plainly indicated by wet lines along the banks and mud flats, and the danger of being stranded on a sand-bar until the following spring was too great a possibility to be overlooked. Supplies were consequently unloaded with all the expedition possible, and the steamer returned to fort Yukon.

Had our time of arrival been delayed a week no difficulty whatever would have been experienced in landing the party at the boundary, as the river rose rapidly in a few days. A whaleboat brought from San Francisco and a large, unwieldly lighter borrowed from the Alaska Commercial company were the sole means of transportation at our command.

Lack of time forbids me to enter into a detailed account of the many difficulties and vexatious delays encountered in conveying 25 tons of supplies piecemeal 60 miles upstream in the face of a strong current, broken into rapids in many places, and around banks undermined by the action of the water and fringed with fallen trees. Many mishaps occurred despite all precautions, and serious casualties were often avoided by a mere hair's breadth. On one occasion the entire party, including several Indians, narrowly escaped drowning by being drawn into the swirling waters. Harkert, a member of the party, had the misfortune to lose the end of one finger while handling a heavy box, and Polte, another of the men, had an ankle broken while assisting the men in tracking the heavy lighter upstream.

The Indians, unfitted by disposition or previous training for such arduous work, proved unreliable. It was unfortunate, too, that early in the season an Indian, while attempting to convey a heavy tow-line across stream in his frail canoe, was capsized and drowned. The accident led to open hostility on the part of the natives, and but for the timely intervention of the Hudson Bay company's post trader, Mr Firth, the consequences might have proved serious. Several plans to murder the entire party were discussed among the hot-headed younger Indians, but the wiser counsels of older heads prevailed, and as our acquaintance with the natives progressed their mistrust and hostility gave place to friendliness.

Preliminary observations made at Rampart house demonstrated the necessity of a further march of 33 miles upstream before the boundary would be reached. A well sheltered spot was finally selected in a timbered valley at the mouth of Sunaghun river, and preparations were at once begun to build a comfortable log house for winter quarters. The work was often interrupted by snow-storms of frequent occurrence, beginning in August. Ice began to form along the river banks in early September, and by the end of October a snowy mantle covered the country, and all the streams were fast locked in ice. The log cabin and all observatories were ready for occupation by October 1. The days rapidly shortened as the season progressed, and on November 16 the sun in his course southward disappeared beneath the horizon. During the shortest days lamps were extinguished at 11 a m and lighted at 1 p m. By 2 p m observations upon the stars were perfectly practicable. This state of affairs prevailed until January 26, on which date the sun reappeared. As the first few feeble rays of the luminary struggled through the frost-laden windows the spirits of the men brightened, and, rushing forth from the cabin, they capered about like mad men in an excess of joy.

Many Indians visited our camp during the winter months, the best season for travel. In this region of soft snow the kind of sled used on the coast is unsuitable, and is replaced by a toboggan seven feet long and two feet wide, with a large roll in front to fend off the snow. The dogs, usually four in number, are hitched tandem and so close together as to necessitates cutting off their tails. No sled dog in the Porcupine river country possesses this ornamental appendage, for it is amputated early in youth.

Among the coast tribes all the dogs possess large bushy tails, which serve the admirable purpose of keeping their noses warm in the cold winter nights. No sled trips, with the single exception of one to Rampart House late in December, were made at this time. There was no particular necessity for them, and no member of the party possessed sufficient enthusiasm to undertake a journey for the pleasure to be derived from it.

As stated before, scarcely a day passed that some Indian did not make camp Colonna his abiding place until kicked out. We found the natives inveterate beggars. There was some excuse for this, as early in January the stock of provisions at Rampart house became exhausted. The natives with characteristic improvidence had neglected in summer to lay up food for the winter, and the new year found starvation staring them in the face. Several hunting parties had gone out, to return empty-handed and to report that the deer had migrated southward. Many Indians were reduced to the necessity of subsisting upon moose-skin bags, deer-skin thongs, and old sled covers. Several old people died of sheer starvation, and the outlook grew gloomy. Timely assistance from the missionary, Mr Wallis, and a case of flour from camp Colonna tided over the emergency until a few deer were secured by an expert hunter, who had been permitted the use of a Winchester rifle from our camp.

The main food supply of the Porcupine River Indians consists of fish and reindeer meat. In early spring this fare is supplemented by a vegetable diet of wild rhubarb and a root resembling licorice. Later in the season blueberries, raspberries and wild currants are found in abundance.

Salt is never used. Although we were supplied with an abundance of this article and offered it to the natives gratis, none seemed to desire this addition to their cooked meat. Scurvy is unknown in this portion of Alaska, and the remoteness of the settlements from the civilizing influence of the whites has prevented the introduction of several fatal diseases, but scarlet fever nearly depopulated the country many years ago. The prevailing distemper now seems to be of a pulmonary nature. Many natives seemingly in perfect health were suddenly attacked, and in a few weeks succumbed to acute pneumonia or galloping consumption. Medicine is of no avail. The doctor who accompanied the expedition administered gallons of physic, but if not present to watch the patient the course of treatment was at once discontinued unless beneficial results followed the first dose. As several Indians treated by the doctor died, his influence over them rapidly waned. From implicit confidence, the natives suddenly reverted to extreme distrust and resumed the rites for curing the sick practiced by their own "shamans." Very little attention is shown the sick. We detected the post trader's hunter in the act of devouring some crackers supplied him for his daughter, who was sick abed. The girl subsequently died, doubtless of starvation, abandoned to her fate by her unnatural father. Shortly afterward a young woman in the settlement was taken sick and permitted to slowly starve to death by a sister, who subsequently attempted the destruction of her surviving child by tying it to a stake out of doors and leaving it to freeze in the winter night.

Though the Indian may evince affection for his children, it extends to no other member of the family. Father and mother, brother and sister, wife and husband are neglected as soon as sickness overtakes them, often abandoned, and not seldom expedited into the other world by means of a club in order to save further trouble. No instance of infanticide came under my notice during our stay on Porcupine river, although very common among the coast tribes of Bering sea, and especially at Saint Michael. Cannibalism is by no means rare. A shocking instance of this was reported to us during our stay at Rampart house. Two women, running short of provisions, killed a man and a boy while asleep, and subsisted upon the remains for several weeks.

Though grasping, unscrupulous, and often dishonest in his dealings with the whites, in his own tent the Indian is a creature of another stamp. His ideas of hospitality are strangely inconsistent with his conduct in other matters. The last morsel of food is shared cheerfully with the hungry stranger, the warmest place before the fire is assigned for his use, and the snuggest corner in the tent is reserved for his sleeping hours. In the matter of cleanliness and morality the native is like unto his ancestors. No exhortation by the most eloquent missionary can force him to bathe. He fears the water like a cat. No amount of scriptural teaching can convey to his brain the first glimmering of the meaning of such a word as morality; and unless he is permitted to carry with him at all times a plentiful stock of certain insects he considers his usefulness at an end. It is somewhat singular that a race of beings so degraded and having so little need of a full language should be credited with a vocabulary of twenty thousand words. Mr Wallis, the present Church of England missionary at Rampart house, doubtless carried away by enthusiasm, assured me that in every respect the native language was far superior to the English tongue. While this statement should be taken *cum grano salis*, it is undoubtedly true that the language in question is superior to most of the native tongues in northern Alaska. Commencing at Senati's village, the language remains unchanged until Peel river is reached. It is much to be regretted that Archdeacon McDonald has provided no vocabulary or grammar to accompany his translations of the New Testament into the native tongue.

The various tribes speaking this language are divided into the Kutcha Kutchin (Senatis tribe); the Natsei Kutchin (Dwellers in the North), numbering 150 or thereabouts, residing in the country north of fort Yukon, and known also as the Gens de

Large; the Vunta Kutchin, or Lake Indians, inhabiting the region of the lakes northeast of Rampart House; the Nun Kutchin or River Indians; the Trangik Kutchin, or Black River Indians, residing on the river of the same name; and the Takudh tribes, living in the vicinity of la Pierre's house. Excepting the Takudh tribes, the other natives enumerated, numbering perhaps 500, trade at Rampart house. In former times this post was a source of great profit to the Hudson Bay company, as many black-fox skins were brought in by the Natsei Kutchin. During our ten months' residence but two skins of this kind were secured, and the yearly total of other furs has correspondingly diminished. The greatest bulk of furs is now obtained from the Black river country, and consists chiefly of black bear and beaver skins.

Eskimos from the northern coast sometimes visit Rampart house in order to exchange walrus lines for wolverine skins, which are afterwards traded to passing whalers for whisky or old-fashioned breech-loading Winchesters.

Early in March it was decided to take a journey northward along the boundary to the shores of the Arctic ocean.

A request was therefore sent to Mr Firth, at Rampart house, to provide dried meat for the trip and engage the services of two reliable natives with sleds and a runner to go ahead. This was accordingly done. Seven men and four sleds of four dogs each left camp on March 27, bound for the Arctic ocean. Two of the Indians, Edward and Moses by name, had traveled over the proposed route before, while engaged in trading with the Innuit of the northern coast, so no concern was felt on this score. The temperature had risen gradually during the previous day, and bright skies and sleeping winds indicated that the time was ripe for making the start. In addition to the dried meat, pemmican and a supply of canned meats, with a modicum of alcohol stowed away in the event of snake bite, completed the stock of provisions. My sled was loaded with a camera outfit and various instruments for the determination of geographical positions, heights, etc.

It was noon when the final preparations were completed and the party started. Bergman, Foreman and Engelstad accompanied the party. On the first day six miles were made, and the party camped for the night in a grove of spruce, with dry standing wood conveniently near. The mode of camping as practiced by the Indians and hunters along the river is as follows: A well-sheltered spot is selected in a clump of spruce, with abundance of dry wood in the immediate vicinity. After unhitching the dogs, which is the first proceeding, the snowshoes are removed and used as shovels to clear away a space twenty feet square and from two and a half to five feet in depth. An abundance of green boughs are then scattered evenly over the floor, the sides braced by brush, and a back rest is secured by laying several sticks lengthwise to a height sufficient to serve as a wind break. A quantity of dry timber is then heaped up on the opposite side and fired. Skins are spread over the spruce brush on the floor, parkas, blankets, harness, etc, are hung over the sides, and the camp is finished. The dogs are fed first, after the meat carried for the purpose has been thawed out before the fire. During this interval the men, in our case at least, stay the pangs of hunger by pieces of pemmican, succulent as chips, followed by the inevitable pipe. A pot full of dried meat is then boiled and a large kettle of strong tea brewed; pilot bread or flapjacks, if procurable, complete the bill of fare. We had provisions for twelve days, but expected to be away for eighteen, so it behooved us to watch the larder with a jealous eye.

Early in the morning, next day, the party followed the windings of Sunaghun river, and ascended the long slope leading to Boundary rock, so named from its proximity to the international boundary. It was decided to ascend the rock, which projects about 100 feet above the general surface. From this elevated point, 2,700 feet above the sea and 1,900 feet above camp Colonna, an excellent view was obtained of the surrounding country. To the eastward the windings of the Porcupine could be traced for miles; to the westward a short but bold range of mountains, seemingly volcanic, cut off the view. A bank of fog overhung the river, and masses of vapor filled the valleys in various directions. There was scarcely enough wind blowing to lift a feather, and all looked forward in happy anticipation to a swift and easy journey. It was determined to camp for the night in a small valley some few miles to the northward, and all haste was made to rejoin the sleds, which were on the full gallop and liable to outdistance us. A few minutes after overtaking the sleds a sudden roaring assailed our ears, a fog-bank to the eastward burst asunder, and from its recesses issued forth a wind that nearly swept us from our feet. Clouds of glittering snow filled the air and beat upon us with all the fury of a hail-storm. It was only by the most strenuous exertions that we were enabled to reach the sleds, which had taken shelter under the lee of a small hill. In that brief time the end of my nose, one temple and the tip of the right ear were frozen solid, and a broad white streak fully an inch wide, extending from eye to chin, bore evidence of the rapidity with which a man may freeze if the conditions be favorable. All expedition possible was necessary to gain the shelter of the friendly trees. For the remainder of that day, that night, and until noon of the following day the shrieking north wind swept over the trackless wastes in all the fury of a Dakota blizzard. Traveling was quite out of the question; men and dogs huddled together in a promiscuous heap, striving to secure protection from the biting blast.

The next morning everything had changed; the sun shone out bright again, and the wind had died away. During the forenoon we climbed continually up the further side of the valley, and about 12 o'clock reached the summit of a pass at an altitude of 2,500 feet. Spread out before us and extending eastward to the furthest horizon, appeared a plain covered with a dense growth of spruce, birch and cottonwood—a veritable oasis in the midst of utter desolation. Its western limit was a plateau, doubtless the northern continuation of the eastern front of the Porcupine ramparts. Fifty miles away to the northward a range of low mountains was discerned, trending to the eastward, and forming the northern boundary of the plain. As I afterward discovered, they form the true water-shed of northeastern Alaska and the country beyond to Mackenzie river.

It took three days to cross this plain. On the first day a tribe of Nigalek Eskimos were encountered. They were fine-looking savages and seemed much surprised to meet white men so far away from the trading posts. They broke camp on the following day and started northward for the summer hunt on the Arctic.

We crossed innumerable lakes during the next few days, and on the fifth day crossed the mountains at an altitude of 3,00 feet. The descent on the northern slope was abrupt. My burly foreman covered the distance rapidly by sliding down head foremost, necessitating various repairs to certain portions of his trousers. We found the temperature much lower on the northern side of the mountains, ranging from — 20° to — 50° Fahr. I slept in a parka and beneath a deerskin robe. In the morning the long hair around the front of the hood was one mass of ice, which had to be thawed out before the parka became manageable.

After descending the mountains, the route led through a valley hemmed in by most forbidding-looking mountains, running up in jagged spurs to a height of 6,000 or 8,000 feet. Three rivers in this valley run into one, which has its outlet near the eastern extremity of the basin. A large area was covered with ice, the result of overflow, but at the outlet the current had worn its way through the ice, and the vapor arising from the exposed surface gave the appearance, at a distance, of a boiling spring. This river was followed to the shores of the Arctic ocean, passing often between towering mountains or through gloomy canyons, where the wind howled dismally.

On the eighteenth day, April 8, the ocean was reached. A stiff breeze was blowing from the southeast and the mercury registered — 30°. A fire of driftwood was made and shelter was secured under the lee of a snow bank. The drifting snow shrouded the horizon until late in the afternoon, when the wind ceased and a long line of hummocky ice was revealed skirting the gloomy shore.

A record of our visit was inclosed in a brass shell, some observations were made, and early the next day the return trip was begun. Camp Colonna was reached in six days, a rapid journey considering the nature of the country, the frigid temperature and the depth of the snow.

Although the season was already well advanced and the sun well on his northern journey, not the slightest evidence of a thaw could be detected north of the valley of the Three Rivers. The stream, which was followed to the ocean, was frozen to the bottom, objects ten feet beneath the ice being plainly visible through the transparent medium.

COLLINSON'S ARCTIC JOURNEY

BY

General A. W. GREELY

(Presented by title before the Society April 3, 1892)

Somewhat more than a year ago the members and guests of the National Geographic Society had the great pleasure of hearing from the lips of Lieutenant-Commander Charles H. Stockton, U S N, a detailed and interesting account of his remarkable voyage in the U S S *Thetis*, during the summer and autumn of 1889, from San Francisco through Bering strait, around point Barrow, eastward to the mouth of Mackenzie river, and thence westward to Herald and Wrangell islands, whence he returned to his home port. It was a remarkable voyage, and Commander Stockton deserves especial credit for the professional ability and personal energy displayed by him throughout so trying and so successful a trip.

This account, somewhat enlarged, has been written up by another hand than Stockton's and published for a very large audience, the readers of *Scribner's Magazine*, April, 1891. The value of all journeys to remote regions depends primarily on the fidelity and accuracy with which the account of such voyages may be written. No one who knows Commander Stockton, or who has heard his personal account, doubts that he has rather understated than exaggerated the circumstances of his voyage. It is therefore with a feeling of very great disappointment that every well informed reader must have perused the opening paragraphs, which are incorrect in statement and most unjust by inference to the gallant predecessors of Commander Stockton.

The article, entitled "Where the Ice never Melts," begins as follows:

> "Two score years ago—it was in August, 1850—a vessel lay at anchor far to the north, beyond the Arctic circle. To the south of her rose a lofty cone-shaped island; to the north, to the east, to the west, beyond the narrow lane of open water wherein she lay, stretched for untold miles the blue ice, that, hard as granite, yields nothing to the blaze of the sun.

Above her was the gray Arctic sky, colder even to behold than the blue ice itself. All around was the silence of the far north—the terrible Arctic silence that drives men mad with the longing for some sound. Only the coming and going of the vessel's crew gave life to the scene.

"The vessel was Her Britannic Majesty's ship *Investigator*, Captain McClure; the place was the mouth of the great river Mackenzie; the island was that named in honor of the famous astronomer, Sir William Herschel.

"For nearly two score years no vessel crossed the waters of Mackenzie bay. Herschel island, unvisited for more than a generation, was but a name on the maps. At last one summer drove back the ice farther than before in forty years, and the west wind helped it, and then through the narrow lanes of water and through the shifting ice came nine vessels, eight of them dingy craft—whaling vessels—but the other a trim ship, whose sails were white, whose metal-work shone, from whose peak fluttered the stars and stripes—the United States steamer *Thetis*, commanded by Lieutenant-Commander Stockton, the first man-of-war that ever reached Herschel island, the first vessel ever to fly in that lonely place the flag of the United States."

The Arctic voyage made by the late Captain (afterwards Admiral) Sir Richard Collinson in H M S *Enterprise*, from 1851 to 1854, was perhaps, everything considered, the most successful expedition made in Arctic research prior to the use of steam. Collinson passed point Barrow in 1851 and wintered for that season in Walker bay (71° 35′ N., 170° 39′ W.), on Prince Albert land, to the east of Bank's or Baring's land. The next season, 1852–3, he wintered in Cambridge bay (69° 3′ N., 105° 12′ W.). He left Cambridge bay in the summer of 1853, on August 10, and on September 15 reached Camden bay, near Flaxman island, between the Mackenzie and point Barrow. The sea was nearly open, but strong easterly winds, packing the ice to the west of the bay, formed a sufficient barrier to prevent Collinson escaping from the ice, especially as he was depending entirely on sail. The *Enterprise* here wintered in 70° 8′ N., 145° 29′ W., and in the ensuing summer, on July 20, 1854, was able to sail eastward to Bering strait.

As already said, Collinson's voyage was remarkably successful. Herschel island, which was reached by Stockton and the American whalers *under steam*, is about 15° in longitude east of point Barrow; but Collinson took his vessel *under sail* about 40° east of that point, or nearly three times as far beyond point Barrow.

Parry, in his wonderful voyage to Winter harbor, traversed only 30° of longitude from the open water of Lancaster sound, but Collinson took his vessel nearly twice as far from the free waters of Bering strait. It should be noted to Collinson's credit that the series of straits through which he tacked his vessel were the worst that have ever been successfully navigated to a considerable distance by any Arctic expedition, and that in addition to his journey from Bering strait to Cambridge bay and return he also carried the *Enterprise* up McClure strait to as high a point as was reached by the *Investigator*. In short, no other vessel came so near completing the Northwest Passage as the *Enterprise.*

The writer of the article referred to was not ignorant of Collinson's journey, for on page 480 he refers to the fact that Collinson wintered at Camden bay in 1853–4.

On the other hand, McClure never visited Herschel island. It is not mentioned in any of his reports, and the track charts, both in Armstrong's "Northwest Passage" and in Osborn's account of McClure's voyage, show that the *Investigator*, under McClure, left the American coast near Camden bay and steered northeastward into the polar pack, into which the *Investigator* penetrated nearly ninety miles from land. Obliged by the closing ice to turn backward, McClure made Pelly island, on the eastern side of Mackenzie river, thus making a long detour in which his nearest approach to Herschel island was at a point about twenty-five miles northeast of it.

The records thus show that McClure found an open sea from point Barrow eastward in 1850, Collinson in 1851 and 1853, and Stockton in 1889, while the American whalers came safely back in 1890. In short, it may be said that nearly every year the Mackenzie may be reached by steam whalers, and that the ice is neither eternal nor fixed along the shores of northern Alaska and the Mackenzie River region.

It appears to be a proper labor for the National Geographic Society to favor the correction of errors relating to noted journeys and ill known regions; hence this attempt to do justice to Collinson and to correct the inferential error as to the Mackenzie river which by a flight of fancy only, can be described as a land "Where the ice never melts."

NOTES.

Topographic Survey of Canada.—Some two years ago a book on the subject of photographic surveying by Mr E. Deville, surveyor general of Canada, was issued by the Dominion land office. Apparently this is a book of instructions, and treats exhaustively of the methods of photographing and of using photographs for constructing maps therefrom.

Since few are acquainted with this subject, it may be well to characterize briefly the method of surveying by photography. A few points, including all occupied stations, are located by angular measurements. From the occupied points, photographs of the surrounding topography are taken, a complete round of the horizon usually being made from each station. Devices are employed for facilitating the measurement of horizontal and vertical angles from the photographs, and the photographs are sent to the central office at Ottawa, where maps are constructed from them. Angles are measured from the photographs, and thus all points for location are fixed, their heights determined and contour lines located.

To topographers on the southern side of the boundary this appears to be a very indirect way of making a map. Most of those who have studied the subject are aware that this method has been experimented with by several countries and discarded by all except Italy and Canada. The topographers of all other countries are accustomed to making maps directly in the field, using the country itself as copy, and not passing it through the medium of a photograph. By this simple and direct method it is believed that a more lifelike transcript of the original can be obtained, and, moreover, that the work can thus be done more rapidly and at less expense.

A few sheets recently issued by the Dominion land office appear to sustain this position. They are lithographed on a scale of 1 : 40,000, relief being expressed by contours at intervals of 100 feet and by shading. They represent a portion of the Rocky mountain region on the line of the Canadian Pacific railway. In many respects these maps are very creditable productions. A commendable attempt has been made to map a wild and unknown region, and the use of hill shading, combined with contours, is a move toward giving a graphic presentation of the appearance of the country. The shading is not altogether satisfactory, owing, perhaps, to lack of practice on the part of the draughtsman, as this is something which requires years of study to produce with good effect. The maps are printed in five colors, though probably one of these, red (used to represent trails and roads) might well have been replaced by black. The brown for the contours, green to represent forests, and blue for drainage, with black for culture, gives one of the most satisfactory and effective combinations possible.

There are, however, some serious defects in these maps. The representation of the topographic features is hardly natural. There is a want of detail and little suggestion of the ruggedness of the country. An experienced topographer immediately notes many features which are plainly due to misinterpretation of the photographs. From the appearance of the country as mapped one would expect to be able to take a pack-train anywhere, whereas in reality the ruggedness of the country forbids travel even on foot in the greater portion of this region. These are results of the extreme generalization due to the making of maps from photographs. The scale employed might well be reduced, say, to 2 miles to an inch. This scale would be amply large to show every detail represented, and would be more in consonance with the vertical scale of 100-foot contour intervals which is employed.

Apparently but a small number of stations were occupied in mapping the country. On one of these sheets in particular, the Anthracite sheet, but one station appears to have been occupied in a total area of 65 square miles. The expense of this work, eight dollars per square mile, is double that of work on a scale of 2 miles to the inch on this side of the boundary, with which it may be compared.

H. M. W.

Lieutenant Peary's Crossing of Northern Greenland.—The following account of this remarkable journey is condensed from the only official sources available, which are the accounts over Lieutenant Peary's signature in the New York *Sun* of October 25 and 31, 1892. Lieutenant Peary's party of seven wintered at Red cliff, on the shore of McCormick bay, in about 77° 7′ N. 71° W. On April 30, 1892, the advance travelling party left Red cliff, followed May 2 by Lieutenant Peary. Besides the leader, the expedition consisted of Dr Cook, Gibson, Astrup, Matt and seven Eskimo, with three sledges and 20 dogs. Within a few miles the summit of the inland ice was reached at a spot 2,500 feet above sea level, where a cache camp was established near a "nunatak" (the Eskimo name for a rocky peak rising above the level of the surrounding inland ice). From this point Matt was sent back, owing to a frozen heel. A second "igloo" (snow-house) was built on May 8, but afterward snow-houses were dispensed with as demanding too much time to construct.

By May 14, after extremely fatiguing work and double banking, the true inland ice may be said to have been reached. By this time 16 out of 20 dogs remained and the disabled sledges were reduced from eight to four, all of one type. The party were individually equipped with a deerskin "kooletah" and sleeping bag, a sealskin "timiak," and seal "kamiks" or moccasins. The party crossed the divide of the inland ice between Whale sound and Kane basin at an elevation of 5,000 feet, and thence descended toward the basin of Humboldt glacier. The course of travel was toward the northeast, and camp Separation was made 130 miles from McCormick bay. At this point it was decided that Lieutenant Peary should go forward with Astrup, while Dr Cook and Gibson, with a light sledge and two dogs, and rations for twelve days, should return to McCormick bay.

On May 31 Lieutenant Peary reached the divide of inland ice and looked down on the basin of Petermann fiord. He was obliged, owing to crevasses, to deflect ten miles to the eastward, where he made camp Petermann, at which he remained 36 hours to determine his position and take bearings. From this point gigantic crevasses obliged him to travel due eastward for ten miles, when he took a course northeastward, hoping to clear the basin of Sherard Osborne fiord.

Crossing another divide of the inland ice, June 8 found Lieutenant Peary and his party descending into Saint George fiord, which penetrates far inland. Here they were detained two days by a severe storm, after which the character of the glacier ice to the northward was so unfavorable that they were obliged to turn southward and eastward, and after two days of hard work found that they had lost 15 miles of their northing, besides injuring their team. The point reached on the inland ice was now 6,000 feet above the level of the sea. A northeasterly course was again followed, but unfavorable ice and enormous crevasses obliged frequent detours eastward.

On June 26, still at an elevation of 6,000 feet, the course was northeastward, but land appearing in that course, a detour eastward was again necessary, which led to a comparatively flat, round-topped, ice-clad land. Skirting the edge of the inland ice parallel with the land, they reached their highest northing on the 82d parallel. Here there was land to the northwest, northward and northeast. Of its character Lieutenant Peary says: "Dark-brown and red cliffs looked down into a grand, vertical-walled canyon reaching up toward our camp; and everywhere, to the northwest, north and east, black and dark-red precipices, deep valleys, mountains capped with cloud-shadowed domes of ice, stretched away in a wild panorama." From this point Lieutenant Peary was obliged to travel toward the southeast parallel with the edge of the inland ice and the shore land.

On July 1 a wide opening between high vertical cliffs allowed Lieutenant Peary to travel northeastward and quit the summit of the inland ice, then 5,000 feet above sea level. Following down a steep gradient toward the red-brown land, rivers and lakes became visible along the margin of the ice, and the party finally reached the highest point of a moraine after wading many streams and floundering through much melting snow. Leaving Astrup and his team at this point, Lieutenant Peary started northeastward to climb a cliff which apparently commanded a view of the coast and seemed to be only five miles away. The mountain appeared to recede as he advanced, and after eight hours' work to reach the summit, it proved that intervening hills shut out a full view of the coast. By this time Lieutenant Peary's foot-gear was practically worn out and his feet injured from the broken sharp rocks, and it was only by improvising foot-gear from his sealskin mittens and cap that he was able to return to camp. On July 3 with Astrup he descended to the shore and kept along the crest of rock-strewn mountains.

Finally, on July 4, they reached the summit of a rocky plateau with a sheer face rising 4,000 feet above the bay, which was named Independence bay from the day of its discovery. On the east was a great ice stream named Academy glacier, beyond which rose a yet higher vertical cliff, on a portion of which rested a great projecting tongue of inland ice.

Of the view Lieutenant Peary says: "Some 15 miles northeast from where we stood these cliffs ended in a bold cape, just beyond the fan-shaped face of the great glacier, and the shore from there swept away to the eastward. West of us lay the opening of the fiord which had barred our northern advance. Northwest stretched steep, red-brown bluffs with a flat foreshore reaching to the water's edge. The resemblance of these bluffs to the eastern shore of McCormick bay was very striking. Close at hand a single isolated ice cap crested these bluffs, but disappeared in the middle distance, and beyond that the shores which stretched far away to the northeast were free of snow and the summits free of ice caps.

"The bay itself beyond the glacier face seemed perfectly smooth, and far out in its center a clouded appearance showed the beginning of the process of disintegration in the formation of water pools upon the surface. Between the bold cape on the right and the distant northern shore the white level of the sea ice stretched out to meet the distant horizon over the mysterious eastern Arctic ocean."

Observations for position were made, those for longitude being based on equal altitudes, with the resulting latitude of 81° 37′ 4″ N, and a longitude (from map) of about 34° W. A cairn was raised, in which were placed a record of the journey, a thermometer, and copies of the New York *Sun* and *Harper's Weekly*. The national flags belonging to the Philadelphia Academy of Natural Sciences and the National Geographic Society (the latter flag presented by Miss Dahlgren) were displayed. The arctic poppy and other flowers, purple and white, were present, together with the snowbunting. Musk-ox trails were frequent, and five musk-oxen were killed. The return to McCormick bay was made in nearly a straight line, and the main divide of the inland ice was crossed at an elevation of 8,000 feet. The main incidents of the return journey were an experience of the most violent storm and the loss of several dogs, whereby the number was reduced to five. The return journey occupied thirty-one days.

The journey of Lieutenant Peary is most extraordinary. Its most important geographic result is the determination of a great fiord opening eastward into the Greenland sea at a point some 200 miles north of the highest position reached on the *eastern* coast of Greenland by any of Lieutenant Peary's predecessors.

Perhaps not less important is the confirmation of the opinion expressed eight years ago by General Greely that Greenland ends near the 82d parallel, and that the land to the northward is probably separate. Lieutenant Peary's most northerly point, in latitude 82°, was that looking down on the great fiord which debouches in Independence bay. It is of course not proved, but it is almost beyond question, that this is a continuation of Nordenskiold inlet, which begins in the Polar ocean near the 83d parallel. Of this fiord, discovered by Lieutenant Lockwood May 6, 1882, that lamented and distinguished officer says: "The fiord at whose mouth we camped ran to the southeast or south to an immense distance; no land visible at its head." Lockwood was a very conservative man, and he charted this fiord southeastward to only longitude 45, which is but five degrees eastward, or less than fifty miles northwest of the most northerly point reached by Lieutenant Peary. The character of the land seen by Peary to the north and northwest indicates satisfactorily that these two fiords are one, as charted by Lieutenant Peary in the New York *Sun* of October 31. The discovery of musk-oxen at Independence bay confirms General Greely's supposition, put forth in 1884, that these animals reach the eastern coast of Greenland through Nordenskiold or some adjacent inlet.

In his sketch map (New York *Sun*, October 31) Peary extends the northern coast of Independence bay some fifty miles eastward, to about 25° west longitude. This easterly extension of bold, high, ice-free land, with intervening water, whereon the ice was in the process of disintegration, makes it exceedingly doubtful if a very high northing can be made on that coast, with McCormick bay as a base. With Thank-God harbor as a home station, however, there will be no serious difficulty in making a very high latitude, say 85° N., either via Lockwood's route or across the inland ice to Independence bay.

A. W. G.

Geographic Prizes.—The National Geographic Society, with a view of encouraging geography in the public high schools of the United States, has instituted certificates and medals which are to be awarded annually in each state to such graduating pupils of public high schools as shall write the best original geographic essays on subjects to be selected by a committee of the Society. It is intended that each essay shall pertain to the continent of

North America, and that it shall be comprehensive in its scope and limited in its length, so as to afford opportunity for originality of treatment. The coöperation of state superintendents of education will be sought by the Society. The best essayist of each state will receive a certificate of efficiency from the National Geographic Society. The Geographic Gold Medal of the National Geographic Society will be awarded to the best essayist of the entire country, while the second best essayist will receive a certificate of honorable mention. The subject of the essay for 1893 will be announced shortly.

GENERAL RULES.

1. Essays will be received only from such public high schools as formally announce their intention to compete by May 31 of each year.
2. All essays must be entirely composed by the pupil, who must certify on honor that he has not received aid from any person.
3. No essay shall exceed 2,500 words in length.
4. In each state the superintendent of public schools, if his coöperation can be secured, will select by such process as he deems advisable the three best essays, which shall be passed on by a committee of the National Geographic Society in order to select the best essay for each state and for the United States.
5. The certificate issued to the best essayist of each state shall set forth in proper terms that . . . ., being one of . . . . essayists from . . . . public high school, in the state of . . . ., is awarded this certificate by The National Geographic Society for his proficiency in geographic science.
6. No certificate shall be awarded to any competitor unless in the opinion of the judges the essay offered possesses sufficient merit to justify such award.

It is desired that the superintendent of public schools in each state shall select, by such method as he deems advisable, the three best essays, and from the collection of such essays the committee of the National Geographic Society will select the best essay for each state and for the United States. One of the most important aims of the National Geographic Society is to stimulate and make more practical the study of geography, particularly with reference to America. The Society therefore seeks the coöperation of all educational workers in making its labors more efficient and general. To this end gifts for medals and scholarships are solicited and identification with the Society by active membership and personal effort are urged.

The Society already comprises among its active workers a considerable number of geographic scientists, who have given liberally of their time and efforts with a view of stimulating public interest in geographic education. The Society is a working one, and in its efforts to exercise an educational influence over the whole of the United States feels justified in asking liberal support from high-spirited citizens. The Society numbers among its members over 700 persons and has active representatives in every state and territory.

General A. W. Greely, United States Army; Professor T. C. Mendenhall, superintendent of the United States Coast and Geodetic Survey, and Professor W. B. Powell, superintendent of public schools of the District of Columbia, constitute the committee charged with the selection of the subject and award of the prizes for 1893.

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