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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

THE GEOGRAPHY AND GEOLOGY OF ALASKA

A SUMMARY OF EXISTING KNOWLEDGE

BY

ALFRED H. BROOKS

WITH A SECTION ON CLIMATE

BY

CLEVELAND ABBE, JR.

AND

A TOPOGRAPHIC MAP AND DESCRIPTION THEREOF

BY

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RELIEF MODEL OF ALASKA.

By E. E. Howell, from base map by U. S. Geological Survey.

GEOGRAPHY AND GEOLOGY OF ALASKA.

By Alfred H. Brooks.

INTRODUCTION.

Alaska, the largest outlying possession of the United States, is that great land mass forming the northwestern extremity of the North American continent, whose western point is within 60 miles of the Asiatic coast (Pl. II). About one-quarter of this area lies within the Arctic Circle, and from the standpoint of geographic position must be regarded as an arctic province; but the southern seaboard, exposed to the warm winds and waters of the Pacific, gives to the entire southern portion of the territory[a] a comparatively warm climate. It is not generally realized that the range of climate in Alaska is greater than that between Florida and Maine. At the southernmost point of the Pacific coast the mean annual temperature is not far from that of the city of Washington, the winters being warmer and characterized by less snowfall; the Yukon Valley on the other hand has a winter climate similar to that of northern Montana and Dakota; while in the extreme northern part of the territory the meteorologic conditions are invariably arctic.

Though as yet only sparsely settled, Alaska's vast area and great resources make it one of the most important possessions of the United States and promise its rapid development. During the years 1890 to 1900 the population increased from 32,052[b] to 63,592. The mineral output, which in 1890 was valued at less than $800,000, exceeded $9,000,000 in 1904, and the fisheries show a corresponding growth. This rapid development has attracted public attention and led to urgent demand for explorations, surveys, and other investigations. So actively has this work been pushed, both by public and private enterprise, that exact knowledge of the geography, geology, and mineral resources of the interior has made greater strides within the last eight years than during the preceding thirty-one years since the acquisition of Alaska. The facts regarding the geography and geology, scattered as they are through the many books and reports of this period, are not always readily accessible, and the time seems ripe to present them in a summarized form.

The topography of Alaska is varied and complex (see Pl. I), and it is not easy to present briefly even the salient features. The limited number of pages here

[a] While Alaska is usually designated a "Territory," legally it is an unorganized territory, district, or colony, as it has not a Territorial form of government.

[b] Twelfth Census, 1900, vol. 1, p. 47.

devoted to the subject precludes the possibility of detailed treatment, even if the facts were available. Much of the description has been taken from the results attained by other investigators, the writer being personally familiar with only a part of this large province. A list of the publications consulted is appended.

The larger geographic features of Alaska are now fairly well known, though the detailed surveys which are demanded by the development of many localities have hardly been begun. Preliminary surveys have been completed of all but three[a] of the larger rivers. The most important mountain ranges have been at least outlined (fig. 3). Only three large areas remain almost entirely unmapped: One in southwestern Alaska, between Cook Inlet and the lower Kuskokwim, and the others in northern Alaska, embracing the Arctic watershed east and west of the Colville River. Nearly all the surveys of the interior, however, have been of a preliminary and exploratory character, and to meet the requirements of exact geography must be followed by more detailed mensuration.

Though the coast line has been fairly well known for more than half a century, knowledge of the interior has been gained chiefly within the last two decades. This has not yet found its way into text-books and has too often been entirely ignored by cartographers. If facts are presented which may seem elementary, it is because even well-informed people have been known to harbor misconceptions in regard to the orographic features, climate, and general character of Alaska. Those who read of the perils and privations of winter travel and explorations are apt to picture a region of ice and snow; others, again, who have personal knowledge of the tourist route of southeastern Alaska, regard the whole district as one of rugged mountains and glaciers. In point of fact, glaciers are now nearly limited to the ranges bordering the Pacific and to the two slopes of the Alaska range; and even during the greatest development of glaciers but a small portion of Alaska was under ice (see map, Pl. XXII).

As a treatise on geography would hardly be complete without some discussion of the climate, meteorologic data have been compiled by Mr. Cleveland Abbe, jr., but the discussion of this does not pretend to be more than a cursory treatment of the subject.

The scope of the paper seems to require also a brief summary of the development of geographic knowledge of Alaska. This subject, with its many ramifications, is of fascinating interest and offers a magnificent field for the trained historian. If the accompanying sketch of discovery and exploration awakens any measure of popular interest the writer will feel amply rewarded for having attacked a theme which hardly falls within the scope of his investigations.

When this compilation was begun it was intended to be chiefly a description of the topography of Alaska, as illustrated by the accompanying map (Pl. XXXIV, in pocket), which was compiled under the direction of the late R. U. Goode. In the course of the work there accumulated much geologic as well as geographic material which seemed worthy of inclusion in the report. As no comprehensive statement of the geology of Alaska has been made since the modern epoch of investigation was begun, an attempt will be made to give a summary of all results achieved. Since the writer has obtained much of his knowledge of the facts from

[a] The Noatak, Alsek, and upper Colville. The lower Colville has been mapped. Some large tributaries of the Kuskokwim and the lower Yukon are also unsurveyed.

the work of others, he disclaims any pretense of making an entirely original contribution to geologic science. He feels, however, that a personal familiarity with a considerable part of the province, gained during seven consecutive seasons of field work, will justify him in presenting conclusions which may in some cases be at variance with those in the reports on which he must draw for his facts.

Throughout this report attempt will be made to credit borrowed material to the source from which it is drawn. Where such matter has been obtained entirely from published reports there is no difficulty in so doing; but as regards investigators of the Geological Survey, with whom the writer has collaborated both in field and in office, the case is somewhat different, for it is not always possible to know whether this or that theory originated with the writer or with one of his colleagues. It will, then, perhaps suffice to state that this report could not have been prepared without the explorations and researches of the geologists, F. C. Schrader, Walter C. Mendenhall, Arthur J. Collier, J. E. Spurr, and Arthur C. Spencer; and the surveys of the topographers, T. G. Gerdine, D. C. Witherspoon, D. L. Reaburn, W. J. Peters, and E. C. Barnard. Each of these men, in the course of from two to six years of field work, has made important contributions to the knowledge of the geography and geology of Alaska, and not all of these results have yet been put in print. In the last season (1903) L. M. Prindle, C. W. Wright, Arthur Hollick, G. C. Martin, F. L. Hess, and Fred H. Moffit have carried on geologic work in Alaska, and the writer has made use of their work now in course of publication. He has also been fortunate in having access to the manuscript reports of Walter C. Mendenhall and F. C. Schrader on the Copper River basin, to which references will be made. The matter here presented should be credited in a measure to all of these investigators, but for many of the theories advanced the writer alone is responsible.

As this manuscript goes to press there has been opportunity to incorporate some of the results of the field work of 1904. As far as possible these have been embodied in the text, but in some instances it has been found advisable to add them only as footnotes. During the past summer F. E. and C. W. Wright extended the geologic reconnaissance in southeastern Alaska. In southwestern Alaska G. C. Martin and T. W. Stanton have determined the general Mesozoic section, while F. H. Moffit has made a reconnaissance of the northern part of the Kenai Peninsula. A. J. Collier has mapped the geology of the Cape Lisburne region, and L. M. Prindle and F. L. Hess have made contributions to the knowledge of the metamorphic terranes of the Yukon-Tanana district.

It is the writer's purpose to describe in nontechnical language the larger geographic features and discuss their relation as far as the data available will permit. In the treatment of the geology, however, less effort will be made to make the matter acceptable to the lay reader. It is hoped, however, that a brief summary of the salient features of the geologic history may be not without interest to the general public. If this paper serves in some measure to dispel the popular fallacies regarding Alaska and to disseminate more accurate knowledge of its geographic and geologic features, the purpose of its publication will be accomplished.

DESCRIPTIVE GEOGRAPHY.

GEOGRAPHIC POSITION AND AREA.

Alaska in its greatest extent is included between the meridians of 130° west longitude and 173° east longitude, and between the parallels of 51° and 72° north latitude. It is bounded on the north by the Arctic Ocean, on the west by the Arctic Ocean, Bering Strait, and Bering Sea, on the south and southwest by the Gulf of

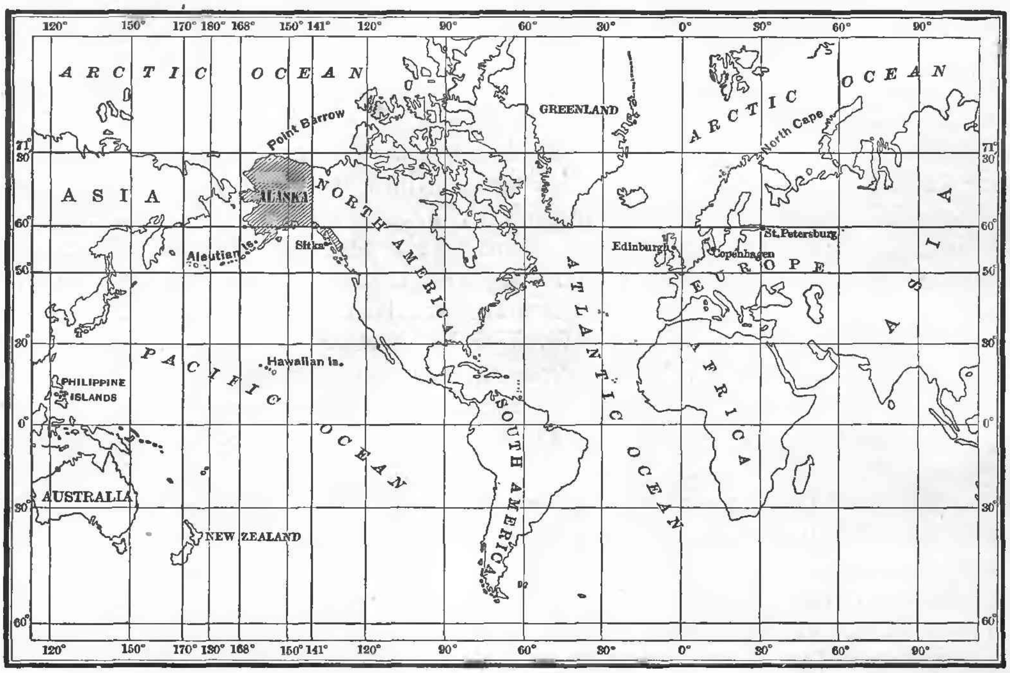


FIG. 1.—Map of the world, showing geographic position of Alaska.

Alaska and the Pacific Ocean, and on the east by the Yukon Territory and British Columbia. The eastern boundary from the Arctic Ocean to the neighborhood of Mount St. Elias is the one hundred and forty-first meridian; thence southeastward to Portland Canal it is irregular and can not be described in general terms.

The geographic position of Alaska is shown on the accompanying chart of the world (fig. 1). It is in approximately the same latitude as the Scandinavian Peninsula; Point Barrow, its northernmost point, is in about the same latitude as North Cape; Dixon Entrance, which marks its southern boundary, is nearly on the same parallel as Copenhagen; St. Elias is in the latitude of Christiania and St. Petersburg; and Sitka, the capital of Alaska, is in the latitude of Edinburgh. The longitude of the western terminal of the Aleutian Islands is almost identical with that of the New Hebrides Islands and is the same as that of New Zealand, and Cape Prince of Wales, the most westerly point of the mainland, is nearly as far west as the Samoan Islands. Thus a person traveling from New York to Attu Island, the westernmost of the Aleutian chain, on reaching San Francisco will have accomplished less than half the journey from east to west.

The area of Alaska is about 586,400 square miles, one-fifth that of the United States. The popular conception of the size of Alaska is based on maps of North America, which always distort it. Fig. 2, which shows Alaska superimposed on a map of the United States of the same scale, demonstrates that the distance from the easternmost to the westernmost point in Alaska is equal to the distance from the Atlantic to the Pacific in the latitude of Los Angeles, and that its

FIG. 2.—Map showing the relative size of Alaska and the United States.

northernmost and southernmost points are nearly as far apart as the Mexican and the Canadian boundaries of the United States.

GENERAL GEOGRAPHY.

The main mass of Alaska is nearly rectangular and is carved out from the continent by Mackenzie Bay on the north and the Gulf of Alaska on the south (see Pl. I). An extension to the southeast is furnished by the so-called panhandle of southeastern Alaska, and to the southwest by the Alaska Peninsula and the Aleutian Islands.

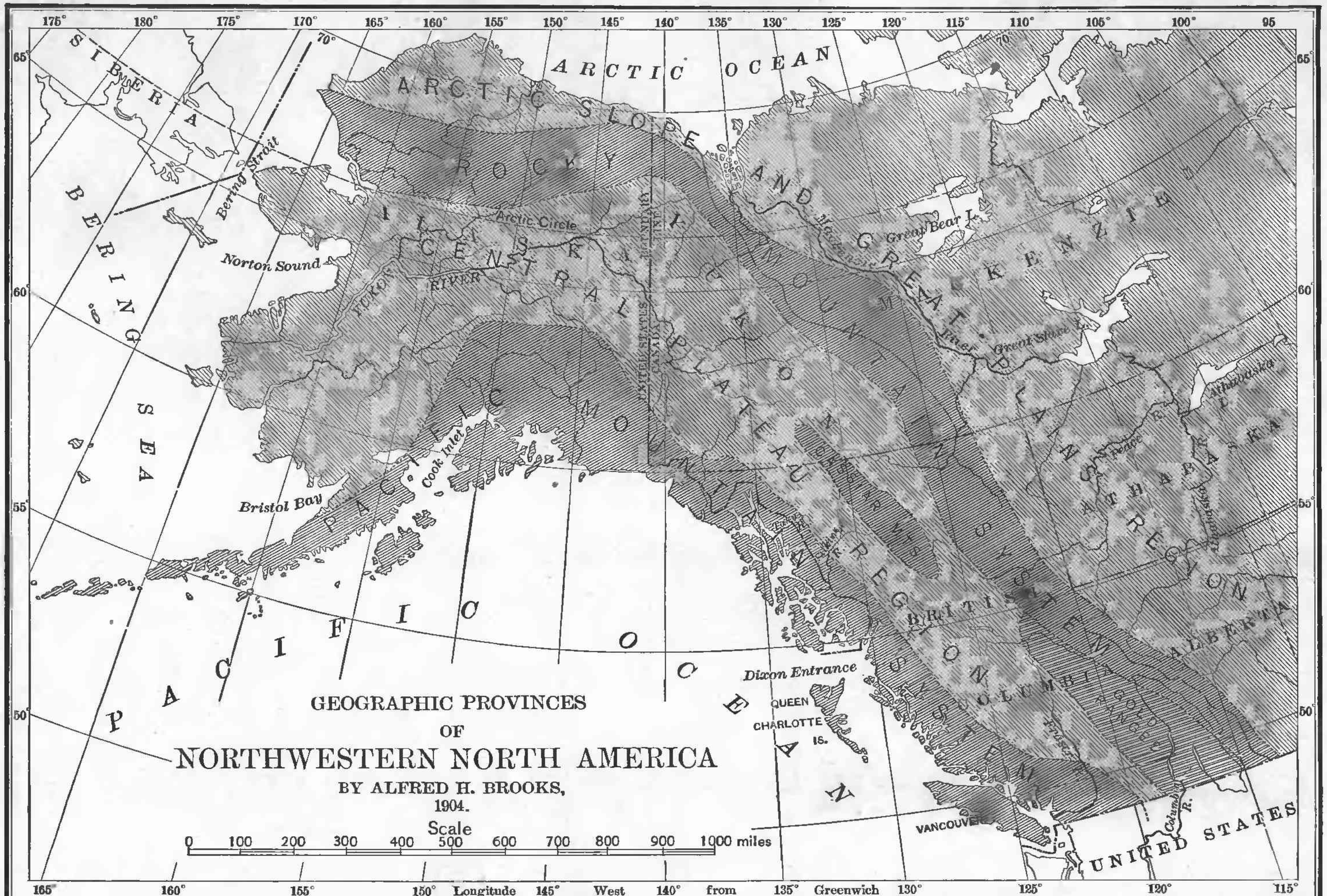
Alaska has three peninsulas of considerable size (Pl. XXXIV). The Alaska Peninsula stretches to the southwest, and with the archipelagoes beyond—the Aleutian Islands belonging to Alaska and the Commander Islands belonging to Russia—forms a broken barrier between Bering Sea and the Pacific Ocean. The Kenai Peninsula, which is much smaller than the Alaska Peninsula and lies farther east, is separated from the mainland by Cook Inlet on the west and Prince William Sound on the east, with Kodiak and the adjacent islands forming an extension to the southwest. The Seward Peninsula, whose extremity marks the westernmost point of the continent, extends from the central part of Alaska and is bounded on the north by Kotzebue Sound and the Arctic Ocean, and on the south by Norton Sound and Bering Sea. The Seward Peninsula and the Chuckchee Peninsula of Siberia, which are separated by Bering Strait, 60 miles in width, divide Bering Sea from the Arctic Ocean.

Around the Gulf of Alaska the Pacific coast line forms a deep reentering angle, the eastern leg of which borders the panhandle of the territory usually called southeastern Alaska, while the western leg is the shore line of the Alaska Peninsula. The axes of the dominant mountain ranges (Pls. I and VII) also undergo a marked change in direction, parallel to this crescentlike bend of the southern coast line (see p. 287). This bend is, indeed, the topographic record of an important structural feature.

The main topographic features of Alaska are similar to those of the western United States. The highlands of Alaska, like those of the United States and Canada, are in general parallel to the coast line, and the investigations of Doctor Dawson[a] and others have shown that the four topographic provinces of the United States are fairly well defined throughout western Canada and continue into Alaska. A broad, mountainous belt, designated by Major Powell[b] the Pacific Mountains, but here referred to as the Pacific Mountain system, including the Coast Ranges of California, Oregon, and Washington, the Sierra Nevada and the Cascade Range, extends along the western margin of the United States and continues northward into Canada. East of this lies the Central Plateau region, or Great Basin, as it is usually called. This is essentially a high plateau belt, though it contains mountain ranges, and it, too, finds its northern counterpart in British Columbia. The eastern limit of this plateau region is marked by a number of parallel ranges, grouped together under the name[c] Rocky Mountain system, which also, like the Pacific Mountain system, extend into Canada. To the east of the Rocky Mountain system are the Great Plains, which stretch northward to the Arctic Ocean. The lines of demarcation between these provinces are usually sharply drawn. Each is of a dominant topographic type, though each exhibits many minor topographic subdivisions.

Along the Pacific coast of Alaska and British Columbia is a mountainous belt 50 to 200 miles in width, which is the westernmost of the four provinces, and may be designated the "Pacific Mountain system." It properly includes the mountainous Alexander Archipelago and Aleutian Islands, as well as a number of other island groups. While this region is in the main rugged and mountainous, its ranges are distinct and often separated by broad valleys or indentations of the coast line, forming in several cases large basins, like that of the Copper River. Except for a section of the inner slope, which drains into the Yukon

[a] Dawson, G. M., On the later physiographical geology of the Rocky Mountain region in Canada: Trans. Royal Soc. Canada, vol. 8, sec. 4, 1890.
Geological record in the Rocky Mountain region in Canada: Bull. Geol. Soc. America, vol. 12, 1901, pp. 57-92.
[b] Powell, J. W., Physiographic regions of the United States: Nat. Geog. Soc., Mon. I, pp. 96-100.
[c] Major Powell terms these the Stony Mountains, op. cit., p. 100.


GEOGRAPHIC PROVINCES
OF
NORTHWESTERN NORTH AMERICA
BY ALFRED H. BROOKS,
1904.
Scale
0 100 200 300 400 500 600 700 800 900 1000 miles
Longitude West from Greenwich
ARCTIC OCEAN
ARCTIC SLOPE
ROCKY MOUNTAIN SYSTEM
CENTRAL PLATEAU REGION
PACIFIC MOUNTAIN SYSTEM
PACIFIC OCEAN
BERING SEA
SIBERIA
Bering Strait
Norton Sound
Arctic Circle
YUKON RIVER
Bristol Bay
Cook Inlet
Dixon Entrance
QUEEN CHARLOTTE IS.
VANCOUVER
UNITED STATES
BRITISH COLUMBIA
ALBERTA
ATHABASKA
Great Bear L.
Great Slave L.
Athabaska L.
Mackenzie
UNITED STATES
CANADA

and Kuskokwim, its waters reach the Pacific through streams flowing transverse to the axis of the mountains.

East and north of the Pacific Mountains is the Central Plateau region, corresponding in a broad way with the Central Plateau of the western United States and Canada. The term "plateau" can be assigned to only a portion of this province, and even that is not a plateau in strict sense. For the most part this region is a gently rolling upland, in which the rivers have trenched broad channels, and which is of low relief compared with the adjacent mountain ranges (Pl. XXX, *B*). The interstream areas are the remnants of a former plateau surface, which has been dissected by erosion, and whose rolling surface slopes gently to the north and west. The continuity of this plateau is broken by a number of mountains and mountain groups which rise above the general level, but these are of much less extent and relief than the similar features of the plateau region of the western United States and Canada. This belt is drained largely by the Yukon and Kuskokwim rivers into Bering Sea, and includes a number of lowland areas of considerable extent. Among these the flats of the middle Yukon and upper Kuskokwim and the lowlands which extend along Bering Sea adjacent to the deltas of the Kuskokwim and Yukon are notable.

East and north of the plateau province a broad cordillera forms the third of the geographic divisions, and is the northern extension of the Rocky Mountain system (Pl. II). The ranges of this division, like those of the Pacific Mountain system, also undergo a marked change in direction. As in the United States, they trend northwestward, but swing to the southwest at the Arctic shore, which they touch again north of Bering Strait. The drainage of the southern slopes of the mountains is chiefly tributary to the Yukon, while the northern slope drains into the Arctic Ocean.

The Great Plains east and north of the Rockies form the fourth province. In Alaska this province is represented by an area of low relief which lies between the western extension of the Rocky Mountains and the Arctic Ocean and is designated the "Arctic slope region." This area, like the corresponding one in the western United States, is really a slightly elevated plateau, which slopes to the north from the foothills of the Rocky Mountains (Pl. XXIX, *B*). It is dissected and more or less rolling, and its waters flow northward into the Arctic Ocean.

COASTAL FEATURES AND ISLANDS.

GENERAL DESCRIPTION.

Alaska's shores are washed by three great oceans—the Arctic on the north and northwest, Bering Sea on the west, and the Pacific on the south (Pls. VII and XXXIV). The northern Pacific is deep, and the coastal shelf bordering it is, as a rule, very narrow. Similar conditions prevail in the southwestern part of Bering Sea adjacent to the Aleutian Islands, which are elevated points on a narrow submarine ridge between the Bering Sea and the northern Pacific, and from which the coastal shelf sinks abruptly toward the west. On the other hand, that part of the Bering Sea adjacent to the mainland is shoal. The 100-fathom line enters the

Bering Sea near the eastern end of the Aleutian Islands and turns to the northwest, passing south of St. Matthew Island in the direction of the Siberian coast. As far as can be determined from the small number of soundings, this shoal continues along the Arctic coast, 30 or 40 fathoms being the limit of depth discovered (see Pl. I).

Thus, two distinct types of coastal topography are recognizable. Along the Pacific Ocean and the southern portion of Bering Sea the shores are rocky and abrupt, broken by countless indentations, and bordered by deep water close in to the land (see Pls. III, IV, *A*, and IV, *B*). In complete contrast are the coastal features of northern Alaska, where the Arctic Ocean and most of the Bering Sea are characterized by shoal water for a long distance from land, and by a low shore line with many straight, long, unbroken beaches (Pls. VI and XXX, *A*). While the southern coast, with its abrupt cliffs, towering snow peaks, and deep tidal waterways, offers an infinitely varied scenery hardly paralleled, the shores of Bering Sea and the Arctic Ocean, with their long stretches of sandy beach and flat exposure of treeless plains, are monotonous in the extreme.

SOUTHERN ALASKA.

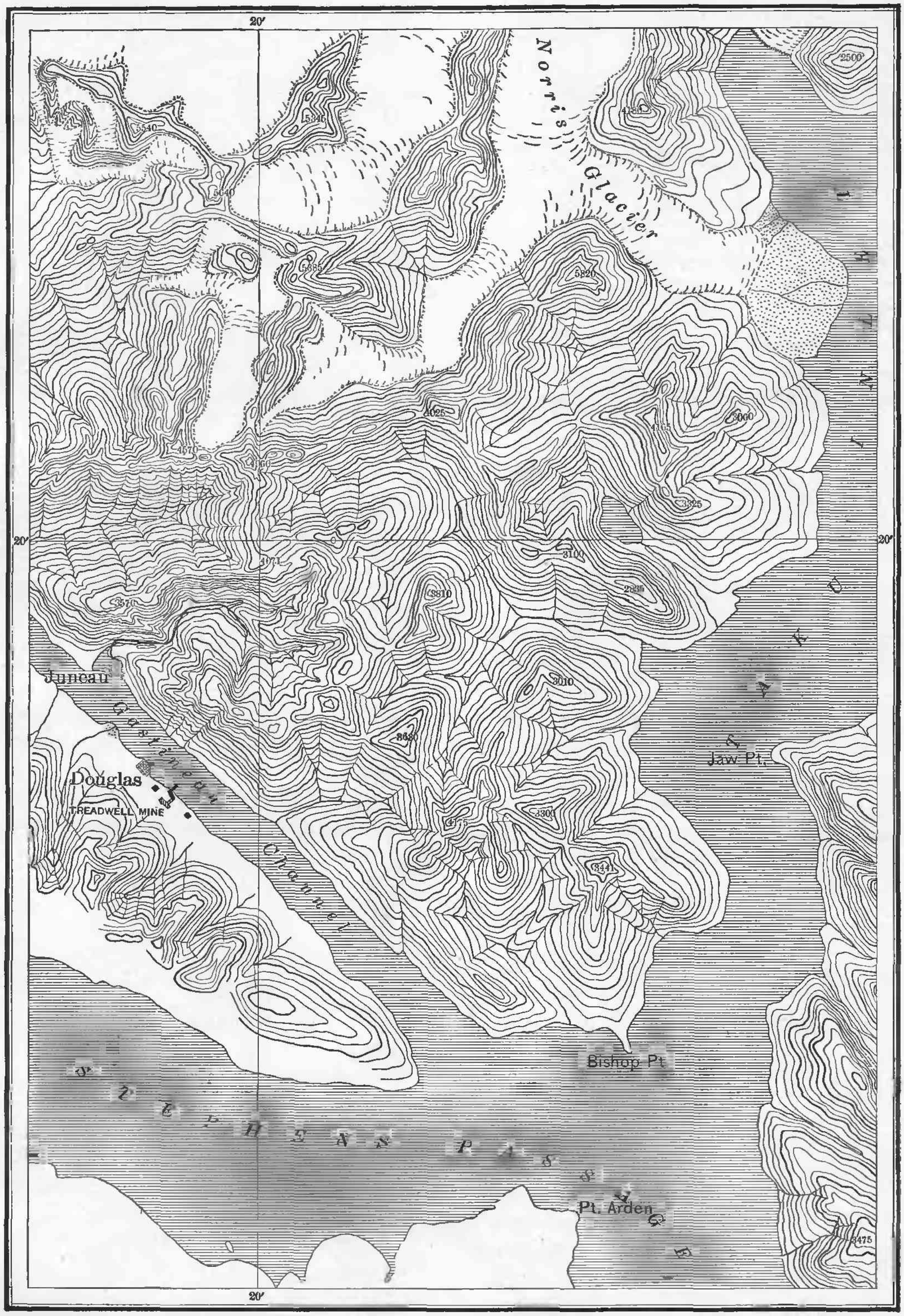
GENERAL FEATURES.

East and south of Bristol Bay and the Alaska Peninsula the shore topography is characterized by great irregularity; deep embayments penetrate the mainland, and many islands are separated by a network of rocky straits. From the narrow coastal shelf the sea bottom descends very rapidly to great depths, and the land rises steeply from tide water. The limit of wave action is usually marked by a rock bench or a narrow rocky beach, which is terminated inland by a cliff. This type of shore topography is well shown on the accompanying map (Pl. III) and photographs (Pls. IV, *A* and *B*, and V) of Gastineau Channel. It is characteristic of the whole Pacific coastal belt, including the Aleutian Islands, except the shores of Cook Inlet and a stretch of about 200 miles in the St. Elias region between Lituya Bay and the western limit of the Copper River delta, where the shore line is even and the land rises gently inland.

FIORDS OF SOUTHEASTERN ALASKA.

The southern coast of Alaska has the shape of a broad crescent which opens out to the Pacific Ocean. The southeastern horn of this crescent includes the Alexander Archipelago and its scores of islands, great and small, penetrated and separated by an intricate system of tidal waterways, some of which extend far inland and give the coast the fiord character which has made its scenery famous the world over. These channels (see Pl. XXXIV, in pocket) fall into two general systems, of which one trends approximately north and south, and the other about N. 70° W., though there are many variations from these courses. The largest of the fiords which penetrate the mainland are Glacier Bay and Lynn and Portland canals.

Glacier Bay stretches about 60 miles northward from Icy Strait. Its shores are broken by numerous embayments, fed by tide-water glaciers. The bay splits the southern end of the St. Elias Range into two parts, the southernmost of which



TYPICAL SHORE TOPOGRAPHY OF SOUTHERN ALASKA, GASTINEAU CHANNEL, AND TAKU INLET.

TOPOGRAPHY BY INTERNATIONAL BOUNDARY SURVEY

Scale

0 1 2 3 4 5 6 7 8 9 10 miles

1904

is known as the Fairweather Mountains. Forty miles east of Glacier Bay the mainland and the archipelago are cleft by a remarkably straight waterway known as Chatham Strait and Lynn Canal. This fiord extends nearly 175 miles from the open ocean, forking at its upper end into two branches, the western called Chilkoot and the eastern Taiya Inlet. For many miles the shores of Lynn Canal are bounded by steep rock walls, which often rise sheer from the water, and at its head the peaks of the Coast Range reach a height of 8,000 and 9,000 feet above the sea.

Portland Canal, which marks the southeastern boundary of Alaska, is a narrow waterway extending about 100 miles inland from Dixon Entrance. Unlike most of the other fiords, it is characterized by a number of large bends, but its general direction is northerly. Along its course, which lies chiefly through the Coast Range, the relief is between 5,000 and 6,000 feet.

In these fiords the sea bottom usually falls off abruptly close to land, often reaching a depth of 60 or 70 fathoms within a few yards (Pl. IV, *B*). The deepest soundings thus far made in these inland waterways register 300 to 400 fathoms, and depths of 100 to 200 fathoms are not uncommon. It is further evident that the contour of the ocean floor is often of a basinlike character.

The fiords which penetrate the mainland receive numerous glaciers from the large névé fields of the Coast and St. Elias ranges. Those of Glacier Bay are best known because they are each year visited by many tourists. Besides the tide-water glaciers, there are many others discharging into the tributaries of the channels.

ALEXANDER ARCHIPELAGO.

The largest islands of the Alexander Archipelago, beginning at the north, are Chichagof, Baranof, Admiralty, Kupreanof, Kuiu, Prince of Wales, Etolin, and Revillagigedo. The longer axis of nearly all these has a northwest-southeast direction, and they all possess strong relief, bold coast, and irregular shore lines. Chichagof and Baranof, in the northern end of the archipelago, are cut off from the mainland by Cross Sound and Icy Strait, and from the islands on the east by Chatham Strait. Together they form a wedge-shaped land mass which is split into two islands by Peril Strait, a winding waterway whose hidden rocks and strong tidal currents give it its well-merited name. The islands are mountainous, with a relief of 3,000 to 5,000 feet, and their axis is in line with the axis of the St. Elias Range to the northwest. Kruzof, a small island adjacent to Baranof on the west, is of interest because it contains Mount Edgecumbe, the only volcano of southeastern Alaska.

Admiralty Island, east of the two above described, is long and narrow, with rugged highlands, which may also be considered a southern extension of the St. Elias Range. On the east Stephens Passage separates it from the mainland, and on the south Frederick Sound divides it from a group of islands, the largest of which are Kupreanof and Kuiu. These two have less relief and are especially characterized by great irregularity of shore line. In fact, the many channels and embayments which cut into Kuiu Island give it the form of a dendritic land mass. Mitkof Island lies southeast of Kupreanof, from which it is separated by Wrangell Narrows, next to Peril Strait the most dangerous of the passages used by vessels.

South of Sumner Strait the Alexander Archipelago is divided by Clarence Strait into the Prince of Wales group on the west and the Revillagigedo group on the east. Prince of Wales Island,[a] the largest of the archipelago, is about 140 miles long and 40 miles wide. Its coast line is broken by many deep embayments, and where these lie opposite each other the width of the island is reduced to but a few miles. These opposing fiords are, in some instances, connected by broad depressions, with low divides. The relief of the island varies from 1,500 to 3,600 feet. The mountains, the highest of which reach an altitude of 3,600 feet, form no well-defined ranges, but have a general northwest-southeast linear arrangement.

In topographic relief and geographic position the Revillagigedo group of islands properly forms a part of that irregular mountain mass known as the Coast Range; their highlands have the same general trend and reach an altitude of 3,300 feet.

The traveler who threads his way among the waterways of the Alexander Archipelago will gain the impression that the region is one of strong relief, with practically no lowlands or flat valley floors; but this is true only in part. Along the water courses are many valleys with broad bottom lands, while at the mouths of the largest rivers are extensive lowlands, formed by flood plains.

At the coming of the white man southeastern Alaska was inhabited by the Thlinkits and Haidas, native tribes which had developed a higher degree of civilization than any others of Alaska. These held not only the islands but also portions of the mainland, and were dependent for food on the abundant game and fish. In their large dugout canoes, fashioned of cedar, they made extensive journeys on the inland waterways. They were physically and mentally superior to the natives of the interior, and held them more or less in subjection, not permitting them to come to the coast. Later, when the white traders had established themselves, these coast natives became the middlemen for the trade with the interior, which was very lucrative until the English established themselves on the Yukon. Regarding this as an invasion of their territory they made a marauding expedition in 1852 and burned Fort Selkirk, one of the English posts established at the junction of the Pelly and Lewes rivers a few years before.

These natives were the last of the coastal tribes with which the Russians came in contact, and were never subjected by them. Baranof Island was selected for the first Russian settlement in the archipelago, and subsequently for the site of their capital, New Archangel, now known as Sitka. As southeastern Alaska was the most accessible region of the territory, it was the first to have its mineral resources developed. It now possesses a dozen centers of active mining operations, and has a larger permanent population than any other part of the territory. Next after mining, its most important industry is furnished by the salmon fisheries.

CROSS SOUND TO PRINCE WILLIAM SOUND.

Between Cross Sound and the mouth of the Copper River the coast line trends northwest to southeast with comparatively even outline. Lituya Bay, about 40 miles northwest of Cross Sound, a T-shaped indentation, is connected with the ocean

[a] Prof. Paper U. S. Geol. Survey No. 1, 1902, pp. 35-37.

by a narrow channel. The most extensive embayment along this portion of the coast is Yakutat Bay, which is shaped like a funnel. From the upper end of Yakutat Bay a long arm, known as Disenchantment Bay, stretches to the southeast. The southern portion of this arm is separated from the ocean by a broad morainic flood plain that receives a number of large glaciers from the St. Elias Range (Pl. XXIII, *B*).

Near the mouth of the Copper River the coast line bends abruptly to the northwest, and the shallow embayment thus formed is known as Controller Bay. Between Controller Bay and the ocean is Kayak Island, which is probably the point in Alaska first reached by white men (p. 107). Kayak Island and the adjacent Wingham Island have comparatively low relief, as has also Middleton Island, which has an area of only a few square miles and lies about 50 miles to the southwest in the open ocean.

At Copper River delta is a broad lowland and shoal waters extend for some distance seaward, but westward the shores are again abrupt and the waters deep. Prince William Sound, whose entrance lies about 50 miles west of the mouth of the Copper River, has a very irregular outline. Its channels and fiords penetrate far into the Chugach Mountains, from which they receive many glaciers, and the surface rises rapidly from sea level to 6,000 and 7,000 feet. The sound contains numerous islands, the largest of which, Montague and Hinchinbrook, separate it from the open sea. The coast line has the same character along the southern margin of the Kenai Peninsula.

COOK INLET.

Cook Inlet, the largest embayment of the Pacific coast line, stretches northeasterly about 150 miles and then makes an abrupt bend, continuing eastward about 30 miles under the name of Turnagain Arm. The shores of the latter are abrupt and rocky, but along Cook Inlet the coastal relief is more gentle. The northern end is bounded by the broad flats of the lower Sushitna River, and its eastern shore is formed by a plateau 300 to 400 feet high, which slopes westward from the base of the Kenai Mountains.

A broad gravel plain 75 to 150 feet high extends northwest of the upper end of the inlet, and plain and plateau present to the water front steep escarpments, at the foot of which there is a beach of varying width. On either side of the entrance to the inlet the shores are abrupt and more or less irregular. A small island in this part contains the beautiful Augustine Volcano (see Pl. X, *A*).

SOUTHWESTERN ALASKA.

A group of islands is cut off from the mainland by Shelikof Strait. Kodiak, which is about 100 miles long and 40 miles wide, is the largest of these and also one of the largest islands of Alaska. It is characterized by comparatively low relief—not more than 3,000 or 4,000 feet—and many broad, open valleys with gentle slopes. These highlands have been described as a southern extension of the mountains of the Kenai Peninsula. On the southeastern shore of this island the

Russians (p. 110) made their first permanent settlement in Alaska, in 1783. North of Kodiak lies Afognak Island and innumerable smaller ones.

Southwest of Kodiak the shore line has the same broken character as along Prince William Sound, and usually rises rapidly to the slopes of the Aleutian Range. In the extended axis of the Kodiak group lie three small clusters of islands known as the Semidi, the Shumagin, and the Sannak islands, all of strong relief and irregular shore lines.

ALEUTIAN ISLANDS.

This archipelago, the most extensive of Alaska, stretches from the extremity of the Alaska Peninsula 1,200 miles toward the Siberian coast. Its axis at first trends about 70° south of west, but turns near the one hundred and seventy-ninth meridian into a direction 70° north of west. The islands lie in a belt 20 to 50 miles in width, and their shore line has the same irregularity that characterizes most of the Pacific coast. The relief is greatest near the eastern end of the archipelago and decreases to the west. Little is known of this chain with the exception of its eastern end, which has received more attention because it lies on the steamer route to the Bering Sea and Arctic Ocean.

Unimak, the easternmost of the chain, is separated from the mainland by a very narrow strait and from the rest of the group by Unimak Pass, which is the usual thoroughfare of vessels bound for the northern Bering Sea. It is about 70 miles long and 25 miles wide, and contains at least two active volcanoes, the highest of which is Shishaldin, which has an altitude of 8,000 feet. The largest of this group, Unalaska, is of importance, because it contains a coaling station and the port for north-bound vessels. Its highest point is Makushin, a volcano about 4,000 feet in altitude. So little is known of the islands to the west that it is hardly worth while to mention them individually. The westernmost group, better known as the Near Islands, marks the western limit of Alaskan territory.

The Aleutian Islands are still occupied by an aboriginal population, though the ravages of the Russian fur traders at one time threatened to almost exterminate it. These natives make their way from one island to another in their skin boats, which are similar to those used by the Eskimos. They have depended for their living chiefly on the capture of the valuable sea otter, but this animal is now threatened with entire extinction.

NAVIGATION.

The coastal navigator of southern Alaska can in clear weather usually locate himself by some mountain peak or headland, and will find deep water close to shore. When fogs prevail, the many rocky islets and barriers studding the channels and inlets are, even when charted, a constant menace. The enormous tide of this part of the Pacific forms an additional source of peril, as when confined to narrow waterways it produces strong tidal rips dangerous to encounter in rocky channels. The abundance of good harbors along this coast, however, offers ready shelter from storms.

NORTHERN ALASKA.

GENERAL FEATURES.

The coast features of the southeastern shore of Bering Sea are similar to those of southern Alaska, but north of Bristol Bay and the Alaska Peninsula shallow water is usually found near the land. The shore line is very regular, and the slope of the shallow sea floor is preserved by the land shelving gently from the sea. In many places the surface rises inland by a series of terraces. The characteristic topographic features are bold headlands connected by crescent-shaped beaches with even shore lines, which are sometimes almost straight and uninterrupted for many miles (see Pls. VI and XXX, *A*). An abrupt escarpment often marks the limit of wave action, and where there has been a series of recent elevations, a succession of benches gives an échelon type of topography to the coastal zone. Occasionally a terrace broadens out to many miles in width, forming a coastal plain. This is well illustrated by the map of the western end of the Seward Peninsula (Pl. VI), and the photograph of part of the same general region (Pl. XXX, *A*).

Another typical feature of the northern coast line is the barrier beaches which are built up by the surf in shallow water. These beaches extend parallel to the general trend of the coast and are usually separated from the mainland by shallow salt-water lagoons. In some instances such lagoons form almost continuous waterways for many miles along the coast and are used as routes of communication by the natives when the open sea is too rough for their skin boats.

While these types of coastal topography are dominant they are by no means the only ones to be found. For example, the Seward Peninsula contains at least one tidal inlet, Imuruk Bay, which has the bold shore line characteristic of the indentations so common on the Pacific coast.

BERING SEA COAST.

Bristol Bay, a deep indentation of triangular outline bounding the Alaska Peninsula on the north, is practically the meeting place of the northern and southern coastal types; in outline it resembles the southern, while in detail it conforms to the northern. It is split at its upper end into two minor bays, which are unnamed. Among the margins of these embayments low gravel beaches slope up to coastal plains. To the northwest a smaller indentation, which has received the name Kulukak Bay, is cut off from Kuskokwim Bay on the north by a minor peninsula, whose highlands are part of the Ahklun Mountains (see p. 38, Pl. VII).

From Kuskokwim Bay northward the deltas of the two greatest rivers of Alaska—the Yukon and Kuskokwim—present to the sea a front of over 300 miles, in the form of a low coastal plain (pp. 39 et seq.). The coast line here bends to the northeast and between the Yukon Delta and the southern shore of Seward Peninsula is the great embayment of shoal water known as Norton Sound. Fifty miles northeast of the Yukon Delta lies a small group of islands, on the largest of which—St. Michael—is the port where transfers are made from the ocean steamers to the steamers which ply on the Yukon River. The upper end of the sound, because contracted by a minor peninsula on the south, is known as Norton Bay.

The southern coast of Seward[a] Peninsula is broken by Golofnin Bay and Port Clarence with its several arms; the northern, by a succession of lagoons, of which the largest is known as Shishmaref Inlet. The following description is quoted from the report cited:

"Two kinds of shore-line topography can be differentiated—one characterized by a low coastal plain, with many lagoons and sand spits; the other by bold cliffs that rise abruptly from the sea or from a narrow, rocky beach. Broadly speaking, the coast topography of the western half of the peninsula is mainly of the first description, while that of the eastern half is more bold and rocky.

"The lower part of Golofnin Bay is bounded on both sides by rocky cliffs, with narrow, shelving beaches. The precipitous character of the coast extends westward for about 30 miles, until near Topkok Head the escarpment recedes inland and a coastal plain intervenes between the uplands and the water line. This coastal plain broadens rapidly westward, until at Port Safety it attains a width of about 12 miles. Thence, sweeping around behind the highland that forms the blunt, rocky headland known as Cape Nome, it continues westward with gradually decreasing width to Rodney Creek, where the escarpment that marks the beginning of the highlands is not more than half a mile from the sea. Between Cape Nome and Topkok the continuity of the shore line is broken by large lagoons and other similar bodies of water. West of Cape Nome the shore line, as far as Cape Rodney, is almost straight and uninterrupted save for the tidal inlets at the mouths of the larger rivers. This coastal plain is nearly level, sloping gently toward the sea, here and there interrupted by an escarpment and carried to a higher level by a well-marked bench.

"From Cape Rodney the coastal plain is of varying width, including numerous salt-water lagoons and lakes. At Port Clarence it runs out into a long, narrow sand spit embracing the harbor. Inside of this sand spit the eastern shore of Port Clarence presents a bold wall of cliffs, with only here and there a crescent-shaped beach.

"As both Grantley Harbor and Imuruk Basin are subject to the ebb and flow of tides, their shore lines must be considered part of the coast line. Two narrow sand spits, between which a deep channel is kept open by the tide, separate Grantley Harbor from Port Clarence, and a narrow, winding canal with steep rock walls connects it with Imuruk Basin. From the southern shore of Imuruk Basin the Kigluaik Mountains rise abruptly, almost from the water's edge. At the upper end of the basin and encircling it on the north is a flat, swampy plain, pitted with water bodies large and small, the partially filled portion of the greater depression which the basin once occupied.

"Along the open coast on the north side of Port Clarence is a low plain which includes a lagoon about 20 miles long. To the west, near Cape York, cliffs rise abruptly from the water, with only an occasional small beach. These cliffs are unbroken except by stream valleys and at York, where there is a small crescent-shaped plain half a mile in width between the upland and the beach.

"From Cape Prince of Wales to Shishmaref Inlet the coast line is not marked by any escarpment, and a gently sloping plain extends for some distance inland. In

[a] Brooks, Alfred H., Reconnaissance in Cape Nome and adjacent gold fields, U. S. Geol. Survey, 1901, pp. 49-51.

A. VIEW DOWN GASTINEAU CHANNEL FROM MOUNT JUNEAU.

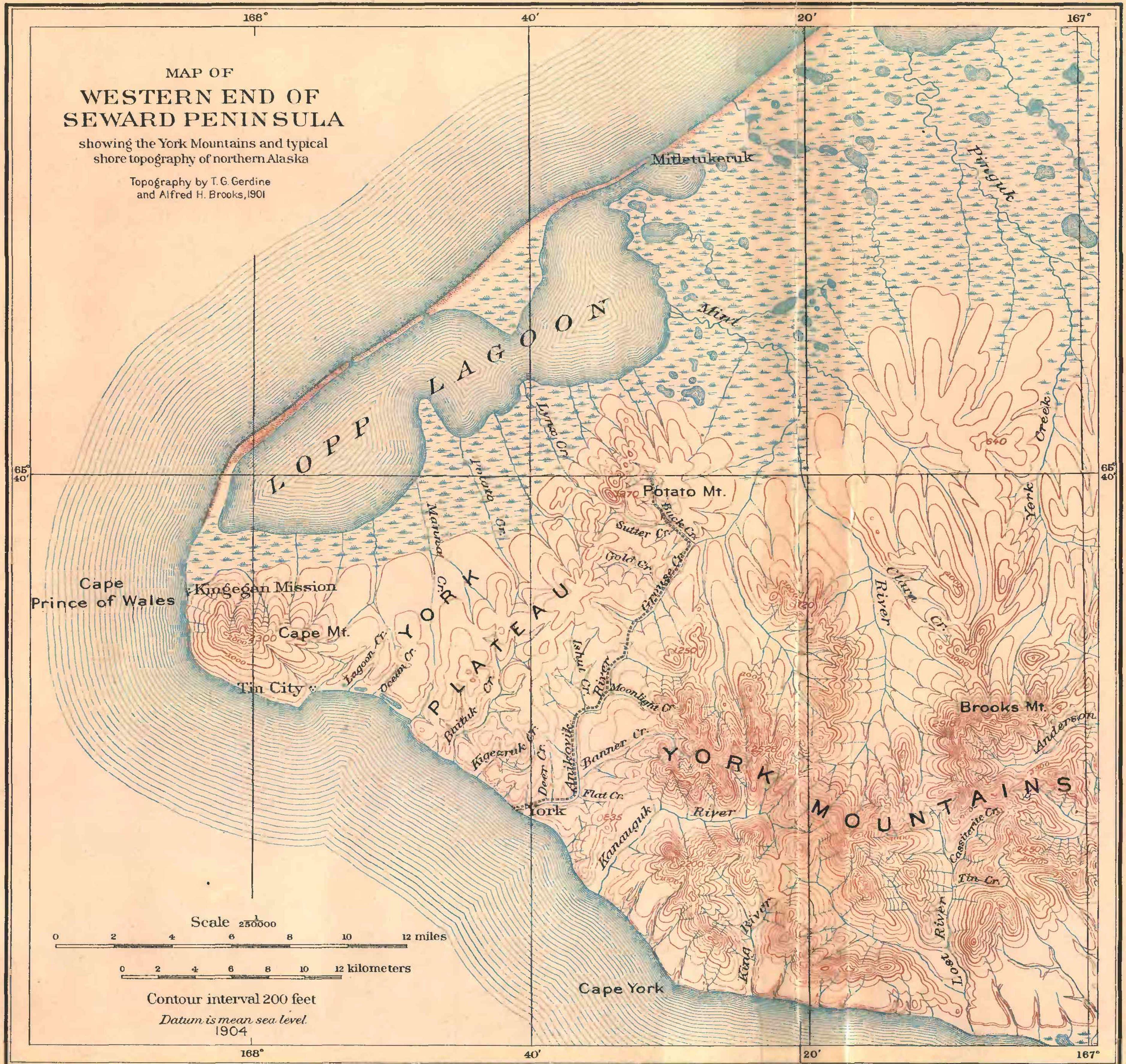
Showing typical shore topography of southern Alaska.

B. HUNTER BAY, PRINCE OF WALES ISLAND.

Illustrating deep-water conditions close to land.

GASTINEAU CHANNEL AND JUNEAU.

Showing abrupt slope from tide water.



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this plain are narrow salt lagoons and lakes, one near Cape Prince of Wales being about 20 miles in length. An abrupt escarpment is said to bound the water from Shishmaref Inlet nearly to Cape Espenberg, but the cape itself is a low sand spit."

ARCTIC OCEAN COAST.

Cape Espenberg, the northernmost point of the Seward Peninsula, and Cape Krusenstern, to the northeast, mark the entrance to Kotzebue Sound, the largest indentation of the Arctic coast line of Alaska. This body of water has a fairly even shore line on the south, but on the east is broken up into numerous embayments, of which Hotham Inlet and Eschscholtz Bay are the largest. The following description is quoted from Mendenhall:[a]

"The long, slender peninsula separating Hotham Inlet from the main waters of Kotzebue Sound has but little relief; in the northern part, where it is broadest, heights of but 300 to 400 feet are reached. Long stretches of shore stand at about the level of extreme high tide, and the occasionally recurring shore bluffs of sand, clay, and frozen muds do not run generally more than 100 feet above mean-tide level. Choris Peninsula, the highest point of this long spit, has its summit 360 feet above the water. Along the southern shores of Kotzebue Sound low sea cliffs and flats alternate, the latter marking the outlets of streams. Rounded ridges and hills, sometimes reaching heights of 1,200 to 1,300 feet, but usually lower, extend inland and separate the wide, flat river valleys. The Kiwalik, Swan (Kugruk), Ipnechuck [Inmachuk], and Goodhope rivers are the principal streams entering the sound from the south. The Buckland River, larger than any of these, flows into Eschscholtz Bay from the southeast."

A low coast line, with long stretches of sandy beaches diversified by lagoons and tidal inlets, stretches northwest from Kotzebue Sound to Point Hope, a jutting sand spit, then turns due north for 100 miles to Cape Lisburne, and bending at right angles extends due east for 60 miles. While this shore line is low, hills, some of them mountains in height, are not far inland. These are the terminations of the great Rocky Mountain system, which stretches through the western United States (Pl. II), Canada, and northern Alaska.

After this easterly trend the coast curves broadly to the northeast and continues in the same general direction to Point Barrow, the northernmost cape of the continent. To about Cape Beaufort the character of the coast is determined by an upland region, which is probably part of the plateau adjacent to the Rocky Mountains on the north and which extends almost to the sea. Near Cape Beaufort this upland falls off to a lower upland, which extends northward for several hundred miles and ends in an escarpment, marking the southern end of the coastal plain proper. Throughout this region a sandy beach and narrow coastal plain intervene between the upland and the sea.

The coastal plain of the north Arctic slope has already been described as lowland, which, sloping gently to tide water, is extended seaward by the shallow ocean bottom. It fronts the entire north Arctic coast, from near Cape Belcher to the

[a] Reconnaissance from Fort Hamlin to Kotzebue Sound: Prof. Paper U. S. Geol. Survey No. 10, 1902, p. 27.

international boundary. The actual shore line is characterized by long stretches of crescent-shaped, sandy beaches, often cut off from the mainland by large lagoons. Considered in detail, it is very regular, yet the contour as a whole follows many variations; broad embayments, some of which run far inland, alternate with sand spits or low forelands, giving the coast a cusped aspect. The mouths of the larger rivers are marked by indentations, and even where there are no considerable tributaries the shore line is frequently broken. Small, low islands, sometimes in short chains, in places lie close to land.

As this north shore line has not yet been surveyed in detail, no more than a general description of it is possible. Of the characteristic indentations mentioned Dease Inlet, a deep bay into which Chipp River empties, is 20 miles southeast of Point Barrow, and with Smith Bay on the east cuts out a minor peninsula of the coast. Still farther east lie Harrison, Gwydyr, and Camden bays and Yarmouth Inlet.

NAVIGATION.

This northern type of shore line presents both advantages and disadvantages to navigation. The rocky reefs and barriers, which are so dangerous to vessels on uncharted waters, are uncommon; but, on the other hand, the low coast line affords the navigator few points of recognition, and he is likely to encounter shoal water out of sight of land. The most serious drawback, however, is the almost utter lack of good harbors. At Nome the absence of shelter from southerly storms has within the past four years caused the loss of hundreds of thousands of dollars in vessels and cargoes. The rise and fall of tides in the Arctic Ocean and Bering Sea is compartively small, so that, as the even shore line offers few narrow straits, this coast is comparatively free from strong tidal currents.

ISLANDS.

The Alaskan islands of the Arctic Ocean are too insignificant to be worthy of note, but those of Bering Sea are numerous and often of considerable importance. Several of these, though belonging to Alaska—as some of the Aleutian chain for instance—are far distant from its shores.

Bering Strait, like the waters which it connects, is comparatively shallow, with a maximum depth of about 32 fathoms. The strong current[a] drawing through it to the north is probably the cause of its remaining open during the winter, when the seas which it connects are covered with ice, for such records as are available go to show that the strait is very seldom frozen over.

In the middle of Bering Strait, on either side of the boundary between Alaska and Siberia, rise the Diomede Islands, the smaller, Little Diomede or Krusenstern, belonging to Alaska, and the larger, Big Diomede or Romanzof, to Siberia. Both have steep shores rising to flat-topped summits, which occupy nearly their entire areas. The eastern or Alaska channel of the strait has a width of about 30 miles,

[a] Jarvis, D. H., Alaska coast pilot notes on the Fox Island passes, Unalaska Bay, Bering Sea, and Arctic Ocean as far as Point Barrow: Bull. U. S. Coast Survey, No. 40, p. 53.

while the western or Siberian is somewhat narrower. Fairway Rock, a flat-topped pinnacle with an area of several acres, lies in the eastern channel.[a]

About 50 miles due south of Cape Prince of Wales is King Island. This islet, which is little more than a double-peaked hill only a few square miles in extent, rises about 600 feet above sea level, and so steep are the slopes that the scanty Eskimo population has developed a form of hillside dwelling partly supported on poles. Its steep, rocky shores are broken only here and there by beaches, where landings can be made.

St. Lawrence Island, about 150 miles south of Bering Strait, is about 100 miles long by 10 to 30 miles wide. It is mountainous, the higher peaks reaching altitudes of probably 2,000 feet, and the shores rising by an abrupt escarpment from a narrow beach. It has a considerable Eskimo population, which communicates with the mainland by means of large skin boats, called "oomiaks."

St. Matthew and Hall islands, which lie 170 miles southwest of St. Lawrence, deserve only passing mention. They are small, of rather low relief, and have no particular importance. Almost due east of the last-mentioned islands is Nunivak Island, which is cut off from the mainland at the Yukon delta by Etolin Strait. This is a large island of low relief, chiefly notable because it is a serious menace to navigation, as it lies near the track of vessels bound for Nome.

From a commercial standpoint the most important islands in the Bering Sea are the Pribilof Islands, which lie well out in the Bering Sea southwest of Nunivak and nearly 500 miles south of Cape Prince of Wales. Besides some smaller rocky islets and reefs the group includes St. Paul and St. George, two islands of low relief and gently sloping shores. The great importance of the Pribilof Islands is due to the fact that they are the breeding ground of the fur seals. The estimated value of the fur-seal catch, from the purchase of Alaska to 1901, aggregated $35,000,000.[b]

In 1870 the islands became, by Congressional enactment, a Government reservation, on which the right to kill fur seals is sold to the highest bidder. The ravages of the Canadian pelagic sealing vessels in this neighborhood has led to the long seal-fishery controversy with England.

OROGRAPHIC FEATURES.

INTRODUCTION.

It has been shown that Alaska is geographically divisible into four provinces, which can be regarded as northerly extensions of similar provinces in the western United States and Canada. Naming them from south to north, they are the Pacific Mountain system, the Central Plateau region, the Rocky Mountain system, and the Arctic Slope region (Pl. VII). Of these the first, adjacent to the southern coast, has the greatest relief, as it embraces several of the highest mountains on the

[a] Projects for the connection of Alaska and Siberia by railway are current in periodical literature. Such a railway would require a tunnel in four sections. The easternmost, connecting Cape Prince of Wales with Fairway Rock, would be 20 miles in length. The next, to Krusenstern Island, would have a length of 10 miles. The third section, to Romanzof Island, would be comparatively short, while the fourth, joining Romanzof Island and the Siberian coast, would be at least 25 miles long. The ferry connection between the two continents would be impracticable in winter because the ice floes that are swept through the strait during half the year make it entirely unnavigable.

[b] Austin, O. P., Commercial Alaska in 1901: Summary of Finance and Commerce, Treas. Dept. Bur. of Stat., May, 1902, p. 3943.

continent, while the Arctic Slope region, the northernmost of the provinces, is the one of lowest relief. Broadly speaking, all of the orographic features decrease in altitude toward the north and west.

PACIFIC MOUNTAIN SYSTEM.

GENERAL RELATIONS.

The Pacific Mountain system embraces a broad zone of ranges, and stretches parallel to the southern coast line of Alaska, forming, like it, a reentrant angle, or, more properly, a curve concave toward the south. The system is broadest near the apex of the angle, narrowing toward the southeastern boundary of the territory on one hand and toward its southwest limit in the Alaska Peninsula on the other.

Besides numerous inferior tranverse lines of height, this system embraces four important ranges, whose extended axes are approximately parallel to each other and to the general trend of the coast line (see Pl. VII). Of these the Coast Range, the St. Elias Range, and the Aleutian Range lie adjacent to the coast, while the Alaska Range is inland and forms the northern border of the system.

In British Columbia the system embraces only the Coast Range, unless the highlands of Vancouver Island[a] be regarded as a distinct range. This simplicity of structure is continued for about 900 miles northward as far as Lynn Canal, but west and northwest of this point the system becomes more complex and embraces two or three distinct ranges, separated in some instances by broad valley basins, in addition to other subordinate mountain masses.

COAST RANGE.

The Coast Range extends from near the boundary of Washington northward through British Columbia into southeastern Alaska, where it lies partly in Alaska and partly in Canadian territory. Following the coast line for nearly 900 miles, it passes inland behind the St. Elias Range near the head of Lynn Canal. Thence it can be traced northward, decreasing in altitude and gradually losing definition until it finally merges with the interior plateau near Lake Kluane in longitude 138° 30′.

This range has no well-defined crest line, but is rather a complex of irregular mountain masses, occupying a coastal strip between the Pacific Ocean and the Central Plateau region. Both Hayes[b] and Dawson[c] have called attention to the uniformity of the summit levels between altitudes of 5,000 and 6,000 feet in Alaska, and 8,000 and 9,000 feet in British Columbia, which, viewed from a similar altitude, gives the range the appearance of a dissected plateau (Pl. XXVIII, *A*). This feature will receive further consideration in the discussion of the topographic development (p. 287).

The limits of the Coast Range are not always sharply defined, as in many places it merges with the Central Plateau, and on its seaward side is sometimes

[a] Dawson differentiated the Coast Range from the Vancouver Range, a subdivision which the writer does not deem justifiable. Trans. Royal Soc. Canada, 1890, vol. 8, sec. 4, p. 4.

[b] Hayes, C. W., An expedition through the Yukon district: Nat. Geog. Mag., vol. 4, 1892, p. 128.

[c] Dawson, G. M., Report on the area of the Kamaloops map sheet, British Columbia: Ann. Rept. Geol. Survey Canada, new series, vol. 7, 1894, p. 10 B.

not clearly differentiated from the mountains of the Alexander Archipelago. It has a width of about 100 miles near Fraser River, which decreases to about 50 miles near Lynn Canal.

Considerable areas on the coast side of the range are drained by the Taku and Stikine, two large rivers flowing seaward transverse to its axis; while the Unuk, a smaller river following a similar course, probably receives some of the inland drainage. On the seaward face of the range most of the drainage is carried to salt water by many small streams that flow through sharply cut valleys, and have their sources in glacial cirques, which are frequently still occupied by ice. The larger streams of this class, such as the Skagway and Dyea rivers, occupy typical U-shaped glaciated valleys. The range is often indented and interrupted by the many tidal waterways already described (see pp. 18–20).

The sea slope of the Coast Range has a heavy precipitation, which falls chiefly as snow in the higher valleys and on the mountains, but near sea level in the form of rain. In Alaska the lower reaches of the Pacific slope are heavily forested with spruce, hemlock, cedar, and alder (see Pl. XII). The upper limit of thick timber, which is about 4,000 feet near Dixon Entrance, descends northward until near Lynn Canal it is about 3,000 feet. The inland slopes of the range, except where broken by broad valleys, have a low precipitation.

ST. ELIAS RANGE.

The name St. Elias Range[a] has usually been applied to the rugged mountain mass along the coast of Alaska between Cross Sound and Mount St. Elias. Here the name is given a broader significance and includes the Chugach, Kenai, and Skolai mountains, which are orographically a western extension of the St. Elias Range. The mountains of the Alexander Archipelago are properly a southeastern extension, but as they are separated from the mainland and divided into different groups by broad tidal waterways they can hardly be included under the same name.

Thus defined, the St. Elias Range extends northwesterly from Cross Sound, bends westerly near the mouth of the Copper River, and near the head of Prince William Sound, in longitude 147°, turns sharply southwest and merges into the highlands of the Kenai Peninsula. Near the one hundred and forty-second meridian the chain is parted by the valley of the Chitina River into two divergent ranges. The southernmost, here called the Chugach Mountains, forms the main range across the head of Prince William Sound. The northernmost, under the name of the Nutzotin Mountains, stretches westward and forms a connecting link between the St. Elias and Alaska ranges.

The St. Elias Range is a rugged mountain mass throughout its extent, varying in width from 50 miles near Cross Sound to nearly 100 miles at Mount St. Elias, and then narrowing down to less than 20 miles to the southwest in the Kenai Peninsula.

Near Cross Sound some peaks of the Fairweather group rise abruptly from tide water to altitudes of over 15,000 feet. Westward the range increases

[a] There seems to be no warrant for the term "St. Elias Alps," used by some writers.

in height and complexity, culminating in Mount St. Elias (Pl. VIII, *A*) and Mount Logan, 18,024 and 19,500 feet in height. Here the mountain front is 20 to 30 miles from the coast, and the intervening space is occupied by a series of foothill ridges, or a shelving coastal plain, in many places covered by huge glaciers. This part of the range, as yet practically unexplored, consists of a complex of rugged peaks, with intervening valleys and depressions deeply buried in glacial ice and snow. Russell, who viewed it from the upper slopes of Mount St. Elias, describes it as "a vast snow-covered region, limitless in expanse, through which hundreds and probably thousands of barren, angular 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."[a]

From Cross Sound to the Copper River the St. Elias Range forms a rugged coastal barrier, broken only by the broad valley of the Alsek River. As far as known, there are no passes through this part of the range, except some high divides occupied by glaciers.

West of St. Elias the southern fork, called the Chugach Mountains, stretches parallel to the coast, skirting the northern shore of Prince William Sound, then bending to the south merges into the lesser heights of the Kenai Mountains (Pl. VII). This range, like the one to the east, is a complex mountain mass about 50 miles in width, whose peaks reach altitudes of 8,000 to 10,000 feet. It is broken near the one hundred and forty-seventh meridian by the valley of the Copper River, and farther west by several gaps, the lowest of which, called Thomson Pass, is the one used by the military trail which leads into the Copper River Valley from the coast. To the east the Chugach Mountains are practically unbroken. There is said to be a pass about 4,000 feet in height near the head of the south fork of the Chitina, but it has not been explored. The summits of these mountains, like those of the Coast Range, have a generally uniform altitude[b] (Pl. XXVIII, *B*).

The Talkeet[c] Mountains form a minor range lying to the northwest of the Chugach Mountains, from which they are separated by the valley of the Matanuska River (Pl. VII). On the north they are cut off from the Alaska Range by eastern tributaries of the Sushitna. To the east they fall off rapidly to the Copper River Plateau and to the west to the Sushitna River lowland. They are an isolated highland mass, which belongs to neither the Chugach nor the Alaska mountains and whose highest peaks, according to Mendenhall, probably reach altitudes of 5,000 to 6,000 feet.

A description of the Copper River Plateau properly belongs elsewhere, but this name is applied to the broad, flat basin which is drained by the Sushitna and Copper

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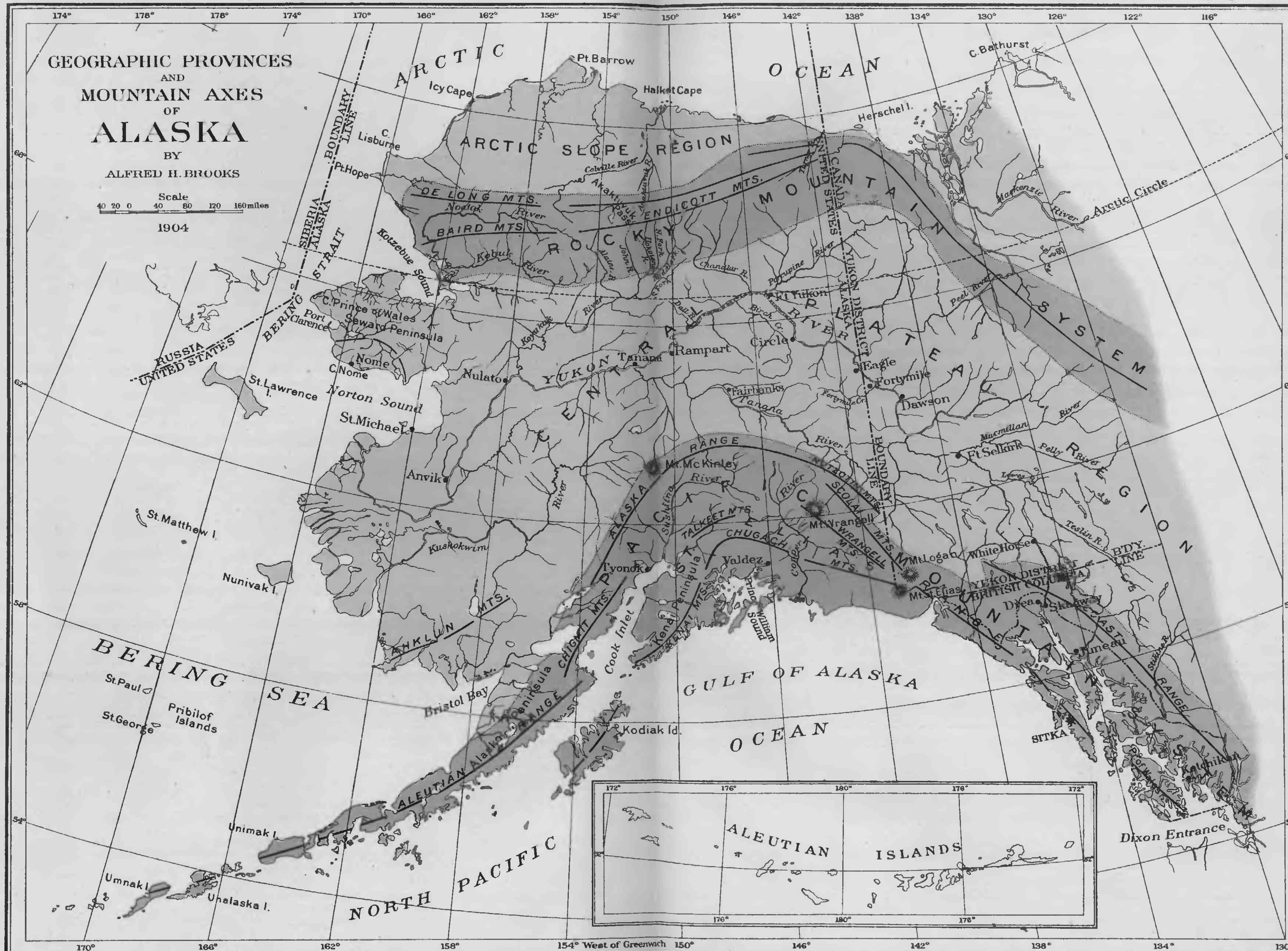
[a] Mount St. Elias and its glaciers: Am. Jour. Sci., 3d series, vol. 43, 1892, p. 171.

[b] Geology and Mineral Resources of the Copper River District: U. S. Geol. Survey, 1901, p. 65.

[c] Eldridge, G. H., A reconnaissance in the Sushitna basin and adjacent territory: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, p. 8.

Mendenhall, W. C., A reconnaissance from Resurrection Bay to the Tanana River: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, p. 297.



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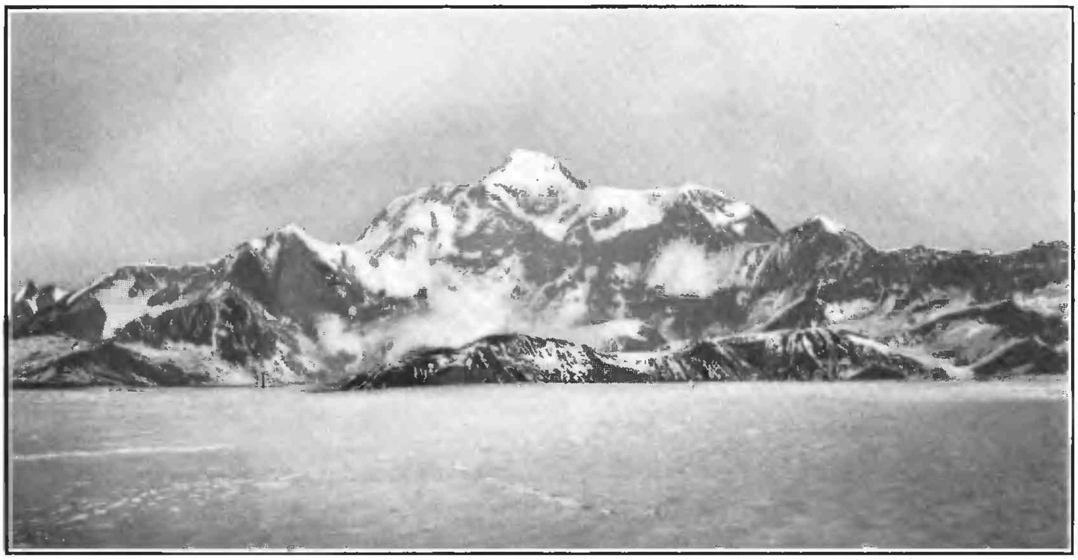
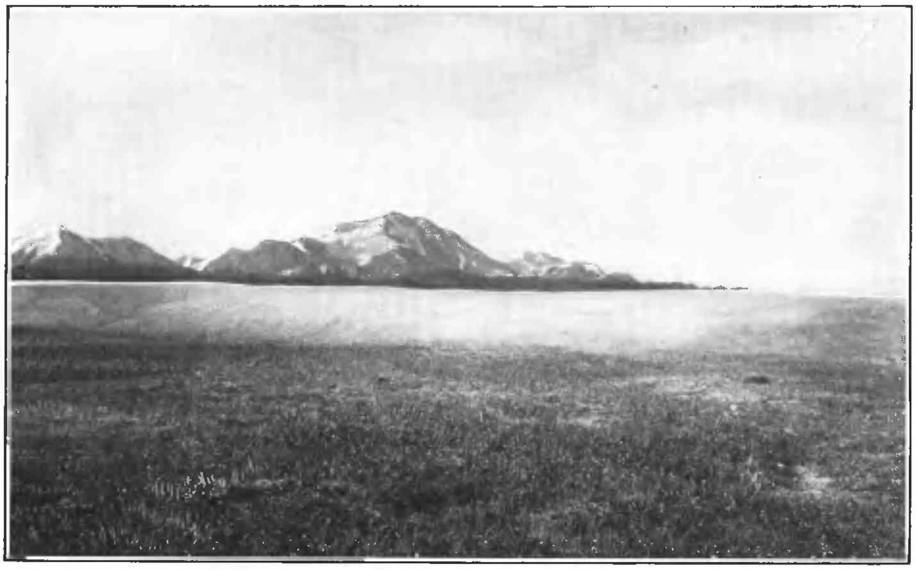
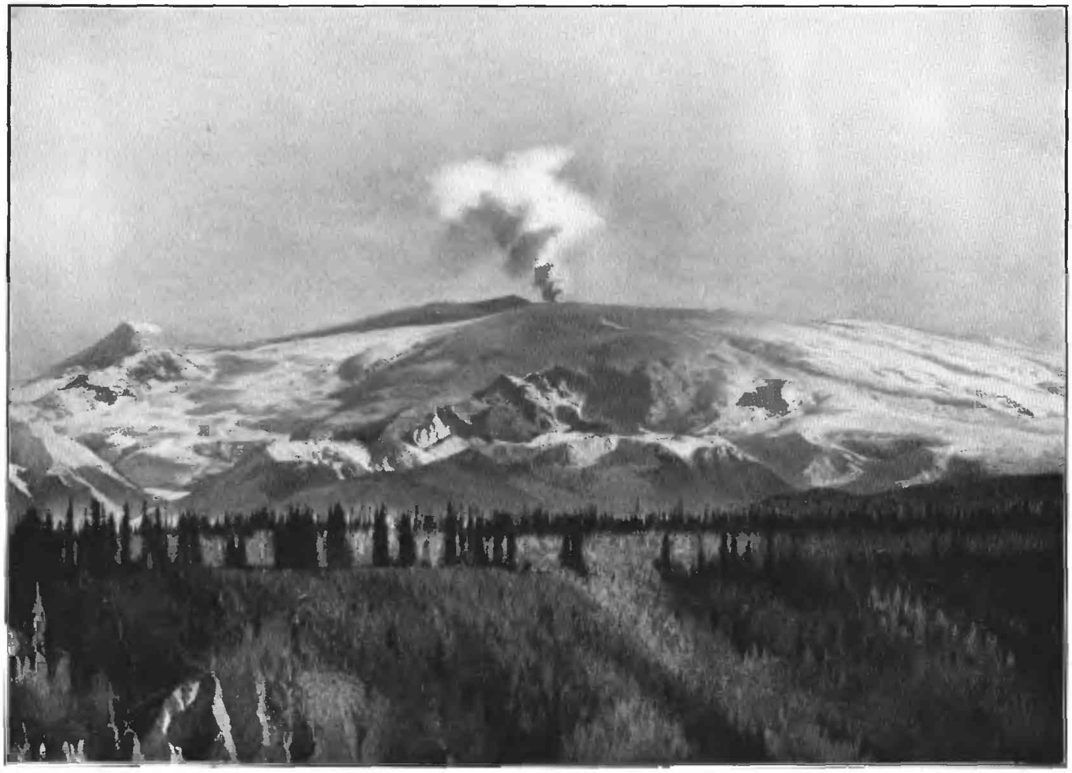


A. MOUNT ST. ELIAS FROM THE SOUTH.

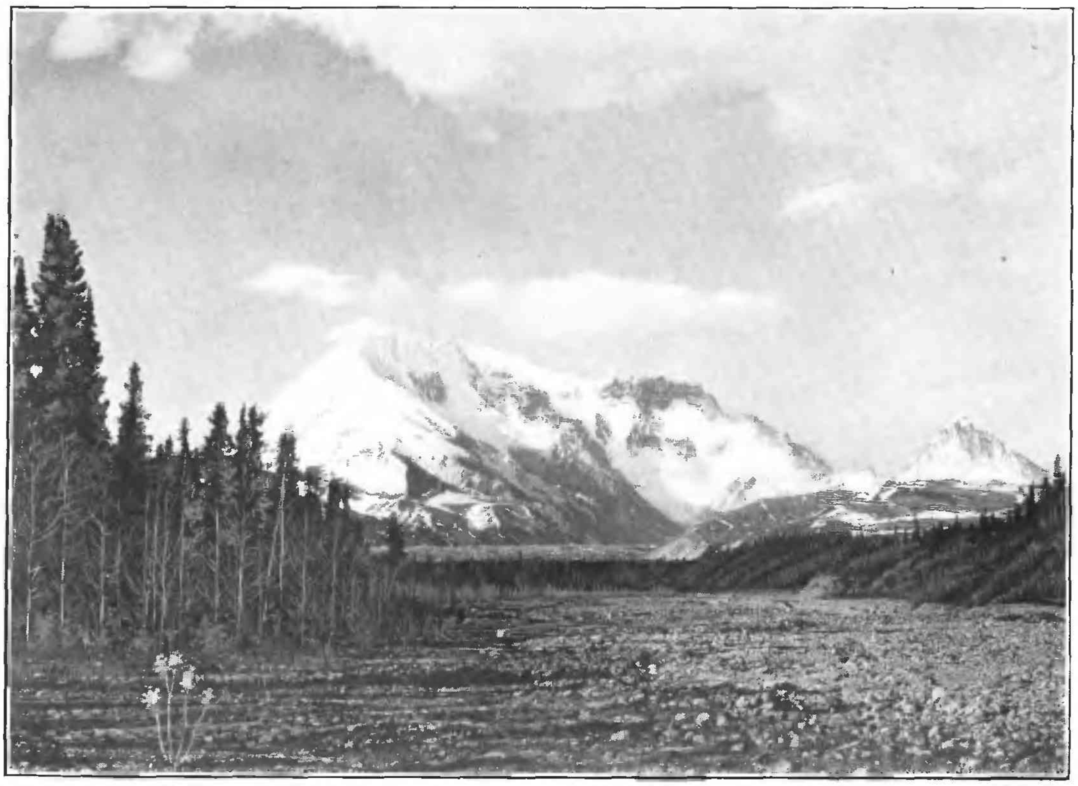


B. MOUNT McKINLEY FROM THE NORTHWEST.



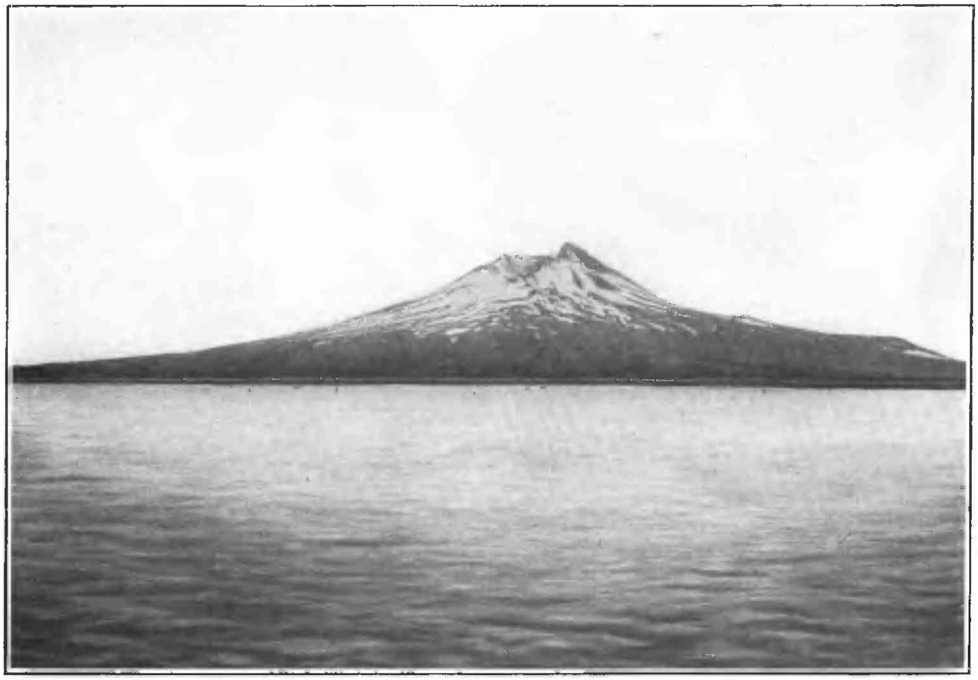
A. MOUNT WRANGELL—AN ACTIVE VOLCANO.

View taken from the Government trail above Tonsina Bridge, 45 miles from the summit of the mountain.



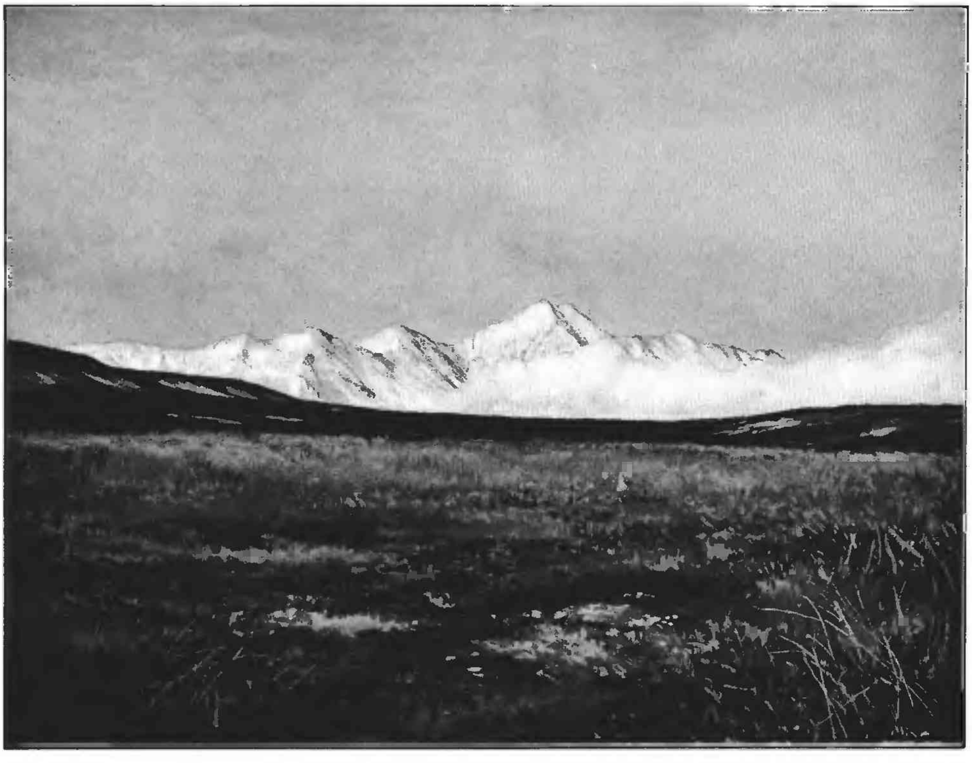
B. MOUNT DRUM, COPPER RIVER REGION.

A dissected crater.



A. MOUNT ST. AUGUSTINE, COOK INLET.

A typical ash cone.



B. INLAND FRONT OF ST. ELIAS RANGE, WHITE RIVER BASIN.

Showing abrupt transition to the plateau.

rivers and is hemmed in by the Chugach Mountains on the south, the Talkeet Mountains and Alaska Range on the west and north, and the Wrangell Mountains on the east (Pl. XIV, *B*).

Toward their western limit the Chugach Mountains bend to the south and merge with the Kenai Mountains (Pl. VII), occupying the eastern half of the Kenai Peninsula. These are described by Mendenhall[a] as follows:

"The Kenai Mountains, as that part of the St. Elias system which forms the axis of the Kenai Peninsula is called, form a belt 60 miles wide in the northern part of the peninsula and somewhat narrower toward the south. But little is known in detail of the interior of these hills, but that little indicates that they reach altitudes of 6,000 or 8,000 feet; that they have been dissected by a drainage system which became fairly mature before it was disturbed, and that, therefore, they are intersected by rather broad, high valleys. All their higher parts are snow clad, and numerous glaciers flow down from them to the inlets of the Pacific and become the sources of the streams which drain the peninsula."

The low gap, filled with glacial ice, which separates the Chugach and Kenai mountains has long been used by natives as a route of communication between Prince William Sound and Turnagain Arm. On the east side of the peninsula the coast line is indented by many embayments, and the mountains rise precipitously from the water; on the west they fall off more gradually to the Kenai Plateau, which stands about 200 feet above tide water. The highlands of Kodiak Island to the south can be regarded as a southern extension of the Kenai Mountains.

Near the one hundred and forty-first meridian the St. Elias Range is split by the valley of the Chitina River. The northern branch, sometimes called the Skolai Mountains, extends westward until cut off by the head of the Copper River. On the north it is separated from the Nutzotin Mountains by valleys of streams which are tributary to the upper Tanana, and on the south it merges into the Wrangell group. The Skolai Mountains are rugged, with altitudes of 7,000 to 10,000 feet. Schrader and Spencer[b] have called attention to their even crest line.

All the ranges thus far described as composing the Pacific Mountain system belong to that class of the earth's features which are the result of differential erosion in regions of deformation and uplift. The Wrangell Mountains, however, which in point of geographic position must be classed with the Pacific Mountain system, owe their origin to the accumulation of volcanic material in times so recent that the forces of erosion have not yet removed it. Their highlands have the irregular form characteristic of volcanic mountains which are built up of lavas rather than of ash deposits (see Pl. IX, *A* and *B*).

Mendenhall[c] describes them as follows:

"The Wrangell group occupies a rudely elliptical area, with the extensive lowlands of the Copper and the Chittyna [Chitina] valleys on the south and west, but connected toward the east with the somewhat greater heights of the St. Elias Alps. A well-marked depression on the north, which extends from the upper Copper across the Nabesna and the Chisana to the White, separates them from the neighboring Nutzotin

[a] Mendenhall, W. C., A reconnaissance from Resurrection Bay to the Tanana River, Alaska, in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, p. 296.

[b] Geology and Mineral Resources of a portion of the Copper River District, Alaska: U. S. Geol. Survey, 1901, p. 65.

[c] The Wrangell Mountains, Alaska: Nat. Geog. Mag., vol. 14, 1903, pp. 399–400.

and Mentasta ranges. Measured along the greater diameter of the ellipse from Skolai Pass northwestward to the outer base of Mount Drum, the extent of the group is about 100 miles, while the other diameter at right angles to this is approximately 70 miles in length. Within this area of 5,500 square miles are at least ten snow-clad peaks 12,000 feet or more in height. Several of these are unnamed, and two of them, Mounts Sanford and Blackburn, are higher than Mont Blanc or any of the peaks within the borders of the United States.

"A * * * list of the principal peaks and their elevations * * * is appended here:

	Feet.
Mount Sanford	16,200
Mount Blackburn	16,140
Mount Wrangell	14,000
Mount Regal	13,400
Mount Zanetti	12,980
Mount Jarvis	12,300
Mount Drum	12,000
Capital Mountain	9,697
Mount Gordon	9,100
Snider Peak	8,345

"In addition to these summits, to which names have been applied, there are two or three unnamed points on the ridge between Wrangell and Blackburn which are 10,000 feet or more in height, while between Blackburn and Regal one peak is 13,400, another 12,925, and a third 12,185 feet high.

"The Wrangell Mountains lie between the meridians of 142° and 145° west longitude and the parallels of 61° 20′ and 62° 30′ north latitude. The one hundred and forty-fourth meridian and the sixty-second parallel intersect just east of the crater of the central peak—Mount Wrangell."

Summary.—The St. Elias Range is a rugged mountain mass parallel with and close to the Pacific coast from Cross Sound as far as the entrance to Cook Inlet, with one spur, the Skolai Mountains, stretching to the northwest. On the seaward side the range presents an abrupt escarpment, often rising directly from the water, while its northern slopes almost everywhere fall off abruptly to the Central Plateau.

Near Cross Sound the timber line is at about 2,500 feet, but the mountains are usually too steep to permit any but the scantiest growth of vegetation. Where a piedmont plain intervenes between the mountains and the water, it is clothed with dense forests of spruce with some hemlock and occasional cedar. Bordering Prince William Sound the forests are almost entirely of spruce and are limited to the lower 300 feet of the mountain slopes.

ALEUTIAN RANGE.

The Aleutian Range is the third of the coastal barriers of the Pacific Mountain system. It embraces the highlands which skirt the Pacific side of the Alaska Peninsula from Unimak Pass to Cape Douglas, at the entrance of Cook Inlet. This range trends northeast as far as Cape Douglas, where it ends abruptly, but an offset to the west, represented by a broad lowland, carries what is probably the same mountain axis to the west side of Cook Inlet, where it is continued northeast by the Chigmit Mountains (Pl. VII). The latter have been traced northward to about latitude 61°, where they fall off to a lowland. The mountainous Aleutian Islands, stretching nearly 900 miles westward from the mainland, are a southwest continuation of the Aleutian Range. Their shore lines are abrupt and rocky and their relief very strong.

The Aleutian Range of the mainland is at its greatest width almost 80 miles, near latitude 58°, where the topography is complex and irregular. Northward it rapidly narrows until at Cook Inlet it becomes a single ridge. Like the ranges previously described, it was first outlined by a zone of deformation and uplift, but its present relief is due, for the most part, to volcanic ejecta, and is made up of a series of volcanic peaks distributed at irregular intervals along a northeast-southwest axis. The highlands are broken by many broad, flat divides. Redoubt Volcano, the most northerly of these, is something over 11,000 feet in height. To the southwest the volcanic peaks decrease in altitude, the highest in the Aleutian Islands having an elevation of about 6,000 feet. Many of these show the beautiful, symmetrical form of typical ash cones. Among the finest is Mount Augustine, which forms a small island near the entrance to Cook Inlet (see Pl. X, *A*).

Little is known of the western slope of the Aleutian Range. In about 59° 30′ latitude the range falls off very abruptly to Lake Iliamna, but to the north, where it has been little explored, it does not appear to be sharply differentiated from the southern part of the Alaska Range.

Most of the Aleutian Range lies in the great timberless belt which extends from the latitude of Kodiak Island on the Pacific, along the shores of Bering Sea, and northward and eastward along the Arctic Ocean to the vast barren ground area of northern Canada. Toward the northern end of the range, however, the lower slopes are timbered with spruce and birch, and nearly everywhere in the timberless region the lower valleys contain a thick growth of willow (Pl. XII).

ALASKA RANGE.

The Alaska Range, the northernmost of the Pacific system, is a rugged mountain mass, which extends northeast from the vicinity of Lake Clark and, sweeping around the Sushitna and Copper River basins, forms the watershed between the Pacific drainage on the south and east and the Kuskokwim and Yukon waters on the north and west.

Its crest line, which is well defined and remarkably regular, lies close to its western margin. On the east and south a series of foothills intervenes between the mountains and the lowlands of the Sushitna Valley and the Copper River Plateau, while on the west the mountains descend abruptly to a gravel plateau, which slopes westward and merges with the Kuskokwim lowland (Pl. XXXII, *A*). At the north front there is an equally abrupt transition from the rugged mountains to the lowland of the Tanana Valley. A very striking feature of the topography is the line marking the northwestern base of the range, which is remarkably even for 200 miles (see Pl. XI). Of the southern projection of the range little is known; it probably extends southward and includes the mountainous region in the vicinity of Lake Clark. The axis of the range is crescent shaped (see Pl. XI). It extends northeasterly to the one hundred and fifty-first meridian, thence easterly as far as the Tanana; thence to the southeast to the Nutzotin and Skolai mountains, which link it to the St. Elias Range.

The mountainous belt which constitutes this range averages 50 to 60 miles in width. As the crest line lies near the western margin, the easterly drainage courses lie in deep-cut valleys before emerging on the valley lowland of the Sushitna River. Because of this and of the greater precipitation on the coastal side of the divide, the streams flowing into the Pacific are much larger than those to the west and north which thread the mountains in short valleys and then debouch upon the gravel-floored plateau.

No altitudes have been determined near the southern end of the range, but in the vicinity of Lake Clark the mountains probably do not rise above 5,000 [a] or 6,000 feet. Toward the north the relief increases until near the sixty-second parallel the mountains have a height of 10,000 feet. In this region Mount [b] Spurr, south of the Yentna basin, has an altitude of 10,500 feet, while Mount Russell [c] and Mount Dall,[d] north of the Yentna basin, reach elevations of 11,300 and 9,000 feet, respectively.

Spurr gave the name "Tordrillo Mountains" to that part of the Alaska Range south of the passes connecting the Skwentna and upper Kuskokwim drainage basins. As these mountains are actually coextensive with the rest of the range they seem hardly to deserve a separate designation. Their peaks reach 6,000 to 7,000 feet in altitude. The broad valley of the upper Kuskokwim separates this part of the range from an area of lesser altitude, termed by Spurr the "Terra Cotta Mountains," which is also an integral though subordinate part of the Alaska Range.

During an exploration made in the summer of 1902 the writer saw from the distance another mountain group which belongs to this range, but is as yet unexplored. These mountains lie to the southwest of the upper Kuskokwim and apparently form the watershed between the Kuskokwim and Haliknuk basins. Their peaks reach above the line of perpetual snow, and they are the source of some small glaciers. These mountains appear to be a southwestward extension of Spurr's Terra Cotta Mountains, but they far exceed these in altitude.

The culminating peaks of the Alaska Range are Mount McKinley, 20,300 feet (Pl. VIII, *B*), the highest on the continent, and 14 miles to the south, Mount Foraker, 17,000 feet. Both lie in about latitude 63°. These two are dome shaped, and tower far above the adjacent mountains, which are 10,000 to 11,000 feet high. These peaks are visible from Cook Inlet and have been known to white men for nearly one hundred years, but were not indicated on maps until recently. Mount McKinley was known to the Russians as "Bulshaia" and to the natives of Cook Inlet as "Traleika," both names signifying high or big mountain. In 1895 it

[a] The writer is indebted for this information to Mr. Wilfred H. Osgood, of the Biological Survey, Department of Agriculture, who visited Lake Clark in 1902.

[b] Named after J. E. Spurr by the writer.

[c] Named after I. C. Russell by the writer.

[d] Named after William H. Dall by the writer.

was named Mount McKinley by W. A. Dickey, who ascended the Sushitna River for a short distance and called attention to its tremendous height. In 1898 George H. Eldridge (p. 127) and Robert Muldrow, of the United States Geological Survey, determined its position and altitude, and in the following year Lieut. Joseph S. Herron (p. 131) named the second high peak "Mount Foraker." In 1902 a more extended exploration of the range was made by Alfred H. Brooks and D. L. Reaburn, who were the first white men to reach the base of Mount McKinley. Toward the northeast the range decreases in height to 7,000 and 8,000 feet near the Cantwell River, but still farther eastward, near the Tanana, there is a group[a] of mountains with altitudes of 9,000 to 14,000 feet.

In about latitude 62° are several passes through the range at an altitude of 3,000 or 4,000 feet.[b] These all lie in a belt 10 miles in length, and lead from the drainage basin of the Yentna on the east to the East Fork of the Kuskokwim on the west. Though traversed only a few times by white men, they have long been in use by the natives.

To the northeast the Alaska Range presents an almost unbroken crest line for nearly 200 miles. As far as known there are no gaps below the snow line until Caribou Pass, at the head of the Cantwell, is reached. This is a broad depression, compared with the southern passes, and stands at an elevation of only about 2,400 feet above sea level, dividing the Chulitna waters tributary to the Sushitna, on the south, from the Cantwell waters tributary to the Tanana, on the north. It is the lowest as well as the most practicable pass through the Alaska Range, and, like the southern passes, has long been used by the natives. One hundred miles to the east the Delta River breaks through the mountains and forms the only water gap in the range. The valley of Delta River, according to Mendenhall,[c] is rather narrow, with precipitous walls. Between it and the Cantwell the range has not been explored, but it is hardly probable that there are any low passes.

The eastern end of the Alaska Range is split by streams tributary to the Tanana and White rivers into two masses; the northern, called the Nutzotin, and the southern, the Skolai Mountains (Pl. VII). The latter would form a highland link between the Alaska and St. Elias ranges but for the intervention of the upper Copper River Valley.

In a previous report the writer has described the Nutzotin Mountains,[d] from which the Nabesna and Chisana rivers emerge to debouch on the broad gravel plain of the upper Tanana Valley. From the Nabesna these mountains extend southeasterly as far as the White River, but in the last 20 miles decrease very much in elevation until they are merely low hills. If the axis of this range were extended southeast of the White, it would coincide with that of the mountains north of Lake Kluane, which attain considerable altitude. These, so far as observed, seem to constitute a more or less well-defined range as far as the Kaskawulsh

[a] Mount Hayes, 14,000 feet; Mount Kimball, 9,000 feet.

[b] These passes—Ptarmigan, Rainy, and Simpson—have been explored and in part surveyed, and further exploration may discover others.

[c] Mendenhall, W. C., A reconnaissance from Resurrection Bay to the Tanana River: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, p. 300.

[d] Reconnaissance from Pyramid Harbor to Eagle City, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 346.


RECONNAISSANCE MAP OF
MT. MC KINLEY REGION,
ALASKA
Alfred H. Brooks, Geologist in charge.
Topography by D. L. Reaburn.
Surveyed in 1902.
Additional information compiled from
surveys by U.S. Geo. Survey and U.S. Army.
Scale 1/625,000
Contour interval 200 feet.
Datum is mean sea level.
Probable drainage not surveyed.
Dates indicate camps.
1904
YUKON RIVER
TANANA RIVER
KUSKOKWIM
CHULITNA RIVER
SUSHITNA RIVER
COOK INLET
Rampart
Ft. Gibbon
Harper Bend
Coskakat
Tortella
Cone Hill
Unsuzi Mt.
Lake Minchumina
Lake Tukamiza
Chitsia Mtn.
Telida
Mt McKinley
Mt Foraker
Mt Russell
Mt Dall
Farewell Mt
Egypt Mt
Kliskon Mt
Yenlo Mt
Distin Pk.
Alger Pk.
Mt. Estelle
Beluga Mt
Mt Sushitna
Sushitna Station
Kroto
Mt. Spurr
Tyonok
Ladds
North Foreland
Fire Id.
Pt Mackenzie
Pt. Campbell
Pt Possession
Turnagain Arm
Knik Arm
Hope
Sunshine
Esther Id
Talkeet Mountains
Chugach Mountains
ALASKA RANGE
154° 153° 152° 151° 150° 149° 148°
65° 64° 63° 62° 61°
JULIUS BIEN & CO. PHOTO. LITH. N.Y.

River, beyond which they probably merge with the Yukon Plateau, though the mountains lying immediately north of the Chilkat River may belong to the same uplift. This chain has an extreme width of about 20 miles, and its highest peaks reach elevations of 10,000 or 11,000 feet.

In the Nutzotin Mountains are numerous gaps offering routes of trave between the Copper River and the Tanana, of which the Mentasta and Suslota passes are the best known. To the east the mountains are broken by the valleys of the Nabesna and Chisana rivers, which rise south of the Nutzotin Mountains in the Skolai Mountains and unite later to form the Tanana.

The southern and eastern slopes of the Alaska Range near Cook Inlet, up to about 1,200 feet, constitute a beautiful park-like region, sprinkled with groves of spruce, birch, and cottonwood, and abundant open meadows of fine grass. Between 1,200 and about 3,000 feet is a belt of alder and willow thickets. In the upper Sushitna and upper Copper River valleys the limit of thick timber rises somewhat and spruce predominates (Pl. XII).

Timber covers the western and northern slope of the range up to between 3,500 and 4,000 feet, and is much smaller than on the coast side of the divide, consisting chiefly of spruce, with some white birch and cottonwood. Near the upper limit of spruce timber there is an abundance of good grass. Stunted willow is found in the high valleys and gulches up to an altitude of 4,000 to 5,000 feet.

CENTRAL PLATEAU REGION.

GENERAL FEATURES.

North and west of the rugged, snow-covered ranges of the Pacific Mountain system the aspect of the country changes abruptly (Pls. X, *B*, and XXX, *B*). A rolling upland about 200 miles wide, deeply dissected by well-developed drainage systems, with stream valleys and broad lowlands, and diversified by scattered mountain masses and isolated peaks that rise above the general level, stretches from the Pacific Mountain system on the south to the Rocky Mountain system on the north and from the lowlands which skirt Bering Sea to beyond the international boundary (Pl. VII). Broadly speaking, its limits correspond with those of the Yukon and Kuskokwim basins combined. While this province as a whole is an upland region, it includes a number of large lowland areas, such as the coastal plain, which will be described later (pp. 39 et. seq.).

One traversing the valleys and lowlands only of this central province might describe it as an agglomerate of hills, ridges, and mountains irregularly distributed and without system, but from a higher altitude the tops of the hills and ridges appear to mark a gently undulating plain. From about the level of this plain the drainage channels are almost entirely hidden and the upland surface sweeps off to the horizon, broken only here and there by peaks or mountain masses which rise above the general level (see Pls. X, *B*, and XXX, *B*). Such a view conveys almost the same impression of monotony as one across the Great Plains east of the Rocky Mountains, and shows the strong contrast between the plateau province and the rugged mountains on either side. Flat-topped interstream areas mark the remnant of a dissected plateau, called by Hayes[a] the "Yukon Plateau," whence this province derives its name of "Central Plateau region" (Pl. VII).

This plateau province of Alaska is coextensive with that of British Columbia and Yukon Territory, called by Dawson the "British Columbia Plateau." As has already been shown, the same general physiographic feature can be traced northward from the western United States through Canada into Alaska.

ALTITUDE OF PLATEAU.

Near the northern boundary of British Columbia (latitude 60°) the plateau has an altitude of about 5,000 feet at its western margin; it slopes downward toward the center of the province and probably rises again toward the Rocky Mountain front. It also declines northwestward to an altitude of about 4,000 feet near the intersection of the sixty-third parallel with the Yukon.

The plateau continues its northwesterly direction as far as the great bend of the Yukon, then encircling the broad lowland known as the Yukon Flats, it falls off still more to the southwest until it has an altitude of less than 2,000 feet near the Lower Ramparts, latitude 66°. In the Koyukuk basin the plateau level is apparently represented by hills whose summits stand at altitudes of about 3,000 feet.[b]

The region northeast of the Yukon has been little explored, but the plateau province probably extends to the front of the Rocky Mountain system, about 50 miles northeast of Dawson, and embraces the valleys of most of the tributaries of the Yukon.

The lower Yukon and Kuskokwim offer less definite evidence of the plateau, for the topography is characterized by broad lowlands interrupted by irregular hills and ridges, which seldom rise above 2,000 feet, and decrease in height toward the coast. These may be remnants of the plateau.

SEWARD PENINSULA UPLAND.

The Seward Peninsula, as a whole, falls within the plateau province, though here the plateau feature itself is not strongly emphasized. The characteristic topographic[c] types are rounded hills and ridges 800 to 2,000 feet in height, forming an irregular upland, which usually rises away from the coast (Pl. XIII). This upland is broken by many broad valleys with gentle slopes, which in some cases become basin lowlands of considerable extent; and is diversified by isolated peaks and several larger mountain masses which rise above the general level. Old degradational surfaces are marked by high benches and terraces up to a height of about 1,500 feet. Some of these have been ascribed by the writer to marine erosion, and they may belong to the same period as the Yukon Plateau. This theory, however, seems hardly tenable in view of the improbability that such a comparatively insignificant feature would be preserved during the long period which has elapsed since the uplift of the Yukon Plateau.

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[a] Jour. School Geog., vol. 1, 1897, p. 239.

[b] Schrader, F. C., Reconnaissance along the Chandlar and Koyukuk rivers, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 1, 1900, p. 464.

[c] Reconnaissance in the Cape Nome and Norton Bay Regions, Alaska, in 1900, U. S. Geol. Survey, 1901, pp. 16-20.

BOUNDARY OF PLATEAU AND MOUNTAIN RANGES.

In northern British Columbia the line between the plateau and Coast Range is not sharply drawn, because of a gradual merging of the topography of the two provinces. In Alaska, on the other hand, the change from the plateau province to the bounding mountain ranges is often very abrupt. This feature is especially striking along the northern front of the St. Elias Range, where the smooth, grassy, flat-topped remnants of the plateau end abruptly against the steep slopes of the rugged, snow-covered mountains. In the upper White River basin an escarpment usually marks the boundary (see Pl. X, *B*). Similar relations were observed in the upper Tanana Valley, where the Alaska Range falls off abruptly to the plateau, and also along the northwestern front of the Alaska Range, in the headwater region of the Cantwell, where the remnants of the plateau stand at about 3,000 feet. Farther to the southwest the front of the Alaska Range is deeply buried in overwash gravels, and the piedmont plateau thus formed obscures the definition of the plateau proper, which may be represented by some flat-topped spurs, seen as prominent shoulders along the front of the range, at an altitude of about 4,000 feet.

The northern and eastern limits of the plateau province have been studied in only a few places. Near the sixty-seventh parallel Schrader[a] describes the mountains to the north as falling off abruptly for 2,000 feet to the level of a plateau which has an altitude of 3,000 feet.

PLATEAU RANGES AND MOUNTAINS.

Dawson[b] has described a number of well-defined ranges which lie within the Central Plateau region of British Columbia, under the name "Gold Ranges," but these die out near latitude 60°, and north and west of them there are no important ranges in the province. Isolated peaks which rise above the plateau level are very common, and there are several minor ranges, such as the so-called Glacier Mountains, which rise about 2,000 feet above the plateau level in the upper part of the basin of the Fortymile[c] River. These mountains have a northeast-southwest trend, and reach altitudes of 5,000 and 6,000 feet.

Spurr,[d] in his studies of southwestern Alaska, described some mountains which may stand above the plateau. The southernmost, the Ahklun Mountains (Pl. VII), stretch to the northeast from the shores of Bering Sea, forming the rugged peninsula which is cut out from the mainland by Kulukak Bay on the south and by the deep indentation at the mouth of the Kuskokwim on the north. These mountains have a width of about 60 miles, and are known to extend 200 miles inland. If they continue beyond this point they lie, between Lake Clark and the middle Kuskokwim, in a region which has not been explored. It may be that further studies will show them to be a southwestern extension of the Alaska

[a] Reconnaissance along the Chandlar and Koyukuk rivers, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 463.

[b] Dawson, G. M., On the later physiographical geology of the Rocky Mountain region in Canada: Trans. Royal Soc. Canada, vol. 8, sec. 4, 1890, pp. 4 and 5.

[c] See Fortymile atlas sheet, U. S. Geol. Survey.

[d] Reconnaissance in southwestern Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 240-241.

SKETCH MAP SHOWING DISTRIBUTION OF FORESTS AND OF GLACIERS AND SNOW FIELDS

COMPILED BY ALFRED H. BROOKS

Scale

0 100 200 300 400 500 miles

1904

Range. The higher peaks of the Ahklun Mountains reach altitudes of 7,000 and 8,000 feet.

Spurr gave the name Kuskokwim Mountains to a low range which lies in the central Kuskokwim Valley, between latitude 61° and 62°. These may, however, be a remnant of the plateau which has been reduced by erosion to a ridge-like form. The relief is probably not over 2,500 feet. On Herron's[a] map accompanying his report on the upper Kuskokwim basin are indicated some mountains which stretch in a northeasterly direction from latitude 63° 30′ to about latitude 64° 30′. These Herron designates under the native names Sischu and Chitanatala mountains, and estimates the height of the former, which is the most easterly, at 1,500 to 2,000 feet. The writer, who had a view of them from the western slope of the Alaska Range, is inclined to regard them as considerably higher. Though 50 to 70 miles away, they stood out clearly 1,000 to 1,500 feet above the plateau level, which is probably something lower than 3,000 feet. One peak was actually determined to be 4,000 feet by D. L. Reaburn, the topographer who accompanied the writer.

In the Seward Peninsula is a well-defined mountain range, which stands far above the general level of the upland. Its axis is shaped like a crescent, both points of which touch Bering Sea, while its arc lies 50 miles inland. Broad valley lowlands divide the range into three parts, each with a separate name. The first group on the west, the Kigluaik Mountains, has a maximum altitude of 4,700 feet; the Bendeleben Mountains, the second group, reach 3,500 feet, while the Darby Mountains, the third group, are not over 2,000 feet high. Isolated peaks rising above the general upland are very common in the peninsula, but those already described and the York Mountains, lying in the western part of the peninsula, are the only considerable mountain masses.

Attention has been drawn to the more important mountain groups within the Central Plateau region. As more detailed surveys are carried out other highland masses will undoubtedly be discovered which must be classed with them. Single peaks elevated far above the plateau surface are very common, and in some cases have a linear arrangement which suggests that they are the remnant of a former mountain range.

COASTAL PLAINS.

As the Yukon Plateau approaches Bering Sea it gradually loses its distinctive features; the valleys broaden, the interstream areas grow smaller and lower, and, finally, 100 miles or more from tide water, the uplands end and the valley floors merge with the coastal plain which skirts the eastern shore of Bering Sea. This coastal plain, which is by far the largest of this region, is of low relief and about 25,000 square miles in extent. It embraces the lower Kuskokwim and Yukon valleys as far north as Norton Sound, and for the most part is in the deltas of these two great rivers (Pl. XXXIV).

Topographically, it is a level tract, here and there interrupted by hills and ridges, usually less than 1,000 feet in height, which form conspicuous features in the otherwise monotonous landscape. Such a range of hills stretches 100 miles northeastward from the central part of the Yukon Delta. The hills reach altitudes of

[a] Herron, J. S., Explorations in Alaska in 1899: War Department, Adjutant-General's Office, No. 31.

2,000 feet and are believed to be of recent volcanic origin. The coastal plain slopes gently toward the sea from an inland margin which is probably less than 100 feet above tide water. In some places it is bordered inland by steep escarpments, while at other points it merges into the valley floors of the streams.

Watercourses meander sluggishly across the plain, their floors but slightly incised below its general level. During the spring freshets these overflow their banks, seeking new channels and silting up old ones, and a large part of the plain becomes a swamp, with an ill-defined drainage and dotted with lakes. There are no trees—nothing to break the monotony of the landscape but small bunches of willows.

Among the other and lesser coastal plains of this province, that of the Nushagak River region is worthy of note. As far as can be learned from the meager accounts, this lowland stretches inland from Bristol Bay, embracing the lower courses of the Nushagak and Kvichak rivers and the region lying adjacent to the lower end of Iliamna Lake. Smaller coastal plains are also found along both the southern and northern shores of the Seward Peninsula.

INTERIOR LOWLANDS.

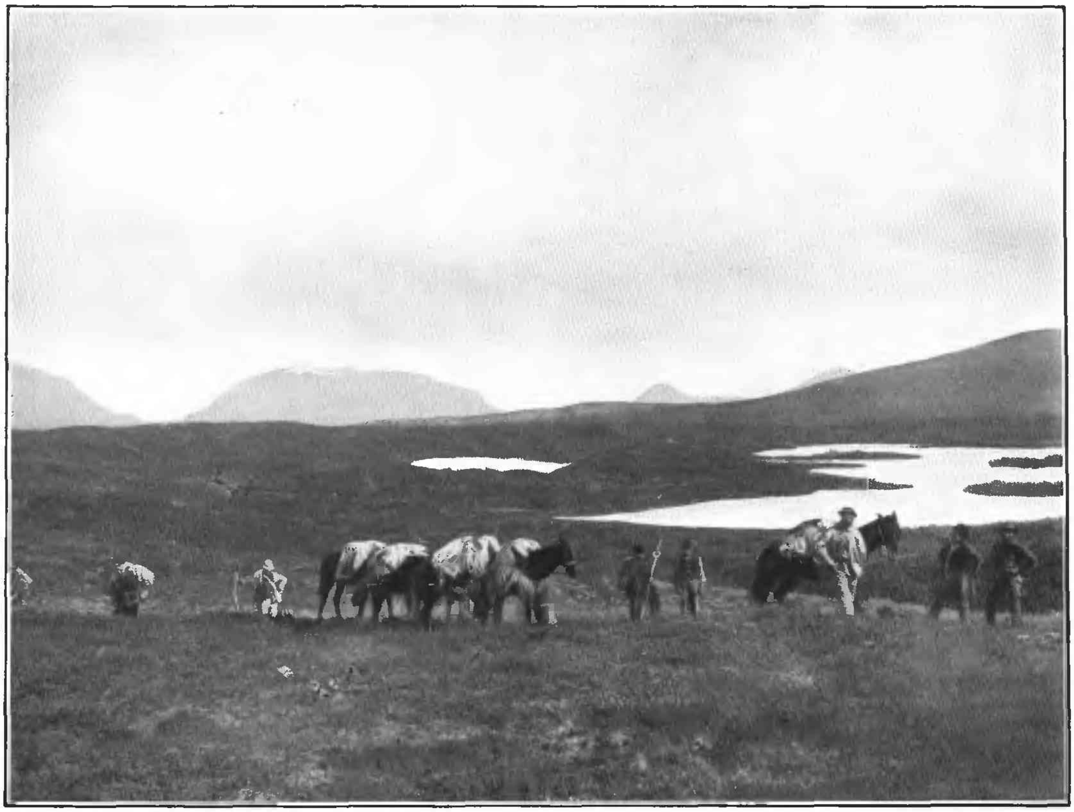
Besides these coastal features there are also large lowland tracts in the inland parts of the province. The largest of these is the so-called Yukon Flats, a depressed area at the great bend of the middle Yukon, about 200 miles long and 40 to 100 miles wide, which is nearly bisected by the Arctic Circle. It has an altitude of about 500 feet and, as its name implies, is a monotonous lowland throughout its extent. Broadly speaking, its outline is rectangular, but its periphery is irregular. The upland which surrounds the flat is distinctly of the plateau type; in some places it falls off precipitously to the lowland; in others, it is separated from the lowland by hills of less relief, which make the transition more gradual. At its southern end the lowland ends abruptly at a rocky escarpment, which rises to the flat-topped hills of the plateau.

This lowland forms part of the valleys of the Yukon River and its tributary, the Porcupine. Through it the Yukon meanders in numerous channels, broadening out in places to probably 20 miles; and where it is joined by large tributaries the lowland extends up their valleys for a greater or less distance (see Pl. XIV, *A*).

Another depressed area, similar to the Yukon Flats, lies between latitude 63° and 64° in the Kuskokwim drainage basin. This, which may be called the upper Kuskokwim Flat, is essentially an area of low relief, through which the drainage channels meander with great irregularity. As it lies in part in an unmapped region, its limits can not be given in detail, but it may be said to extend eastward to the base of the Alaska Range, while to the north it is coextensive with the valley lowland of the lower Tanana, and on the west it is bounded by an escarpment. The southern boundary has not yet been determined. Near the base of the Alaska Range, on the east, the flat is deeply buried in a heavy deposit of gravel, forming a piedmont plateau (Pl. XXXII, *A*), which slopes westerly until it finally merges with the silt deposits of the central part of the flat.

UPLAND OF SEWARD PENINSULA NEAR HOT SPRINGS.

A. NORTHERN MARGIN OF YUKON FLATS IN CHANDLAR VALLEY.



B. NORTHERN MARGIN OF COPPER RIVER PLATEAU.

SUMMARY.

The great interior upland, which has been designated the Central Plateau region, stretches northward from the inland ranges of the Pacific Mountain system to the foothills of the Rocky Mountain system. Into this upland the drainage courses have incised channels varying from 1,000 to 4,000 feet in depth, giving a very irregular topography. The summits of the unreduced hills and ridges, lying between the waterways, mark a gently rolling plain which slopes toward the north and west. Viewed from one of these summits, the sky line is characterized by marked regularity, and is broken only here and there by highland masses, which rise above the general level and, in some instances, are of sufficient extent and altitude to be called ranges. There are also within this province a number of large lowland areas, which stand from 1,000 to 1,500 feet below the upland.

This Central Plateau region is coextensive with the plateau region of British Columbia, and can be regarded as belonging to the same physiographic province as the Great Basin region of the western United States. The history of its development will be discussed in another part of this paper, but a clearer conception of its form may be obtained from the statement that it is due to erosion and is not a constructive plain of deposition. The land mass which now constitutes the plateau stood formerly at a lower altitude, and its surface, except for some unreduced areas which now form the mountains and solitary peaks of the upland, was gradually reduced by subaerial erosion to a seaward-sloping plain. After reduction, differential elevation took place, and as the activity of the streams and rivers was renewed, they began channeling out their present valleys. In this manner was evolved the present topography of flat-topped summits, which mark the former plain of erosion, and which are separated by the more recently carved drainage channels.

The plateau province is, as a rule, well forested, though the trees are not of great size. On the Seward Peninsula spruce and cottonwood are limited to the eastern end. Spruce forests reach the coast along the eastern shore of Norton Bay, but the timber line strikes inland, crosses the Yukon and Kuskokwim near the head of their deltas, and again reaches the coast near the head of Bristol Bay. On the seaward side of this line nothing but stunted willow is found, and that only in the creek and valley bottoms (Pl. XII).

Above the delta the banks of the Yukon and its larger tributaries, the Koyukuk, Tanana, Porcupine, and White rivers, are usually well forested (Pl. XV, *B*). The upper limit of timber varies according to local conditions, but shows a decline toward the northern side of the basin. On the White and upper Tanana the limit of heavy spruce growth is about 3,500 feet, while on the Koyukuk it is less than 3,000 feet.

The chief varieties of trees are the spruce (which is most abundant), white birch, poplar, and aspen (usually called "cottonwood" by miners and prospectors). There are also many varieties of willow and several of alder; and tamarack has been found on the lower Tanana and upper Kuskokwim.

Sweeping generalizations have been made by some writers regarding the important timber resources of the Yukon Valley, but these have not been borne out by the observations of the writer, who has traveled extensively throughout this region. In the valley lowlands of the Yukon and tributary streams it is not uncommon to find small groups of trees which will measure 2 and 2½ feet in diameter at the butt. These, however, are exceptional, for most of the trees are only from 5 to 12 inches. The timber with proper protection would be ample for local use, but has no value for export. Large quantities are annually destroyed by fire, for which the natives must largely be held responsible. The writer has remarked again and again that the Alaska Indians are utterly careless about forest fires. It seems probable that they deliberately burn over large tracts in order to somewhat reduce the insect pest. That this indifference to forest fires was not learned of the white men is shown by the fact that many tracts are found which must have been burned over long before the appearance of any foreigner.

ROCKY MOUNTAIN SYSTEM.

GENERAL DESCRIPTION.

The name Rocky Mountain system has long been applied to the easterly group of ranges forming the great cordillera of western North America. The limits of this system are in most cases sharply drawn, for it is bounded on the east by the low plateau region usually known as the Great Plains and on the west by the elevated plateau province termed the Great Basin.

The Rocky Mountain system continues northwestward from the western United States through Canada nearly to the Arctic Ocean. South of Mackenzie Bay it turns almost at right angles, crosses the international boundary (the one hundred and forty-first meridian) in about latitude 68°, and continues, in a direction a little south of west, across northern Alaska to the Arctic Ocean. (Pl. II.)

In the United States the Rocky Mountain system is complex and includes several high ranges whose axes are in general parallel, together with numerous transverse lines of height. This complexity is retained nearly to the northern boundary of British Columbia (latitude 60°), where the system[a] is composed of several approximately parallel ranges 3,000 to 4,000 feet in height. These are not persistent for any great distance, but give place toward the north to other parallel ranges, which die away northward. Thus the axes of the ranges have an échelon character which, as far as known, holds northward to the international boundary. The Northern Rockies of Canada have not been extensively explored, however, and little is known of them beyond the fact that they constitute a mountainous belt about 50 miles wide which stretches northward from the Liard River nearly to the Arctic coast, and forms in general the watershed between the Yukon on the west and the Mackenzie on the east. McConnell,[b] who crossed this divide at the Peel River portage, in about latitude 67°, describes two distinct ranges, about 4,000 feet in altitude and flanked on either side by high plateaus. West of the international boundary the mountains increase in both height and complexity to about the one hundred and fifty-first meridian, and from there to the Arctic Ocean decrease in altitude.

[a] McConnell R. G., Report on an exploration in the Yukon and Mackenzie basins, N. W. T.: Ann. Rept. Geol. Nat. Hist. Survey Canada, vol. 4, 1890, pp. 8D and 9D.
[b] Ibid., p 119D.

The name "Endicott Mountains" was first given by Lieutenant Allen[a] to a high range of mountains seen by him toward the north during his exploration of the Koyukuk. Schrader,[b] who made the first detailed studies of the geology and geography of these mountains, has accepted this name and extended its application to include all of the ranges which go to make up the Rocky Mountain system of northern Alaska. The great mountain mass which extends across northern Alaska from the Arctic Ocean to the international boundary can, therefore, be designated the Endicott Mountains, and this term may be regarded as synonymous with the Rocky Mountain system of Alaska.

As much of this system has not been surveyed and hardly explored, the ranges composing it can not be described in the same detail as those of the Pacific highland belt. As far as known, this system always embraces at least two distinct ranges. The topography is rugged and the transverse valleys are sharply cut. The longitudinal valleys are broad, with gentle slopes, some of them of a basin type, like that of Noatak River, which divides the system into different ranges. In the eastern part the southern and higher range forms the watershed between the Yukon and Arctic waters. To the west the waterways of the two drainage areas interlock, and the watersheds are very irregular.

The system as a whole is sharply defined. It is bounded on the south by the Central Plateau and on the north by the Arctic Slope region. Its southern limit, at the international boundary, lies about 100 miles north of the Porcupine River, and extends in a southwesterly direction, parallel to the general courses of the Yukon and Porcupine rivers, to its intersection with the sixty-seventh parallel of latitude, which it follows approximately to Kotzebue Sound. (Pl. VII.)

The southern slope of the mountains rises rather abruptly from the upland region of the Koyukuk River, which belongs to the plateau province. The line between the uplands and the mountains, where it has been mapped, is irregular, at one point bending southward to include a spur, at another forming a deep reentrant into the front of the range. On the Arctic slope the descent to a low plateau region is still more abrupt. For long stretches the mountains present a bold escarpment to the north, and the sharp transition from the smooth, moss-covered plateau to the bold, rugged mountains is very striking (Pl. XXIX, *B*). Where the drainage channels leave the mountains the frontal scarp is broken by indentations, and if the river is a large one, like the Colville, this indentation extends into the mountains for many miles. The seaward slope of these ranges trends southwestward by a series of reentrants of an échelon type.

EASTERN PART OF ROCKY MOUNTAIN SYSTEM.

Near the international boundary the mountainous belt, which is upward of 100 miles in width and contains peaks as high as 7,000 or 8,000 feet, is divided on the maps into the British Mountains on the north and the Davidson Mountains, which are higher, on the south. But the meager notes published by Mr. J. H.

[a] Allen, H. T., An expedition to the Copper, Tanana, and Koyukuk rivers, Alaska, 1885. Washington, 1887.

[b] Schrader, F. C., Reconnaissance in northern Alaska: Prof. Paper U. S. Geol. Survey No. 20, 1904. A preliminary statement is contained in an article entitled "Geological section of the Rocky Mountains in northern Alaska:" Bull. Geol. Soc. America, vol. 13, 1902, pp. 233-252.

Turner,[a] who crossed this region along the one hundred and forty-first meridian, in connection with the boundary survey, would point to the conclusion that there are a number of ranges forming a complex mountain mass, but broken by broad, low gaps.

While no actual surveys have been made of the eastern part of this mountain belt, explorers who have visited the Mackenzie River and the north coast of Alaska have not hesitated to name the mountains which they could see to the south and west. Thus the names Gilbert, Davis, Buckland, and Richardson appear on charts to designate various parts of one general range which forms the northern part of the system between the international boundary and the Mackenzie River.

West of the boundary (see Pl. VII) the northern front is made up of a number of minor ranges, whose axes have an échelon relation. The British Mountains, for instance, stretch as far west as the one hundred and forty-second meridian and break off abruptly to the Arctic lowland; then the range is continued westward by the Romanzof Mountains, which in turn end abruptly near the one hundred and forty-sixth degree of longitude; a deep reentrant carries the mountain front back to the Franklin Mountains, which are believed to continue to about the one hundred and forty-eighth meridian, where they also end abruptly; and the front again retreats inland by another reentrant which carries it into an unexplored region. These ranges which mark the northern limit of the system probably do not reach altitudes over 3,000 or 4,000 feet.

WESTERN PART OF ROCKY MOUNTAIN SYSTEM.

Little is known of the westward extension of the chain as far as the one hundred and fifty-second meridian, except that it is a high, rugged mass made up of two or more ranges. At this point, however, somewhat detailed studies have been made by Schrader, who describes the Endicott Mountains (as he terms them) as made up of two more or less distinct ranges, separated by a less elevated, though also mountainous belt. The northern range reaches altitudes of something over 6,000 feet, and the southern of a little less than 5,000 feet: the whole embracing a rugged mountain mass about 80 miles in width.

To the west the two ranges described diverge and are separated by a depressed area which contains the headwaters of the Colville and Noatak rivers. The northern range, named the De Long Mountains by Stoney,[b] stretches almost due west, decreasing in height north of the Noatak River Valley and dying out in the highlands of the peninsula which terminates westerly in Cape Beaufort. The highest altitudes in those mountains are probably 3,000 to 4,000 feet.

The southern range, to which Stoney gave the name "Baird Mountains,"[c] bends slightly to the south at the one hundred and fifty-third meridian, and then, extending westward with decreasing altitude, forms the mountainous divide between the Noatak and Kobuk rivers and appears to end abruptly close to the sea north of Kotzebue Sound. The lower valley of the Noatak lies transverse to these moun-

[a] Ann. Rept. U. S. Coast and Geodetic Survey for 1891, pt. 1, p. 88.

[b] Stoney, G. M., Naval Explorations in Alaska: United States Naval Institute, Annapolis, 1900.
See, also, Mendenhall, W. C., A reconnaissance from Kotzebue Sound to Fort Hamlin: Prof. Paper U.S. Geol. Survey No. 10, 1902.

[c] On some maps the name "Jade Mountains" is used to designate this range.

tains and cuts completely across them. While the elevation of the range averages less than 3,000 feet, some of the peaks near the coast may reach altitudes of 4,000 feet.

The Waring Mountains, also with an east-west axis, are defined on the north by the Kobuk Valley and on the south by the Selawik Valley. They probably belong to the Rocky Mountain system, though their low altitude of 1,500 to 2,500 feet suggests that they may form part of the Central Plateau province. Less defined are the highlands named by Stoney the Schwatka, Melville, and Lockwood mountains, which trend in various directions, and would seem to be transverse lines of height and watersheds rather than distinct ranges.[a]

The Rocky Mountain system west of the one hundred and fifty-second meridian, as far as its geography has been determined, would thus seem to embrace two fairly well-defined ranges which extend with decreasing altitude westward to the Arctic Ocean.

SUMMARY OF ROCKY MOUNTAIN SYSTEM.

The group of ranges termed the Rocky Mountain system, stretching northwestward through Canada, loses much of its relief and complexity as it approaches the Arctic Ocean, but after bending to the southwest and entering Alaska, again becomes a complex mass. It is continued southwestward as a great trans-Alaska chain to which the name Endicott Mountains has been applied. Near the one hundred and fifty-third meridian it splits into two diverging ranges which extend westward to the Arctic Ocean. On the south the mountains are bounded by the interior plateau from which they are not always sharply differentiated, but the lines of demarcation from the Arctic Slope region are well defined.

Schrader[b] has called attention to the plateau character of the Endicott Mountains mass. Viewed from altitudes of 6,000 feet the mountains show a remarkably even sky line and strongly suggest that they have been carved from a former plateau (Pl. XXIX, *A*).

The southern slopes of these ranges are dotted with a moderate growth of spruce, interspersed with birch and a little aspen and poplar up to an altitude of 1,000[c] to 2,000[d] feet (Pl. XII).

The valley of the Kobuk[e] River is well timbered with spruce, birch, and cottonwood. The growth is thickest in a belt a mile or two wide, lying adjacent to the river bank,[f] beyond which it is scattered over the valley slopes and in all the sheltered tributary gulches and valleys up to an altitude of about 1,000 feet. Stoney[g] makes mention of a spruce cut on the upper Kobuk which was 50 feet long and 16 inches in diameter at the butt. The spruce, as a rule, averages from 5 to 10 inches in diameter, but 12-inch trees are not uncommon. As elsewhere in this northern region, several varieties of willow and alder occur above the limit of spruce timber.

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[a] See map in Stoney's report.

[b] Reconnaissance along the Chandlar and Koyukuk rivers, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2. 1900, p. 463. Geological section of the Rocky Mountains in northern Alaska: Bull. Geol. Soc. of America, vol. 13, 1902, p. 236. Prof. Paper U. S. Geol. Survey No. 20, 1904, pp. 42–43.

[c] Schrader, F. C., Recent work of the United States Geological Survey in Alaska: Bull. Am. Geog. Soc., vol. 34, 1902, p. 16.

[d] Turner, J. H., Alaskan boundary survey: Nat. Geog. Mag., vol. 4, 1892, p. 196.

[e] Bull. American Geog. Soc., vol. 34, p. 9.

[f] Information furnished by Mr. L. M. Prindle, who spent a year on the Kobuk.

[g] Naval Explorations in Alaska, U. S. Naval Institute, 1900, p. 81.

The lower valley of the Noatak[a] is forested scantily with spruce and cottonwood, and above, where it is crossed by the one hundred and sixty-second meridian, is almost devoid of timber, except a little scattered spruce and stunted willow.

Forests are almost entirely absent on the Arctic slope of the mountains. Along the stream bottoms is a stunted growth of willow which yields a limited supply of fuel for cooking. Some spruce is reported on the upper waters of the Turner River, which flows into the Arctic near the boundary.

ARCTIC SLOPE REGION

INTRODUCTION.

Near the international boundary the northern face of the Rocky Mountain ranges rises almost directly from the sea, with only a few miles of low coastal plain between it and the Arctic Ocean (see Pl. XXIX, *B*). To the west the coast line bends northward and the mountain front southward, thus widening out this coastal belt to upward of 150 miles near the one hundred and fifty-sixth meridian. At Point Barrow the coast line makes a right-angled bend to the southwest, and the coastal belt rapidly narrows again, so that near the one hundred and sixty-third meridian the northern front once more abuts almost directly on the sea.

This province, which embraces both plateaus and coastal plains, has here been termed the "Arctic Slope province." It corresponds physiographically with the Great Plains region of the western United States and Canada (Pl. II).

SUBDIVISIONS OF THE PROVINCE.

Schrader,[b] who has studied this province along the valley of the Colville River, divides it into two subprovinces, the Anaktuvuk Plateau and the Coastal Plain. The plateau lies immediately adjacent to the mountain front, where it has a height of about[c] 2,500 feet. Thence it stretches northward, retaining its character as a rolling upland and sloping gently toward the Arctic for about 80 miles from the mountains, where, according to Schrader, the Coastal Plain begins. He makes no mention of any sharp demarcation between the plateau and plain, and it would be inferred that there was a gradual transition between the two topographic forms, their difference lying in the fact that the plateau is gently rolling while the plain is absolutely flat. In the account of the development of the topography it will be shown that the two types differ genetically. The higher plateau is an uplifted eroded surface, while the lower is a constructional form, being built up of horizontally stratified sediment (p. 279).

In many places a true coastal plain standing but a few feet above sea level intervenes between the lower plateau and the Arctic. This is a flat, featureless plain, its monotony broken only by an occasional flat-topped hill—the remnant of the lower plateau. In some places the coastal plain is entirely wanting, and the base of the escarpment which marks the northern limit of the lower plateau is washed by waves

[a] McLenegan, S. B., Exploration of the Noatak River, Alaska: Rept. of the Cruise of the Revenue-Cutter Steamer *Corwin*, 1885, pp. 53-80.

[b] A reconnaissance in northern Alaska: Prof. Paper U. S. Geol. Survey No. 20, 1904, pp. 45-46.

[c] Mr. Collier's recent work shows that this plateau is recognizable at Cape Lisburne at an altitude of about 2,000 feet.

of the Arctic, in others it broadens out to 8 or 10 miles; and where the escarpment is broken by the mouths of large rivers the coastal plain merges with the valley floors and is characterized by an undeveloped drainage system, extensive marshes, and innumerable small lakes and ponds. The coast line includes stretches of long, straight, sandy beaches, broken here and there by large lagoons.

Little is known of the Arctic Slope region, except that portion immediately adjacent to the coast and to Schrader's route of travel, but the few scattered observations made by exploring expeditions which have skirted the coast of the Polar Sea lead to the belief that the geographic features described are, in general, persistent throughout the province.

SUMMARY OF ARCTIC SLOPE REGION.

The Arctic Slope region is then a province of comparatively low topographic relief which stretches across northern Alaska, bounded on the south by the front ranges of the Rockies and on the north by the Arctic Ocean. Its southern portion is a high, rolling plateau sloping to the north and then falling by an escarpment to a lower plateau, which also dips to the north and breaks off to the coastal plain by a low escarpment.

The province is a part of the great tundra belt that encircles the Polar Sea, and is entirely without timber. The stream valleys crossing the province, however, contain considerable willow, which becomes more and more stunted toward the Arctic Ocean (Pl. XII). The Eskimos depend on the limited supply of driftwood for fuel when on the coast, and on the willow for their inland excursions.

DRAINAGE.

INTRODUCTION.

When exploration and settlement, for a long time confined to the seaboard, at last began to push inland, the drainage channels naturally afforded the easiest lines of approach. Along the rivers the pioneer could transport necessary supplies in crude rafts or boats built of the timber which grew on the banks; and, later on, the steamboat succeeded craft propelled by hand. It was not until beasts of burden were introduced that extensive land journeys could be undertaken. At first these, too, followed valleys; but later passes through the mountains were discovered and trails were established, to be followed by wagon roads and these in turn by railways.

Not only has the drainage system determined the avenues of approach, but the valleys have yielded nearly all the placer gold and the streams have provided the water power so important to economic exploitation of the ore bodies. Moreover, the best timber and most of the arable land is found on the river banks and along the valley floors.

In short, the water courses are and have been to man the most important physical features of inland Alaska, and for this reason and because they are better known they will be described more in detail than the mountains and plateaus. Even at the risk of repetition, a sketch of the salient features of the extensive drainage system will be presented before the reader becomes lost in the maze of detail.

GENERAL FEATURES.

In Alaska the drainage belongs to three divisions: its southern part, about one-fifth of its area, drains to the Pacific Ocean; the great interior region, covering nearly one-half of all Alaska, drains into Bering Sea; and the rest of the territory, its northern part, drains to the Arctic Ocean.

The Yukon, flowing into Bering Sea, is the master stream (see Pl. XXXIV). This mighty river, the fifth in size of the North American Continent, springs from headwaters in British Columbia, far to the southeast of Alaska, where it fights for supremacy on the one hand with water courses flowing into the Pacific, and on the other with those belonging to the Arctic watershed. The Yukon flows northwest as far as the Arctic Circle, then sweeps around to the southwest, and finally pours its great volume of muddy waters into Bering Sea, over 2,000 miles from the source of its longest tributary. Its basin is outlined in a general way by the boundaries of the Central Plateau province, of which its valley occupies nearly the medial line, and makes with it the same great bend to the southwest, parallel to a similar swing of the two mountain systems on the north and south. The Kuskokwim, also emptying into Bering Sea, is second in size only to the Yukon among Alaska rivers. Its source lies on the western slope of the Alaska Range, and its course is southwesterly, generally parallel to the Yukon.

The Pacific drainage embraces two classes of rivers: first, those whose catchment basins lie entirely within the coastal zone of mountains; and, second, those which flow from sources in the interior beyond the coastal barrier and traverse the mountains on their way to the sea. Of the first the Sushitna and Copper, and of the second the Alsek, Taku, and Stikine are the most prominent examples.

The Arctic Ocean receives waters from a small part of the plateau province through short rivers draining the northern part of the Seward Peninsula, and larger ones flowing into Kotzebue Sound. The larger part of the Arctic drainage is derived from interior valleys and northern slopes of the Rocky Mountain ranges. The Noatak and the Kobuk, which are bounded both north and south by mountains of the northern system, belong to the first of these classes; and northerly flowing waterways which are fed by streams from the seaward slope of the Rockies belong to the second. The Colville, the largest of these rivers, properly belongs to both classes, for its source lies well within the front ranges, through which it passes in a narrow valley.

PACIFIC DRAINAGE.

The larger rivers of the Pacific drainage have southwesterly courses, and many of them flow from sources in the Pacific Mountain system. In southeastern Alaska there are three large rivers which rise in the interior plateau region: the Stikine and Taku traverse the Coast Range to reach the sea, while the Chilkat reaches the coast through the longitudinal valley that separates the St. Elias and Coast ranges.

STIKINE BASIN.

The Stikine River, which finds its outlet near latitude 57°, rises in British Columbia inland of the Coast Range, where its headwaters interlock with those of the Liard, tributary to the Mackenzie, and with streams flowing to the Yukon. In other words, this divide, the most important in the province, distributes waters to three great systems: the Liard, flowing northeastward, traverses the Rocky Mountains and joins the Mackenzie, which flows into the Arctic; the Stikine, with a southerly course, reaches the Pacific through the Coast Range; and the Yukon waters flow to the northwest, on a long journey to Bering Sea.

Along the upper Stikine[a] the valley is rather broad, with a floor 3,000 to 4,000 feet below the inland plateau level; but in crossing the Coast Range it narrows between abrupt walls 1,000 to 8,000 feet high.

At the head of the delta the river emerges from the Little Canyon, which is about three-fifths of a mile long and 50 yards wide, and is bounded by rock cliffs 200 to 300 feet high. Eight miles above is the Kloochman Canyon, 300 feet wide. Above Telegraph Creek a constricted portion of the valley, 30 or 40 miles long, has received the name Great Canyon.

Near its source the river flows from east to west, then it gradually turns southward and traverses the mountains with an almost due southerly course. Twenty miles from the coast the river bends sharply to the west again, and finally reaches salt water at the head of the Stikine Sound, an arm of the sea which is outlined by promontories of the mainland and by several islands. The delta of the river is the silted-up inland extension of this same channel.

On its way through the mountains the Stikine receives several large glaciers. Most of its tributaries are in British Columbia, inland of the Coast Range. Of these the Iskut, confluent from the east near the inland front of the range, is the largest. According to Dawson, the mouth of Telegraph Creek, which is practically at the head of steamboat navigation, is 130 miles from and 540 feet above tide water. The mean velocity of the current to this point is about 5 miles per hour.

The Stikine Valley has long been a route of communication between the natives of the coast and of the interior. The white trader made use of the same waterway, and he was followed by the miner and prospector. In the early seventies, during the height of the excitement attendant upon the discovery and development of the Cassiar gold district, several thousand men made their way inland by this route, and during the Klondike excitement of 1898 it was one of the many routes by which the gold seekers attempted to reach Dawson.

TAKU BASIN.

The Taku River rises in the Central Plateau region of British Columbia, and flows southwest across the Coast Range to salt water at the head of Taku Inlet, a deep indentation of the southeastern coast of Alaska near latitude 58° 30′. Its northern waterways interlock with the streams flowing into Lake Atlin and those tributary to the Teslin, both belonging to the Yukon drainage, and its southern are opposed to tributaries of the Stikine.

The upper Taku[b] and its tributaries flow in broad, open valleys, whose floors are about 3,000 to 4,000 feet above sea level and 2,000 feet below the level of

[a] Dawson, G. M., Report on an exploration in the Yukon district and British Columbia: Ann. Rept. Geol. Nat. Hist. Survey Canada, new series, vol. 3, pt. 1, pp. 46B–51B.

[b] Hayes, C. W., An expedition through the Yukon district: Nat. Geog. Mag., vol. 4, 1893, pp. 117–162.

the plateau. Up to 1,500 feet the valley walls are steep and then slope gently up to the level of the plateau. The valley of the lower Taku, which, according to Hayes, is an inland continuation of Taku Inlet, has abrupt sides, sometimes almost perpendicular for 3,000 to 4,000 feet.

The river is swift, and its waters are heavily laden with sediments. It is unnavigable for steamers, but small boats have been taken up to the south fork, whence an Indian portage trail of 80 miles leads to Lake Teslin. This has been used as a route to the interior by an occasional party of prospectors, but never extensively, even during the Klondike excitement.

CHILKAT BASIN.

The Chilkat[a] River has its source on the Canadian side of the international boundary, in the coastal mountain province, and flowing in a southeasterly direction, through a depression which separates the northern part of the St. Elias Range from the Coast Range, reaches the coast at the head of Chilkat Inlet, a western arm of Lynn Canal. Its headwaters interlock with those of the Alsek, and its largest northern tributary, as yet unnamed, has its source in a glacier which drains partly into the Lewes River.

The upper course of the Chilkat lies through a constricted valley, whose walls rise steeply for 1,000 to 1,500 feet and then slope more gradually to the mountain summits. As the lower valley is merely an inland extension of the tidal fiord that has been filled up by alluvial deposits, its walls merge with the slopes of the inlet.

The valley slopes are broken by benches and terraces, of which the highest observed have an altitude of 1,000 to 1,500 feet. In the report cited these stream benches were considered by the writer to give evidence of recent uplift, but he now regards them as chiefly of glacial origin.

The Chilkat basin lies, for the most part, in high mountains, where the relief is from 5,000 to 7,000 feet; while the divide which separates its headwaters from Alsek drainage is about 3,000 feet above tide. To within 30 miles of the coast the river flows in one stream, then it breaks up into numerous channels meandering over a wide, gravel-filled valley bottom. This results in a broad delta which occupies the head of the inlet and is rapidly encroaching upon it with a seaward extension of silt flats which are uncovered at low tide. The river is turbulent and silt-laden, and descends probably 400 or 500 feet in the lower 70 miles of its course. It has been navigated, with difficulty, by a small steamer as far as Klukwan, an Indian village, about 20 miles from tide water.

The Takhin and Klehini, the largest tributaries of the Chilkat, are both affluent from the west within 10 miles of tide water. They have their sources in glaciers and receive numerous glacial tributaries from the slopes of the St. Elias Range. A number of glaciers also find outlet in the Chilkat itself.

Along the Chilkat and Klehini valleys routes of travel into the interior were established by the coast Indians long before the coming of the white man. After white traders reached the coast, the Chilkat Indians occupying the region

[a] Brooks, A. H., Reconnaissance from Pyramid Harbor to Eagle City, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 347 and 348.

about the head of Lynn Canal became the middlemen, through whom the natives of the interior secured the products of civilization. Their trading expeditions involved a journey of several hundred miles across the divide at the head of the Chilkat River and thence westward along the northern base of the St. Elias Range to the natives of the White River. Jack Dalton, an Alaskan pioneer trader, used this old Indian route during the early Klondike excitement in establishing a trail from Pyramid Harbor up the Chilkat and Klehini rivers and across the divide to the interior. It was at first extensively used for driving cattle to the Yukon, as it passes through an exceptionally good grazing country, but since the building of the White Pass railway this trail has been almost abandoned.

SMALL WATERCOURSES OF SOUTHEASTERN ALASKA.

The Chilkat, Taku, and Stikine are the only large rivers in southeastern Alaska, but there are a number of smaller ones, whose drainage basins lie in the Coast Range. The Taiya River rises in a glacier close to the Chilkoot Pass, and, flowing southwesterly through a rather broad valley, empties into the head of Lynn Canal. The Chilkoot Pass is 3,100 feet above the sea, and the adjacent peaks of the Coast Range reach 7,000 and 8,000 feet. About 4 miles east of the Taiya River the Skagway River is tributary to Lynn Canal. The lower 20 miles of its course is directed southwesterly through a broad valley, upon which it debouches by a sharp curve out of a narrow canyon from the southeast. At this bend it is joined by a small tributary which has its origin at an altitude of about 2,800 feet in the White Pass, 5 miles to the northwest.

The Chilkoot and White passes separate the affluents of Bering Sea on the north from the Pacific drainage on the south. Nowhere in the entire coastal mountain belt do the inland streams find source so near the coast, for the Lewes River, a tributary of the Yukon, springs from a small lake beyond the Chilkoot Pass, not 25 miles from tide water. This natural inland route of travel was in use by the coastal natives when white men first came; it was adopted by the Yukon pioneers, and the beginning of the Klondike excitement found it well established. Thousands of gold seekers transported their equipment with heart-breaking toil across this barrier in 1897 and 1898. In the latter year a trail was established across the White Pass, which soon developed into a wagon road, and was in time followed by the railroad. Upon the opening of the railway in 1899 all other routes across the Coast Range were practically abandoned.

The Unuk River enters Burroughs Bay, an arm of the sea, in latitude 56°, and its lower valley is a silted-up portion of the bay. As far as known,[a] its source must lie near the eastern slope of the Coast Range. It is not navigable for steamers, but prospectors have ascended it in small boats for 20 or 30 miles. The grade of the stream is steep and the current swift. Mining interests which have been developed in the Unuk basin have led to the construction of a wagon road for some distance inland.

The seaward drainage of the Coast Range finds outlet through many small streams into the embayments and channels of the coast line. The gradients of

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[a] Brooks, A. H., The Ketchikan mining district: Prof. Paper U. S. Geol. Survey No. 1, 1902, pp. 36 and 37.

the watercourses are, as a rule, steep, and the streams, which flow transverse to the axis of the range, are torrential. Ice has sculptured the mountains, leaving in its wake many cirques whose floors slope to sea level, or below it, through U-shaped valleys.

There are also many smaller amphitheaters far above sea level, in which streams have incised sharp V-shaped valleys below the old glaciated floor. Some of the glacial channels are of the true "hanging valley" type, which end abruptly, often breaking off in cliffs over which the streams tumble in beautiful waterfalls on their way to the sea.

Much of the precipitation on the higher mountains is in the form of snow, and of the resulting glaciers some of the larger debouch directly into the sea, while the smaller discharge into the rivers. The drainage of the Alexander Archipelago is usually carried to the sea by small streams. Here, except on Baranof Island, there are no glaciers, but the U-shaped valleys, as well as other phenomena, give abundant evidence of former ice erosion.

CROSS SOUND TO CAPE FAIRWEATHER.

For 100 miles west of Cross Sound the St. Elias Range presents a bold, unbroken front to the ocean. In this stretch small streams fed by the perennial snows of the upper heights here and there tumble down the precipitous slope, often almost sheer to salt water. Much of the precipitation is carried down as snow and ice in the numerous glaciers, some of which discharge directly into the sea. The bare rocks, vast expanses of snow and ice, precipitous peaks, and crests rising almost sheer 10,000 to 12,000 feet above the sea, afford a landscape hardly equaled in the world for its grandeur.

ALSEK BASIN.

West of Cape Fairweather an abrupt recession of the mountain front marks the eastern margin of the broad delta of the Alsek River, which, though as yet unsurveyed, is believed to have a width of nearly 40 miles. The small bight in the coast line at the delta front is called Dry Bay. The recession of the mountains continues inland as the eastern wall of the Alsek Valley, a broad depression transverse to the St. Elias Range, and the only break in the coastal barrier between the Chilkat and Copper rivers. The Alsek and its tributaries rise in the inland plateau province in Canadian territory. North of the range the drainage system is characterized by broad valleys which have gently sloping walls, and sometimes widen out into gravel-floored basins. These are often connected by constricted channels with steep rock walls, veritable canyons, in fact. The topographic evidence all points toward recent changes and readjustment of this drainage system (see pp. 284, 285).

Little is known of the Alsek River within the mountains, but it is said to fork about 40 miles from the sea.[a] The eastern branch, called the Tatshenshini River, rises near the headwaters of the Chilkat, flows northwesterly through a succession of valley basins and rock canyons to about the one hundred and thirty-

[a] Brooks, A. H., Reconnaissance from Pyramid Harbor to Eagle City, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 348.

seventh meridian, there makes a sharp bend to the southwest and enters the mountains in a rock canyon several hundred feet deep. The canyon walls are cut off at the top by a bench which has a width of a mile or more, and undoubtedly marks a former valley floor. The canyon and bench are said to be continued downstream nearly to the head of the delta, the depth of the canyon increasing toward the sea.

The Kaskawulsh River, the west fork of the Alsek, has its source near latitude 60° 30′, in a large irregular-shaped lake called Dezadeash, from which it flows northwesterly for about 20 miles; then it bends to the west and finally flows almost due south as it enters the mountains in about latitude 60° 20′. Its upper valley is broad, but of its lower course little is known. One large tributary, the Jarvis River, rises in Aishihik Lake; another, the Oconnor, springs from a glacier of the same name, and receives an unnamed tributary, which also has a glacial source in the high ranges to the southwest near Mount Hubbard.

The following is quoted from a publication by the writer:

"The Alsek River system[a] includes a region of extremely varied topography. Its upper waters lie within the Yukon plateau, and here the valleys have been cut some 3,000 to 4,000 feet below the general level. The basin is drained by valleys which cut entirely through the St. Elias Range, and here the relief must be many thousand feet, but accurate data are entirely lacking. The Alsek is said to be fed by numerous glaciers in that part of its course where it cuts the range. Waterfalls and rapids have been reported on both the lower Tatshenshini and the Kaskawulsh. The elevation of the Dalton House (lat. 60°, long. 137°) is about 2,500 feet, so that the Tatshenshini waters fall about that much in the distance of 100 miles to the sea. As would be expected from this fact, the reports state that the river is swift and turbulent. The maps show that the Alsek empties into Dry Bay, which reaches almost to the base of the mountains. This bay was thus named because its bottom is uncoverd at low tide."

Owing to the turbulent character of the Alsek and its two forks, navigation is impossible for any but small boats, and is very difficult even for these. The coast natives are said to ascend to the forks only. An additional menace to boats is found in the fact that a number of tributary glaciers partly block the river channel. The heavy snowfall and absence of fuel other than willow in the lower Alsek Valley does not invite winter travel. It can, therefore, be assumed that this was never used as a native route of communication between the coast and the interior.

During the rush to the Klondike gold fields, even the Alsek route, uninviting as it seemed, found its victims, and upward of 300 persons landed in the spring of 1898 near the head of Disenchantment Bay. Many of these laboriously hauled their outfits, including boats, across the Hubbard Glacier, a distance of 50 miles or more, to the Alsek River. Here the majority became discouraged, but some persevered and continued up the Alsek during the summer months. Winter camps were established in a region almost devoid of fuel, and great hardships and privations ensued, a number of deaths resulting from freezing and sickness. In the spring of

[a] Brooks, A. H., Reconnaissance from Pyramid Harbor to Eagle City, Alaska; Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 349.

1899 probably not over a dozen of the original number reached Dalton House, on the Tatshenshini River. They had endured eighteen months of hard labor and privation, only to find themselves at a point on the Dalton Trail which can be easily reached from the coast in a few days' travel.

YAKUTAT BAY.

Connecting the delta of the Alsek with Yakutat Bay to the west is a series of lagoons and channels which offer a water passage for canoes; and tributary to these are some small rivers. A railway is now in construction which is to transport salmon from these rivers to the cannery at Yakutat Bay, and it will also be used for exploiting the heavy growth of timber along its route.

Yakutat Bay itself receives no important drainage channels. Westward to the Copper River are miles and miles of glaciers along the coast; some discharge directly into the sea, but most of them front a gravel plain which shelves down to the coast. The few small rivers found in this belt merit no special description; their courses are entirely within the piedmont region, which is heavily forested.

COPPER BASIN.

A broad, gravel- and silt-floored basin stretches north from the inland slope of the Chugach Mountains to the foothills of the Alaska Range. It is bounded on the east by the Wrangell Mountains and the Copper River, and extends westward to the Sushitna basin by a depressed area lying between Talkeet Mountains and the Alaska Range. The basin floor has a monotonous lack of relief, which contrasts strongly with the rugged mountains encircling it (Pl. XIV, *B*). At the escarpment on its eastern margin, where it falls off to the Copper River, it stands about 2,000 feet above sea level, but it rises gently to the west to an altitude of about 3,000 feet at the divide. This topographic feature is, in fact, a plateau built up largely of Pleistocene deposits, deeply dissected near its margins, and called the "Copper River Plateau," by Mendenhall,[a] who was the first to describe it (Pl. XXV). While it is usually an almost unbroken plain, it is varied in places by hills and small groups of mountains, and is dotted with small lakes.

The Copper River Plateau lies entirely within the Pacific Mountain system, and though of low relief, includes three important watersheds. Its eastern drainage falls into the Copper, its western into the Sushitna and Matanuska, and a small area in the north drains to the Tanana through the Delta River.

The Copper River has its source in the mountains east of the plateau, traverses its eastern margin, and, passing through the Chugach Mountains, debouches into the Pacific across a broad delta. Along its upper course it is fed by many glacial streams from the high mountains lying to the south and east, and its westerly tributaries receive a large part of the drainage of the Copper River Plateau. The entire basin comprises an area of about 23,000 square miles. The following general description by Schrader and Spencer still holds good, though the topographic mapping done during 1902 makes it possible to add more details:

[a] Mendenhall, W. C., A reconnaissance from Resurrection Bay to the Tanana River, Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, p. 297.

"Copper River[a] rises on the northern side of Mount Wrangell and, assuming a northward course, which is maintained for about 40 miles, turns toward the southwest and continues for 50 miles, when it turns again and bears more to the east; then, continuing in this direction, it is joined by Chitina River at a distance of about 150 miles from its head. Finally, after having half encircled the great Wrangell group of mountains, the river turns toward the south and traverses the Chugach Range in a comparatively constricted valley, reaching the Pacific Ocean about 150 miles west of St. Elias. It is just below this southerly bend that the river is joined by the Chitina, the tributaries of which reach the glaciated divides of the Tanana and the White on the east and those of the coastal watershed in the region north and west of St. Elias."

The Copper River has its source in a large glacier (Copper Glacier), which is fed by the névé fields of the northern slope of Mount Wrangell, and flowing northward for some 10 miles through a narrow valley it emerges into a broad basin, where its volume is increased by the Batzulnetas River from the east and the Slana River from the north. It flows northwesterly as far as the mouth of the Slana, beyond which it turns first west and then southwest, and is joined by the Chistochina, a river flowing southward through a broad valley from the ice-covered slopes of the Alaska Range.

Below the mouth of the Chistochina a broad basin 60 miles in width stretches from the Wrangell Mountains on the east to the margin of the Copper River Plateau on the west. Both walls of the basin have gentle slopes, broken here and there by terraces of silts or gravels, in which the Copper and its tributaries have often incised sharp channels. South of latitude 62° the walls of the basin approach each other, and finally at the mouth of the Chitina the Copper enters a narrow, steep-sided valley, and follows it for 75 miles to the head of the delta.

In the broader part of its valley the Copper receives from the north the Gakona and the Gulkana rivers, which rise in glaciers of the Alaska Range. The Tazlina, Klutina, and Tonsina are tributary from the northwest, and have their sources along the inland slope of the Coast Range. The Wrangell Mountains contribute a number of glacial streams to this part of the Copper, of which the Sanford, Klawasi, Nadina, Dadina, Chetaslina, and Cheshnina are the largest.

The Klutina Valley is the route of the military trail from Valdez over the Thomson Pass; Copper Center, the most important settlement of the basin, is located at the mouth of the river. Chistochina, the second camp of importance, situated at the mouth of the river of the same name, is the distributing point for the placer fields. Both places are connected with the coast and with Eagle, on the Yukon, by the military telegraph line.

The Chitina River joins the Copper from the east, at the lower termination of the Copper basin, of which the Chitina Valley is an eastern extension. This stream, the largest tributary of the Copper, rises in a glacier on the slopes of the St. Elias Range and flows northwestward through a broad valley about 120 miles long. Its principal tributary is the Nizina, which springs from a glacier of the Skolai Mountains to the north; numerous other streams join it from both north and south.

[a] Schrader, F. C., and Spencer, A. C., Geology and mineral resources of the Copper River district, Alaska: U. S. Geol. Survey, 1901, p. 29.

The lower constricted part of the Copper River Valley, between the mouth of the Chitina and the head of the delta, is in general steep-sided and rockbound, but in only one place can it be designated a true canyon. This, called "Wood Canyon," is several miles in length and has perpendicular walls. The streams tributary to this part of the Copper also flow in narrow valleys with precipitous slopes. The most important are the Tiekel and Tasnuna from the west and the Bremner from the east.

Schrader and Spencer[a] give the following description of the delta:

"Eastward from Prince William Sound the mountains of the mainland are bordered by a low area of mud flats having a width of 5 to 15 miles. Across the eastern portion of this lowland flow Eyak and Sheridan rivers, the latter draining the glacier of the same name. Only a short distance from the mouth of Sheridan River is the westernmost slough of Copper River, the first of the many distributaries of the Copper which come to the ocean at intervals for a distance of over 50 miles along the coast. The lower course of the Copper seems once to have been a wide embayment reaching back into the Chugach Mountains, but this has been filled in by vast quantities of sediments brought down by the river, and the broad delta is the result of their deposition."

The Copper River is a mud-laden, turbulent stream throughout its course. Above the point where it enters the mountains it is usually spread out into numerous channels, with many sand bars and islands. From its source to the sea it falls about 3,000 feet, 1,000 of which is in the lower 200 miles of its course. The average gradient of its entire length is about 12 feet to the mile.

While for the most part unnavigable for steamers, small boats have been used extensively on its turbulent waters and on some of its tributaries. The greatest danger to boating is encountered in passing Childs and Miles glaciers, which in part block the river with their discharge; but these are rapidly receding.

The Copper River natives were accustomed to make annual visits to the coast in their moose-skin boats long before white men ever penetrated the interior basin, and in the low divides between the headwaters of the Copper River and the Tanana they found easy routes for inland excursions which brought them into close relation with the Tanana natives.

In 1898 the first attempt was made to find a route into the Yukon by the Copper River Valley. During the excitement of that year about 3,000 people landed at the upper end of Port Valdez with the intention of crossing the Chugach Range into the Copper River Valley by a route which led over the Valdez Glacier and a high summit (5,000 feet), and thence down a western fork of the Copper River. Though the crossing of the glacier and mountains, while burdened with provisions and outfit, proved a difficult and dangerous task, yet many succeeded, and tons of supplies were thus laboriously taken inland. The War Department has since built a horse trail across the Thomson Pass (2,400 feet) in the Chugach Mountains, which affords an easy route to Copper River and to the Yukon, and is used both winter and summer for the United States mail.

[a] Schrader, F. C., and Spencer, A. C., Geology and mineral resources of the Copper River district, Alaska: U. S. Geol. Survey, 1901, p. 27.

COPPER RIVER TO COOK INLET.

The coastal belt between the Copper River and Cook Inlet sends its drainage to the Pacific through small streams which fall precipitously from the high mountains close to the coast. Many large glaciers discharge into the fiords of Prince William Sound and of the eastern shore of Kenai Peninsula. Portage Bay, the western arm of Prince William Sound, is connected by a low glacier-filled pass with Turnagain Arm. This gap has long been used by the natives. A broad valley stretches inland from Resurrection Bay, and its upper end is separated from streams flowing into Turnagain Arm by a pass only 1,000 feet high. Through this natural highway into the interior a railway is now being built.

Many of the easterly tributaries of Cook Inlet spring from glacial sources in the Kenai Mountains, and these traverse a gently westerly sloping upland to tide water. The largest are the Kaknu and the Kasilof rivers. Three large lakes—Tustumena, Kenai, and Shilak—lie along the border of the upland and the mountains, and drain into Cook Inlet.

SUSHITNA BASIN.

Between the Kenai Peninsula and the Chugach Mountains on the east and the Aleutian and Alaska ranges on the west lies a broad depression; its southern half is occupied by the waters of the Pacific, forming Cook Inlet, and its inland portion by the valleys of the Sushitna and Matanuska rivers. During countless ages these rivers have been building up their delta mouths, gradually encroaching upon tide water, and the valley floors of their lower courses represent the silted-up portions of the former extension of the inlet. The broad tidal flats at the mouths of both rivers bear witness that this action has not been interrupted.

The Sushitna River system drains an area of about 8,000 square miles lying east and south of the Alaska Range. Its western tributaries rise in the glaciers of that range, while its eastern ones reach far out into the Copper River Plateau. The main Sushitna issues from a glacier of the Alaska Range and flows southeast through a narrow valley until it emerges from the mountains upon the plateau, then bends almost due west. This course continues for about 60 miles; for the first 30 in a broad valley, and then through a rock canyon, where the river makes a sharp southerly turn in latitude 63°. Here the valley begins to broaden gradually until it finally merges with the broad basin of Cook Inlet.

On the west the Sushitna is joined by the Chulitna, Peska or Croto, and Yentna, which with their chief tributaries all head in glaciers of the Alaska Range. The mountain portions of streams lie in typical glaciated valleys, with U-shaped cross sections. As they emerge from the mountains their slopes are bounded by high terraces, but these gradually disappear, the walls grow farther apart, and the bottoms finally merge with the Sushitna lowlands. The Tokichitna joins the Chulitna from the west in about latitude 62° 30′. In about latitude 63°[a] the Chulitna receives from a glacier an unnamed tributary which occupies the northerly extension of the main Chulitna Valley. Fifty miles above is a broad gap called Caribou Pass, 2,500 feet in altitude, which separates the Cook Inlet drainage from north-flowing waters.

[a] Eldridge, G. H., See map accompanying Reconnaissance in the Sushitna basin and adjacent territory, Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 1-29.

The Talkeet is the only large eastern tributary of the Sushitna. Along the headwaters of this stream the western extension of the Copper River Plateau enters the Sushitna basin, and the Talkeet for almost its entire length is incised in the plateau. Its lower course lies through a rock canyon.

The Sushitna is a turbulent, silt-bearing stream, which flows in many channels; and the same is true of most of its tributaries. It is not easily ascended even in small boats, though this has been accomplished many times. A steamboat has been taken up the Sushitna as far as the mouth of the Chulitna, and up the Yentna to the mouth of the Keechatna.[a]

The entire Sushitna basin has long been a hunting ground for the natives of Cook Inlet and the Sushitna Valley, and Caribou Pass afforded them means of communication with the Tanana Indians, but it does not seem to have been much used. This is undoubtedly one of the easiest routes through the mountains which separate the Yukon basin from the Pacific coastal province, and is suitable for a railway. Several passes, but of greater altitude, are found near the sources of some of the southern tributaries of the Yentna. These, though they permitted intercourse between the Kuskokwim and Sushitna natives, were nevertheless almost ignored before the coming of the white man.

MATANUSKA BASIN.

Of the rivers flowing into Cook Inlet the Matanuska,[b] emptying into Knik Arm—a long, narrow tidal waterway connected with the northern part of the inlet—is second in size only to the Sushitna. It flows southwesterly from a source north of the Chugach Mountains, near the southwestern margin of the Copper River Plateau, its valley separating the Talkeet Mountains on the north from the coastal mountains to the south. Much of its course is through a canyon incised in an older valley floor, the remnants of which are preserved as gravel-covered benches (Pl. XV, *A*). Its most important tributary is Knik River, which joins it from the east.

The upper end of Cook Inlet receives from the west a number of small rivers, which have their sources on the eastern flank of the Alaska Range, and are mostly glacial streams. To the south the Aleutian Range rises almost directly from the sea, and drains to the Pacific entirely through small streams. As the divide is close to the eastern shore throughout the Alaska Peninsula, there are no drainage ways on the eastern side worthy of mention. The topography of the Aleutian Islands, as far as known, is rugged, and none of them are large enough to feed anything but small streams.

SUMMARY.

The Pacific drainage of Alaska is carried to the sea by six important rivers, and many minor streams. Three rivers—the Stikine, Taku, and Alsek—have their sources in the Interior Plateau region, and break through the coastal mountain belt to reach tide water. The valley of another, the Chilkat, separates two of the coastal ranges. The Copper River also traverses one range of coastal

[a] Brooks, A. H., Exploration in Mount McKinley region: Prof. Paper U. S. Geol. Survey. (In preparation.)

[b] Mendenhall, W. C., Reconnaissance from Resurrection Bay to the Tanana: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 7. 1900, p. 299.

A. VIEW UP MATANUSKA VALLEY FROM GLACIER POINT.

Showing recent gorge in older valley.

B. YUKON VALLEY AT DAWSON.

mountains, but as the Pacific Mountain system broadens out to the northwest and includes several ranges, its headwaters do not reach inland to the plateau province; its drainage basin includes a large part of the so-called Copper River Plateau, which is hemmed in on three sides by high mountain ranges. The Sushitna, the sixth of the important rivers, has its basin entirely within the Pacific Mountain system. Its lower valley is an inland extension of the Cook Inlet depression, and it receives the eastern drainage of the Alaska Range and a part of that of the Copper River Plateau.

Much of the Pacific drainage is from a region of abundant precipitation, and in volume of water the streams are out of proportion to the areas which they drain. In the highlands much of the precipitation is snow, which finds its way to the lowlands in the form of glaciers.

BERING SEA DRAINAGE.

OUTLINE.

Bering Sea drains nearly all of the vast Central Plateau region and much of the inland slopes of its bordering ranges, an area comprising not only over half of Alaska but also a considerable part of British Northwest Territory and British Columbia. For purposes of discussion it is convenient to consider this drainage in its four natural subdivisions, named from south to north as follows: Bristol Bay, Kuskokwim River, Yukon River, and Norton Sound. The rivers and streams flowing into Bristol Bay, a deep indentation of the shore line north of the Alaska Peninsula, comprise the southernmost of these divisions. The Kuskokwim basin lies adjacent on the northwest, and is in turn bounded also on the northwest by the great Yukon basin. The fourth province embraces the many small rivers which flow into Norton Sound.

BRISTOL BAY.

The largest volume of water contributed to Bristol Bay comes through the Kvichak, which joins the bay at its extreme northern end and drains an area blocked out by the northern end of the Aleutian Range on the east, the Alaska Range on the north, and the Kuskokwim divide on the north and west. This basin includes also the two largest lakes of Alaska, Iliamna and Clark. The Kvichak heads in the former and flows southwest across a lowland for about 50 miles, into a tidal estuary at the head of Bristol Bay. The fall from the lake to the sea does not exceed 50 feet, and the Kvichak is reported to be very shallow and its current not swift. Large rowboats ascend to its source without serious difficulty.

Iliamna Lake, a broad sheet of water, lies between the fifty-ninth and sixtieth parallels of latitude; its most easterly point is said to be only 12 miles distant from tide water at Cook Inlet. No surveys have been made of the lake, but according to report it is about 50 miles long and 15 or 20 wide, with an elevation of less than 50 feet above tide. The lower shores are bordered by a broad lowland which stretches southwest beyond the valley of Nushagak River to Bering Sea and southward along the western shore of the Alaska Peninsula. On the south and east the Aleutian Range constitutes a barrier between Iliamna Lake and Cook Inlet. At its lower end it measures 50 miles or more in width and 3,000 to 4,000 feet in altitude; but to the north both width and altitude decrease until a single ridge 2,000 or 3,000 feet in height is all that intervenes between the lake and tide water. The east shore of the lake is said to be formed by a gravel-floored plain sloping up to the abrupt face of the mountains. A pass at a height of about 800 feet affords an easy route of communication between the upper end of Iliamna Lake and a bay of the same name on Cook Inlet, and has long been in use by whites as well as natives.

The tributary drainage is unmapped, but the Nogheling, which drains Lake Clark at the north, and is not over 30 miles in length, is probably the largest river. The difference in altitude between the two lakes has been estimated at from 50 to 100 feet, for the Nogheling is known to have a very steep gradient, with many rapids and probably falls.

Lake Clark,[a] also unsurveyed, is reported to be 55 miles long and about 10 miles wide at its lower end, narrowing to 2 miles at its upper end. Its geographic position is undetermined, but the eastern shore is probably at least 25 miles west of Cook Inlet—possibly 50. The Chulitna River, which enters the lake from the north, is said to have its source in the mountains lying 30 or 40 miles west of the upper part of Cook Inlet. The eastern tributaries of the lake are short, as they rise in the Aleutian Range which skirts the eastern shore. Several of the most northerly emerge from small glaciers. The western tributaries are longer and several are known to rise in small lakes, but beyond this little is known about them. The Chulitna, possibly the largest, flows through a lowland region, and near its headwaters a short portage connects it with waters flowing into Nushagak River, also tributary to Bristol Bay.

Around the upper end of Lake Clark the mountains are said to be bold, with altitudes of 5,000 to 6,000 feet; but they decrease in height to the south, and near the southern end of the lake fall to a rolling upland of low relief. The actual shores of the lake are said to have gentle slopes, and terraces are reported on its east side near the southern end.

A deep estuary forming the northwest arm of Bristol Bay receives the waters of the Nushagak River, which far exceeds the Kvichak in length, though not in volume. One hundred miles from tide water the river divides: The west fork rises in Tikchik Lake, said to be about 20 miles long and to be linked on the north with a series of smaller lakes, affording an almost continuous water route to the middle Kuskokwim; and the east fork, called the Mulchatna, has its source near the head of the Chulitna, which empties into Lake Clark, and is connected with the Nushagak by the short portage already referred to. Wood River rises in a lake about 20 miles from the coast and flows southward into the same estuary as the Nushagak.

A number of small rivers which drain small lakes are tributary to Bristol Bay through southerly courses. The largest of these, the Togiak,[b] has its source

[a] The writer is indebted to Mr. Wilfred H. Osgood, of the Biological Survey, for sketch map and notes on this region in advance of the publication of his report. Mr. M. W. Gorman, who collected in the Lake Clark region for the Department of Agriculture, also kindly furnished valued information.

[b] Spurr, J. E., A reconnaissance in southwestern Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, p. 87.

in a lake of the same name, about 50 miles from the coast. Togiak Lake is about 15 miles in length and lies in a broad valley, which opens toward the south and merges with the lowland belt bordering Bering Sea. The natives have a portage route from the head of a stream entering the west side of the lake to the head of Kanektok River, which flows westward into the Kuskokwim estuary.

A large part of the Alaska Peninsula drains into Bering Sea through streams flowing from lakes within the mountain belt of its eastern half. After leaving the mountains these streams traverse with sluggish currents the lowland belt which skirts the western shore of the peninsula, and as the lowlands gradually narrow to the south the streams become correspondingly shorter. None of these water courses have been accurately mapped, and few are of sufficient size to merit special description.

The affluents to Bristol Bay are, as a rule, short and drain lakes which are not far above sea level. Iliamna and Clark, the largest of these lakes, receive the waters of a large area, including the southern end of the Alaska Range and the western slope of part of the Aleutian Range. The topography is of two essentially different types: First, the coastal lowlands, over which the drainage channels meander sluggishly; and secondly, the mountain region, where the drainage system is better defined. The lakes so abundant in the region lie, for the most part, at or close to the line of demarcation between these two topographic provinces.

KUSKOKWIM BASIN.

The area roughly blocked out by the Alaska and Aleutian ranges, the Tanana and Yukon rivers, and Bering Sea has been explored only in part. Its topography, as far as known, consists of rounded hills and low mountains, seldom exceeding 2,000 feet in altitude, interpenetrated by broad river valleys and many lowlands. As has been indicated, the waters of the eastern part of this area, including Lakes Iliamna and Clark, find outlet into Bristol Bay through several small rivers; but the greater part of the drainage is carried to Bering Sea by the Kuskokwim River, the second in size of Alaska, possessing a catchment basin of probably more than 50,000 square miles.

Many headwater streams of the Kuskokwim rise in glaciers on the inland slope of the Alaska Range and flow northwesterly, their channels gradually uniting into four or five rivers which are tributary to the two trunk streams, whose junction in latitude 63° can be regarded as the beginning of the Kuskokwim proper. Geographic usage has applied the name Kuskokwim to the southern fork, while the other, whose valley trends northeast and southwest, is called the East Fork of Kuskokwim. Mr. Spurr informed the writer that there is very little difference in the volume of the two rivers at their junction, but the southern, or Kuskokwim proper, is somewhat larger. According to this nomenclature the Kuskokwim River rises in the unexplored mountain mass at the southern extension of the Alaska Range, and its headwaters probably interlock with streams tributary to Lake Clark.

The Spurr [a] party, which explored the Kuskokwim River, reached it on their way through the Alaska Range in latitude 62°. Between that point and its source

[a] Spurr, J. E., Reconnaissance in southwestern Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 51 and 52. See pp. 128 et seq., this report.

the river is unsurveyed, but it is known to extend due south for 20 miles through a broad valley with slopes that rise gradually to mountains 5,000 and 6,000 feet in altitude (Pl. XI). In about latitude 62° the river makes a right-angled bend to the west and breaks through a minor range in a rock canyon about 5 miles in length. A broad valley[a] above this canyon is continued to the south as a depression, from which a pass leads into the valley of the Pleasant River, belonging to the drainage system of the Sushitna on the east side of the range. Beyond the mountains the Kuskokwim flows for 40 or 50 miles through another wide valley running north and south, the upper part of which is occupied by the Hartman River. The valley slopes are steep, broken only here and there by irregular glacial terraces, while the mountains on either hand rise to altitudes of 6,000 and 7,000 feet. In this interval the Kuskokwim receives two important tributaries, the Rohn River from the east and Post River from the southwest. The valley of the former is glaciated and reaches well back into the Alaska Range to a glacial source. Post River[b] occupies a broad, flat valley verging to the southwest, and its upper course is bounded on the west by snow-covered mountains, from which small glaciers discharge into the Post River or its tributaries.

From the point where it leaves the mountains in latitude 62° 30′, to its junction with the East Fork, the Kuskokwim flows northwesterly across the upper Kuskokwim Flat. This has already been described as a broad lowland area, to which the Alaska Range falls off abruptly (Pl. XI). At the base of the mountains the lowland has an altitude of about 4,000 feet, and slopes gradually to the northwest. As will be shown elsewhere, this was a region of slight relief which has been deeply buried in overwash, glacial gravels, and silts during the retreat of the ice sheet; and into these loose deposits the Kuskokwim has incised its channel to a depth of a hundred feet or more, sometimes carving out bold bluffs by undercutting.

Between the mountain front and the fork the Kuskokwim receives three tributaries from the east, the Jones, Dillinger, and Tonzona rivers, of which the two latter are the largest and have glacial sources. All of these emerge from the mountains in U-shaped valleys, and cross the plain through canyons incised in the gravels to a depth of a hundred feet or more.

The current of the upper Kuskokwim is swift, and above the mouth of the Hartman River is hardly navigable even for canoes. Below this point it broadens out into many channels, broken by islands and sand bars, and obstructed by snags and driftwood. According to a rough estimate by the writer, the current is 5 to 6 miles an hour at the mouth of the Rohn River, but as the river approaches its junction with the East Fork its course becomes more tortuous and its current more sluggish.

The East Fork of the Kuskokwim rises in about latitude 64° 30′, where its drainage courses dovetail with streams flowing northward into the Tanana. An easy portage route, long used by the natives, leads from these headwaters to the Cosna River, tributary to the Tanana. In latitude 64° another portage trail, about 15 miles in length, is used by the natives in passing from the East Fork

[a] Spurr, J. E., Reconnaissance in southwestern Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, map No. 6, p. 102.

[b] This river was omitted from Spurr's map. See map accompanying report entitled, An exploration in the Mount McKinley region, Alaska. (In preparation.)

to Lake Minchumina, which is drained by the Kantishna, a tributary of the lower Tanana. The broad valley of the East Fork trends southwest between low hills.[a] Most of its waters come from the east, for on the west the watershed which divides its drainage from that of the Yukon lies close to the valley's edge.

Its chief easterly tributaries, the Chedotlothna and Tatlathna, meander for the lower 20 miles of their courses through broad flat valleys, and above to the base of the mountains they are incised to a depth of 100 feet or more in the gravel plateau. Near the mountains the rivers break up into many minor streams, the majority of which find their sources in glaciers. Some of these glaciers reach to the lowland and discharge into the streams near the foot of the range; but where they have retreated the water courses penetrate to their fronts in U-shaped valleys.

Herron[b] Glacier, one of the largest, is fed by the snow fields of Mount Foraker and continues to the front of the range, where it discharges into Herron River, a southern fork of the Tatlathna.

Below the junction the Kuskokwim continues its northwesterly course for 30 miles, and here receives one important tributary from the west, the Tachat River. This stream is unmapped, but is reported to have its source near an eastern tributary of the Innoko, which flows into the Yukon, and to be connected with it by a short portage.

Near the one hundred and fifty-fifth meridian, where the Kuskokwim encounters a series of low hills, it makes a right-angled bend to the south, and a few miles farther on low hills appear on its eastern side also, the flats are left behind, and for nearly 100 miles the valley is well defined, bounded by hills whose summits seldom exceed 1,000 feet. Then in latitude 62° the east wall of the valley recedes, giving place to broad lowland; and the river receives the Chagavenapuk, an unexplored easterly tributary. The main river now flows southwest for 50 miles, closely hugging the low hills, which still continue on the northwest. A right-angled bend to the northwest then brings it into the so-called Kuskokwim Mountains, and it is joined by the Holiknuk, a river said to rise far to the south, in headwaters which interlock with those of the Nushagak and streams flowing into Lake Clark. For a distance of about 200 miles, in which it receives several small tributaries, the Kuskokwim flows through the Kuskokwim Mountains in a broad, flat valley, characterized by large rectangular bends; then in about latitude 61° 30′ it enters the flat tundra belt of the coastal region. Spurr[c] has noted that this junction between the mountains and the tundra is abrupt. Near the southern limit of the mountains, the Kuskokwim and Yukon are separated by only 15 miles of flat tundra, and a series of lakes and streams afford an easy portage for small boats.

As it meanders sluggishly through many tortuous channels across the coastal lowland, the Kuskokwim receives one important tributary from the east, the Kwikli. The small delta of the Kuskokwim, embraced within a belt probably 20 to 30 miles wide, is in strong contrast with that of the Yukon, which occupies more than 100 miles of the coast of Bering Sea. Several small rivers flow into

[a] Herron, J. S., Explorations in Alaska in 1899; Adjutant-General's office, No. 31.

[b] Named by the writer after Capt. Joseph S. Herron.

[c] Reconnaissance in southwestern Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, p. 69.

Kuskokwim Bay, of which the Kanektok, the largest from the east, rises within the Ahklun Mountains, 50 miles beyond the foot of the range.

This second largest river of Alaska drains a large area lying west of the Alaska and Aleutian ranges, and south and east of the lower Yukon. Its headwater tributaries, of which the most important have their sources in glaciers from the western slopes of the Alaska Range, flow westward across a lowland area and unite in two main trunk streams, which in turn unite to form the Kuskokwim proper. The Kuskokwim Valley for about 400 miles below the forks is broad, widening out to a lowland. Farther downstream the river leaves the upland region and continues to the sea across the coastal tundra belt. Its mouth is characterized by the absence of any considerable delta.

The Kuskokwim is navigable for steamers up to the forks, 500 miles from the mouth, and the ascent was first made in the summer of 1901. The southern fork, or Kuskokwim proper, can probably be ascended for 20 miles or more by steamer, and the East Fork a somewhat greater distance, while small boats can push still farther. Attention has already been called to the portages which connect some of the tributaries of the Kuskokwim with those of the Yukon basin. Though Kuskokwim River is easily navigable, before the coming of the white man the natives of the upper river seem to have had little communication with those near the coast. Their intercourse was rather with the natives of the Tanana and Yukon.

Russian traders had established themselves on the Kuskokwim 300 or 400 miles from the mouth before the middle of the nineteenth century, but after the transfer of the territory this post was abandoned, and the natives of the upper river long depended for their supplies on the lower Yukon trading posts, where they took their furs for barter. Since the establishment in 1901 of a trading post near the great forks of the river, 500 miles from the sea, the natives have avoided the long journey to the Yukon.

YUKON BASIN.

GENERAL DESCRIPTION.

The Yukon is the largest stream of Alaska, the main artery of an extensive drainage system which gives easy access to much of the vast intermontane region. To the natives the river is and has been all important, for through countless generations its waters have furnished them fish for food and easy routes of travel by canoe and raft in summer and sled and dog-team in winter. The white men, too, found access to the interior by this river. The Russians, coming from the west in search of furs, dragged their clumsy boats for a thousand miles against its current; while the English traders, who reached its headwaters from the east, descended in their bark canoes for hundreds of miles. One of the headwater tributaries rises in the Chilkoot Pass not two score miles from tide water on the Pacific, and furnished an inland route to the coast natives and later to the prospectors who discovered the Yukon gold fields. Now the railway through the Coast Range makes the upper Yukon basin still more accessible. Scores of steamers navigate the Yukon during the summer months, and its frozen surface affords a highway for winter travel. In short, the settlement by natives and whites and the development of all the mining interest of the great interior region of Alaska and northwestern Canada were only made possible by the Yukon waterways.

The Yukon, with its longest tributaries, the Lewes and Teslin, has a length of about 2,300 miles and a catchment area of about 330,000 square miles, over half of which is in Canada. The following table shows it to be fifth in rank among the rivers of North America:

Length and drainage area of five chief rivers of North America.

Rivers.	Length. (Approximately.)	Area of drainage. (Approximately.)
	Miles.	*Square miles.*
Mississippi, with Missouri	6,000	1,244,000
Winnipeg and Nelson	3,840	486,500
Mackenzie	2,868	677,400
St. Lawrence	2,600	565,000
Yukon, with Lewes and Teslin	2,300	330,000

The Yukon is comparable in length to the St. Lawrence,[a] but drains a much smaller area. The discharge of the Yukon has been approximately gaged by Dawson[b] at the confluence of the Pelly and Lewes, or the head of the Yukon proper. This, based on approximate current measurements made late in the summer, when the river is about at mean height, showed a discharge of 66,955 cubic feet per second.

Ogilvie, who made a more careful measurement of the Yukon at the international boundary, makes the following statement:

"At the boundary the river is somewhat contracted and measures only 1,280 feet across in the winter, but in summer, at ordinary water level, it would be about 100 feet wider. Immediately below the boundary it expands to its usual width, which is about 2,000 feet. The cross-sectional area at the boundary, measured in December, 1895, is 21,818 feet. There is a channel 600 feet wide, not less than 22 feet deep, and one 400 feet wide not less than 26 feet deep. During summer level those depths would be not less than 4 feet deeper, and the cross-sectional area 27,000. The discharge at this first level is approximately 96,000 cubic feet per second; at summer level it approximates 135,000 cubic feet; at flood level it approaches 180,000 cubic feet or more, possibly reaching for short times 225,000."[c]

The following extract, kindly furnished the writer by the Superintendent of the Coast and Geodetic Survey, is from the report of Asst. G. R. Putnam, of April 30, 1900:

"To obtain an approximation to the discharge of the Yukon, a cross section and current observations were obtained opposite Azacharak Hill (73 miles from the mouth), where the river is well confined between banks and carries all the water

[a] It should be noted that the St. Lawrence drainage basin includes the Great Lakes, an area of about 90,000 square miles.

[b] Dawson, G. M., Yukon district and British Columbia: Ann. Rept. Geol. Nat. Hist. Survey Canada, vol. 3, pt. 1, 1889, p. 18B.

[c] Ogilvie, Wm., The Klondike Official Guide, Buffalo, 1898, p. 56.

except what little may escape through Kashunuk slough. A drawing of this cross section is attached. The area was 160,000 square feet and the surface currents varied from 2.20 to 0.98 knots per hour. On the assumption that the current throughout each division of the section was the same as that on the surface, the discharge of the river was computed to be 436,000 cubic feet per second on September 8, 1899.

"This was at low summer stage, about 12 feet below the flood high-water line, as indicated by the gravel beach on the north shore and the débris on the inundated banks on the south shore. It is believed, however, that the river discharge is much less during the winter months, so that the above may not be far from the average for the year. It is about two-thirds that of the Mississippi. A comparison of cross sections of the Kwikluak and Kwikpak passes just below the separation indicates that the former carries over 75 per cent of the water of the river. The branch of the latter that is used by the steamers, the Apoon, carries apparently less than 1 per cent of the total discharge of the Yukon; the Kawanak, about 14 per cent, and the Okwega, about 3 per cent.

"Tidal observations were made at five points above the mouth; at the last station, 62 miles (statute) from the Kwikluak's mouth, the mean range was 0.4 foot per day."

The St. Lawrence has a discharge of about 900,000 cubic feet per second, or more than double that of the Yukon. This is what would be expected, for the St. Lawrence not only drains a much larger area (the ratio is about 5 to 3), but its basin receives much greater precipitation than that of the Yukon.

The sources of the Yukon lie in British Columbia. All of its upper drainage channels trend north and northwest until it reaches the Arctic Circle, where it makes a right-angled bend to the southwest, and continues in this general course until it empties into Bering Sea. From latitude 60° to about latitude 65°, where it enters Alaska, it flows through the Yukon Territory, and less than half of its basin lies in Alaska.

The Yukon basin, comprising an irregular area in Alaska and adjacent portions of Yukon Territory and British Columbia, is roughly outlined on the north, east, and northeast by the Rocky Mountain system, and on the south by the Pacific Mountain system. There are no considerable highlands on the southeast, for there the tributaries of the Yukon, Liard, and Stikine interlock irregularly within the plateau region. The chief tributaries of the Yukon are the Koyukuk, Tanana, Porcupine, White, Pelly, and Lewes. The main stream begins with the junction of the Pelly and Lewes, which are entirely within Canadian territory.

LEWES RIVER.

The source of the Lewes is in a small lake on the northern flank of the Coast Range only 25 miles inland from the head of Lynn Canal, a tidal estuary of the Pacific. In its upper course the Lewes flows through a chain of lakes which are connected by narrow, turbulent stretches of the river. The larger lakes from south to north are Bennett, Tagish, Marsh, and Lebarge. Tagish is very irregular in outline, probably because it is a flooded valley system. Here, as well as at Lake Bennett, the land often slopes abruptly from the water level, but the other lakes usually occupy only a part of the wide valley floor. Below Lake Tagish the valley is 1 to 5 miles wide, and though the slopes are usually gentle, the actual river banks are often silt and gravel bluffs, rising 50 to 100 feet above the water, and forming a terrace whose flat top extends to the valley wall proper (Pl. XXV, *B*). White Horse Rapids and Miles Canyon are formed by a mass of recently extruded igneous rock, incised to a depth of 100 feet by the river (Pl. XXVI, *A* and *B*). Five Finger Rapids are also due to a partially dissected rock barrier which has been uncovered by erosion, owing to a shifting of the channel.

Near its source the valley of Lewes is incised to a depth of about 3,000 feet below the general level of the plateau (5,000 feet), and as the plateau slopes to the northwest with about the same grade of the river the relief does not change appreciably.

A broad depression marking an abandoned valley stretches northwest from the lower end of Lake Bennett to a few miles above White Horse Rapids. This flat gap, 2 to 10 miles in width, floored with silt deposits, affords a natural route of communication which has been followed by the Yukon and White Pass Railway connecting Skagway, Alaska, with White Horse, Yukon Territory.

The Lewes has many tributaries, which will only be mentioned in passing. The Takhini River, confluent from the west, in latitude 61°, rises near the sources of the Chilkat and Alsek rivers. The Teslin,[a] the largest tributary and longer than the Lewes above the junction, flows northwest through a remarkably straight valley 2 to 10 miles in width, which is incised in the plateau.[b] The upper end of the valley is occupied by Teslin Lake, about 75 miles long, in which the Teslin finds its source.

Near latitude 62° the swiftly flowing Big Salmon River joins the Lewes from the southeast. This stream forks about 40 miles above its mouth. Its valley, incised in the plateau to a depth of 2,000 to 2,500 feet,[c] is bounded on the east by a high mountain mass, which towers far above the plateau level and forms the divide between the Lewes and Pelly waters. Fifty miles below, the Little Salmon, a small river, is confluent to the Lewes from the north.

Lewes River descends about 500 feet between its head at Lake Bennett and its junction with the Pelly, a distance of about 400 miles, but the gradient is very irregular. The velocity of the current varies greatly, according to the stage of the water, but at medium high water is probably between 3 and 4 miles per hour. Above the mouth of the Teslin the Lewes is most commonly confined to one channel, while in its lower portion it becomes more tortuous, and islands and sloughs are frequent.

There are no serious difficulties to steamboat navigation on the Lewes up as far as the White Horse Rapids, though at low stages the upper end of Lake Lebarge is very shallow. The White Horse Rapids and Miles Canyon are impassable to up-bound steamers, but obstruct only a few miles of the river, for above them are 100 miles of navigable waters as far as Lake Bennett. The now well-established route of travel to the Klondike is by railway from the coast to White Horse and thence by steamer to Dawson. The downstream journey occupies two to three days and the return four to six. The Chilkoot Pass route to Yukon waters was long

[a] The native name of this river is Teslin, but it is generally known as the Hootalinqua.

[b] Hayes, C. W., An expedition through the Yukon district: Nat. Geog. Mag., vol. 4, 1892, p. 132.

[c] McConnell, R. G., Salmon River gold fields: Summary Report Geol. Survey Canada, 1901, pp. 23 and 24.

jealously guarded from the white man by the Chilkat Indians of the coast, who desired to continue their monopoly of the interior fur trade. The first prospectors crossed the Chilkoot in 1880, and within a few years it became the chosen gateway to the Yukon gold fields, so that when the wild rush to the Klondike took place probably over three-quarters of the gold seekers selected the Lewes River route. The Coast Range barrier once surmounted by crossing the pass, an all-water route to the Klondike for small boats lay open, for it is possible for a skilled pilot to run the White Horse Rapids with comparative safety.

PELLY BASIN.

Pelly River[a] has its source in two small lakes which lie in latitude 61°, not far from the headwaters of the Liard. Hence it flows northwesterly through a broad valley characterized by an abundance of sand and gravel terraces. Bold bluffs of unconsolidated material, which end above in broad terraces which stretch to the true valley walls, usually confine the river to narrow channels. These features indicate that the sharp trenching of the river in the old valley floor is of comparatively recent date. During this downcutting some rock barriers have been exposed, in which steep-walled canyons have been incised.

The Pelly receives many tributaries from the north and south, of which the Macmillan, confluent from the north about 50 miles from the Yukon, is the largest. This stream rises on the western slopes of the front ranges of the Rockies and flows almost due west. McConnell[b] describes the topography adjacent to it as follows:

"The general character of the country in the vicinity of the Macmillan is mountainous, although the ranges, as a rule, are isolated by wide valleys and depressions. Below Kalzas River the Macmillan is bordered on the north by the Macmillan Mountains—a long ridge with fairly even slopes except near the center, where it rises about 1,000 feet above the tree line and is broken into a number of rocky peaks, the highest of which has an elevation of about 3,800 feet above the level of the river, or 5,600 feet above the sea. Opposite the Macmillan Mountains the country between the Macmillan and the Pelly is occupied by a high plateau-like mass with smooth outlines, the summit of which rises just above tree line to an elevation of about 2,700 feet above the valley. East of this plateau is a wide depression, extending east to Dromedary Mountain and south to the Pelly. This depression is faced on the north of the Macmillan by Kalzas Mountain and the range connected with it. Kalzas Mountain rises 4,300 feet above the valley and is the highest peak along the main Macmillan River. Northeast from it, at a distance of 10 miles, is Clark Peak, a conspicuous conical mountain, visible from almost every elevation climbed to along the river.

"The region north of the Macmillan, between the valley of Moose River and Russell Creek, is occupied by a high broken plateau, deeply trenched by numerous streams flowing into the surrounding valleys. South of the Macmillan the country bordering on the valley, with the exception of a couple of relatively unimportant depressions, is rough and mountainous from Dromedary Mountain east to the Forks. The mountains, mountain groups, and broken uplands along the Macmillan Valley

[a] Dawson, G. M., The Yukon district and British Columbia: Ann. Rept. Geol. Nat. Hist. Survey Canada, new series, vol 3, 1889, p. 119B.

[b] McConnell, R. G., The Macmillan River, Yukon district: Summary Rept. Geol. Survey Canada for 1902, p. 23.

have a common origin and may be briefly described as representing surviving fragments of an extensive highland, the major portion of which has been destroyed by subaerial denudation and erosion."

An abandoned drainage channel is described by McConnell,[a] which runs northwesterly, crossing the lower Macmillan diagonally, and intersects the Klondike River near its mouth. Its southeastern extension forms a part of the Pelly Valley.

The gradient of the Pelly has not been measured, but is known to be considerably steeper than that of the Lewes, for in the lower 300 miles of its course it descends probably 1,000 feet, but is said to be navigable[b] to steamers for 250 miles.

The Hudson Bay traders explored the Pelly, approaching it from the Liard divide, as early as 1840, and established a trading post at Pelly Banks. This route to the Yukon via Liard proved so difficult and dangerous that the post was abandoned a few years later.

SUBDIVISIONS OF THE YUKON VALLEY.

The Yukon from its source, at the junction of the Lewes and Pelly rivers, flows to Bering Sea through a valley probably 1,500 miles[c] in length, and receives many tributaries. Four subprovinces, each of which has certain characteristic topographic features, are recognizable in the Yukon and can be conveniently used as a basis of description. In the account of these different parts will be included the tributary valleys. The valley above the flats, about 450 miles long, will be called the "upper Yukon." A second subdivision, termed the "Yukon Flats," embraces the great lowland of the central Yukon Valley already described. Below this is the "Rampart region," a third subdivision, a constricted part of the valley, which extends to the mouth of the Tanana. The rest of the Yukon Valley, which is broad and finally widens out to the delta, is the fourth subdivision, called the "lower Yukon."

THE UPPER YUKON AND TRIBUTARIES.

The valley of the upper Yukon is 1 to 3 miles in width and is bounded by walls which rise to the level of the plateau, 1,500 to 3,000 feet above the water (Pls. XV, *B*, and XVI, *B*). Its general northwesterly trend is modified by a series of large bends which are very suggestive of incised meanders inherited from an older drainage system. Along this stretch the river varies in width from a quarter to half a mile, usually has but one channel, broken by an occasional island, and has a velocity of 3 to 5 miles an hour.

SELWYN RIVER.

The Selwyn River, the first considerable tributary to the upper Yukon, joins it from the south, about 40 miles below the junction of the Pelly and the Lewes. It is said to fork about 5 miles up above its mouth.

WHITE RIVER BASIN.

Sixty miles below the Selwyn a large, muddy, turbulent river joins the Yukon from the west. The current of this stream is so swift that it crowds the lighter-

[a] McConnell, R. G., The Macmillan River, Yukon district: Summary Rept. Geol. Survey Canada for 1902, p. 22.
[b] Ibid. p. 20B.
[c] No accurate surveys of the entire Yukon have been made.

colored waters of the main stream well toward the east bank. Both its valley and bed are wider than the Yukon at the junction. The muddy white color of this tributary led to its being named the White River[a] by Robert Campbell, an officer of the Hudson Bay Company, who discovered its mouth in 1850. The White River[b] has a general northerly course and its large tributaries are all from the east. Its drainage basin is irregular in outline and has an area of about 13,000 square miles, of which less than half is in Alaska. Its source lies in the northern lobe of the Russell Glacier, which occupies Skolai Pass, a break in the northern fork of the St. Elias Range, whence it flows eastward for nearly 40 miles in a broad gravel-filled valley nearly parallel to the St. Elias Range, and receives from it numerous small glacial tributaries. Gradually the valley narrows from 8 miles to 1 or 2 miles in width where it is crossed by the international boundary, below which the stream is constricted in places, with a canyon-like character for about 20 miles, and then opens out to a broad lowland floored with gravel. This lowland has an area of 1,000 to 1,500 square miles, and embraces not only the White River Valley, but to the west also a part of the upper Tanana Valley, and is extended eastward by the flat valleys of some large tributaries. Below the lowland region the valley of the White narrows to 1 to 3 miles. Terraces bound its slopes as far as the mouth of the Klotassin, where they give way to occasional rock bluffs, which occur at intervals to its junction with the Yukon.

The peaks of the St. Elias Range, near the source of the White, are 10,000 to 14,000 feet in altitude, but a short distance to the north the mountains fall off abruptly to the level of the plateau—about 5,500 feet—which in turn slopes northward to less than 4,000 feet at the Yukon. The floor of the upper valley lies 1,000 feet below the plateau, but the relief gradually increases downstream to over 2,500 feet at the mouth.

The total length of the White is about 200 miles, of which 160 are in Canadian territory. The river is shoal throughout its course, and except in a few short rock-cut canyons has numerous channels, is studded with constantly shifting sand bars and islands, and has all the characteristics of an overloaded stream. No current determinations have been made, but rough estimates show the velocity to vary from 3 to 9 miles per hour.

Sixty miles from the Yukon the White forks. Though the two branches are of about equal size, the westerly one occupies the continuation of the lower valley and retains the name of the main river, while the easterly one is called the Klotassin. The Klotassin flows at right angles to the main valley, and probably rises close to the source of the Selwyn River. Twenty or 30 miles from its mouth the Klotassin receives the Donjek,[c] the largest tributary from the south. This stream has a volume which probably nearly equals that of the White. It rises in a glacier of the St. Elias Range, flows northwesterly for 20 miles through a broad, gravel-floored

[a] The Lake Kluane Indians call White River the Natzanka. The Tanana Indians (Tetling natives) call it Nasina, or Taztana.

[b] Brooks, A. H., A reconnaissance in the Tanana and White river basins in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 418–449. A reconnaissance from Pyramid Harbor to Eagle City, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 350–351.

[c] The old maps of the White River basin show the Donjek as being directly tributary to the White, but recent explorations by Canadian surveyors show this to be an error. It is sometimes called the East Fork of White River.

basin which narrows down to a canyon, below which the valley broadens out, and is joined from the east by the Kluane River, the outlet of the lake of the same name. Near its mouth the Donjek receives the waters of Lake Wellesley through a small westerly tributary.

Lake Kluane lies in one of the depressions marking abandoned drainage courses which are traceable from Lake Dezadeash to the White. The lake is a beautiful sheet of water some 50 miles in length and 5 to 8 miles in width, surrounded by highlands rising to heights of 2,000 and 3,000 feet, in some places abruptly from a narrow, rocky beach, and in others from lowlands. The lowlands which skirt the north and south ends of the lake are dotted with clumps of trees, and interspersed with grassy meadows.

A small stream entering Lake Kluane from the east, has a valley which, too, forms a part of the former drainage system mentioned above. The Slims River, another tributary, finds its source in the Oconnor Glacier, which emerges from a valley in the St. Elias Range and discharges partly into White and partly into Alsek waters. The Nisling River, which joins the Donjek River some miles below the mouth of the Kluane, has its headwaters near those of the Nordenskiold, a tributary of the Lewes, and flows through a broad valley whose slopes are often terraced.[a] The Klutlan, confluent to the White a few miles below the international boundary, emerges as a large stream from underneath the Klutlan Glacier, about 10 miles south of the main valley.

The swift waters of the White River make it unnavigable for steamers, and it can be traversed in small boats only with great difficulty. W. J. Peters and the writer, in 1898, ascended the White about 100 miles in canoes, and this is probably the highest point which has been reached by an upstream boat trip, though several prospectors have built boats near the head of the river and made the journey to the mouth without serious difficulty. The natives occasionally make the downstream trip in improvised skin boats, but always return by land.

STEWART RIVER.

The Stewart River joins the Yukon from the north, 10 miles below the mouth of the White, and is described by McConnell as follows:[b]

"The Stewart is one of the main tributaries of the Yukon. It rises in the unexplored Pacific-Arctic watershed ranges lying between the heads of the Peel and Pelly rivers, and flows in a general westerly direction toward the Yukon Valley. From Frazer Falls to its mouth, a distance of nearly 200 miles, it is a large stream, seldom less than 150 yards in width, and often more than double this size. It is navigable throughout the season by ordinary shallow-draft river steamers all the way to the Frazer Falls. From the Mayo to its mouth the current flows from 3 to 5 miles an hour, with occasional accelerations on the bars. Above Mayo River the current decreases to a rate of 2 to 3 miles an hour, and bars are almost entirely absent. At the Frazer Falls the Stewart flows for a third of a mile with great velocity through a narrow canyon bounded by vertical walls of hard quartzose schist. The word "falls" is a misnomer, as the grade in the canyon is fairly uniform and the

[a] Tyrrell, J. B., The Yukon district: Summary Rept. Geol. Survey Canada for 1889, p. 40.
[b] McConnell, R. G., The Yukon district: Summary Rept. Geol. Survey Canada for 1900, pp. 39 and 40.

total descent was estimated to be only 30 feet. Above the falls the river is interrupted by occasional short riffles for several miles, but farther up its course is reported to be clear to the main forks, a distance of about 60 miles, and up the north branch for a considerable stretch beyond. The east branch is reported to be a rapid stream, constantly interrupted by rapids and canyons. * * *

"The country bordering the lower part of the Stewart River is nearly everywhere of a mountainous character, and may be described as a high plateau deeply dissected by a multitude of wide and often interlocking valleys. The hills project above the valleys in isolated masses, in irregular-shaped groups, and in well-defined ranges. The outlines are generally rounded and the elevations range from about 2,500 to 4,000 feet above the main valleys. The lower slopes are clothed with a forest of spruce, poplar, birch, willow, and alder. Above a height of about 2,500 feet the surfaces are usually bare. The bottom lands of the Stewart often exceed 2 miles in width and are seldom less than a mile, and those of many of the tributaries, notably Crooked River and Lake Creek, are even wider. Below the mouth of Clear Creek the Stewart has cut a comparatively narrow rock-walled channel through the bottom of the older valley. The deepening of the valley is evidently due to the same elevatory movement that affected the Klondike region and evidences the wide extent of that uplift."

SIXTYMILE CREEK.

The Sixtymile Creek heads on the Alaskan side of the international boundary, flows southerly and easterly, and empties into the Yukon near latitude 63° 30′. The valley is incised in the plateau[a] similar to the other tributaries of the Yukon already described. The gold placers in its upper basin have long been reached by trail from the Fortymile Creek, but recently the Canadian authorities have constructed a road from the Yukon to the boundary.

KLONDIKE RIVER.

The name Klondike, which has become a household word nearly all over the world, is often indiscriminately used to designate all of Alaska and adjacent parts of Canada, though it rightly applies to only a few hundred square miles of the Canadian Yukon basin.

The Klondike River enters the Yukon from the east near the sixty-fourth parallel of latitude. It is a small stream that would hardly deserve description were it not for the world-wide fame which its placer fields have attained. These rich gold deposits lie in both the Klondike and Indian River basins, which are tributary to the Yukon within a few miles of each other. Dawson, with a population of 5,000 or more, located on the Yukon at the mouth of the Klondike River, is the distributing point for this mining district. The following quotation from McConnell describes this region, which lies entirely within Canadian territory:

"The Klondike region[b] may be described as a high plateau, cut in all directions by numerous deep and wide branching valleys. The general aspect, viewed from one of the higher elevations, is rough and hilly but fairly regular. The outlines are rounded, the slopes even, and sharp peaks are notably absent. The region is really

[a] McConnell, R. G., Summary Rept. Geol. Survey Canada for 1901, p. 34.

[b] McConnell, R. G., Preliminary report on the Klondike gold fields: Geol. Survey Canada, No. 687, pp. 6 and 7.

formed of a system of long, branching, round-back ridges, separated by deep, wide, flat-bottomed valleys. Most of the ridges, speaking broadly, center in the Dome, the highest eminence in the district.

"The ridges have an average elevation above the valley bottoms of 1,500 feet. They are deeply gashed on both sides by steep gulches and are surmounted by numerous bare, rounded prominences separated by wide depressions. They radiate in irregular curved lines from the Dome and descend gradually, throwing off branches at intervals, toward the main water courses.

"The elevation of the ridges and surmounting hills is fairly uniform. The Dome has an elevation of about 4,250 feet above the sea, 3,050 above the Yukon at Dawson and about 500 feet above the ridges at its base. It is not conspicuously higher than other hills in the neighborhood, and the gradual decrease in elevation outward along the ridges is scarcely noticeable to the eye.

"The valleys are wide and flat-bottomed in their lower parts, but gradually narrow toward their heads into steep-sided, narrow gulches which terminate abruptly in steep, rounded, cirque-like depressions cut into the sides of the ridges. The valley flats are marshy, partly wooded, and wider on the Indian River than on the Klondike slope. The flats bordering the lower parts of Dominion Creek have a width in places of nearly half a mile.

"The streams are small, seldom exceeding 15 feet in width, even at their mouths, and along the productive portions of the valleys are much less. They fall rapidly near their heads, but in descending the valleys the grade soon diminishes, and in the case of Dominion and other Indian River creeks does not exceed, in the lower parts of the valleys, 25 feet to the mile. The Klondike streams are somewhat steeper, the grade averaging in the lower parts of the valleys about 40 feet to the mile.

"The Klondike River is a large, rapid stream, averaging about 150 feet in width. It is interrupted by frequent bars, and has a fall of from 12 to 15 feet to the mile. Indian River, which forms the southern boundary of the district, is a much smaller stream. It has a width of from 20 to 40 yards, but is very shallow, the water on the bars seldom exceeding a few inches in depth."

FORTYMILE BASIN.

Fortymile Creek, confluent to the Yukon from the west about 40 miles above the boundary, is the main stream of a dendritic drainage system which reaches far to the southwest toward the Tanana. Its basin lies close to the international boundary, and a small part of it is in the Yukon Territory.

The upper tributaries of this system lie in broad, shallow valleys with walls rising gently for 1,000 feet to the level of the plateau, and with flat floors over which the streams meander sluggishly. These headwater basins are drained by channels[a] sharply incised in an older valley floor which has been almost entirely eroded. At the forks, 75 miles from the mouth, the valley floor of the Fortymile lies about 2,000 feet below the plateau, and the river here flows through a narrow canyon[b] which is incised in an older valley floor, the remnants of which now form

[a] Goodrich, H. B., Recent warpings [in the Yukon district], as shown by drainage peculiarities, Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 276–289.

[b] See Fortymile atlas sheet, U. S. Geol. Survey.

benches 600 feet above the present water level (Pl. XVII, *B*). This older valley floor has a width of a mile or more, and has been traced by the writer downstream as far as the boundary, below which no observations have been made. About 25 miles from its mouth Fortymile Creek descends precipitously through a rock canyon to the level of the Yukon. Below this canyon the valley opens out and the current becomes sluggish.

In the lower 60 miles of its course the Fortymile descends about 400 feet, and is, in fact, a series of small rapids alternating with reaches of smoother water. While ordinarily not regarded as navigable, a steamer has been taken up it for 20 or 30 miles, but more commonly supplies are transported to the placer camps within its basin by a species of long, narrow craft known as a "Yukon poling boat."

Fortymile Creek has long been one of the routes of communication between the natives of the upper Tanana and the Yukon. These crossed the divide, and, building skin boats or rafts on Fortymile, descended that river to the Yukon and returned by land.

SMALL TRIBUTARIES OF THE UPPER YUKON.

Between the international boundary and the flats the Yukon receives many tributaries from both sides, most of which are small. Seventymile Creek enters the Yukon from the west, about 30 miles below the boundary. In its lower 10 miles it meanders through a broad, flat-bottomed valley, while the upper portion of its valley is sharply incised in an older valley similar to Fortymile.

Tatonduk River enters the Yukon from the east, a few miles below the Seventymile, and its headwaters are close to those of the Porcupine.[a] The Tatonduk Valley is made up of a succession of broad, flat basins, connected by sharply cut canyons. Charlie River, which joins the Yukon from the west a few miles below the Tatonduk, has not been surveyed.

SUMMARY.

The chief tributaries of the upper Yukon, besides its two parent streams, the Lewes and the Pelly, are the White, Stewart, and Fortymile, with also a host of smaller ones. The upper Yukon flows through a steep-walled, rather narrow, and somewhat winding valley, and, like most of its tributaries, lies entirely in the plateau province. The Lewes rises on the inland slope of the Coast Range, the White on the flank of the St. Elias, while the Stewart has its source in the Rockies.

YUKON FLATS.

GENERAL DESCRIPTION.

The Yukon Flats are great lowlands which stretch for 200 miles along the middle Yukon, with a width of 40 to 100 miles; their topography has already been described (Pl. XIV, *A*). Within the flats the river makes the great bend which changes its course from northwest to southwest.

No surveys have been made of this part of the river, but in places the stream probably broadens to 10 and possibly 20 miles, and includes an intricate network of waterways, with some channels having a perceptible if not strong

[a] Ogilvie, William, Exploratory Survey of Part of the Lewes, Tatonduk, Porcupine, Bell, Trout, Peel, and Mackenzie rivers, 1887-88, Ottawa, 1890. McConnell, R. G., Report on an exploration in the Yukon and Mackenzie basins, N. W. T.: Ann. Rept. Geol. Nat. Hist. Survey Canada, new series, vol. 4, 1890, pp. 1D-163D, map sheet No. 9.

current; while others are sloughs, with almost stagnant water. The shifting waterways form many oxbow lakes. These channels are separated by sand bars and islands, for here, where the river is ever changing, new courses are constantly being cut and old ones abandoned and filled up by the silts of the heavily burdened waters. This action of the river makes navigation an ever-changing problem to the steamboat pilots, who, on account of the absence of charts, are entirely dependent on knowledge acquired by experience. During the Klondike rush Indian pilots steered most of the steamers, but these have now been largely replaced by white men trained on the Mississippi under similar conditions of navigation.

From the steamer deck the Yukon Flats present a monotonous expanse of sand bars and low, densely forested spruce islands, through which the boat follows a tortuous channel among a bewildering maze of tributary and distributary water-courses, with an occasional glimpse of the distant rim of the plateau which surrounds the lowland. The presence of man in this dreary tract is made manifest only in the clearings from which the spruce has been cut for fuel, or in the occasional small Indian settlement, or wood-chopper huts. At low water 10 or 15 feet of frozen silt bank is exposed, while during floods the river is almost even with the surface of the islands.

PORCUPINE BASIN.

The Porcupine River, one of the larger tributaries of the Yukon, and confluent at the great bend 3 miles north of the Arctic Circle, has its source in latitude 65° 30′, only 60 miles from the Yukon. For over 100 miles it keeps a northeasterly course until, impinging on the inland front of the Rocky Mountains, it turns abruptly to the west and continues in a westerly and southerly direction to its junction with the Yukon. Its basin has an area of nearly 30,000 square miles and is for the most part in Canadian territory. It has been explored by Ogilvie[a] and McConnell.[b]

Above the great bend the Porcupine has a broad valley 1 to 3 miles in width, with gentle slopes, and cut to a depth of 1,000 feet or more below the plateau level. Bell River, a small eastern tributary confluent at the bend, is connected by a portage across the mountains with Rat River, a tributary of the Mackenzie. Below the bend the valley is usually wide, except where the river flows through small rock canyons, which are incised below an old valley floor. In the so-called "Ramparts," near the international boundary, the valley becomes contracted and assumes a canyon-like character, and this continues for 50 miles to the Yukon Flats, in which the river becomes a many-channeled, comparatively sluggish stream and joins the Yukon through several channels. The Old Crow River, the largest tributary, is confluent from the north, a few miles above the Ramparts, and has its source in the Arctic Yukon watershed. The Salmon River, also from the north, joins the Porcupine within the flats, but its headwaters probably do not reach the Arctic divide, while the drainage from the south is brought in by the Bluefish River above and the Black River below the Ramparts.

[a] Ogilvie, William, Exploratory Survey of Part of the Lewes, Tatonduk, Porcupine, Bell, Trout, Peel, and Mackenzie rivers, 1887–88, Ottawa, 1890.

[b] McConnell, R. G., Report on an exploration in the Yukon and Mackenzie basins, N. W. T.: Ann. Rept. Geol-Nat. Hist. Survey, Canada, new series, vol. 4, 1890, pp. 1D–163D.

McConnell[a] states that the Porcupine is navigable for small steamers above the Ramparts, and records currents in this part of the river of from 3 to 5 miles per hour. Turner[b] reached a point 39 miles below boundary with steamer during the low stage of the water in August, and reports that except at low water a steamer could easily reach the boundary. The Hudson Bay Company had in 1847 established the route from the Mackenzie to the Yukon by way of the Bell and Rat River portage, which for hundreds of miles is probably the only low pass through the Rocky Mountains. This has therefore been a well-established route of communication of white traders for upward of half a century, and must have been known to natives long before.

CHANDLAR BASIN.

The Yukon has an almost due westerly course for nearly 20 miles from the mouth of the Porcupine, and then makes a sharp bend to the southwest, and here the Chandlar River[c] is confluent from the north through a number of tortuous channels. This river[d] has its source well within the Endicott Range, in which it has a general southerly course, while in the flats it flows about east. In the mountains the Chandlar Valley is from 1 to 2 miles in width, and the walls rise steeply to altitudes of 3,000 feet above the river. Above the sixty-eighth parallel of latitude the river has incised a new channel to a depth of 100 feet in an older valley floor, while below the river widens out and for about 50 miles meanders over an alluvial plain, which occupies a basin of varying width and whose surface abuts abruptly against the steep valley walls. Chandlar Lake, about 10 miles in length, occupies the lower end of this basin, and a few miles below its outlet the valley contracts and the gradient of the stream becomes greater; but 20 miles below, at the southern limit of the mountains, the valley broadens and for 50 miles farther is incised into the plateau, which stands at about 3,000 feet, and the walls have gentle slopes. The river here receives a number of important tributaries from the north and west, which have their sources in the Endicott Mountains. Its entire basin has not been surveyed, but probably includes about 10,000 square miles.

Near the sixty-seventh parallel of latitude the Chandlar enters the Yukon Flats, where it usually has diverse channels, with many sand bars and islands, and must maintain a considerable current, as it descends about 300 feet in a distance of 40 or 50 miles (Pl. XIV, *A*). The Chandlar, navigable for steamers for only a few miles, can be ascended by canoe for about 200 miles, though portages are necessary around the rapids near the foot of the lake. Portage routes connect its upper waters with the Koyukuk basin.

BIRCH CREEK.

Birch Creek, which enters the Yukon from the east about 20 or 30 miles below the mouth of the Chandlar and in the lower 75 miles of its course, meanders across the Yukon Flats, where it receives several tributaries from the west. Its general

[a] McConnell, R. G., Report on an exploration of the Yukon and McKenzie basins, N. W. T.: Ann. Report Geol. Nat. Hist. Survey Canada, new series, vol. 4, 1890, p. 129D.

[b] Turner, J. H., The boundary north of Fort Yukon: Nat. Geog. Mag., vol. 4, 1892, pp. 189–190.

[c] On some old maps called the Gens de Large River.

[d] Schrader, F. C., A reconnaissance along the Chandlar and Koyukuk rivers, 1899: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 464–467.

course is northwest, and near latitude 65° 30′ it is only 15 miles distant from the Yukon, where it bends from the south, and its headwater drainage channels, which lie in a broad valley, interlock with tributaries of the lower Tanana. Birch Creek is navigable for small steamers only in the flats, and its importance rests solely on the placer gold which has been mined in its basin.

HOSIANA RIVER.

This stream joins the Yukon nearly opposite Birch Creek. Its headwaters are known to reach to the Koyukuk divide, though its basin has not been surveyed. Its valley is one of the routes followed by prospectors in reaching the Koyukuk from the Yukon.

BEAVER CREEK.

This stream, which is unnavigable, enters the Yukon from the south about 20 miles below the mouth of Birch Creek. Its headwaters are dovetailed with streams flowing into Birch Creek and with tributaries of the lower Tanana. Beaver Creek flows northeasterly as far as the point where it leaves the uplands; it then makes a right-angled bend to the west and south, and for about 20 miles skirts the escarpment which marks the southern limit of the Yukon Flats. Within this lowland it is sluggish and has a tortuous course. The right-angled bend in the flats is paralleled by a similar bend in Birch Creek, and these two striking changes in direction are probably due to the same cause.

DALL RIVER.

The Dall River enters the Yukon from the north, a few miles above the Ramparts. It is described by Mendenhall as follows:

"The Dall River[a] joins the Yukon 9 miles above Fort Hamlin, near the western edge of the great Yukon Flats, the lower 50 or 60 miles, about half the length, of Dall River lying within these, although near their western limit. The country is utterly devoid of relief and contains a great number of sloughs and ponds, many of them old and abandoned courses of the Dall and its tributaries, so that during periods of high water the entire area is flooded and the course of the river is marked only as a lane through the spruces and willows. At such times it may be difficult to find land areas of sufficient size for camping purposes, and transportation by other means than boats is out of the question.

"For about 25 miles below Dall City the river, although not in the Yukon Flats proper, wanders back and forth across a rather broad valley, bounded at some distance on either side by hills which approach the river and increase in height toward its source. Near the upper end of this stretch a branch almost equal in volume to the main stream joins the latter from the north. Dall City, so called, consists of two or three abandoned prospectors' cabins, and lies at the point where Dall River is crossed by the overland trail at the entrance to the canyon-like upper portion of the valley. Our party did not traverse this canyon, since it is impassable for small boats, as it has a fall of nearly 1,000 feet in an air-line distance of less than 10 miles.

"The general divide between the Dall River and the Koyukuk stands at between 3,000 and 3,500 feet above tide, the gap at the head of the Dall River being cut 1,500

[a] Mendenhall, W. C., Reconnaissance from Fort Hamlin to Kotzebue Sound, Alaska: Prof. Paper U. S. Geol. Survey No. 10, 1902, pp. 21 and 22.

feet below this level. The hills immediately to the north of the Dall River are broad, smooth, rounded ridges, standing above timber line, and very generally devoid of all vegetable growth except hardy lichens. An area of much more rugged forms, but standing at approximately the same elevation, lies north and west of the portage in the direction of Fish Creek and Jim River.

"A conspicuous valley leads northeastward from a point north of Dall City, and is probably drained by the Hosiana or Swift River, which empties into the Yukon between the Dall and the Chandlar."

The Yukon receives many other streams within the flats, but these are not of sufficient size to call for special description, and, moreover, as the region has not been surveyed, little is known of them.

SUMMARY.

Within the flats the Yukon receives only three important tributaries—the Porcupine, Chandlar, and Dall rivers. The Porcupine drains a large area lying east and southeast of the great bend of the Yukon, which is entirely within the plateau province, but it receives some drainage from the western flank of the northern Rockies. The Chandlar rises within the Endicott Mountains, which form the Yukon-Arctic watershed, then flows through a part of the plateau province. Two smaller streams—Birch and Beaver creeks—contribute most of the drainage from the south, and the Dall River rises within the plateau province and after crossing a part of the lowland enters the Yukon from the north.

RAMPART REGION.

Near the sixty-sixth parallel of latitude the flats end abruptly at a scarp which forms the northern boundary of a part of the plateau. This stands between 1,800 and 2,000 feet above sea level, and is often called the Lower Ramparts of the Yukon. The Yukon traverses this upland by a narrow, somewhat winding valley, whose walls often rise rampart-like, either directly from the water or from a narrow terrace (Pl. XVI, *A*). The stretch of the valley, between 110 and 130 miles long (measuring around the bends) and one-half mile to 3 miles wide, continues unbroken from the Yukon Flats to the mouth of the Tanana. The general course is southwesterly, but it has many windings which strongly suggest incised meanders, the relics of a former flood-plain condition.

The Rampart region with the broad, sweeping curves of the river and the steep valley walls, clothed with spruce, cottonwood, and birch, varied by bare cliffs, is the most picturesque part of the Yukon. The Russian Lieutenant Zagoskin, in 1848, reported the Yukon as unnavigable above the lower end of the Ramparts, though its ascent and descent by steamer is attended by much less difficulty than in any other part of the river, for the current probably does not exceed 5 or 6 miles per hour, and there are few shifting sand bars to contend with. In this region a few streams are confluent from both north and south, but none is large enough to be called a river, though one, Ray River, passes as such. All of these water courses flow in normal valleys, broad, gravel-filled near their mouths, narrowing upstream to sharply trenched, rock-floored canyons toward their headwaters. The largest are Hess, Minook, and Shevlin creeks from the south and Ray River from the north.

A. YUKON VALLEY IN RAMPARTS.

Showing abrupt slope of valley wall from water.

B. YUKON VALLEY AT EAGLE.

LOWER YUKON.

GENERAL DESCRIPTION.

Under the name lower Yukon is included the portion of the river which is between the Ramparts and the sea, and which, measured along the bends, has a length of about 800 miles.

The Ramparts end at the mouth of the Tanana, where there is an abrupt change in the contour of the valley. The gorge suddenly opens to a broad lowland, which along the Yukon is 15 to 20 miles in width, but stretches up the tributary Tanana Valley for a distance of 200 miles, with a width of 20 to 100 miles. The northwestern boundary of the valley is a series of low mountains whose base the Yukon hugs. The southern wall is 15 to 20 miles distant near the Tanana, but gradually approaches downstream, thus reducing the width of the valley. Throughout its course to the head of the delta the Yukon continues to skirt its north bank, and though the width of the valley varies it is never less than 2 or 3 miles, while the river itself flows through many channels and is broken by numerous islands and sand bars.

The general trend of the lower Yukon is west for an air-line distance of 200 miles, then south-southwest for 200 miles to another great bend below, and then west-northwest to the head of the delta (Pl. XXXIV). Well-defined north and west walls of the valley continue nearly to the head of the delta, but 100 miles above the delta the south wall gives way to the lowland coastal plain, with here and there an occasional isolated hill. There are no topographic surveys of the lower Yukon, but the relief is probably not much more than 1,000 feet.

The delta begins near the sixty-third parallel of latitude where the river divides into a number of divergent channels which find their way to the sea with general northerly and northwesterly courses. The Apoon Pass[a] is the northernmost and the Kwikluak Pass the most southerly of these waterways which reach the open sea at points about 75 miles apart in an air line and 40 or 50 miles from the head of the delta. An intricate maze of waterways lies between the two channels, some of which flow chiefly to the Bering Sea; others connect with such channels, but many are blind sloughs affected only by the ebb and flow of the tide. The interstream areas not more than 10 feet above low tide are swampy and dotted with innumerable small lakes. Here, as in the flats, the Yukon is constantly shifting its channels, the changes are brought about largely by the current and tides, but are aided by the scouring of the ice which accumulates in the delta after the break up in the spring and which forms dams that cause new channels to be cut and old ones to be silted up.

Throughout its course the Yukon is a mud-laden stream, but it is more heavily charged with sediments above the flats than below, for during its comparatively sluggish course throughout this lowland belt it drops a part of its load. The silt-laden waters of the lower river are making rapid inroads on the sea by extending the delta. Russell made the only attempt on record to ascertain the proportion of sediment held in suspension by the Yukon waters, and his determinations were made on the lower river and in midsummer. In winter the waters are said to be perfectly clear.

[a] Jarvis, D. H., Alaska coast pilot notes on the Fox Island Passes, Unalaska Bay, Bering Sea, and Arctic Ocean as far as Point Barrow: Bull. U. S. Coast and Geodetic Survey No. 40. See also Charts Nos. 9373 and 9374, United States Coast and Geodetic Survey.

Sediment in the water of the Yukon.[a]

Locality.	Date.	Grams in a liter.
Below mouth of the Tanana:		
Lofka	July 22, 1889	0.9817
Nulato	July 24, 1889	1.1147
Nowikakat	July 25, 1889	.7783
Above mouth of the Tanana:		
Entrance of Lower Ramparts	July 27, 1889	.2754
Five miles above Lower Ramparts	July 28, 1889	.2078

[a] Russell, I. C., Surface geology of Alaska: Bull. Geol. Soc. America, 1889, vol. 1, p. 116.

Though no accurate data are available concerning the rate of the seaward growth of the Yukon Delta, it is evident that this reclamation is going on very rapidly.

The following note on the composition of Yukon water has been published by F. W. Clarke:[a]

"On June 14, 1904, Mr. F. L. Hess, of the United States Geological Survey, collected, at my request, a sample of water from the Yukon River. The sample was taken in midstream, above the town of Eagle, a little below north latitude 65°, and nearly on the boundary between Alaska and Canada. It was fairly but not absolutely clear, and contained 0.1565 gram of suspended inorganic sediment, as weighed after ignition. The soluble inorganic constituents of the water are given in the subjoined analysis by Mr. George Steiger, and there was also some organic matter undetermined. The CO_3 represents normal carbonates only, in order that the water may be compared with others which are stated in similar terms; the silica and alumina are conventionally reported as present in colloidal form.

	Parts per million.	Percentage of total solids.			
		A. Yukon.	B. St. Lawrence.	C. Rhine.	D. Baikal.
CO_3	45.1	46.16	44.43	47.06	49.85
SO_4	10.5	10.75	11.17	12.61	6.93
Cl	.4	.41	2.41	4.17	2.44
NO_3	....	....	....	....	.21
PO_4		....	....	.28	.72
Ca	21.7	22.21	20.67	27.36	23.42
Mg	4.6	4.71	6.44	5.57	3.57
Na	6.0	6.14	4.87	2.69	5.85
K	Trace.	Trace.	....		3.44
NH_4	....	....	....	....	.08
SiO_2	7.6	7.78	10.01	.17	2.03
Al_2O_3	1.8	1.84	....	.09	1.46
Fe_2O_3	....	....	....		....
	97.7	100.00	100.00	100.00	100.00
Salinity in parts per million	....	97.7	148.0	178.0	69.0

[a] The water of the Yukon: Jour. Am. Chem. Soc., vol. 27, 1905, pp. 111-113.

"The CO_2 'half combined' in the Yukon water is 20.5 parts per million.

"The columns which give the percentage composition of the mineral matter dissolved in the river water are peculiarly useful. They enable us to compare different waters with one another independently of the great variations which they exhibit in respect to dilution. Out of a large number of analyses of river and lake waters, which I have reduced to uniform standards, the following approximate most nearly to the Yukon:

"B. The St. Lawrence, opposite Montreal. Analysis by Norman Tate. The high silica is due in part to the influence of the Ottawa, and the chlorine may represent pollution.

"C. The Rhine, at Cologne. Average of four analyses by Vohl. The high chlorine is again noticeable.

"D. Lake Baikal, Siberia. Analysis by Schmidt.

"The Yukon, then, at least where the sample was taken, is a fairly typical calcium carbonate water with a remarkably low proportion of chlorides. It belongs to a large and well-defined group of natural waters, and it is desirable that other rivers of the far north should be examined for comparison with it. Such rivers probably represent the minimum of contamination through human agency, and their composition is therefore particularly significant for geological discussion. Rivers, however, vary in composition from time to time and place to place, and a single analysis does not give all the information that is needed. I hope that later samples from other points on the Yukon may be available for analysis, in order that its possible variations may be discovered and recorded."

Though the Yukon delta properly includes only that part of the coastal plain included between the distributaries of the river, the broad lowland which embraces the deltas of the Yukon and the Kuskokwim has an extreme breadth of upward of 200 miles, and might well be grouped with the delta flats. There can be no doubt that at some time a part of the Yukon waters found its way across these lowlands and deposited the sediments by which they were made to encroach upon the sea. This region embraces a flat which is but a few feet above tide water and is drained by sluggish meandering rivers and dotted by many lakes. Its smooth surface is interrupted here and there by low, isolated, hills, while the shore line is broken by inlets and tidal lagoons. At low tide this low coastal plain is extended a long distance seaward by mud flats.

The lower Yukon offers no serious menaces to navigation by river steamers, but like the upper river it is uncharted, and except in the delta mouth its channels are unbuoyed. From the mouth of the Tanana to the delta the river flows through two or more channels, and, in places, these diverge so as to include a breadth of 2 miles or more, dotted by islands and sand bars. Here, too, the channels are constantly shifting, but the greatest depth of water is usually found near the north and west bank. The current is estimated at from 1½ to 4 miles an hour, and the influence of the tide reaches to the head of the delta.

In the delta steamers usually follow the northernmost waterway called Apoon Pass, for this has a well-defined, though shifting, channel through which 4 feet can be carried at mean low water. At the mouth of the pass the water shoals to $1\frac{1}{2}$ feet at low water and steamers are forced to take advantage of high tide to cross the bar. From the Apoon mouth the river steamers make their way across a stretch of about 60 miles of open sea to St. Michael Island, which possesses the only harbor, and that but a poor one, along many hundred miles of the coast, and here the transfer to ocean steamers is made. The passage from the mouth of the river to St. Michael in the flat-bottomed river steamers can be made in safety during calm weather, but at other times is not unattended with danger.

The scenery of the lower Yukon offers but little of interest to the traveler. The mighty river, with its dark-yellow waters, is not without its grandeur, and the rounded valley slopes, dotted with spruce and deciduous trees, are not without picturesqueness, but for hundreds of miles there is almost no change in the aspect of the landscape. The upper reaches of the lower Yukon are heavily forested, but as the sea is approached the trees become more scattering, and finally, a few miles above the delta, give way entirely to the tundra, with its dreary, monotonous view. Inland the moss- and grass-covered lowlands stretch almost unbroken to the horizon, except for distant, rounded highland masses, while seaward there is no break in the lowland, and its smooth surface merges with the plain of the sea. The delta supports a large, though migratory, Eskimo population, which finds its way about among the intricate waterways in large skin boats (oomiaks) and kayaks, and is almost entirely dependent on the sea for food.

TANANA BASIN.[a]

The Tanana River, the longest tributary of the Yukon whose basin lies entirely in Alaska, empties into the latter just where it emerges from the Ramparts. The Tanana Valley, about 400 miles long, trends northwesterly parallel to the main stream above the big bend, and drains an area of probably 25,000 square miles. The Alaska Range bounds the basin on the south and is the breeding ground of the glaciers, from which most of the southern tributaries of the Tanana spring. The headwaters of the many tributaries from the north interlock with streams which flow directly into the Yukon above the Ramparts.

Near latitude 63° and longitude 142° the river breaks into two tributaries of about equal volume. For the eastern, which follows the extension of the axis of the main valley, the name Tanana was retained in the reports cited; to the western was given the name Nabesna.[b] Schrader, however, who has more recently visited this region, reports that usage among both prospectors and natives has definitely assigned the name Chisana to the east fork, and this designation will here be adopted and the name Tanana limited to the river below the junction of the Chisana and the Nabesna.

A large glacier, which lies on the north slope of the Skolai Mountains, gives rise to the Chisana, which, near its source, is joined by two glacial tributaries nearly as large as itself. These three streams occupy a broad basin, which is nearly 5,000 feet above the sea, and is bounded on the south by the Skolai Mountains and on the

[a] Brooks, A. H., A reconnaissance in the Tanana and White river basins in 1898. Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 449-451. A reconnaissance from Pyramid Harbor to Eagle City: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 351 and 352.

[b] Formerly used by the upper Tanana natives to designate the main river, but its use in this connection seems long since to have been abandoned.

north by the Nutzotin Mountains. On the south a broad, flat depression 1,000 feet above the floor separates the basin from the White River drainage to the east, while on the west a somewhat narrower pass, with an altitude of 5,800 feet, divides it from the Nabesna drainage. Leaving this basin the Chisana traverses the rugged Nutzotin Mountains in a narrow, steep-sided valley, and here receives a number of glacial tributaries. This canyon is about 15 miles long, and in it the river descends nearly 800 feet. Below it opens out, bends to the north, and about 25 miles from its source the river debouches on the broad lowland which is coextensive with that of the middle White and the upper Tanana. The Chisana crosses this lowland and, making a right-angled bend to the northwest, hugs the foot of the north wall of the valley to the junction with the Nabesna. Several streams are tributary to the Chisana from the east and north within the lowland. These flow in broad, flat, gravel-filled valleys, with low gradients.

The Nabesna springs from a large glacier on the north slope of the Wrangell Mountains, flows northeasterly in a broad valley for 20 miles, where it is joined by other glacial streams, and then traverses a narrow, steep-walled valley in the Nutzotin Mountains, whose summits rise 3,000 to 4,000 feet above the water. In about 20 miles the intermontane part of the valley widens out, and 10 miles farther the Nabesna Valley merges with the lowland, crosses to the north wall of this lowland, and meets the Chisana flowing from the east.

The Tanana Valley falls into three physiographic provinces, which can be conveniently used for purposes of description. The broad lowland near the head is called the "upper Tanana;" the constricted part of the valley between the Tetling and Delta rivers is termed the "middle Tanana," while the broad portion between the Delta and the mouth will be designated the "lower Tanana."

The head of the Tanana at the junction of the Chisana and the Nabesna rivers is in a broad lowland, gravel floored, with plain surface, but here and there interrupted by small hills and knolls. This lowland slopes northward from the base of the mountains to the north valley wall with a sufficient grade to give the streams which follow it a swift current. The flat is extended east by a broad depression which connects it with the lowland of the middle White River, already described. It has an extreme width of 25 miles, and the part drained by the Tanana River is nearly 60 miles long.

Ten miles below the junction of the Chisana and Nabesna the Tanana enters the constricted part of its valley, which has a width of about 2 miles. Here the stream is called the middle Tanana, and receives the Tetling River from the south. The Tetling is a clear-water stream draining several lakes—the largest about 2 miles long—which lie near the southwestern margin of the lowland and which probably owe their origin to the damming of the former course of the Tetling by the delta deposits of the Nabesna. One of the trails from the Copper River reaches the Tanana at the mouth of the Tetling River.

The middle Tanana Valley is formed by a series of connecting basins which are parallelogrammatic in outline, and are incised to a depth of 2,000 to 2,500 feet below the upland surface. These basins are bounded by escarpments whose windings give a succession of elbow-like forms to the valley walls, which fall into two parallel systems, outlining a series of parallelograms. The river, which hugs the north side of the valley, emphasizes this topographic feature. The basins are from 1 mile to 20 miles in length and 1 mile to 7 miles in width, and probably are determined largely by structural[a] lines in the bed rock.

Near the one hundred and forty-third meridian the Tok River joins the Tanana from the south. This clear-water stream, of no considerable size, has its source in the Mentasta Mountains to the south, which do not reach the altitude of perpetual snow and hence do not contain any glaciers.

Twenty miles below the Tok there is a telegraph station and small settlement at the crossing point of the trail from Valdez on the coast to Eagle on the Yukon. This trail traverses the mountains to the south by a broad pass, but 2,800 feet above sea level, which probably affords the most feasible railway route from the Copper to the upper Yukon.

Two turbulent silt-laden rivers, the Robertson and Johnson, join the Tanana from the south, and their unexplored sources lie in the snow-covered Alaska Range to the south. Both emerge from the mountains in U-shaped gorges, and the deltas of both are rimmed by bluffs of glacial silts. A striking feature of both streams is the marked upstream bends which they make at their junction with the Tanana, a feature usually interpreted as indicating a reversal of the drainage of the main stream.

The Gerstle River, a much smaller stream, which, it is reported, enters the Tanana from the south, about 10 miles below the Johnson, is less well known, but its valley has probably the same general features as that of the Johnson.

The northern tributaries of the Tanana are all sluggish, flow in broad, shallow valleys, and two of them—the Goodpaster and the Volkmar—are confluent to the middle Tanana. It is very unfortunate that local usage among prospectors has interchanged the names of these two rivers. As originally named by Allen[b] the upper of these two rivers should be called the Goodpaster, and the lower the Volkmar, and this usage was adopted by the writer after his journey of 1898, but the first prospectors who ascended the Tanana gave the name Goodpaster to the lower river. In spite of the published maps it has been impossible to change this usage, which has become fixed since the discovery of gold in this region has attracted a large mining population. On the accompanying map (Pl. XXXIV) the names have been changed to conform to local usage. The Volkmar has not been surveyed, and little is known of its course except that its headwaters interlock with those of Fortymile. The headwaters of the Goodpaster lie opposite those of Birch Creek; its valley is 10 or 11 miles in width in its lower portion,[c] but rapidly narrows upstream. Just above the mouth of the Volkmar, at a place called "Masons Narrows," the Tanana is much contracted, being not over 200 or 300 yards in width.

Four or 5 miles below the Goodpaster the Delta River, a rushing, mud-laden stream, joins the Tanana from the south. Its delta has pushed the main stream against the north wall of the valley, causing a series of small rapids. The Delta[d]

[a] Reconnaissance in Tanana and White river basins: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 480–481.

[b] Allen, H. T., An expedition to the Copper, Tanana, and Koyukuk rivers in the Territory of Alaska, 1885, Washington, 1888. See map of Tanana.

[c] Castner, J. C., Reports of explorations in Alaska: War Dept., Adjutant-General's Office, No. 25, pp. 189–272.

[d] Mendenhall, W. C., A reconnaissance from Resurrection Bay to the Tanana River, Alaska: Twentieth Ann. Rept. U S Geol Survey, pt 7, 1900, p. 300.

rises within the Copper River Plateau and flows northward for 40 miles in a narrow, rock-bound, steep-walled valley through the Alaska Range, whose summits rise 6,000 to 7,000 feet above the water. Here it is fed by many glacial tributaries. Like the other southern tributaries its delta is bounded by glacial silt bluffs 100 to 200 feet in height. Below the mouth of the Delta River the south wall of the Tanana Valley rapidly recedes from the river and the latter here enters the great lowland which extends to the Yukon, 200 miles to the west. This section of the river has been called the lower Tanana. The north wall of the valley presents a series of salient and reentrant angles, which are like those formed by the escarpments bounding the the basins of the middle Tanana, and which like them are topographic expressions of structural lines. As the lower Tanana follows the north wall of the valley it makes a succession of great right-angled bends. Bates Rapids is a term rather loosely applied to part of the Tanana stretching about 100 miles below the Delta River, where the Tanana flows through numerous channels, separated by sand bars and islands, with a current of 5 to 9 miles. At several places it has been crowded against the rocky north wall, the moraines of former glaciers, and there are short stretches of what might be called rapids.

Twenty miles below the Delta River the width of the Tanana increases to 4 or 5 miles, then it gradually decreases and is about a half mile wide 60 miles below. Here the stream has only one or two channels, with a current of but 2 to 4 miles. A few miles from the Yukon the Tanana again broadens and joins the main river through several mouths.

The lower Tanana is incised into the plateau to a depth of 1,500 to 2,000 feet, though the ridges which bound the valley on the north, in the lower 20 miles, do not reach the plateau level, as they rise only 700 to 1,000 feet above the water. The valley floor has a very perceptible slope from the base of the highlands on the south to the north wall, and consequently the southern tributaries are swift flowing. The valleys of the northern confluents are broad and have low gradients.

The Salcha[a] River enters the Tanana from the north, and has a broad, flat valley, while its headwaters probably lie opposite those of Birch Creek.

Twenty-five miles below the Salcha the valley wall to the north of the Tanana is broken by a broad lowland, which probably stretches at least 40 or 50 miles to the northeast, and is drained by the Chena River. In its lower portion the Chena is tortuous, with a moderate current. It is said to be connected with the Salcha by a long slough, which is parallel to the Tanana and a mile or two north of it.

Twenty miles west of the mouth of the Chena the Tanana makes a right-angled bend to the southwest, and 40 miles farther downstream is joined by the Cantwell from the south. Several small unmapped streams join the Tanana from the south between the Delta and Cantwell rivers, and of these the Mahutzu and the Silok have their sources in glaciers on the north slope of the Alaska Range.

The Cantwell, a good-sized river, has a glacial source, well within the Alaska Range. In latitude 63° 40′ it splits into branches of equal size. The eastern

[a] Spelling in accordance with rules of the United States Board of Geographic Names. In former reports and maps usually called the Salchaket, which is also local usage.

branch, called Yanert Fork, drains a group of glaciers lying near Mount Hayes, and follows a U-shaped valley, a mile or two in width, to its junction with the other fork, which is regarded as the main Cantwell. This fork rises in a glacier near the south slope of the Alaska Range, and is separated from Sushitna waters by a broad gap only 2,400 feet above the sea. For 10 miles below the junction the Cantwell traverses a minor range in a canyon-like valley, which merges into a broader valley bounded by gravel terraces, which continues 10 miles more to where the river debouches on the Tanana lowland. Here it usually has several channels with numerous sand bars. The fall from the forks to the mouth is about 600 feet, which gives the stream a very steep gradient.

From the Cantwell Delta the Tanana flows northwest for 20 miles to another bend, which gives it a westerly course. Here the Tolovana River is confluent from the north. Like the Chena River, it drains a broad lowland,[a] which stretches 50 miles or more to the north, and receives many tributaries which flow in tortuous courses and with low gradients. Many lakes and small ponds, usually surrounded by belts of treeless swamp, are irregularly distributed through this lowland. The streams are deep and muddy bottomed. Their surfaces are 10 to 20 feet below the valley floor at low water in the fall, but during floods are nearly flush with it. The banks are usually firm, and covered with a thick growth of birch and cottonwood.

At the boundaries of the lowland the slopes rise gently to the plateau level 1,500 to 2,000 feet above the floor. This flat, a perfect maze of waterways, is almost impassable during the summer except by boat. The natives traverse this area in their little birch canoes in summer while hunting and fishing, and in winter the frozen waterways afford highways of travel for their dog teams.

The Kantishna, which enters the Tanana from the south about 50 miles below the Cantwell is probably 300 yards wide at its mouth, and has only one channel. The headwaters of this river drain the north flank of the Alaska Range between Mount McKinley and the Cantwell basin. Near latitude 64° 30′ the Kantishna is split into two streams of nearly equal size, and the eastern one is called the Toklat, while the west fork retains the name Kantishna. About 10 miles above its mouth the Toklat divides into a number of channels, each of which has its source in a glacier on the north slope of the Alaska Range (see Pl. XI).

The Kantishna drains Lake Minchumina,[b] an irregular body of water about 15 miles long by 10 miles wide, which lies close to or at the northern limit of glaciation. This is the northernmost lake of any considerable size in the Yukon basin. The Kantishna and its tributaries occupy broad, flat valleys, except a few of the headwater streams which rise back of the mountain front and have typical glaciated valleys. The more northerly drainage channels interlock with those of the East Fork of the Kuskokwim, from which they are separated by a low divide, crossed by a short portage trail long used by the natives. The lower Kantishna has not been mapped, but is known to cross the Tanana lowland with a fairly steep gradient, and to be separated by low hills from the Cosna River Valley to the west.

[a] Brooks, A. H., An exploration in Mount McKinley region. (In preparation.)

[b] Herron, J. S., Explorations in Alaska: War Dept., Adjt. Gen. Office, No. 31, Washington, 1909.

The Cosna,[a] probably 50 miles in length, rises in a highland mass west of Kantishna, which may be a remnant of the plateau. The Chitina River, a smaller stream, enters at the great double loop of the Tanana known as Harpers Bend.

At the mouth of the Kantishna is another right-angled bend below which the Tanana has a northwesterly course for 20 miles. Where it again bends west it is joined by Baker Creek.[b] This large stream forks about 10 miles from the Tanana, and the large easterly tributary is called the Hutlina. Both forks flow in broad, flat valleys near their mouths, but their upper courses have not been surveyed.

It has been shown that the Tanana is formed by the junction of the Chisana and the Nabesna, which rise in glaciers in the Wrangell Mountains. The headwaters lie in broad basins; the streams traverse the Nutzotin Mountains in narrow valleys, and then debouch on the broad lowland in which they combine to form the Tanana. The main stream, after leaving this lowland, traverses a series of small connecting parallelogram-shaped basins, below which its valley opens out and continues as a broad lowland to the junction of the Tanana and the Yukon. The length of the Tanana, measured along its longer bends, is nearly 500 miles, that of the Chisana is about 100 miles, and that of the Nabesna somewhat more. The tributaries from the south rise, for the most part, in the glaciers of the snow-clad Alaska Range, and are swift-flowing, turbid streams, while those from the north are of less volume, have clear water and sluggish currents.

In 1893 the first steamer ascended the Tanana about 100 miles, and in 1898 two steamers were successfully taken up to the Chena River, a distance of about 225 miles. Since 1901 steamers have made frequent trips between the Chena and the Yukon, and one at least has reached the mouth of the Delta River above, but encountered many shoals. With a favorable stage of the water it will probably be possible to ascend the river with small powerful boats to the crossing of the Fortymile and Copper River trail, for rough determinations made by the writer show that the current rarely exceeds 8 miles, and there are only a few short rapids in the entire length of the river. At high water a small shallow-draft launch could possibly be taken 150 miles above the Fortymile trail crossing to the great bend of the Chisana, but the Nabesna is entirely unnavigable. The Chena and the Tolovana are reported deep enough for steamers for 100 miles, measuring around the bends of the rivers. The lower Kantishna is also navigable for steamers for 100 or 200 miles and the lower Volkmar can probably be ascended for short distances.

The Tanana Valley has long been known for its heavy growth of spruce, some of which on the lower river attain diameters of 18 inches to 2 feet. Some tamarack has been found in the Tanana Valley and the adjacent parts of the Kuskokwim Valley, and throughout the lowland areas are extensive meadows of good grass. These facts, together with the coal supply found on the Cantwell, make the lower Tanana one of the most desirable parts of the Yukon basin for permanent habitation. If the great interior ever attracts an agricultural population it will certainly first seek the Tanana Valley. Those who have wintered on the lower Tanana claim that the climate is much milder than in adjacent parts of the Yukon basin, but this assertion remains to be substantiated by meteorologic records now entirely lacking.

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[a] See Herron's map.

[b] Called by the natives Sitchlocket.

There are two groups of Tanana natives—those of the upper and those of the lower valley. Before the coming of the white man these groups were probably fairly distinct, for the river, their natural means of communication, is not easily navigated in their frail canoes. The upper river Indians above the range of the salmon, which constituted the chief article of food for those of the lower river, were dependent on game and small fish. The headwater natives had close communication with those of the Copper and Fortymile valleys through the low gap in the divides which separate these drainage basins, while those of the lower river were geographically closely connected with the inhabitants of the upper Kuskokwim and lower Yukon.

TOZI RIVER.

The Tozi,[a] about 100 miles long, flows southwest and has its source near the headwaters of several tributaries of the Koyukuk, Ray, and Melozi, which flow into the Yukon. Though its valley has not been mapped, it is known to lie in a region of no great relief.[b] The headwaters of the Tozi are connected with those of Kanuti River, a tributary of the Koyukuk, by portage trail.

NOWI RIVER.

The Nowi,[c] which enters the Yukon from the southwest, about 75 miles below the mouth of the Tanana, is about 100 miles[d] long. It rises on the eastern flank of the Kaiyuh Mountains and flows northeasterly. Its headwaters are said to be connected by a short portage with the Innoko and also with Kuskokwim waters.

MELOZI RIVER.

The Melozi[e] drains a considerable area lying between the Yukon and lower Koyukuk. In its upper portion it trends westerly and southwesterly, but within 20 miles of the Yukon it flows south and east. According to Lieutenant Allen,[f] the valley of the Melozi, which is about 100 miles in length, is incised into the so-called Yukon Hills, whose summits stand 1,000 to 2,000 feet above the sea and probably mark the plateau level. Ten miles below the Melozi the Soonkakat, a small river which rises near the Koyuk, enters the Yukon from the southwest.

KOYUKUK BASIN.

The Koyukuk[g] joins the Yukon from the northwest about 450 miles from Bering Sea. Its drainage basin has an area of approximately 25,000 square miles and includes the southern ranges of the Rocky Mountain system which here form the Yukon-Arctic watershed. The valley of the Koyukuk, including that of its longest fork, is upward of 300 miles in length, while the river measured around the bends must be 600 or 700 miles long.

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[a] Generally known as the Tozikakat.

[b] Allen, H. T., Reconnaissance in Alaska, pp. 94-97.

[c] Known as the Nowikakat in Alaska. This usage is in accordance with the ill-advised decision of the U. S. Board on Geographic Names.

[d] Dall, W. H., Alaska and its resources, 1870, pp. 87 and 282.

[e] Generally known as the Melozikakat.

[f] See map accompanying Allen's report.

[g] Schrader, F. C., A reconnaissance along the Chandlar and Koyukuk rivers, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 462-471.

Between the Arctic Circle and latitude 66° 30′ the trunk stream splits up into a number of forks which do not differ greatly in size. Of these the so-called Middle Fork, probably the longest, rises north of latitude 68° near the northern margin of the range and for 100 miles occupies a mountain valley which is sharply trenched to a depth of 2,000 to 3,500 feet below the summits. The valley of the North Fork is about 10 miles west of the Middle Fork and probably has the same general character. Both forks make southwesterly bends before they come together to form the Koyukuk River proper in a lowland which stretches southward from the edge of the mountains.

Wild Creek, a large stream with a course in general parallel to the North Fork, joins the Koyukuk a few miles below the junction of the two forks. Its source has not been surveyed, but probably, like that of the North Fork, it lies far within the great mountain mass which lies to the north. Wild Creek flows southeasterly in its upper course, but like the other rivers described it makes a southwest bend near where it leaves the mountains.

The lower reaches of the North and Middle forks and Wild Creek lie in a broad valley basin which is about 20 miles long and 5 miles wide at its upper end, but which narrows to 2 miles near the mouth of Wild Creek. Gently sloping walls bound the basin, which has a level and silt-covered floor, and at its southern end merges into the Koyukuk flats.

Fifteen miles below the junction of the North and Middle forks the John[a] River is confluent from the north. It rises near the northern margin of the mountains and traverses nearly the entire range before it enters the plateau region. Its headwaters are opposed to those of the Anaktuvuk, which is tributary to the Colville, flowing into the Arctic Ocean. The valley walls of the John River rise precipitously, its gradient is steep, and the lower reaches, broad and level, merge into the flats of the upper Koyukuk (Pl. XXIV, *A* and *B*).

A few miles above the mouth of the John River the Koyukuk enters a low, silt-covered flat, which is about 40 to 50 miles long and 20 to 30 miles wide, and slopes gently from north to south. The eastern rim of this flat is outlined in part by the South Fork, which joins the Koyukuk from the east, close to the Arctic Circle, and heads in the rugged mountains north of the sixty-seventh parallel of latitude. It flows in general southwesterly, parallel to the Middle Fork and to the upper Koyukuk, and traverses the eastern margin of the Koyukuk Flats, bends sharply to the west, and joins the Koyukuk after traversing the lowlands.

Within the lowland the Fickett River joins the Koyukuk from the north, heading well within the mountains to the north. Though its course has not been mapped, it is known that a broad valley extends for 10 to 20 miles up from its mouth. At the mouth of the South Fork the Koyukuk makes a westerly bend and thence flows in a tortuous course across the lowland for about 50 miles to the Alatna River, where it turns to the southwest, and 10 miles farther down enters an upland region. The Koyukuk Flats have been outlined only in part by surveys, but are known to comprise a large level basin which has an altitude

[a] Schrader, F. C., Reconnaissance in northern Alaska: Prof. Paper U. S. Geol. Survey No. 20.

of about 600 feet, and above which the highland rises 2,000 to 3,000 feet by gentle slopes.

The lowland floor is extended northward for 20 to 30 miles by the broad, flat valley of the Alatna[a] River, which upstream gradually narrows and becomes steeper walled, but continues to be flat and is traversed by the river in many meanders. The source of the Alatna lies in an unexplored part of the Endicott Mountains. A portage trail connects the Alatna with Kobuk waters near the sixty-seventh parallel of latitude. Below the mouth of the Alatna the Koyukuk flows southwesterly, with many minor bends, for 100 miles. Along this portion of the river the valley is from 1 to 2 miles wide, and the walls rise rather abruptly to an upland which stands between 1,500 to 2,000 feet above the river.

A few miles below the flats the Kanuti River is tributary from the southeast. Its source[a] lies in a mountain mass 2,000 to 3,000 feet in height, which is drained in part by the Dall River, a tributary of the Yukon. The following is from Mendenhall's[b] description:

"The Kanuti River is approximately 200 miles long, and within that distance its valley presents great physical diversity. It heads in the same mountains whose northern slopes are drained by Fish Creek and Jim River, but within a few miles of its source it enters a relatively flat basin, 9 or 10 miles long and half as wide, which contains a number of small lakes and ponds, although standing at an elevation of between 1,200 and 1,400 feet. This basin, like all similar topographic features in the north, whatever their relation to sea level, is a marsh covered with the usual tundra growth. At its lower end, in longitude 150° 45′ west, the river enters a restricted valley, so steep walled in places as to deserve to be called a canyon and having a maximum depth of 2,000 feet. The gorge-like character prevails for about 30 miles, and through this portion the river can scarcely be called navigable, since it is a succession of rapids, and the river channel throughout is obstructed by bowlders of all sizes. Below this stretch the valley gradually broadens, and near the camp of July 12 is an extensive flat, which is perhaps a part of the broad basin in which the lower portion of the South Fork of the Koyukuk flows.

"Within this lower basin the Kanuti River receives a large tributary from the south in the direction of the sources of the Tozi and Melozi, and 25 miles above its mouth the river plunges into a second canyon about 10 miles long and 500 feet in depth. This is the most beautiful section of the river; the stream is swift, but free from dangerous rapids, and the bluffs of slate and sandstone rise sheer from the water to a height of several hundred feet. Ten miles above the mouth it receives the waters of the Mentanontli, descended by Lieutenant Allen in 1885 after his overland journey from the Yukon.

"The hills which border this lower section of the Kanuti River and adjacent parts of the Koyukuk are seldom more than 1,500 feet in height, are not excessively steep, and are well timbered."

Near latitude 65° 40′ the Koyukuk Valley makes a northwest bend, and 50 miles

[a] Mendenhall, W. C., Reconnaissance from Fort Hamlin to Kotzebue Sound: Prof. Paper U. S. Geol. Survey No. 10, 1902, p. 24.

[b] Ibid., pp. 22 and 23.

below swings to the southwest and the valley opens out. From this point to the Yukon the gradient is low and the river is tortuous, with numerous channels.

Below the Kanuti the Koyukuk receives a number of important tributaries, but few have been mapped in any detail. The Hogatza River interlocks its headwater drainage with southern tributaries of the Kobuk, and the two drainage systems are said to be connected by easy portage. The other tributaries of the lower Koyukuk flow from the west and are smaller than those described.

In ordinary stages of water steamers ascend the Koyukuk 440 miles, to the trading post of Bergman, the current averaging probably 4 miles an hour, and at high water steamers can be taken 100 miles farther upstream. The upper Koyukuk and most of its tributaries are navigable for small boats only, and often not even for those, except in their lower courses.

The natives make use of the river in their journeys, and have communication with the middle Yukon by the portages to Dall, Chandlar, and Melozi rivers. The passes into the Kobuk and the rivers flowing northward were probably little used, as the natives in the Arctic watershed are Eskimo, and previous to the coming of the white men their intercourse with the Indians of the Yukon waters was anything but friendly.

KALTAG RIVER.

The Kaltag, a small river, enters the Yukon from the northwest, 60 miles below the mouth of the Koyukuk. It rises not far from Unalaklik waters and flows through a broad valley. The two valleys offer winter routes of travel from the Yukon to Norton Sound and are followed by the military telegraph.

KAIYUH RIVER.

The Kaiyuh River, the next considerable tributary to the Yukon below the Koyukuk, has its source in the mountains of the same name. As far as known, it flows southwesterly and has a length of probably 60 miles.

INNOKO RIVER.

Halfway between the Bering Sea and the mouth of the Koyukuk, in latitude 63°, the Innoko River joins the Yukon from the east, but a part of its drainage is carried by the Shageluk Slough, which enters the Yukon 60 miles farther downstream. The source of the Innoko is on the east flank of the Kaiyuh Mountains, about 30 miles to the east of the Yukon. The lower valley of the Innoko was visited by the Russian Lieutenant Zagoskin[a] in 1844, and the present mapping of the river is largely based on his notes. The Innoko is believed to occupy a broad valley which, for 150 miles, is parallel to the Kaiyuh Mountains.

ANVIK RIVER.

The Anvik River, probably not over 100 miles in length, drains the neck of land lying between the lower Yukon and Norton Sound. Its headwaters lie in a highland mass 2,000 to 2,500 feet high and only about 20 miles from salt water. The streams whose junction forms the Anvik flow easterly, but the Anvik has a southerly course parallel to the Yukon.

[a] Zagoskin's Reise im Russischen Amerika: Erman's Archiv für Wissenschaftlichen Kunde, vol. 7, 1849, pp. 432–440.

No streams of importance join the Yukon between the mouth of the Anvik and the delta, which has already been described as a maze of intricate waterways (see p. 79).

SUMMARY.

The Yukon, the largest river of Alaska, has its source in two rivers, which rise in northern British Columbia and have northwesterly courses. The Yukon flows northwest as far as the Arctic Circle, where it swings to the southwest, parallel to the crescent-like bend made by the two dominant mountain systems and to the great reentrant angle in the southern coast line. The Yukon Valley is narrow and steep sided to where it meets the Yukon Flats, a great lowland area in which the river spreads out into numerous channels. Below the flats the valley is again constricted for a distance of 200 miles in the Rampart region, but from the Tanana to the sea it broadens out and near the delta finally gives way to the coastal tundra belt.

The Yukon Valley and much the greater part of its basin lie in the Central Plateau region, while its larger southerly and easterly tributaries, such as the Lewes, White, and Tanana, drain a part of the inland ranges of the Pacific Mountain system, and the headwaters of the easterly and northerly tributaries, such as the Pelly, Stewart, Porcupine, and Koyukuk, receive waters from the southern and western slopes of the Rocky Mountains. The Yukon is fifth in size among North American rivers. It is navigable from its head, at the junction of the Lewes and Pelly, to its mouth, a distance of probably 1,800 miles. Steamers have been run on nearly all its larger tributaries, and the navigable waters in the entire basin probably aggregate over 3,500 miles, about three-fourths of which are in Alaska.

NORTON SOUND.

Between the coast line east and north of the Yukon Delta and the southern shore of the Seward Peninsula are the shallow bodies of water known as Norton Sound and Norton Bay. The streams flowing into these waters are mostly short, and near their mouths meander sluggishly over the plain, which nearly everywhere stretches inland from tide water. Among the largest of these streams is the Unalaklik River,[a] tributary to Norton Sound, whose source lies in a group of hills forming the Yukon divide. This river flows in a general westerly course, and its entire length is probably not over 50 miles. It can be ascended in small boats, and a portage trail of 30 miles connects the head of boat navigation with the Yukon River at the mouth of the Kaltag River. Fifty miles to the north is the Shaktolik River, a smaller stream, whose headwaters probably do not reach beyond the coastal plain. The unsurveyed Ungalik and Inglutalik rivers are probably larger and are also tributary to Norton Bay from the east.

SEWARD PENINSULA.[b]

The Bering-Arctic watershed follows a sinuous line along the longer axis of the peninsula to Cape Prince of Wales, and sends the waters of over two-thirds

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[a] Allen, H. T., Reconnaissance in Alaska, pp. 109-113 and map 5.

[b] Brooks, A. H., A reconnaissance of the Cape Nome and Norton Bay regions: U. S. Geol. Survey, 1901, pp. 53-55.
Mendenhall, W. C., A reconnaissance in the Norton Bay regions: U. S. Geol. Survey, 1901, pp. 195-198.
Collier, A. J., A reconnaissance in the Northwestern part of the Seward Peninsula: Prof. Paper U. S. Geol. Survey No. 2, 1902, pp. 13 and 42.
Moffit, F. H., The Fairhaven gold placers of the Seward Peninsula: Bull. U. S. Geol. Survey No. 248.

A. VALLEY OF FOX RIVER, SEWARD PENINSULA.

B. VALLEY OF FORTYMILE RIVER NEAR THE BOUNDARY.

of its area southward to the Bering Sea. The highlands consist of rolling upland 1,000 to 2,500 feet above the sea (Pl. XIII), and there are some isolated mountain masses which stand higher, but the latter in no case determine the east and west divide. The headwaters of the streams flowing into the Arctic and Bering seas interlock irregularly within the upland, throwing the watershed first north, then south, and giving it the irregularity which has been described. The Koyuk River, one of the largest of the peninsula, enters a small tidal estuary at the head of Norton Bay. Its source is in a gravel-floored basin, which lies well toward the center of the peninsula and is bounded on the south by the Bendeleben Mountains, which rise 2,000 feet, and by highlands on the north, rising 1,500 feet above its floor. The Koyuk flows in a tortuous course and with sluggish current across this basin, which it leaves through a narrow valley with a steep gradient. This canyon-valley type continues eastward for about 20 miles, to where the river enters another broad, level-floored valley which extends east and south, gradually opening out and merging into the coastal plain of Norton Bay.

The Kwik River enters Norton Bay 20 miles west of the Koyuk. It flows southward through a broad and almost featureless depression which northward is connected with the Koyuk basin by a low pass.

Eight miles west of the Kwik is a lagoon into which flows the Tubutulik River. This stream rises in a group of low mountains 30 miles from the sea, traverses a small basin, then takes a tortuous course through the hills and enters the coastal plain 10 miles from the sea. The Kwiniuk River, which empties into the same lagoon, rises in low hills 10 miles from the coast and flows in a broad valley from which it emerges on the coastal plain.

At Cape Darby the shore line suddenly retreats inland, and to the northwest are Golofnin Bay and Golofnin Sound. At the head of the sound is the broad delta of Fish River, and the valley of the latter stretches northward for 10 miles as a broad depression, then contracts for a few miles only to open again to a second extensive lowland, which also includes the lower reaches of the Niukluk River, the principal tributary of the Fish. The Fish rises in a basin which is typical of the basins at the headwaters of many rivers of northern Alaska (fig. 5). These basins are level, gravel-filled depressions encircled by uplands whose slopes often rise abruptly. Within them the streams have low grades and flow with tortuous courses, but below them flow through narrow canyon-like—often rockbound—valleys, with straight courses, steep gradients, and frequent rapids. The basin of the Fish is of rectangular outline, 30 miles long and 20 miles wide, and below it is a constricted valley which is about 10 miles long, less than a mile in width, and has abrupt walls. Within the basin the river is tortuous and has a sluggish current, while in the canyon it is comparatively straight and descends through a series of rapids.

Niukluk River, the largest confluent stream, joins Fish River about 20 miles from the sea. Near the mouth its valley has a width of about 6 miles, which gradually decreases to less than a mile near Richter Creek, while 8 miles above the stream flows for 2 miles through a steep-walled rock-bound canyon 50 feet deep. Above the mouth of the Casadepaga the valley broadens out to a basin (Pl. XXXIII, *A*) separated by only a very low divide from the Kruzgamepa, which flows into Port Clarence. The two basins connected by a sharply incised valley are striking features. The valley of Casadepaga River, the chief tributary of the Niukluk, is broad, with gentle slopes, broken by gravel terraces up to an altitude of 600 feet. The headwaters of the Casadepaga are connected by a low, gravel-filled divide with Solomon River, which flows southward.

West of Golofnin Bay the Solomon and Eldorado rivers, as well as many smaller streams, carry the drainage southward through broad open valleys, whose slopes are often terraced. The Eldorado and Nome rivers rise in gravel-filled basins of the type already described, which to the north are connected by broad passes with Kruzgamepa waters, and to the south are succeeded in turn by a constricted valley and a broad valley whose floor merges into the coastal plain. The Snake, Penny, and Cripple river valleys merit no special description. Near the coast they are broad, and their floors are extensions of the coastal plain, above which they become constricted.

Sinuk River,[a] which empties into the sea about 30 miles west of Nome, is one of the largest rivers of the southern watershed of the Seward Peninsula, and receives the drainage from the southern slope of the Kigluaik Mountains. It emerges from the mountains in a narrow gorge and flows in a broad depression parallel to the range for about 15 miles, turns southward and reaches the sea through a broad flat valley. Its waters, as well as the headwaters of its chief tributary, Stewart River, are connected by a broad, gravel-filled pass with the Kruzgamepa Valley.

Fairview and Feather rivers are streams of minor importance which flow westward from the southern flanks of the Kigluaik Mountains. Tisuk Creek is somewhat larger and drains the northern slopes of the Kigluaik Mountains, from which it emerges in a narrow valley which broadens out. In its lower course the current meanders sluggishly over a flat valley floor and finally empties into a lagoon of Bering Sea. A gravel-filled divide about 200 feet high separates the Tisuk from Canyon Creek, which flows northeastward into Imuruk Basin.

A number of small streams flow into Port Clarence and Grantley Harbor from both the north and the south, but the Bluestone River drains the larger part of the area lying between the Kigluaik Mountains and Port Clarence. Its headwaters are in a basin-shaped valley, but at the mouth of the Alder it enters a rock-cut canyon, below which it flows through a broad valley tributary to the Tuksuk Channel.

The head of Imuruk Basin is bounded by a flat, swampy area, through which meanders a broad river, sometimes called the Kaviruk, which forks about 20 miles from the bay. The southern fork, called the Kruzgamepa, rises well within the Kigluaik Mountains, flowing southward till it leaves them, then takes a northeasterly course and encircles the east end of the range. This part of the valley lies in the same lowland that includes the upper basin of the Niukluk. The northern fork of the Kaviruk, called the Kuzitrin, has its source in a broad, flat basin in which it is joined by its chief tributary, the Kougarok. Below the basin it flows through a rather narrow valley for about 20 miles, and debouches on the plain at the head of Imuruk

[a] Locally often called the Sinrock River.

Basin. A third large area is drained into Imuruk Basin from the north by the Agiapuk River.

Between Port Clarence and York are several streams which have in general a southerly course, but which are insignificant in size. West of Cape York the first important river is the Kanauguk, which lies well within the York Mountains.

The Arctic drainage of the Seward Peninsula, embracing probably not over a third of its area, is all of practically the same general type. The headwater valleys are broad and open, and the watersheds separating them from the valleys of the streams flowing south are often very low. The passes are broad and gravel-filled, and suggest recent changes in drainage. The valleys of the northward-flowing streams open out as they approach the Arctic, the gradients become less, and finally the floors merge into the coastal areas, through which the streams meander with sluggish currents. Many of the Arctic streams empty into large lagoons, which are cut off from the ocean by long barrier beaches. The streams on the Arctic coast are straighter than those flowing into Bering Sea. The easterly streams flow northeast, the westerly ones northwest. West of Cape Espenberg the Serpentine, Arctic, Kougarok, Pinguk, and Mint are the chief rivers, while the Goodhope, Cripple, Inmachuk, Kugruk, Kiwalik, and Buckland drain the northeastern part of the Peninsula.

The Buckland River, which flows into Eschscholtz Bay, a part of Kotzebue Sound, through a long tidal estuary, rises about 75 miles southeast of the bay, and opposes the drainage flowing on one hand into Norton Bay and on the other into the lower Koyukuk. The lower 60 miles of this river were explored in 1849[a] by expeditions sent out from H. M. S. *Herald* and *Plover*. The reports of these parties show that dead water extends for about 30 miles from the mouth, and that there are no serious rapids for 30 miles farther upstream. There is a native settlement near the head of the river which is connected by portage trail with the Kateel River, a tributary of the Koyukuk.

ARCTIC DRAINAGE.

OUTLINE.

Though the Arctic coast has been explored and roughly charted for upward of half a century, there are still large tributary areas practically unknown. The relief and drainage indicated on the accompanying map (Pl. XXXIV) are based on observations made from the coast and on the results of the few exploring expeditions which have penetrated inland, and will, therefore, require much revision after more extended and systematic surveys are executed.

The streams tributary to the Arctic Ocean drain less than one-third of Alaska and fall into two groups: First, those flowing westerly into Kotzebue Sound, and, second, those having northerly courses and emptying directly into the Arctic Ocean. The drainage of the northern half of the Seward Peninsula, which might properly fall into the second division, has already been considered.

[a] Mendenhall, W. C., Prof. Paper U. S. Geol. Survey No. 10, 1902, p. 12.

HOTHAM INLET DRAINAGE.

The eastern coast of Kotzebue Sound is broken by many deep embayments and inlets. The largest of these—Hotham Inlet—is a long, irregular-shaped body of water, cut off from the sound by a long, narrow neck of land. The largest tributaries of Kotzebue Sound—the Noatak, the Kobuk, and the Selawik—flow into the inlet. The drainage basins of the first two are probably entirely within the ranges which make up the Rocky Mountain system in this part of Alaska, while the valley of the Selawik probably marks the southern margin of the system.

The Selawik, the southernmost of the three, empties into Selawik Lake, which is connected by a narrow water passage with the head of Hotham Inlet. This lake or lagoon undoubtedly owes its origin to the building out of the delta of the Kobuk River, which has thus cut off a part of the former extension of the inlet. Several smaller bodies of water to the east are connected by tidal [a] channels with the larger basin.

A broad delta marks the mouth of the Selawik [b] River, whose various channels connect with the above-described lagoons. The Selawik rises on the north slope of a group of mountains 3,000 to 4,000 feet high, whose southern slopes drain into the Koyukuk. The upper valley is probably rather narrow, but for 60 miles above its mouth the river meanders across a broad, level-floored valley. On the north the Waring Mountains, which are from 2,000 to 2,500 feet high, separate the Selawik from the Kobuk drainage, while to the south the highlands are probably of less altitude. Several good-sized tributaries join the lower course of the Selawik. Of these the Kugerack from the north is separated by a very low divide from waters flowing into the Kobuk.

According to Stoney [c] 16 feet of water can be carried over the bar of the deepest of three outlets of Lake Selawik, and he reports also 6 feet of water in the river as far as the "forks," [d] to which point the current is less than 3 miles per hour.

The eastern shore of Hotham Inlet is formed by the broad delta of the Kobuk [e] River, whose headwaters have not been explored, but are known to lie about 200 miles due east of Hotham Inlet, in a high mountain mass near latitude 67°, longitude 155°. In the same region are probably the sources of the Alatna, which flows south into the Koyukuk; of the Noatak, which flows west into Kotzebue Sound, and of a branch of the Colville, which flows northerly into the Arctic Ocean. The general trend of the valley of the Kobuk is east and west with, however, a number of broad bends. The lower half of the valley is characterized by a broad, flat depression, while the upper half, made up of a series of basins and connecting canyons, is of the general type already described (pp 281–283).

The Kobuk is between 400 and 450 miles long and receives many tributaries—all the larger ones from the north. Its basin has an area of probably 8,000 to 9,000 square miles, and is incised into a mountainous belt made up of several ranges which have altitudes of from 2,000 to 4,000 feet, and which are believed to be the

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[a] Cantwell, J. C., Exploration of the Kowak River, Alaska: Cruise of the Corwin in the Arctic, 1884, p. 68.

[b] Geo. M. Stoney, Lieut. U. S. N., Naval explorations in Alaska: U. S. Naval Institute, pp. 41 and 54.

[c] Ibid., p. 55.

[d] Stoney probably refers to the mouth of the Kugerack, which is the largest tributary of the Selawik.

[e] The description of Kobuk basin is largely taken from a "Reconnaissance from Fort Hamlin to Kotzebue Sound," by W. C. Mendenhall: Prof. Paper U. S. Geol. Survey No. 10, 1902.

western extension of the Rocky Mountain system. Of the numerous lakes in the upper valley, Walker Lake, the largest, 14 miles long by 2 miles wide, is known to be of glacial origin. The walls surrounding it rise to altitudes of 3,000 or 4,000 feet. The Kobuk flows through Walker Lake and below the outlet receives the Kichaiak, a small creek from the east. This stream heads in a pass opposite Help-me-Jack Creek, a tributary of the Alatna River, and is used as a summer route between the Kobuk and Koyukuk waters. It was first explored in 1901 by the Mendenhall party.

Above the lake the Kobuk flows southeasterly through a comparatively narrow valley, while below the valley broadens out to 4 or 5 miles and the river swings to the southwest. In this upper course it receives the drainage of Nutuvukti Lake, which lies a few miles to the northwest, and is separated by a broad flat divide less than 200 feet high from Reed River, another northwesterly tributary of the Kobuk.

Twenty miles below Walker Lake the Kobuk Valley swings to the southwest, and at the so-called "Gorge" (Pl. XXXIII, *B*) contracts to a mile or less in width, then takes a westerly course and opens out to 8 or 10 miles. Reed River enters from the north, not far below the gorge, and is said to be connected by winter trail with upper Noatak. Beaver Creek, which joins the Kobuk a few miles below, is the outlet of a small lake lying 25 miles north of the main river.

Near the one hundred and fifty-sixth meridian the Pah River enters the Kobuk from the south. Its headwaters lie opposite the headwaters of the Dakli River, which flows southward into the Koyukuk. A low depression between the two streams—Zane Pass—affords an easy route between the two basins. A few miles above the Pah is a small tributary from the north, which drains Lake Selby,[a] situated just at the northern margin of the valley. The Mauneluk River, confluent 20 miles below, drains two small lakes 10 and 15 miles to the north. The next river of importance, going downstream, is the Kogoluktuk, which flows from the north. Its headwaters are said to be connected by a low pass with the streams flowing northward into the Noatak.

In the 50 miles below the mouth of the Kogoluktuk the Kobuk receives several minor tributaries from both sides and the Ambler—the largest tributary—which is confluent from the north near the one hundred and fifty-eighth meridian. The Ambler rises within 15 miles of the Noatak,[b] and is one of the chief routes of communication for the natives between the two basins. In its upper course the Ambler flows southwest probably in a narrow valley to within 25 miles of the Kobuk, where it bends westerly and traverses a broad flat valley, which continues to its mouth, and in which it receives its one important tributary, the Redstone River.

From the gorge to about the one hundred and sixtieth meridian the Kobuk Valley is a broad depression, in which the river has a tortuous course. Near the meridian mentioned the valley suddenly contracts to a width of about 2 miles, and then the walls again recede and the valley merges into the plain of the delta. The Squirrel River, tributary from the north near the head of the delta, rises in the Baird Mountains, the watershed between the Kobuk and the Noatak.

[a] Naval Explorations in Alaska (map).

[b] Naval Explorations in Alaska, pp. 37 and 38.

Near the one hundred and sixty-first meridian the north wall of the valley recedes and swings around the head of the eastern arm of Hotham Inlet, while the mountain range which forms the south wall terminates abruptly at the delta, a featureless plain, across which the river sends its drainage to the inlet through innumerable tortuous channels. The delta is about 30 miles square, and is bounded on the south by Selawik Lake and on the west and north by Hotham Inlet. It is traversed by a maze of intricate waterways, with numerous lakes and lagoons, is being rapidly extended seaward, and is constantly encroaching on the shallow waters of Hotham Inlet.

The Kobuk is navigable for river steamer as far as Camp Riley, 225 miles from the mouth, and small launches have been run above this point. Cantwell and Stoney,[a] who explored the Kobuk in 1884 and 1885, made use of launches and steamers on the lower 200 miles of the river, but for many years after no attempt was made at steam navigation. In 1898 upward of 1,500 gold seekers made their way to Kotzebue Sound and many ascended the Kobuk, using several steamers and launches, and encountering no serious difficulties below Camp Riley.

Stoney[b] reports that the entrance to the deepest channel in the delta is off Nimiuk sand spit, and that there are two fathoms of water over the bar, while Mendenhall[c] states that the deepest channel begins near the passage to Selawik Lake. The exploration of the Mendenhall party proved that although the upper river contains several rapids it is navigable, at least as far as Walker Lake, for canoes handled by experienced men. The descent of the lower 200 miles of the Kobuk is only 200 feet, and the current is moderate. Walker Lake, about 400 miles from the inlet, stands about 400 feet above tide.

The Noatak is the third and probably the largest of the three rivers which flow into Kotzebue Sound from the east. Its head lies near the sources of the Colville and Kobuk, and its general course is westerly until it approaches within 30 miles of the coast, where it bends sharply and reaches the sea at the north end of Hotham Inlet by a general southerly course. So far as known the valley of the Noatak consists of a number of broad flat basins connected by neck-like canyons.

There are no accurate maps of the Noatak, and explorations have been carried over only a part of its basin. The following statements are based on reports by McLenegan[d] who ascended the river to about the one hundred and fifty-seventh meridian in 1885, and by Stoney[e] and Howard[f] who explored a part of its headwaters in 1885 and 1886.

The source of the Noatak is in a mountain mass which also gives rise to the Kobuk and Alatna rivers on the south and to branches of the Colville on the north. Its upper course is northwest in probably a rather narrow valley, where it gradually swings to the west, and near the one hundred and fifty-sixth meridian opens into a broad basin, across which the river makes tortuous mean-

[a] Naval Explorations in Alaska, pp. 37 and 38.

[b] Ibid., p. 49.

[c] Ibid., p. 27.

[d] McLenegan, S. B., Explorations of the Noatak River, Alaska: Report of the Cruise of the Revenue Steamer *Corwin* in the Arctic Ocean, 1885, Washington, 1887, pp. 53–80.

[e] Stoney, Geo. M., Naval explorations in Alaska: Naval Institute, 1900, pp. 37–40 and 54–55 and 66–68.

[f] Howard, Lieut. W. L., was a member of Stoney's party.

ders. Broad low passes separate this part of the valley from Colville waters on the north and Kobuk waters on the south. Below this upper basin the valley contracts somewhat and then in a few miles again broadens into a basin, probably 10 to 20 miles in width, and receives a tributary from the south called by Stoney "Caribou River" (Cutler River). Through this lowland the river flows westerly to about the one hundred and fifty-ninth meridian, where it bends south and flows through a canyon 4 or 5 miles in length, below which the valley broadens again, and about 20 miles farther downstream the river enters another broad basin, through which it takes a westerly course. Forty miles below the valley again contracts and the river, bending to the southwest, enters the so-called Grand Canyon, which is 6 to 8 miles long. Below the canyon both valley walls rapidly recede, encompassing a lowland which is 20 miles in width and is sparsely timbered with spruce and within which the river swings from the southwest to south. Where the river leaves this lowland it flows almost due east; it bends to the south and traverses the western extension of the Baird Mountains in a series of long, sweeping curves. The valley is here only about 2 miles in width, with one rock-walled canyon 2 miles in length. A short distance below the canyon the river emerges on the coastal plain, and then, after making a double bend to the east and south, reaches the delta, where it is diverted into three or four main channels, through which it finds its way to the sea. The delta of the Noatak forms the northern shore of the Hotham Inlet and appears to be of much less extent than that of the Kobuk.

The four gravel-floored basins and the connecting canyons described above are striking topographic features of the Noatak Valley and resemble similar forms in the Kobuk Valley, as well as in some of the valleys of the Seward Peninsula (pp. 93–95). In the basins the valley slopes are gentle, and the Noatak River meanders over the gravel floor in one or more channels, while in the canyons the walls rise abruptly and the river has usually but one channel.

The Baird Mountains, a well-defined range south of the Noatak, extend east and west and form the watershed between the drainage basins of the Noatak and the Kobuk rivers. They reach altitudes of 3,000 to 4,000 feet, and are said to fall off to the Noatak Valley gradually through a series of foothills. The slope to the north from the Noatak Valley is also gradual to the so-called De Long Mountains, which are somewhat less well defined and probably lower than the Baird Mountains. Both ranges are included in the Rocky Mountain system.

The height of the walls of the Noatak Valley has not been determined, but it is probably not over 2,000 or 3,000 feet. As far as known, the Noatak receives no large tributaries. The current of the stream is reported to be swift, and in the basins the river is split up into many shallow channels, so it is very doubtful whether steamboat navigation would be feasible. It is reported that there are 6 feet of water in the delta, but above, according to McLenegan's soundings, the river rapidly shoals to 1½ and 2 feet. The Noatak Valley lies just north of the limit of timber, but spruce grows sparsely in its lower 100 miles, and cottonwood is found for some distance above. while willow alone is found in its upper valley (Pl. XII).

The natives travel along the entire length of the Noatak, but their more permanent habitations are among its headwaters, from which they have communication with the Kobuk on the south and the Colville on the north. Along the latter stream and the Chipp River they make annual excursions to the north Arctic coast for purposes of hunting and fishing.

KOTZEBUE SOUND TO POINT BARROW.

From Kotzebue Sound the Arctic coast line extends northwest as far as Cape Hope, then bends to the north and finally to the northeast as far as Point Barrow. The rivers which enter the Arctic along this stretch of coast are, for the most part, unmapped and unexplored.

Seventy-five miles northwest of Hotham Inlet the Kivalina and Wulik flow into a large lagoon. These two rivers head near the great southerly bend of the Noatak and flow nearly west.[a]

The Kukpuk River enters the Arctic Ocean at Point Hope. In its lower reaches it is bordered by a broad valley, which is cut in a highland mass 1,000 to 1,500 feet in altitude, and which has a general east-west trend. It flows across a broad delta into Marryatt Inlet, a tidal lagoon. The barren beach of this lagoon, modified by wave and current action, forms the long sand spit called Point Hope. The Pitmegea River, which enters the ocean at the bight in the coast line east of Cape Lisburne, has a northwesterly course, and its valley is incised in the uplands which are not over 1,000 to 2,000 feet high. The four rivers described lie entirely within the highland region, which is regarded as the western extension of the Anaktuvuk Plateau of the Arctic Slope region.

The highlands which northward from Kotzebue Sound rise either directly from the sea or from a narrow coastal plain trend inland northeast of the Pitmegea River and give way to a low tundra, across which streams meander sluggishly, without any well-defined valleys, and which is dotted with lakes and extensive marshes. The lack of relief makes changes of drainage very common, and these are probably often brought about by ice barriers. The Kupowra and several smaller rivers which enter a lagoon about 40 miles northeast of the Pitmegea rise in the highland region to the south, but in their lower course meander over the coastal plain. The Utukok reaches the sea 100 miles to the northeast and the Kuk at Wainwright Inlet, a small tidal estuary near Cape Collie.

NORTH ARCTIC DRAINAGE.

East of Point Barrow the Arctic slope is drained by three main rivers, the Meade, Chipp, and Colville, and many smaller unexplored and unnamed streams all having northerly courses, which in their lower reaches flow across the tundra in tortuous channels.

The Meade River probably has its source in highlands, near latitude 69° and longitude 157°. Its lower valley was explored by Ray,[b] who, in 1883, during a

[a] The positions of the valleys of these rivers is strongly suggestive of the idea that one or the other may have been the former outlet of the Noatak. There is, however, no topographic evidence availabe to prove or disprove such a hypothesis.

[b] Ray, P. H., Expedition to Point Barrow, Alaska: 48th Cong., 2d sess., Ex. Doc. No. 44, pp. 26–28.

winter overland journey from Point Barrow, ascended it from latitude 70° 30′ to about latitude 70°. Where he first saw the river he describes its valley as shallow, winding, and incised to a depth of 100 feet in sands and gravels. Upstream, to the south, the valley continues its tortuous course, but the relief near the highest point reached by Ray had increased to about 200 feet, and Ray states that the source of the river lies in a low range of mountains, probably the western extension of Anaktuvuk Plateau. The Inaru, a small river, drains some small lakes which lie about 40 miles southwest of Point Barrow and empties into Dease Bay. It flows parallel to the lower Meade.

The Chipp[a] River has two outlets, one into the head of Dease Inlet, where it is joined by the Meade River, and another 40 miles to the east in Smith Bay. Its basin is ill defined and is cut up by a maze of waterways. The source of the Chipp, near latitude 68° 30′, lies in a rolling upland region—probably the piedmont plateau (Anaktuvuk) already described. The river follows a very devious course, but its general direction is northerly. Forty miles from salt water it receives one important tributary[b] from the southwest. Howard states that at the head of the Chipp the hills are 500 feet above the valley bottom. Near the seventieth parallel of latitude the river emerges from the uplands and enters the low coastal plain, and here Howard determined its width to be 400 yards and depth 14 feet, but these measurements were made nearly at high water in the spring.

The Chipp is navigable for steamers for a long distance, but as it is locked in the ice all but about two months in the year and as its basin yields nothing of value, this fact is of no commercial importance. Willows 12 feet high are found along its headwaters, but its lower course is entirely destitute of timber A portage trail through a low divide is used by the natives in traveling from the Colville to Chipp waters.

The Colville,[c] which is the largest river of the Arctic slope, enters the sea about 80 miles east of Smith Bay. Its headwaters were explored in 1886 by Stoney[d] and Howard, and its lower course and its chief tributary, the Anaktuvuk, by Schrader[e] and Peters in 1901.

Chandler Lake, in which the Colville heads, lies well within the Rocky Mountains near the intersection of the sixty-eighth parallel and the one hundred and fifty-third meridian. The lake is about 10 miles long and from one-half mile to a mile in width and the adjacent mountains rise 1,000 feet above its surface. A low divide, called Navy Pass, affords a portage route from the lake to Alatna River.

Below the lake the Colville Valley trends northerly, but in 10 miles swings to the southwest, then west, and receives a tributary from the northeast. The westerly course continues for upward of 100 miles, when the valley swings to the north,

[a] Howard, W. L., Expedition to Point Barrow: Naval Explorations in Alaska, pp. 71-77. Native name of this river is Ikipikpung.

[b] On some maps called the Ikipikpung or Ikpikpuk.

[c] Called by the natives Kuyanuk.

[d] Naval Explorations in Alaska, pp. 44-47 and 70-72.

[e] Schrader, F. C., Recent work of the United States Geological Survey: Bull. Am. Geog. Soc., vol. 34, 1902, pp. 9-16. Geological section of the Rocky Mountains in northern Alaska: Bull. Geol. Soc. America, vol. 13, 1902, pp. 233-252. Reconnaissance in northern Alaska: Prof. Paper U. S. Geol. Surv. No. 20, 1904, pp. 46-49.

and near this angle Etivluk River is confluent from the southeast. The Etivluk heads opposite Noatak waters, with which there is easy communication by Riley Pass. Up to the northerly bend and for 10 miles farther downstream the valley is probably rather narrow and lies within the mountains, but near latitude 68° 30′ the river emerges into the piedmont plateau region. There the valley bends eastward and broadens out, while the river channels become more tortuous. Howard estimated its width near this point at 400 to 1,000 yards, and reports that it was studded with islands and sand bars. Between the one hundred and fifty-seventh meridian and the Anaktuvuk, a distance of about 70 miles, the Colville is entirely unexplored.

The Anaktuvuk, which is the largest tributary of the Colville, heads in Anaktuvuk Pass, which has an altitude of about 2,400 feet and marks a decided break in the Rocky Mountains, and from which the John River flows southward into the Koyukuk. This pass is only a few miles from where the range falls off to the piedmont plateau on the north, and the Anaktuvuk soon leaves the mountains. The intermontane part of its valley is wide, with abrupt walls, and is only about 15 miles in length, in which distance the river descends over 200 feet. Leaving the mountains, it enters a broad basin 40 miles in length, which has been incised in the Anaktuvuk Plateau and which receives several tributaries. Below the basin is a small canyon, and there the valley broadens again to 2 or 3 miles, and continues with about this width to latitude 69°. There it is joined by the Nanushuk from the southeast and the Tuluga from the southwest. The valley gradually broadens to where it merges with that of the Colville near latitude 69° 30′.

The mountains at the headwaters of the Anaktuvuk reach altitudes of 6,000 feet, giving a topographic relief of about 3,500. Near the mountains the elevation of the plateau is 600 feet, while near the junction with the Colville it is 400 feet. Above and in the canyon the Anaktuvuk has many rapids and its bed is strewn with glacial bowlders; the lower river has a current of from 2 to 6 miles.

Below the mouth of the Anaktuvuk the Colville flows due north for about 40 miles. The west side of its valley is well defined by a series of bluffs 200 to 400 feet high, but the east slope rapidly recedes and gives place to a broad, marshy lowland dotted with lakes. Near latitude 70° the Colville bends sharply to the east and 10 miles below turns to the north. At this point it enters the coastal plain proper and is joined by the Itvelik River, a large easterly tributary. The delta of the Colville has a frontage of about 25 miles on the ocean and extends back about 10 miles. From the junction of the Anaktuvuk to the mouth of the Itvelik the Colville has a current of 3 to 4 miles an hour, with some small rapids, but below the Anaktuvuk and in the delta there is almost slack water. Stunted willows are found as far north as the mouth of the Anaktuvuk, but below that point even this shrubbery is entirely absent.

The lower Colville could be ascended by steamer, but navigation has no commercial importance. The Colville Valley is, however, a well-established route of travel by which the Eskimos of the upper waters of the Kobuk, Noatak, and Colville reach the Arctic coast. In the spring the natives follow the caribou northward to the edge of the mountains, and then after the ice breaks reach the coast by boats down either the Colville or the Chipp. The return is made by boats to the head of navigation and after winter sets in by dog teams. The wood for constructing the boats is brought either from the driftwood of the coast or across the divide from the valleys of the southerly and westerly flowing rivers. Both the coast and interior of this bleak northern region supports a large population of Eskimos.

Little is known of the Arctic drainage east of the Colville, but there are probably many small rivers which head on the northern slope of the mountains and flow northward to the sea.

During the winter of 1902 and 1903 Mr. S. J. Marsh, of Nome, made a remarkable journey from Camden Bay on the Arctic Ocean to Fort Yukon by way of the Chandlar River. Marsh, who traveled alone, made a sketch survey[a] throughout this difficult journey, and by his unaided efforts explored a region entirely unknown to white men. He reports four rivers[b] of considerable size which enter the Arctic Ocean between the one hundred and forty-fifth and one hundred and forty-ninth meridians. The Kupowra is the most westerly river of this group, and probably has its source opposite an eastern tributary of the Colville. The Sawanukto River, a much larger stream, enters the Arctic through a broad delta about 20 miles east of the Kupowra River. It has its source in a divide which lies well within the mountains and whose southern slope drains into the Middle Fork of the Koyukuk. Near the sixty-ninth parallel the Sawanukto receives from the southeast an important tributary, which is said to be separated by a low pass from Koyukuk waters. The Savaovik River flows into the Arctic near the one hundred and forty-seventh meridian. It is a much smaller stream than either of the two last mentioned. The Canning River, whose broad delta forms the west side of Camden Bay, is the largest of the four streams. It rises near the southern margin of the mountains, opposite streams flowing into the Chandlar River, the two watersheds being connected by low passes. The Canning forks near the sixty-ninth parallel, the two prongs being of about equal size. Marsh also noted a fifth stream of smaller size which he calls the Barter River and indicates as entering the ocean at Manning Point. The Turner[c] River flows into the Arctic Ocean a few miles west of the international boundary. It has its source well within the British mountains. Its headwaters are probably 50 to 100 miles from the sea and its valley is sharply incised.

SUMMARY.

The Arctic drainage of Alaska comprises two systems of watercourses, which trend approximately at right angles to each other. The one which lies entirely within the mountains flows through a series of large basins connected by narrower stretches of valley, with a general east-west trend parallel to the mountain axes. The Kobuk, Noatak, and Colville are the largest rivers of this system and receive their waters entirely from the ranges of the western end of the Rocky Mountain system.

The second drainage system comprises those rivers which drain the seaward slopes of the Rocky Mountains and usually flow nearly due north. They occupy broad, shallow valleys in the piedmont plateau region, and meander sluggishly over the coastal plain. The drainage of the northern portion of the Seward Peninsula and that of the Arctic slope east of Cape Lisburne, including the lower Colville basin, belong to this group.

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[a] The writer is indebted to Mr. Arthur Gibson, of Nome, for a copy of this map.
[b] Most of the names which will follow are native, according to Marsh.
[c] Report of J. H. Turner, Ann. Rept., U. S. C. and Geod. Survey, Pt. I, 1891, p. 87.

HISTORY OF EXPLORATIONS AND SURVEYS.

INTRODUCTION.

The following sketch is based on a rather desultory examination of the literature at odd times during four or five years. While the value of the statements would have been much enhanced by the citation of authorities this was not possible in the time available for preparation.

The bibliography [a] appended to this report contains the titles of all the works consulted, which are only a small part of the voluminous literature upon Alaska. It has been possible to make a more or less careful study of the important publications relating to the Territory since its acquisition by the United States, but many of those which deal with the earlier period, particularly the Russian, were not consulted, and the writer has had to rely in part on the three standard works on Alaska which contain important summaries of its history. These are: Alaska and Its Resources, by William H. Dall, 1870; Report on Population, Industries, and Resources of Alaska, by Ivan Petrof, Tenth Census, vol. 8, 1884, and History of Alaska, by Hubert Howe Bancroft, 1886.

GEOGRAPHY AS RELATED TO DEVELOPMENT.

The history of Alaska will be more easily understood if the avenues of approach for explorers and settlers are briefly discussed. Alaska's peninsular form and irregular shore line give a coast exposure of great extent (Pls. II and VII). Some of this fronts upon the frozen sea and adds little to the accessibility of the country, but much the larger part is washed by waters which are open to navigation throughout the year, and along this extensive seaboard the first explorations and settlements were made. An almost unbroken series of ranges—the Pacific Mountain system—lies near the Pacific shore line and offers a barrier which long prevented inland exploration or settlement; for only within recent years have passes through it been discovered. The broad, depressed interior area lying behind this ridge is again cut off from the coast region on the north and east by another mountain chain, here termed the Rocky Mountain system, which also retarded man's approach, because it interposed a barrier between the interior of Alaska and that extensive system of waterways of northern Canada which enabled the fur traders to find their way across the continent from the Atlantic seaboard. This Central Plateau region, as it has been called, opens out to Bering Sea, into which it pours most of its drainage through two great rivers, the Yukon and Kuskokwim, both of which are navigable and afford easy access to the interior.

Another important geographic feature of Alaska in relation to its development is its juxtaposition to Asia. The westernmost point of its mainland is visible from the Siberian coast across Bering Strait, only 60 miles wide; but as this strait is

[a] The publication entitled, "Partial List of Charts, Maps, and Publications Relating to Alaska and Adjacent Regions, by W. H. Dall and Marcus Baker," Pacific Coast Pilot, Appendix 1, Meteorology and Bibliography, U. S. Coast and Geodetic Survey, Washington, 1879, has not yet been supplemented and remains to-day the only bibliography of works relating to Alaska.

navigable only in summer, it is of less importance as a route of travel than the Aleutian Islands, which form a chain almost connecting the Asiatic and American continents. These islands are mostly intervisible, so that as soon as the western one had been reached from Asia even the Russian traders, who were usually entirely unskilled in navigation, could follow the archipelago eastward to the mainland.

MAIN FEATURES OF HISTORY.

A complete history of the discovery and exploration of Alaska would involve a consideration of the history of eastern Asia and western Canada, as well as of the explorations of the northern Pacific and the Arctic region, and is beyond the scope of the present paper. In the few pages here devoted to the subject it is possible only to broadly outline the progress of discovery, calling attention to a few of the more important expeditions which have added to the geographic knowledge of the country and the agencies which were operative in its exploration. During the two centuries which have elapsed since white men first obtained definite tidings of Alaska, exploration and surveys have been carried on spasmodically by various nationalities and under various auspices. Though the larger geographic features are now fairly well known, there still remain some unexplored areas, and the topographic mapping is hardly begun.

Explorations of the northwestern corner of America may be said to have been made from three directions—from the west by the Russians, across Siberia and Bering Sea; from the east by the English, through the Mackenzie Valley, and from the south by navigators of various nationalities exploring the eastern shore of the Pacific.

Before the end of the sixteenth century Russian fur traders crossed the Urals, gradually extended their operations eastward across northern Asia, and established themselves on the shores of Bering Sea. During this time the French voyageurs and their successors of English blood had been making their way westward from the Atlantic coast. Reaching the Rocky Mountain barrier they were there held in check for over a hundred years, but before the middle of the nineteenth century they had surmounted this obstacle and established trading posts on rivers tributary to the Pacific and the Bering Sea. Meanwhile the Russians crossed Bering Sea and had taken possession of Alaska. By the beginning of the nineteenth century the fur trade which had been developed by these two nationalities had left the hands of individuals and in both cases had come under the control of a strong company. The two rival fur-trading interests, which had been moving toward each other for upward of two centuries, after practically encircling the globe finally came into competition in Alaska. These facts are recited here because the desire to obtain control of and exploit the fur trade was directly or indirectly the prime motive for the early explorations of the territory.

EARLY RUSSIAN EXPLORATIONS.[a]

Less than a century after the discovery of the American Continent Yermac Timofeief and a band of Cossack adventurers crossed the low barrier of the Ural Mountains and began that series of conquests in Siberia which was to make Russia

[a] For the authorities consulted in preparing this sketch see pp. 298–308.

an Asiatic power. While the western nations of Europe were exploring the east coast of North America, and almost before they had obtained a foothold on its shores, the Russian Cossacks had crossed northern Siberia and in 1638 reached the sea of Okhotsk. Step by step these Cossack adventurers made their way across the great lowlands of northern Siberia, traveling with horses by land and skin boats by water. The comparatively peaceful character of the natives and the absence of mountain barriers greatly facilitated the work of conquest.

After reaching salt water it was but natural that the Cossacks should extend their explorations along the coast. In 1648 Deshnef sailed eastward from the mouth of the Kolyma on the Arctic, rounded East Cape, passed through the body of water afterwards named Bering Strait, and wintered at the Anadir River. More than half a century elapsed before this exploration was extended by another Cossack, Popof, who, in 1711, was sent to East Cape to induce the natives to pay tribute. The warlike Chuckchees, who inhabited that part of the Siberian coast, refused to acknowledge the sovereignty of Russia, but Popof brought back an account of the Diomede Islands in Bering Strait and rumors of a continent said to lie to the east.

In course of time news of this discovery was transmitted to St. Petersburg, and the reigning sovereign, Peter the Great, was quick to realize its importance. Spurred on, no doubt, by the knowledge he had of the discoveries and settlements made by the western nations of Europe in the New World, Peter ordered the organization of an expedition which should verify Popof's statements and extend his explorations. Vitus Bering, a Dane and fleet captain in the Russian navy, was placed in charge of the expedition. Peter did not live to see his plans executed, dying soon after signing Bering's orders; but his successor, the Empress Catharine, actively carried out the purpose of her husband. Bering's command, after crossing Siberia, built two small vessels at Okhotsk. In July, 1728, he sailed northward along the coast of Siberia as far as East Cape, passing through the strait which bears his name. From East Cape he stood to the northeast for a day and then returned to his port of embarkation without having sighted the American Continent.

While Bering himself believed that his short voyage definitely proved the absence of an eastern connection of Asia with North America, yet so meager was his evidence that most geographers refused to accept it, and it was not until Cook's voyage, half a century later, that convincing proof was obtained. Bering did, however, discover and name St. Lawrence Island, and may therefore be regarded as the first white man to look upon any part of what is now Alaska.

Three years later a vessel in command of a Cossack named Gwosdef, one of a small fleet sent to subdue the Chuckchees, was blown onto the American coast by a storm, probably somewhere in Norton Sound. The records of this voyage, vague as they are, contain the first reference to the mainland of Alaska based upon the actual observations of white men. In the following year (1729) Bering made a second voyage, which was even less fruitful of results.

The interest excited by these discoveries led to the organization at St. Petersburg of another expedition, of which Bering was again put in command. Such were the difficulties of travel that six years were spent in transporting the party and outfit across Siberia, which at that time afforded nothing except game, fish, and furs, so that all supplies, including the ironwork and tools necessary for the construction of ships, had to be brought from Europe. Finally, in 1741, the expedition sailed from Okhotsk in two vessels, one commanded by Bering himself and the other by Chirikof. These soon became separated, and Bering, sailing eastward, on July 18 fell in with the American coast near Mount St. Elias, which he named, and a few days later landed on what was probably Kayak Island.

With this discovery Bering seemed to consider that his mission was fulfilled, and after a very cursory examination became impatient to return to Asia. The expedition, which had taken years of preparation, turned westward without attempting surveys or investigations and without even making a landing on the mainland of the newly discovered continent. Sailing southwest they discovered the Shumagin Islands, and named them after a member of the crew who was buried there.

Bering's haste to return to Asia again prevented him from making an adequate exploration. He continued westward along the line of the Aleutian Islands, some of which he sighted, but without gaining more than a very superficial knowledge of them. Scurvy broke out among the crew, and the entire party seems to have been bewildered. They sailed hither and yon, now heading for the American, now for the Asiatic coast, at last wrecking their vessel upon Bering Island of the Commander group, now belonging to Siberia. Of those that reached the shore many died, among them Bering, a disheartened and despairing man. The cross over his grave was the first emblem marking the extension of Russian sovereignty eastward of Siberia. The survivors of the ill-fated expedition built a small vessel of the wreckage and returned to Kamchatka.

Chirikof's voyage was even less successful. After becoming separated from Bering he sailed eastward, and on July 15 sighted the continent, probably near Cross Sound. An attempt to land ended disastrously, for both boats were lost, and nearly a third of the crew were killed by the natives. Chirikof hastily put to sea and returned to the Asiatic coast, sighting some of the Aleutian Islands in his passage.

The explorations made by these two navigators, while not fruitful of results commensurate with the elaborateness of the preparations, were yet of the utmost importance from a geographic standpoint. Two points on the American Continent were fixed with a fair degree of accuracy and the location of some of the Aleutian Islands approximately established. These islands, which are part of the broken chain connecting the Asiatic and North American continents, were to become an important factor in the early development of the fur trade of Alaska.

The reports by Bering's crew of the existence of valuable furs in the newly discovered islands east of Kamchatka soon led the hardy Siberian fur hunters, called promyshleniki, to brave the perils of an unknown sea. The first of these was Bassof, who two years after Bering's return reached Bering Island in a small vessel. The rich harvest of furs with which he returned after a year's absence induced him to make a second, and later a third voyage. He was but the forerunner of a swarm of promyshleniki who gradually pushed their way eastward along the Aleutian chain of islands to the mainland of Alaska.

These Siberian fur hunters had up to this time but little knowledge of deep-sea navigation, an ignorance which fitted them in a measure for the task which they had undertaken, for experienced seamen would have refused to take part is such utterly hazardous and foolhardy enterprises. As all iron for shipbuilding on the Bering Sea had to be transported across Siberia to Kamchatka, the result was that a species of vessel was devised which could be constructed without iron, the planks being sewed together with thongs of rawhide in lieu of nailing. Provisions also were scarce in Kamchatka, and these roving traders depended largely on such food as could be obtained from the sea.

In these crude crafts, manned by crews which knew little of seamanship, and usually but ill-equipped and provisioned, these intrepid fur traders boldly pushed out into unknown stormy seas. Many lives were lost by wrecks, starvation, and scurvy, and many of the adventurers met deserved death at the hands of the outraged natives. The risks were great, but when the expeditions were successful the profits were enormous, and the necessary capital for such enterprises was easily procured among the merchants of eastern Siberia.

This vanguard of civilization was made up of men who had no virtues other than valor and intrepidity. Their gradual mastery of the Aleutian Islands, which led to Russia's becoming a North American power, is a tale of blood and rapine, of murder and outrage. Under plea of exacting tribute from the natives they took their furs by force and not by barter, practically reducing the natives to slavery. Their firearms gave them an incalculable advantage over these people, whose arrows and spears were still tipped with bone. The Aleuts, at first friendly to the strangers, only too soon learned their true character; and though not so warlike as the true Eskimos to the north, or the Haidas and Thlinkets of southeastern Alaska, with whom the Russians later came in conflict, did not give up without resistance. Many a bloody and well-deserved reprisal did they inflict on their oppressors. The struggle was, however, hopeless; ravages of the barbaric Siberian fur traders during the half century succeeding Bering's discoveries threatened to exterminate the indigenous population of the Aleutian Islands. While the outrages were largely the work of private individuals they received a certain sanction from the Russian Government, which allowed the traders to plunder and murder the natives at will, but was ready enough to exact tribute on the ill-gotten furs. The cry of the murdered and outraged Aleut did not reach St. Petersburg, or if it did was not heeded.

It was through this murderous crew of traders that the civilized world learned of the Aleutian Islands and the adjacent mainland. Russia was to owe her American colony to the initiation and enterprise of private individuals, for the Court of St. Petersburg paid little heed to its American possessions for more than half a century after Bering's last voyage. But two attempts at official investigation were made, both more or less abortive. In 1767 Lieutenant Synd, of the Russian Navy, was sent out to explore the American coast, and though his results were meager and his statements unreliable, there seems no reason to doubt that he landed on the southern coast of Seward Peninsula. About the same time Captain Krenitzin reached the Alaska Peninsula on a similar mission.

When the Spanish and English first appeared on this coast Russia had no permanent settlement in Alaska. Bering's expedition had discovered a new continent;

yet though a third of a century had passed during which private enterprise had developed a lucrative fur trade in the adjacent islands, no effective attempt had been made to extend his discoveries or to exploit the resources of the main continent. The trading voyages had approximately established the relative location and configuration of the Aleutian Islands and Kodiak. Krenitzin had astronomically determined a few positions in the eastern part of the chain and along the southern coast of the Alaska Peninsula. These, together with Bering's discovery, and a less definite knowledge of the mainland lying adjacent to Bering Strait, comprised Russia's investigations in North America previous to the advent of other nations.

EXPLORATION BY RIVAL NATIONALITIES.

While the Russian influence was extending over Alaska from the west the Spaniards were approaching it from the south, where they had established themselves on the coast of California. Reports of these Russian encroachments led the viceroy of Mexico to send out several successive expeditions to explore the coast and where they found it uninhabited to plant the arms of Spain. Perez, a Spanish ensign, discovered the Queen Charlotte Islands in 1774, and the following year Lieutenant Quadra explored as far north as Cross Sound.

The first important systematic survey of any part of what is now known as Alaska was made by Captain Cook, the great English navigator. Cook sailed from England with two vessels in 1776. His first landfall on the Alaskan coast was in May, 1778, near Mount Edgecumbe, previously discovered by Bodega y Quadra. Thence he sailed westward, exploring Prince William Sound and Cook Inlet as far as Unalaska, where he was received very kindly by a band of Russian traders. It is of interest to note that an American in Cook's vessel, John Ledyard, was the first to interview the Russians.

Cook now entered Bering Sea and continued his surveys of the coast toward the north, through Bristol Bay, Norton Sound, and Bering Strait, until he was checked by the Arctic ice pack. This he skirted westward to where it impinged on the Siberian mainland at a point which he named Cape North, whence he returned to the south along the Siberian coast. The winter was spent in the Hawaiian Islands, and there the famous navigator met his death. The following year his vessels set out again under the command of Clerke, in an attempt to extend the surveys farther north, but the ice pack again interfered before they had penetrated much farther than before.

Cook had been unsuccessful in finding the water passage to Hudson Bay which he sought, but in the course of a single summer he had accomplished many times as much as all previous explorers. His voyage outlined the larger coastal features of Alaska, from about latitude 58° to 70°; definitely established the fact that there was no land connection between America and Asia, and convinced the navigator himself of the futility of seeking a waterway to the Atlantic, a conclusion which was in part based on Hearne's exploration in 1771 from Hudson Bay to the mouth of the Coppermine River. This last result was not generally acknowledged, and it remained for one of Cook's officers, Vancouver, to bring the final proof—not even then accepted by the theoretical geographers—about fifteen years later.

Great as was Cook's contribution to the geography of the Alaskan coast, perhaps of still more lasting importance was his inauguration of a new era in the explorations of the Alaskan seaboard. The vague and haphazard reports of the previous explorers were replaced by concise charts and accurate observations, many of which have stood the test of more detailed investigation. Several officers who accompanied Cook and were trained in his methods returned in later years to the Alaskan coast and continued the work of exploration.

Though some of the promyshleniki had reached Kodiak as early as 1762, it was not until after Cook's voyage that, finding the sea otters were becoming relatively scarce among the Aleutians and the voyages less profitable, they began to seek new hunting grounds to the northeast. Up to this time the fur gathering had been in the hands of individuals or small, weak companies, and hence but little concerted effort had been made. In 1781 a company of eastern Siberian merchants was formed for exploiting the American fur trade. The leader of this organization was Gregor Ivanovich Shelikof, who, with Ivan Golikof, controlled a majority of the shares. Under Shelikof's leadership an expedition was sent out, which, in 1783, founded a colony at Three Saints Bay, near the southern end of Kodiak Island. This was the first settlement within the limits of Alaska and was the pioneer of the Russian occupation, which was to last for three-quarters of a century, until the territory was transferred to the United States.

In the year this colony was founded a group of trading vessels, under the command of Potan Zaikof, reached Prince William Sound. He attempted the same high-handed proceedings which had been so successful among the Aleuts, but found to his cost that he was dealing with a fierce, warlike population, and the expedition ended disastrously. The event was noteworthy, as it was the first time the Russian traders are definitely known to have reached the mainland. Nagaief, a member of this party, discovered the Copper River and ascended it a short distance.

In the meantime the published account of Cook's voyage had aroused other nations to the fact that the rich fur trade in the northwestern extremity of the American continent was rapidly passing into the hands of the Russians. The English traders were the first to follow it up. In 1785 James Hanna visited the west coast of Vancouver Island, in British Columbia, and in the succeeding years made several voyages to the coast of what is now Alaska. Similar trips were made by English and American trading vessels and ships of other nationalities. The published logs and track charts of a number of these vessels added to the general knowledge of the northwest coast. All of these the Russians regarded as unlawful intruders, and many petitions were sent to St. Petersburg protesting against foreign ships engaging in this trade.

While merchants and traders of various nationalities were struggling for commercial supremacy in Alaskan waters, their home governments were not unmindful of the political side of the controversy. The English, Spanish, and French governments showed a desire to wrest some of these new discoveries from the Russians. The Spaniards claimed the coast, because it was a northern extension of their California possessions, and also by right of the discoveries of Bodega y Quadra. The English claim rested on Cook's discoveries.

The Spanish claims were strengthened by an expedition led by Arteaga, with Quadra as second in command, which sailed northward from Mexico in 1779, and visited and surveyed Port Bucareli on the west side of Prince of Wales Island. Later they entered Prince William Sound and, in obedience to their instructions, took formal possession of what they believed were newly discovered lands. They little realized that Cook in the previous year had gone through the same ceremony in the name of the British sovereign almost at the same spot. After extending their explorations to the southwest as far as the southern end of the Kenai Peninsula they returned to Mexico.

The French had no part in the discovery or in the exploitations of the new country; but to gain a valid claim, La Perouse, a naval officer, was dispatched to the northwest coast in 1785. In the following year he landed at Lituya Bay, of which he made a detailed examination and took formal possession. Then, ignoring his instructions to survey the Aleutian Islands, he sailed southward without landing again on the Alaskan coast.

The Spaniards, apparently satisfied that Arteaga's explorations established their territorial claims, took no further action for several years. The publication of Cook's voyages and the report of the numerous trading vessels that visited the northwest coast, however, aroused them again from their lethargy. In 1788, two vessels, commanded by Estevan Martinez and Gonzalez Haro, were dispatched northward to gain further information. While Martinez explored Prince William Sound, Haro visited the Russian establishments on Kodiak Island, and obtained full knowledge of the Russian occupation. Delarof, the director of the colony, took pains to impress the Spaniard with the wide extent and importance of the Russian settlements, of which at that time there were only six. After visiting Unalaska and going through the absurd performance of taking possession in the name of His Most Catholic Majesty of an island which contained a Russian colony and had been under Muscovite influence for upward of a quarter of a century, the expedition sailed for Mexico.

Martinez's report of the Russian occupation showed the viceroy of Mexico that Spanish claims to the northwest coast must be enforced by more decisive action. Both vessels were therefore again dispatched to take immediate possession of Nootka Sound on the west side of Vancouver Island, which had been discovered by Cook and had been used as a rendezvous by English, American, and Portuguese traders. The Spaniards did not molest the American ships, but warned off all those flying English colors. This high-handed action led to an immediate protest by the British Government, and commissioners were appointed by both governments to come to an understanding. The first meeting at Nootka led to a disagreement; but subsequently the Spaniards receded from their position and withdrew their forces, leaving the region in the possession of the traders and natives.

In 1791 Malaspina, an Italian navigator, in command of two Spanish corvettes, engaged in a scientific exploration which was to encircle the globe. He was sent to the northwest coast to explore for a northwest passage, rumors of which were again gaining credence. He made landfall near Mount Edgecumbe, and tracing the coast to the northwest entered Yakutat Bay, then known as Port Mulgrave. The ceremony of taking possession of the newly discovered land was not omitted, though Portlock and Dixon had surveyed and published a chart of the bay some years before, and the Russians had long used it as a rendezvous in their fur-trading expeditions. Malaspina made a cursory examination of Prince William and Cross sounds, and then turned southward.

George Vancouver, one of Cook's midshipmen, was the English representative in the Nootka dispute, and while his conferences with the Spaniards had no immediate result, his later explorations were of the utmost importance. He received orders to survey the coast between the thirty-fifth and sixtieth parallels of latitude, a task which he faithfully executed with his two vessels in 1793 and 1794. In the course of two seasons he accurately delineated thousands of miles of the coast line of southeastern Alaska, and supplemented the work of previous explorers westward as far as Cook Inlet. Not an indentation of the mainland, hardly a break in the shore line of the numerous islands, escaped his notice. His would have been a difficult task even in the days of steam, and to thread the intricate waterways of the Alexander Archipelago and make such surveys as he did within so short a period was little short of marvelous. He was a worthy successor of the great Cook, under whom he had learned navigation and geodesy. After his task was completed the general features of the entire coast line of the mainland of Alaska from Dixon Entrance as far north as Cape Belcher were charted with a fair degree of accuracy.

While the Russians and the Spaniards were attempting to dispossess all other nations of commercial and territorial rights in the coastal zone of Alaska, the English, their most aggressive rivals, were steadily approaching the region from the east. The French pioneers, following the route of the Great Lakes, had crossed half of the American continent long before the Russians had knowledge of the Aleutian Islands, and about the time of Bering's discovery of the mainland of Alaska, Verandrye had reached the foothills of the Rockies near the headwaters of the Missouri. Ten years later another pioneer trader established a post at the present sight of Calgary (Alberta), at the very base of the Rocky Mountains and only 500 miles from the Pacific waters. This post, with many others, was abandoned when Canada passed into the hands of the English.

Henceforth the English fur trade gradually expanded into the region which had been pioneered by the French. The Rocky Mountain barrier for a long time marked the limits of this western fur trade. It remained for Alexander Mackenzie to surmount this barrier, and to introduce a new factor in the development of Alaska. Mackenzie, who was a member of the Northwestern Fur Company, the great rival of the Hudson Bay Company, ascended the Peace River from Lake Athabasca, crossed the Rocky Mountains, then traversed the headwaters of the Fraser, and after crossing the Coast Range reached Pacific waters in the latitude of Queen Charlotte Sound. This journey, which was the first made across the continent north of Mexico, was accomplished in 1793, at the same time that Vancouver was surveying adjacent waters. It was the forerunner of the fierce rivalry which was to spring up between the two great competitors in the fur trade, the Russian-American and Hudson Bay companies.

In spite of the small degree of success achieved by previous official explorations, the authorities at St. Petersburg in 1785 determined on another. This was placed in charge of Joseph Billings, who seems to have been chosen more because he had been attached to one of Cook's vessels than because of any particular merit or experience. Billings sailed from Kamchatka in 1789, and passing through Bering Strait penetrated the Arctic Ocean to about latitude 69° and then returned to Kamchatka. In 1790 he made a second start, and the two vessels of the expedition, stopping at Unalaska and Kodiak, reached Prince William Sound, and then again returned to the point of debarkation. In the following year a third start was made and Billings once more reached Unalaska, whence he sailed northward, touching at Pribilof Islands, Seward Peninsula, and St. Lawrence Island. Billings himself afterwards landed on the Chuckchee Peninsula, Siberia, where he made a hazardous but apparently bootless journey inland. The two vessels wintered at Iliuliuk, Unalaska Island, and the following year returned to Kamchatka. The expedition, which in its preparation and execution had cost seven years of time and large sums of money, accomplished almost nothing beyond gaining some information regarding the abuse of the natives by Russian traders.

RUSSIAN OCCUPATION.

The last two decades of the eighteenth century were to witness important changes in the Russian fur trade. The Shelikof Company, after its settlement on Kodiak in 1783, gradually extended the sphere of its trading operations to the neighboring islands and mainland. In 1788 an imperial ukase granted to this company the exclusive control of the regions actually occupied by its agents. In 1792 an important step was taken in appointing Alexander Andreivich Baranof, chief director of the company's American interests. Baranof, who held this post for twenty-five years, showed himself to be a far-sighted, energetic man, though coarse and unscrupulous. The early years of his administration were a fitting introduction to the stormy ones to follow. At Cook Inlet rival traders had established themselves, who for some time quarreled and fought among themselves, but finally united to oppose their common enemy, the Shelikof Company. At length Baranof was forced to assume authority which he did not legally possess, and restored some measure of peace by arresting and imprisoning the ringleader.

In the meantime Baranof was energetically looking after the interests of the company in other directions. A shipyard was established on Prince William Sound, and attempts were made at agriculture at Kodiak and Yakutat Bay, while the fur trade was pushed vigorously. The first Greek Catholic missionaries arrived from Siberia in 1794, and at the same time the first convicts were imported and settled at Yakutat.

At the close of the century the court at St. Petersburg was beginning to be moved by reports of the disorders and outrages committed by the irresponsible fur traders, and was becoming weary of the quarrels of the rival companies. It was, moreover, desirous of maintaining Russian prestige in America by a responsible representation. Thus it happened that the Shelikof Company, with the aid of financial backing, was able to obtain a new charter under the name of the Russian-

American Company. The imperial ukase which established this company was dated 1799, and granted exclusive privileges of trade and occupation of northwestern America, lying north of latitude 55° and including the Aleutian Islands. The original grant was for twenty years, but two extensions placed Alaska in the hands of this company for sixty years. From this time on the history of Alaska up to its transfer to the United States is practically the history of this company which controlled this great monopoly. The region being now definitely in the hands of the Russians, the limits of whose possessions were determined by treaty with England in 1825, other nations discontinued their explorations.

In its early history the Russian-American Company was too much engrossed in developing the commercial resources of its grant to make any attempts at extensive explorations or surveys. However, as its agents gradually enlarged their field of operations, they gained some knowledge of new areas. The hunting trips had already reached southeastern Alaska, and in 1799 Fort Archangel Gabriel was built on Baranof Island, in Sitka Bay. The warlike Thlinkets of this region were far from submitting to Russian transgressions as did the Aleuts, and during the entire Russian occupation they proved themselves aggressive neighbors. In 1802 they attacked and demolished Fort Archangel Gabriel, and the few survivors were only saved by the timely arrival of an English vessel. Two years later Baranof set upon the Thlinkets in force and drove them out of their stronghold, Sitka, of which he took possession. He soon moved the capital of the colony from Kodiak to this new post, which he called New Archangel.

During the early part of the nineteenth century the activities of the colony, under Baranof's directorship, were in the main confined to commercial lines. But several minor explorations were undertaken, chiefly by naval officers who were in the service of the company. Thus it happened that Khwostof and Davidof made investigations among the Aleutian Islands in 1802. In the following year Bassanof visited the Copper River; and surveys were made in the Alexander Archipelago and the vicinity of Kodiak by Captains Krusenstern and Lisiansky in 1804 and 1805.

When Captain Golofnin of the Russian Navy was sent out by the home government in 1810, and a second time in 1818, for the purpose of investigating the affairs of the company and the status of the natives, some contribution was again made to geographic knowledge, though only incidentally.

The most important exploring voyage of this period was undertaken in the brig *Rurik* by Otto von Kotzebue, of the Russian navy. His purpose was the general advancement of scientific knowledge, including the discovery of a northeast waterway, in the existence of which many geographers still obstinately believed. Sailing from Kronstadt in 1815, Kotzebue reached Kamchatka the following year, whence he headed for Bering Strait. He touched at St. Lawrence Island, rounded Cape Prince of Wales, and coasting along the north side of the Seward Peninsula entered and surveyed the great sound which bears his name. On his return passage he visited Unalaska. After wintering in the Hawaiian Islands Kotzebue made a second trip to Alaska, but did not extend his former surveys.

No systematic explorations or surveys had been attempted under Baranof, but a change came about when the directorship of the Russian-American colony was transferred to naval officers, several of whom were men of scientific tastes and training and did much to foster geographic investigations. Other sciences were not neglected; systematic meteorologic records were kept at Sitka for many years, and a magnetic station was also maintained. Of the directors of the colony Baron F. P. von Wrangell was most prominent. Coming to his post fresh from Arctic explorations, he naturally looked with favor on all geographic investigations, and it was under his régime that the most important of the explorations carried on by the company were undertaken. This work was actively furthered by one of Wrangell's successors, Capt. Michael D. Tebenkof, who was also an explorer. Tebenkof's atlas of the northwestern coast of America, comprising a summary of all previous investigations, is the most important contribution to the geography of Alaska made during the entire Russian occupation.

In 1826 began the most valuable coastal exploration made by the Russian-American Company. This expedition, under the direction of Kramchenko, Etolin, and Vasilief, spent two years in examining the shore line of Bristol Bay and Norton Sound. In the following year Captain Lütké, sent out by the authorities at St. Petersburg, visited Unalaska and the Pribilof Islands and made a careful survey of the northern coast of the Alaska Peninsula. The southern coast of the Alaska Peninsula was mapped a few years later by Vasilief.

Among the lesser expeditions made under the direction of the company may be mentioned the explorations of the Bristol Bay and Kuskokwim regions by Korsakof, Vasilief, and Kolmakof from 1818 to 1832, and Malakof's exploration of the Sushitna in 1834. A more important expedition was one in charge of a creole by the name of Andrei Glasunof, who crossed from the Russian post at St. Michael, Norton Bay, to the Yukon and thence to the Kuskokwim. This, with Malakof's trip up the Yukon as far as Nulato, paved the way for the exploitation of the fur trade of the Yukon River.

By far the most fruitful of the Russian inland explorations was that made by Lieutenant Zagoskin, of the Imperial navy, in 1842–43. Zagoskin ascended the Yukon as far as the mouth of the Tanana and explored the lower stretches of the Koyukuk. Under his auspices a post was built at Nulato. He also traversed the Innoko, an easterly tributary of the lower Yukon, and made his way eastward to Kuskokwim waters. As far as time and means would permit, Zagoskin made track surveys and astronomic determinations of position, meanwhile taking careful notes on the native population and the resources of the region traversed. In the light of subsequent developments it is of interest to note his statement that the Yukon, or Kwickpack as he called it, was not navigable above the mouth of the Tanana.

In the meantime activity in Arctic exploration once more drew the attention of English navigators to the northwest coast. In 1789 Alexander Mackenzie had followed to the Arctic Ocean the great river which bears his name. In 1826 Sir John Franklin had traversed the Arctic coast westward, from the mouth of the Mackenzie as far as Return Reef on the north Alaskan coast; and Capt. F. W. Beechey, of H. M. S. *Blossom*, who had been dispatched to cooperate with Franklin, carefully charted the southern coast of the Seward Peninsula to Cape Prince of Wales, and added many details to the work of Kotzebue in Kotzebue Sound, extending his surveys northward until blocked by ice. A boat expedition under Beechey's mate Elson succeeded in reaching Point Barrow, which, it was hoped, Franklin would be able to reach from the east. But as Franklin was blocked by the ice 100 miles east of Point Barrow, this part of the coast line represented a hiatus in the charts for ten years.

In 1837 Peter Warren Dease and Thomas Simpson, of the Hudson Bay Company, descended the Mackenzie and followed the coast westward. Like Franklin, they, too, were stopped by the ice, but Simpson continued on foot and in native boats. He reached Point Barrow August 4, 1837, thus completing the exploration of the entire coast line of the mainland of Alaska, which was begun by Bering about one hundred years before.

Another impetus to Alaskan exploration was given by the series of Franklin relief expeditions which were sent out by the British Government between 1848 and 1853. While the primary purpose of these expeditions was to find and bring relief to Franklin, yet the commanders incidentally accomplished considerable exploration and charting. An added stimulus was the hope of finding a northwest passage, which geographers were loath to give up. In 1849 Capt. Thomas E. L. Moore in H. M. S. *Plover*, Capt. Henry Kellett in H. M. S. *Herald*, and the yacht *Nancy Dawson*, reached Kotzebue Sound. A boat expedition under Lieutenant Pullen was sent northward, and rounding Point Barrow proceeded eastward to the Mackenzie River, which it ascended to a Hudson Bay post. A second expedition from these vessels explored the Buckland River. Other minor explorations were made by the crew of the *Plover* while she wintered in Kotzebue Sound. Thus Lieut. Bedford Pim crossed the eastern end of Seward Peninsula to the Russian post at St. Michael, and Simpson, surgeon of the expedition, explored the Selawik River and made the first mention of the Kobuk River. The *Plover* spent the two following winters at Point Barrow, from which she continued to send out exploring parties.

In 1850 Commander Robert S. M. McClure, in H. M. S. *Investigator*, sailed eastward past Point Barrow and beyond the mouth of the Mackenzie until he was stopped by the ice. His vessel was never brought through, but eventually his crew, by walking over the solid ice, was the first to make the northwest passage. The following year Capt. Richard Collinson, in H. M. S. *Enterprise*, also passed Point Barrow, and subsequently wintered at Walker Bay, on the north coast of Alaska. In 1853 H. M. S. *Rattlesnake*, Commander Trollope, wintered at Port Clarence, on the south side of the Seward Peninsula, which some of the crew crossed during the winter.

The surveys of these Arctic expeditions were very carefully executed and are still the bases for most of the charts of the regions they cover. The accounts of the voyages are full and contain much valuable information, which up to very recent times was all that was available concerning Arctic Alaska.

In 1848 the American whaler *Superior*, commanded by Captain Roys, ventured through Bering Strait, and was amply rewarded by a good catch. This example was followed by many others in succeeding years. The whaling industry along the Arctic coast of Alaska has continued to be an important one up to the present day, though it received a serious setback during the civil war by the ravages committed by the Confederate privateer *Shenandoah*, which captured and destroyed many vessels of the American whaling fleet. Stations are now maintained by the whaling companies at Point Barrow and Herschel Island, east of the international boundary. The experienced seamen who usually commanded these whalers added not a little to the geographical knowledge of the Arctic coastal region of Alaska.

The only other important American contribution during the period of Russian control was furnished by Lieut. William Gibson, U. S. Navy, who, in command of the schooner *Fenimore Cooper*, of the Rodgers United States Northern Pacific Exploring Expedition, made surveys and explorations among the Aleutian Islands in 1855. Some of the other vessels of the same fleet passed through Bering Strait and into the Arctic Ocean.

Many years elapsed after Mackenzie made his explorations to the Pacific before the English fur trade was to establish itself near the bounds of what is now known as Alaska. Though the Hudson Bay Company was incessantly pushing its outposts to the west, it did not reach the drainage basins of rivers which emptied into the sea through the Russian American possessions until toward the middle of the nineteenth century. Campbell established a Hudson Bay post in 1840 on the headwaters of the Pelly, a branch of the Yukon, and eight years later (1848) built Fort Selkirk, at the mouth of the Pelly. In the previous year, however, Fort Yukon had been built at the mouth of the Porcupine by A. H. Murray, another Hudson Bay agent. The English traders of these posts soon learned through the natives that the Russians were in possession of the lower river, and, probably about 1850, some of them made a trip down the Yukon to the mouth of the Tanana, which was the uppermost point reached by the Russians in their trading expeditions. This was also the point reached by the explorer Zagoskin in his ascent of the river in 1843. It can therefore be stated that the preliminary exploration of the main Yukon by white men was completed by this journey of the Hudson Bay traders, though its first mapping remained to be done by the members of the scientific corps of the Western Union Telegraph Expedition.

In 1834 the Hudson Bay Company had by high-handed proceedings attempted to establish itself within Russian America, in what is now called southeastern Alaska, but it was promptly ejected by the Russian Company. After a conference this coastal belt was, in 1837, leased by the Russians to the Hudson Bay Company for a term of ten years. The Hudson Bay Company, from its two posts in the Yukon drainage basin, controlled the fur trade of the upper river, while the Russian-American Company controlled the trade on the lower river.

One other expedition needs mention—the last of the Russian official surveys in America. In 1863, word having been received at Sitka that American prospectors had found gold on the Stikine River, it was decided to send out an expedition to find out whether these discoveries were in Russian territory. This party, in command of Commander Bassarguine, of the Imperial navy, and accompanied by the American geologist, William P. Blake, made a reconnaissance survey of the lower part of the Stikine.

In 1863 the Western Union Telegraph Company determined to build an overland telegraph line from the western coast of the United States through British Columbia and what was then known as Russian America to Bering Strait. This line was to be connected by cable with a trans-Siberian line, and thus telegraphic communication was to be established between America and Europe. The project, first conceived by Percy M. D. Collins, was a daring one, for it contemplated the building and maintaining of a telegraph line through thousands of miles of almost unexplored territory in America and Asia. The first essential to the project was preliminary exploration of the proposed route. The success of the Atlantic cable led to an abandonment of the enterprise only three years after its organization, but even in that short time important contributions were made to a geographic knowledge of Alaska and adjacent portions of Canadian territory. The explorations in Siberia were also fruitful of important results.

The task which confronted the Western Union Telegraph survey in Russian America was not an easy one. The region to be explored was several thousand miles distant from the nearest port of the United States. While there were some Russian trading posts on Bering Sea and along the lower Yukon, they were widely separated and the Russian knowledge of the interior was practically limited to the lower part of the Yukon and the Kuskokwim. Moreover, the Russian outposts were small and ill equipped, so that practically all supplies had to be taken from the Pacific coast ports of the United States.

Robert Kennicott was chosen as head of the scientific corps, serving under Capt. Charles S. Buckley, engineer in chief of the expedition. Kennicott was a fortunate choice, as he was an able and enthusiastic worker and his previous expedition into the far northwest, in 1860–61, when he had reached Fort Yukon by following the Hudson Bay Company route from the Mackenzie, had fitted him well for the undertaking. He did not live to see the execution of his comprehensive plans, for he died at Nulato in 1866, his death being brought about by the incessant toil and exposure to which he had been subjected. William H. Dall, who took the leadership of the scientific corps, continued alone his researches on Norton Sound and the lower Yukon after the telegraph survey party was disbanded. His book, based on these investigations, and the reports which he wrote later under the auspices of the Coast Survey, are still the standard works on Alaska.

In 1865 Robert Kennicott, Frank Ketchum, and Michael Lebarge had started up the Yukon. After Kennicott's death at Nulato in 1866 Ketchum and Lebarge pushed on up the river to Fort Yukon. In the following year they continued their explorations as far as Fort Selkirk, at the junction of the Lewes and Pelly rivers. Dall and Frederick Whymper reached Fort Yukon in the summer of 1867, after making the first survey of the lower Yukon. In the meanwhile, in 1865, Baron Otto von Bendeleben and W. H. Ennis, also of the telegraph survey, made an exploration from Golofnin Bay to Port Clarence, and J. T. Dyer and Richard D. Cotter crossed overland from Norton Bay to the mouth of the Koyukuk, while Capt. E. E. Smith carried on surveys in the delta of the Yukon.

The geographical results of this survey in Alaska are a map of the Yukon River, definitely establishing the identity of the Yukon of the Hudson Bay Company with the Kwikpak of the Russians, and important additions to the knowledge of the Yukon Delta, Seward Peninsula, and the Norton Bay region. It is interesting to note that the route which these first explorers selected has been practically adopted by the telegraph lines which are now being constructed in Alaska and in Canadian territory. Of still greater importance even than the actual surveys was the more or less exact information which the telegraph survey explorers were able to furnish the American public during and after the negotiations by which Russian America became an American possession.

AMERICAN OCCUPATION.

In 1867 the territory of Russian America passed into the hands of the United States, the treaty being ratified by the Senate on May 28. The territory, which at the suggestion of Secretary Seward was called Alaska, was purchased from Russia for $7,200,000.

At the time of the transfer of Alaska to the United States the coast line had practically been explored throughout and much of it had been charted with a fair degree of accuracy. While the Russian explorations of the coast added many details, it can not be denied that the larger part of this work had been done by half a dozen English navigators—Cook, Vancouver, Beechey, Franklin, Dease, and Simpson. Many of the surveys made by these men have not been duplicated and are still the basis for all of the existing charts. Soon after the transfer the Coast and Geodetic Survey took up the task of charting the coast line of Alaska, on which it has been actively engaged ever since. The magnitude of this task is shown by the fact that the length of the coast line exceeds 20,000 miles. Other Government vessels, such as those of the Revenue-Marine Service, Fish Commission, and Navy, have at various times made contributions to the knowledge of Alaskan coastwise navigation. The results of all of these surveys are embodied in the charts and coast pilots published by the Coast and Geodetic Survey.

Prior to the transfer in 1867, little was known of the interior of Alaska. The Russians had ascended the Yukon for 1,000 miles and the Kuskokwim for 500 miles; had mapped the lower stretches of the Stikine; had ascended the Sushitna a short distance, and had made an abortive attempt to explore the Copper River. They were also familiar with the Alaska Peninsula and the Iliamna Lake region. Following the routes which had been marked out by such explorers as Franklin and Mackenzie, the Hudson Bay Company traders had reached the Mackenzie River, and in the middle of the nineteenth century crossed to the Yukon waters. The telegraph surveys explored the entire length of the Yukon as now defined and made some additions to the knowledge of the geography of the Seward Peninsula. Outside of these explorations, which were practically confined to the lower regions of some of the larger rivers, the newly acquired territory was an unknown land.

On October 18, 1867, the Russian flag was lowered from the flagstaff in front of the governor's residence at Sitka and the United States flag hoisted amidst the booming of cannon. This was the act of formal transfer by which Russian America became Alaska and a possession of the United States. At a number of points in southeastern Alaska and Kodiak extensive barracks were erected and occupied by United States troops, while an army officer represented the Federal Government. But ten years later all troops were withdrawn and for a number of years the country was governed by a naval officer stationed at Sitka. Then even this control lapsed, and Alaska was left for a time in the anomalous position of being without either military or civil government. Finally, in 1884, the first civil code for Alaska was enacted, and this has been modified from time to time by Congressional statute. Though Alaska has been in possession of the United States for upward of a third of a century and has a population of 62,000, it has not yet been granted even a Territorial form of government, being still to all intents and purposes a colony.

As soon as Alaska was transferred to the United States the Coast Survey began to gather notes on its geography, and since has been steadily engaged in charting the shore line and compiling information valuable to navigation. Notable among the first officers of the Coast Survey to investigate Alaska are Prof. George Davidson and Dr. William H. Dall. Mr. Marcus Baker assisted Doctor Dall in this work for several years. He later took up the cartographic study of Alaska, and in 1900 made an important contribution to the knowledge of the Territory by his Geographic Dictionary of Alaska.

Many of the reconnaissance surveys of the coast line were made by naval officers attached to naval or Coast Survey vessels. Much was added to the knowledge of the coast geography by the cruises of the vessels of the Revenue-Marine Service. Besides these surveys, other Government investigation led to reports on sea fisheries, fur trade, and resources in general, but it is not within the province of this paper to make mention of all of these.

Americans were quick to seize the opportunity for trade which the resources of Alaska offered. The interests of the Russian-American Company were purchased by a strong corporation, and other ventures were made by individual merchants. In 1869 a steamboat was first used on the Yukon for trading purposes. During the succeeding decade several posts were established on the lower Yukon, which were annually visited by a steamer making one trip each season from the mouth of the river.

When Alaska first passed into the possession of the United States, little attempt was made to explore the interior. In 1869 Capt. C. W. Raymond, U. S. Army, was sent up the Yukon to determine the approximate position of the international boundary, and thus settle the conflicting interests of American and British traders. The results of the expedition were published in the form of a report, giving data in regard to natives and fur trade, and accompanied by a map of the lower Yukon which was an improvement on that of the telegraph survey, inasmuch as it included several points whose latitudes Raymond had fixed by astronomic observation.

The names of a small group of pioneer traders who some time in the early seventies entered the Yukon basin via the Hudson Bay Company route from the Mackenzie are known throughout Alaska. Conspicuous among these were Jack McQuesten, Arthur Harper, Fred Mayo, Fred Hart, Joe Ladue, and Frank Densmore. These men made many hazardous journeys without any of the aids of the modern explorer, dependent simply on their own resources. They left but few records of these journeys, but we know that Harper visited the White and Tanana, McQuesten the Koyukuk, and Frank Densmore the Kuskokwim; and the knowledge obtained by them entirely through their own efforts or through their intercourse with the natives was later in part embodied in maps of Alaska and in part preserved by word of mouth, and when the prospectors descended the Yukon, in the eighties, it proved of great assistance to them.

Gold was reported on the Yukon as early as the telegraph survey of 1867, but does not seem to have been found in workable quantities for many years later. Just when the first systematic prospecting was done is somewhat uncertain, but it is known that some time between 1873 and 1878 George Holt made his way inland over the Chilkoot Pass and descended the Lewes River. By some reports he is said to have descended the river below Fort Yukon at this time. It seems certain, however, whatever the date of his journey, that this was the first systematic attempt at prospecting on the Yukon.

The Chilkoot Indians, fearing that their lucrative trade with the interior natives would be interfered with, were strongly opposed to allowing white men to cross the coast mountains by their trading route over the Chilkoot Pass. Through the intervention of Captain Beardslee, who commanded the U. S. S. *Jamestown*, this opposition was at length withdrawn, and in 1880 a party of 16 miners, under the leadership of Edmund Bean, crossed the Chilkoot Pass and descended the Lewes as far as the Teslin. These were followed by others who in the next few years traversed the entire length of the Lewes and the Yukon. It was not, however, until 1885 and 1886 that important finds of gold were made.

In 1879 Mr. John Muir and Rev. S. Hall Young visited Muir Glacier and explored Glacier Bay. They were the first white men to examine the bay, though it had been seen in 1877 by Lieut. C. S. A. Wood, while making some explorations in the Fairweather Mountains in company with some native hunters. Muir's published descriptions of the wonders of Alaskan scenery drew much public notice and led in later years to the development of a favorite tourist route through southeastern Alaska.

The most notable contribution to the knowledge of the geography and resources of Alaska was made by Ivan Petrof, an agent of the Tenth Census, who had long been a resident of the territory. He spent two years in traveling along the coast and on the lower Yukon and Kuskokwim, his familiarity with the native tribes and the Russian inhabitants enabling him to obtain much valuable data regarding regions not visited by him. His results and those of the several other experienced men who were employed in this work were compiled by Petrof in an admirable report and published by the Census Office. His general map of Alaska which accompanied this report, though largely based on the statemer s of natives and traders, was remarkably accurate in delineating the general f atures of the geography. He seems to have been the first man to have a clear conception of the distribution of the mountain ranges in Alaska. In judging Petrof's geography, it must be remembered that outside of rough traverses of the Yukon and the lower Kuskokwim the interior of Alaska was known only through the reports of a few traders.

The Indian route to the headwaters of the Yukon had been in use by prospectors for at least two years when Lieut. Frederick Schwatka traversed it in 1883. He crossed the Chilkoot Pass (called by him Perrier Pass) with a small party, and built a raft at the headwaters of the Lewes and continued down the river in this unmanageable craft, running the various rapids,[a] to Fort Selkirk at the junction of the Pelly and Lewes. From this point on he was traversing a river which had been explored by the Western Union Telegraph agents and was already occupied by the fur traders. Schwatka continued his trip to Fort Yukon and thence to the sea. To Charles W. Homan, who accompanied Schwatka as topographer and made sketch surveys throughout the entire journey, correcting them by observations for latitude, belongs the credit of having made the first actual survey of the Yukon and Lewes rivers. Crude as it was, it has only in very recent years been superseded by better work. Schwatka's rather spectacular account of his trip down Alaska's great river, a journey which had been made by many others, did much to rouse public interest in this far away region, and in the course of the following decade a number of exploring parties were sent out.

During the years 1881–1883 a meteorological and magnetic station, in charge of Lieut. P. H. Ray, was maintained at Point Barrow by the United States Signal Service. No explorations or surveys of any importance were attempted.

Dr. Arthur Krause of the Geographical Society of Bremen, Germany, in 1881, made a journey from the coast at Lynn Canal into the Chilkoot River basin. He subsequently published a map which for more than ten years was the basis for all other maps of the region visited by him.

In 1884 Lieut. W. R. Abercrombie, U. S. Army, was detailed to make an exploration of the Copper River. He ascended it a short distance, but his expedition may be looked upon as an entire failure. This work was taken up again in the following year by Lieut. Henry T. Allen, who made one of the most remarkable journeys in the annals of Alaskan explorations. Allen, with four men, landed at the mouth of the Copper River in March, 1885, and made his way up that stream by boat and sled for about 300 miles; then crossed to the Tanana by way of the Suslota Pass, and securing another boat from the natives, continued his journey to the mouth of the Tanana. During this part of the journey the party was dependent entirely upon the country for food, and were in a half-starved condition when they reached the Yukon about the end of June. With indefatigable energy Allen then, with one companion, crossed to the Koyukuk from near the mouth of the Melozi River, and explored it almost from the Arctic Circle to its junction with the Yukon. Crossing by portage from the lower Yukon to Norton Sound, he made his way to St. Michael, whence he returned by steamer to the United States. No man through his own explorations has added more to a geographic knowledge of the interior of Alaska than Lieutenant Allen. Throughout his journey he made careful sketch surveys and noted all facts which came within his observation; and within one season he made maps of three of the larger rivers of the Territory, which, until accurate surveys were made twelve years later, were the basis of all maps. His reports are the work of a careful, painstaking observer, who did his utmost to gain all the information possible.

During the years 1883 to 1886 extensive explorations were made by officers of the Navy and of the Revenue-Marine Service along the rivers tributary to Kotzebue

[a] Schwatka portaged his outfit around Miles Canyon and White Horse Rapids. The raft was allowed to drift through and was caught below.

Sound. These led to a more general knowledge of this remote part of Alaska than of parts which were far more accessible.

In 1883 Lieut. George M. Stoney, who was sent to the coast of northeastern Siberia on the revenue steamer *Corwin* to distribute presents to the natives who had aided the *Jeannette* relief expedition, examined the vicinity of Kotzebue Sound, and with the aid of some natives explored the delta of the Kobuk River, which Simpson had learned of in 1850. Having interested the Navy Department in these explorations, Stoney returned in the following year, and with the aid of a steam cutter and a native boat managed to ascend the Kobuk to the mouth of the Soolukpowaktoark River, and continued up that stream to its source in Walker Lake. In the same year Ensign Purcell of the Stoney party explored Selawik Lake.

A third trip into this region was made by Stoney in 1886, this time accompanied by a large and well-equipped party, which established winter quarters on the Kobuk, about 250 miles from its mouth, and spent the winter in extensive explorations. Stoney explored the headwaters of the Noatak and of the Alatna, the latter a tributary of the Koyukuk, and reached the head of the Selawik River, south of the Kobuk, and Chandler Lake, in which the Colville River has its source. Some of Stoney's officers made trips into the interior. Ensign Reed led a party from the winter camp to the Noatak River, and Assistant Engineer Zane reached the Yukon by way of the Pah and Koyukuk rivers; but the most noteworthy trip was that made to Point Barrow by Ensign W. L. Howard. He left the winter camp in April with two white men and two natives and proceeded northeast across the Noatak to the valley of the Colville, followed this downstream in company with a party of natives for about 20 miles, and then crossed to the headwaters of Chipp River. Here he discarded the dog teams used up to this point for transporting his supplies, and descended the Chipp River to the coast in native skin boats, arriving at Point Barrow on July 15, being the first white man to cross northern Alaska. The results of the expedition were a fairly accurate survey of the Kobuk Valley and sketch maps of the Selawik, upper Colville, upper Noatak, and Alatna rivers. Stoney's was the first attempt at instrumental surveys in the interior of Alaska.

In 1884 Lieut. John C. Cantwell, of the Revenue-Marine Service, explored the Kobuk as far as the mouth of the Black River. In the following year Cantwell succeeded, by using at first a steam launch and afterwards a skin boat, in reaching Walker Lake, near the head of the Kobuk. He was the first white man to reach the upper Kobuk, and, considering the conditions under which the trip was made, prepared a very creditable map of the river. Mr. Charles H. Townsend, of the United States Fish Commission, accompanied the party as naturalist. Another officer of the Revenue-Marine Service, S. B. McLenigan, made an exploration in this region in 1885. With one companion he ascended the Noatak River about 300 miles in a native skin boat, carrying out his instructions in the face of many obstacles and maintaining a sketch survey throughout his journey. His map has not yet been superseded by more accurate surveys.

Mount St. Elias has long been a subject of great popular interest, both because of its altitude, it being at one time considered the highest peak on the continent, and because it was the first point sighted by a white man on the mainland of Alaska. Bering, who discovered and named it, knew it only as a distant peak which loomed above the clouds, for he made no attempt to get near it. The mountain was also noted by Cook, Dixon, and Vancouver during their explorations of the coast line. In 1786 La Perouse, while cruising along the coast, saw Mount St. Elias, and Dagelet, his astronomer, calculated its altitude at 12,672 feet. Five years later Malaspina entered Yakutat Bay and surveyed Disenchantment Bay, its inland extension, which he hoped would prove to be a northeast passage. His determination of the altitude of the mountain as 17,851 feet came remarkably near the truth, considering the adverse conditions under which it was made. In 1737 Sir Edward Belcher visited Yakutat Bay in H. M. S. *Sulphur*. Tebenkof's Atlas, published in 1852, gives the altitude of the mountain as 17,000 feet. In 1874 Dall and Baker, while cruising along the coast, made a rough triangulation and reported the altitude of the mountain at over 19,000 feet.

It was nearly a century and a half after Bering's discovery before any attempt was made to ascend the mountain or even to approach its base. In 1886 Frederick Schwatka, with Prof. William Libbey and Lieut. H. W. Seton-Karr, led an expedition, which was supported by the New York Times, to make the ascent of the mountain. So little was known of the conditions of travel that the party was foredoomed to disaster. Schwatka and Seton-Karr, with a small party, reached a point about 20 miles inland and obtained considerable geographical information which was of great use to the subsequent explorers. Two years later an altitude of 11,400 feet was attained by a party consisting of W. H. Topham, Edwin Topham, and George Broca, Englishmen, and William Williams, an American. A third attempt was made in 1890 by I. C. Russell and Mark B. Karr, with six camp hands, under the joint auspices of the National Geographic Society and the United States Geological Survey, which, though unsuccessful, resulted in some important contributions to the geographic knowledge of the region. Russell and Karr would undoubtedly have reached the top had not a severe storm forced them to retreat after waiting four days in rude shelters in snow banks on the upper slopes of the mountain without fuel and almost without food. Russell, nothing daunted by this experience, in 1891 again essayed the ascent under the same auspices. During this attempt he succeeded in reaching a height of 14,500 feet, but was again forced to return by severe storms. The results of Russell's two expeditions were a large amount of data in regard to the glacial history of the region and a fairly accurate map of the slope of the mountain. His determination of 18,100 feet as its height proved to be remarkably accurate, if one takes into account the conditions with which he had to contend. The Coast Survey triangulation of the following year shows the elevation to be 18,024.

The summit of St. Elias was reached by an Italian, Prince Luigi, who followed the route which Russell had explored and very largely adopted the methods which Russell had recommended. Luigi, in 1897, landed at Yakutat Bay, and with a large, thoroughly equipped expedition made his way across the 40 miles of snow and ice between the coast and the base of the mountain. In his ascent he practically followed Russell's route, reaching the summit July 31, five weeks after leaving tidewater. Prince Luigi's expedition was carefully planned, and he showed himself a capable leader as well as an experienced mountaineer. The report[a] of the expedition contains much that is of geographic interest, but is chiefly valuable as a contribution to the literature of mountaineering.

The location of the international boundary on the Yukon became a question of importance after the discovery of rich gold placers near it. The Canadians were first in the field. In 1888 William Ogilvie and George M. Dawson made surveys of the route from the head of Lynn Canal, in southeastern Alaska, to the mouth of the Lewes River. Ogilvie in the following year extended his surveys down the Yukon to the international boundary, and in 1890 continued his exploration to the head of the Porcupine, which had been surveyed in the previous year by R. G. McConnell, of the Canadian Survey.

Meanwhile the United States Coast and Geodetic Survey had dispatched two parties to the boundary. One of these, under J. E. McGrath, established an astronomic station near the boundary on the Yukon, and the other, under J. H. Turner, made a similar station where the boundary crossed the Porcupine. In connection with this work Turner's party in 1890 made a winter trip with dog teams from the camp on the Porcupine to the Arctic Ocean, following as nearly as possible the one hundred and forty-first meridian. This was the second time that northern Alaska was crossed by white men, the first being three years before by Ensign Howard. McGrath and Turner's surveys were limited to very small areas, but are of general geographic interest, as they represent the first geodetic surveys in the interior of Alaska. Besides the work to which they had been specially detailed, they also kept meteorologic records and made corrections from their route traverses in the existing maps of the Yukon. Prof. I. C. Russell, of the United States Geological Survey, accompanied McGrath to the boundary from the mouth of the river, and thence came to the coast with a party of prospectors by way of Lewes River and the Chilkoot Pass.

In 1890 an expedition was sent out by Frank Leslie's Weekly for explorations in Alaska. The writer has been unable to discover any account of the work of this party. It apparently left the coast at Pyramid Harbor, ascended the Chilkat River, and after crossing the divide explored Lake Kusawa. There the party divided and A. B. Schanz and S. J. Wells descended to the Yukon, while E. J. Glave and Jack Dalton crossed the divide to Alsek waters, and followed the Alsek River to the coast. Later in the season Wells made a trip down the Tanana, and Schanz is said to have visited lakes Clark and Iliamna during the following winter. Glave and Dalton's exploration of the Alsek was a daring piece of work, as its character at that time was entirely unknown. Its course through the St. Elias Range has not even yet been surveyed.

In 1891 Schwatka made his third trip to Alaska. Schwatka, C. Willard Hayes, of the United States Geological Survey, and Mark Russell, a prospector, ascended the Taku River, crossed the divide to Teslin Lake, and in folding canoes, which had been transported across the pass by natives, went downstream to the Lewes River and continued to Fort Selkirk, on the Yukon. Crossing overland to the White

[a] It is somewhat surprising that in the account of this expedition it should be gravely stated that the barometric determination of the altitude of Mount St. Elias of 18,090 feet should be regarded as more accurate than the previous instrumental determinations by Russell. As a matter of fact, J. E. McGrath, of U. S. Coast and Geodetic Survey in 1892, had fixed the height of Mount St. Elias at 18,024 feet by triangulation.

River, near the point where it is intersected by the international boundary, they then continued up the White to its source; and though they were deserted by all of their Indian packers, the three white men of the party went on through Skolai Pass, and, after reaching navigable waters on the Nizina, built a boat and continued down to the Copper River. Doctor Hayes's report and map, which are based on a foot traverse, are remarkably complete and accurate considering the exceedingly trying conditions under which the field observations were made, and give much geologic and geographic information about a region which up to the time of its publication was practically unknown.

In that same year Glave (who later lost his life on the Congo) and Dalton made a second trip into the Alsek basin. This time they are said to have extended their journey westward to the White River basin, but the map accompanying Glave's published account is very inaccurate. The exploit is of interest chiefly because it was the first time in the history of the country that horses were used on an extended journey.

Congress, in 1895, tardily recognized the importance of an investigation of the mineral resources of Alaska, and by a small appropriation enabled the Geological Survey to send its first party to the north. Dr. George F. Becker, aided by C. W. Purington, made a preliminary investigation of the gold deposits, and W. H. Dall studied the coal deposits of the Pacific coastal belt. The following year J. E. Spurr, with H. B. Goodrich and F. C. Schrader, descended the Yukon and visited the more important placers of Alaska and did some topographic as well as geologic mapping.

Even thirty years after its accession the mass of the public was still almost entirely ignorant of the geography, resources, or climate of Alaska. Well-informed people regarded it as a region of perpetual snow and ice, the land of the fur trader, Indian, and Eskimo. A great change was wrought by George W. Carmack's discovery of gold on the Klondike River, in Yukon Territory, during the summer of 1896. This event led to the development of the famous Klondike placer field, which in one year brought more than 50,000 people into Alaska and the adjacent portions of Canadian territory, and made the name Klondike a household word in every civilized country on the globe. Hardly had the Klondike excitement subsided somewhat when the discovery of the Nome placer fields in 1898 again attracted the attention of the world to Alaska, and a second exodus to this northern region took place.

Of the thousands who entered the Yukon basin during the first years of the gold excitement, but a small percentage had any conception of the difficulties with which they would be confronted, and still less had any previous training which fitted them for the work they had so rashly undertaken. Hundreds toiled over the Coast Range passes and made the mad dash to reach the Eldorado their fancies had painted, but, discouraged at the outlook, continued down the Yukon to its mouth, having hardly been out of sight of its banks. The more venturesome prospector, however, found no risk too hazardous, no difficulty too great, and now there is hardly a stream which has not been panned by him, and hardly a forest which has not resounded to the blows of his ax. Evidences of his presence are to be found from the almost tropical jungles of southeastern Alaska to the barren grounds of the north which skirt the Arctic Ocean. While the prospectors have traveled far and wide in Alaska, they have as a class added little to the knowledge of its geography. As a rule they follow but two purposes, one to find gold and the other to get through the country. The information obtained by them is seldom exact, even when available, for their conception of where they have been is often as vague as their ideas as to where they are going. Though their contribution to geographic knowledge is small, these pioneer prospectors, at the expense of hard toil and suffering, if not of their lives, have blazed the way for the settler, miner, and surveyor.

The public interest aroused in Alaska by the finding of valuable placer mines in adjacent territory led to a demand for more definite information, and money was appropriated for investigation in Alaska under various bureaus of the Federal Government. The Coast and Geodetic Survey was enabled to expand its Alaskan surveys, which had been carried on ever since the purchase of the Territory. The Army established military posts to preserve order and to extend relief to the many ill-equipped and inexperienced Argonauts. It also built trails and telegraph lines, which were to become of immeasurable advantage to Alaska, and even attempted some explorations and surveys, but these were only partially successful.

When in 1898 the Geological Survey[a] began its systematic surveys and explorations in the interior of Alaska the problems which confronted it were not easy. The public demanded the immediate publication of maps of unexplored or only partially explored regions. Such maps would have far greater value if they could be furnished while the excitement was at its height, so there was not opportunity for extensive areal mapping. The problem was to make surveys of the main routes of travel, which were chiefly confined to the larger rivers, and to include with these as wide areas as possible. The first season's work resulted in about 3,000 miles of instrumental traverses, with reconnaissance maps of an area of nearly 30,000 square miles, besides more accurate survey of about 2,000 square miles. These traverses were largely confined to the more important rivers. The work had to be planned with a very incomplete knowledge of the geography and of the climate and other conditions of travel of the region, and all supplies and equipment had to be transported from Puget Sound ports. After landing in Alaska the parties were entirely dependent on their own resources for transportation. The first year they made their way by following the waterways in canoes, which were carried on the backs of the men at portages, but after some knowledge of the country was gained it was found that horses could be used to advantage for the transportation of supplies.

The general scheme of operations for the first year included exploration of the Kuskokwim, the Sushitna, and the Copper rivers, as all three of these streams offered possible routes into the interior. The Copper River work was carried on by members of the Geological Survey under the auspices of the War Department, which organized two expeditions for the purpose, one under Capt. Edwin F. Glenn and the other under Capt. William R. Abercrombie.

Glenn, with a small detachment provided with pack horses, left the coast at Cook Inlet and made his way northward along the Matanuska, crossed the

[a] Between 1898 and 1902 the following officers of the Geological Survey took part in the Alaskan work: E. C. Barnard, Alfred H. Brooks, Arthur J. Collier, George H. Eldridge, T. G. Gerdine, W. C. Mendenhall, Robert Muldrow, W. J. Peters W. S. Post, D. L. Reaburn, G. B. Richardson, F. C. Schrader, Arthur C. Spencer, J. E. Spurr, and D. C. Witherspoon.

Copper River Plateau, and descended the Delta River to the Tanana, whence he returned to the coast by the same route. No surveys whatever were made by Glenn, but, fortunately, Mendenhall, of the Geological Survey, who had been detailed to his party, was enabled to carry on a route traverse throughout the journey. Mendenhall's map and report formed a valuable contribution to the knowledge of the geography of Alaska. At the Tanana Lieut. J. C. Castner was detached from Glenn's party to continue the exploration to Circle, on the Yukon. With two men he crossed the Tanana and attempted to make his way up Volkmar River, but the lateness of the season made the plan impracticable. After losing both their horses the three attempted to return to the Tanana on a raft. Their raft was wrecked and everything lost, including their shoes; they reached the Tanana half dead with hunger and exposure, and were fortunate enough to find some friendly Indians. The journey which had cost so much suffering and privation yielded practically nothing of value. Some minor explorations were carried on by Lieut. H. G. Learnard and Sergt. William Yanert, also of Glenn's party.

The second army expedition, under Captain Abercrombie, landed at Valdez, on Prince William Sound. The heavy snowfall prevented an early start, but eventually the entire party, including horses, made its way inland by the Valdez Glacier route, which that year was used by hundreds of prospectors. After reaching the Copper, Captain Abercrombie left the party for a hurried trip to the Mentasta Pass along the trail established by prospectors. Lieut. P. G. Lowe, following a similar route, made his way to Fortymile, and returned to the coast by way of the Lewes River and the White Pass Railway. The rest of the party, under the leadership of F. C. Schrader, of the Geological Survey, did some very creditable work in making surveys and investigations in the lower part of the Copper River basin.

The exploration of the Sushitna was undertaken by Eldridge and Muldrow, of the Geological Survey, with five men. They made their way up the river from Cook Inlet, dragging their supplies in canoes against the swift current. At Jack River the boats were left, and with packs on their backs the party pushed on to the Cantwell River, confluent to the Tanana, but at this point were forced to turn back by the failure of provisions, and reached their boats in a half-starved condition. Surveys were made throughout the journey, and the position and height of Mount McKinley were determined.

The longest exploration of 1898 was that made by Spurr and Post, who ascended the Yentna, the left fork of the Sushitna, and portaging to Kuskokwim waters, descended the latter river to its mouth, and returned to Cook Inlet by a route which crossed the Alaska Peninsula.

The same year the two most important southern branches of the Yukon—the Tanana and White rivers—were surveyed. A party led by Peters and Brooks crossed the Chilkoot Pass and went inland on the snow and ice to Lake Marsh, where, after delaying until the ice broke up, they embarked in canoes for the White River, at which point the surveys began. The ascent of the river was made by dragging the canoes against the rushing current. Six weeks of this toilsome task in the glacial waters brought the party near the head of Snag River, a northern tributary of the White, whence the Tanana was reached by portage, after which the downstream trip to the Yukon was comparatively easy. Exploratory surveys of about 10,000 square miles were made by this party. The same year Barnard, following a similar route from the coast to the Yukon, made a survey of about 2,000 square miles in the Fortymile River basin.

In 1899 Peters and Brooks continued their explorations by a survey extending westward from Lynn Canal along the northern base of the St. Elias Range to the headwaters of the White and Tanana rivers and northward to the Yukon at Fortymile. The journey was made with horses, only five out of the original fifteen reaching the Yukon.

In this year the work of exploring the great waterways was extended north of the Yukon to the Koyukuk, which was mapped by Schrader and Gerdine. Leaving Fort Yukon in canoes, they ascended the Chandlar River, and after making a 16-mile portage reached Koyukuk waters and followed them to the Yukon.

In the fall Schrader and Brooks met at St. Michael and after the close of the work decided to visit the newly discovered placers at Nome. The investigations, while very hastily made, had their value, because they enabled the Geological Survey to publish a report containing authentic information before the exodus to the new gold fields, which took place in the following spring.

The great demand for maps of important mining districts, in 1900, forced the Geological Survey to postpone further explorations. One party, under the leadership of Schrader, Gerdine, and Spencer, mapped a large area in the Copper River basin, both geologically and topographically, while Barnard, Brooks, Peters, and Mendenhall did similar work in Seward Peninsula.

In 1901 the work in northern Alaska was resumed, and a network of surveys completed connecting the Yukon, Koyukuk, and Kobuk rivers, the Arctic Ocean and Kotzebue Sound. Schrader and Peters made a trip which included a journey the entire length of Alaska from its southernmost limit to Point Barrow. Starting in winter, they traveled to the Koyukuk with dog teams, thence ascended one of the north forks of that stream with canoes, crossed to a branch of the Colville, and followed it to its mouth. They then skirted the coast westward to Point Barrow and finally southward to Cape Lisburne, where they were so fortunate as to find a steamer. In course of their journey they traversed the Endicott Mountains, and brought back the first authentic information in regard to this great range. Theirs was probably the most notable exploration which has been made by the Geological Survey. In the same year Mendenhall and Reaburn also made surveys and explorations in this northern region. They reached the mouth of Dall River on the Yukon in June, ascended that stream in canoes, and then by an 18-mile portage reached Koyukuk waters. They descended the Koyukuk to the mouth of Alatna River, which they ascended for about 100 miles, and then made a second portage which brought them to the Kobuk River, which they followed to its mouth. This expedition is of particular interest in that it made the first instrumental survey from the Yukon to tide water. The topographic survey was begun at Fort Yukon and carried through to Kotzebue Sound. It established an altitude of 500 feet for the river at Fort Yukon, which is probably approximately correct.

During the same season Brooks was engaged in geologic studies in southeastern Alaska, and Gerdine, Collier, and Witherspoon did areal mapping in the Seward Peninsula.

The work for 1902 was planned to include an exploration of the largest unexplored area in southern Alaska, and the running of a traverse to the Yukon which should connect the previous surveys of the Sushitna, Kuskokwim, and Tanana. To this end a party led by Brooks and Reaburn extended a survey northwest from Cook Inlet through the Alaska Range, and bending northeast passed close to the base of Mount McKinley and on to the Cantwell River, whence they took a northwesterly route across the Tanana to Rampart on the Yukon. During the same season the areal mapping of the Copper River basin was concluded by parties led by Schrader, Gerdine, Mendenhall, and Witherspoon, while Collier studied the geology of the Yukon, and Peters made a detailed topographic survey near Juneau.

Of the twenty or more parties which the Geological Survey has sent to Alaska, hardly a single one has failed to execute the work allotted to it. This is largely because those who were intrusted with their leadership were specially fitted, by nature as well as by experience and training, for the undertaking. The parties have usually been made up of a few carefully chosen men, and the physical work and discomforts, as well as hardships, have been shared by leaders and men alike. In connection with the topographic surveys geologic investigations have gone hand in hand; in some instances somewhat detailed studies having been undertaken, while in others the work was purely of a preliminary character (see fig. 3).

The topographic and geologic mapping carried on in various parts of Alaska since the organization of systematic surveys has resulted in the completion of a preliminary map of the Copper River basin and of the Seward Peninsula. A considerable area has also been surveyed in the region lying between the Yukon and the Tanana. A more detailed map of a part of the Juneau mining district has been finished, which is to serve as the basis for geologic studies during the coming season.

Besides the geologic work already mentioned, it is planned to make a reconnaissance of the oil fields of the Pacific coast belt of Alaska, and to study the placer fields of both the Tanana-Yukon district and the Seward Peninsula. In addition to this economic work steps have been taken to make a detailed examination of some of the Tertiary and Mesozoic beds exposed along the Yukon.

Subsequent to the work done in collaboration with members of the Geological Survey in 1898, the Army continued to send out expeditions. In the following year some more or less detailed surveys were carried on in connection with constructing the military trail across the Chugach Mountains from Valdez. These operations, as well as some minor explorations, were carried on under direction of Captain Abercrombie. Oscar Rohn, a civilian employee of Abercrombie's party, with one companion, made a daring journey, in which he crossed the Wrangell Mountains to Tanana waters and then returned to Copper River, making a sketch map as well as geologic observations.

Another party, provided with horses and a large river steamer, was sent to Cook Inlet under command of Captain Glenn. The most notable contribution of this expedition to geographic knowledge of Alaska was Lieut. Joseph S. Herron's exploration in the upper Kuskokwim basin. Following the general route previously traversed by Spurr and Post, Herron crossed the Alaska Range and entered the great lowland which lies to the northwest. Here considerable time was lost by a search for natives to act as guides, during which the early frosts killed the grass and the pack horses had to be abandoned. At length, with the aid of Indian guides, Herron's party reached the Yukon in the early winter. C. E. Griffith, a

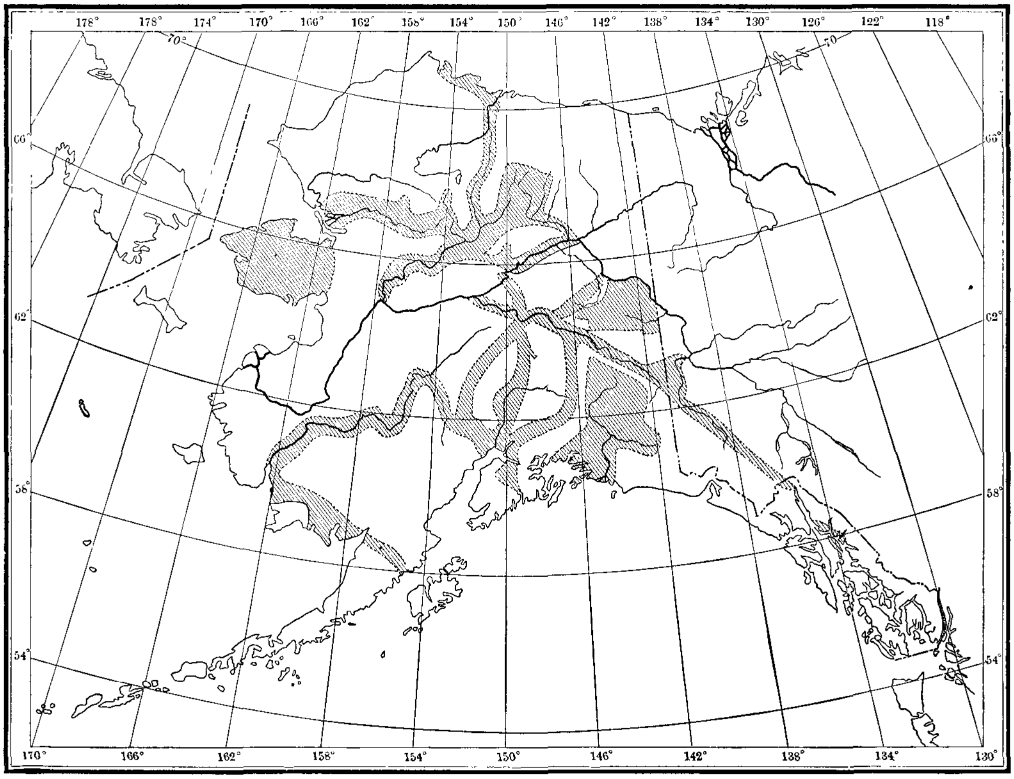

FIG. 3.—Map showing areas surveyed and explored by United States Geological Survey, 1898 to 1903.

topographer of Glenn's command, led a small party from Knik Arm, Cook Inlet, to Eagle, on the Yukon. His route lay partly through the region previously explored by Glenn and Mendenhall, and partly over the well-traveled trail which leads from Valdez to Eagle. George W. Van Schoonhoven, also of Glenn's party, attempted, with a full equipment of horses, to reach the Tanana from Cook Inlet. He first followed the route surveyed by Eldridge and Muldrow in the previous year, but turned back at the Cantwell, reporting the route impassable. In this he was mistaken, for Brooks and Reaburn in 1902 crossed the Cantwell where he turned back, and continued through to the Tanana without serious difficulty.

During the past two years the Signal Corps of the Army has been pushing the work of constructing telegraph lines, and as a result has connected by wire the most important[a] points, both inland and on the coast. Reconnaissance surveys have to a certain extent been carried on subservient and preliminary to the construction of the telegraph lines.

CONCLUSION.

Over a century and a half has elapsed since Bering and Chirikof first sighted the mainland of what is now known as Alaska, and during this time geographical discoveries have been steadily going on within its borders. First came the Russian trader, who in the course of his marauding voyage made his way step by step along the Aleutian Islands to the mainland. Then Cook and Vancouver and other navigators carried on systematic surveys of its shore line. With the organization of the Russian-American Company, in 1799, a new epoch of permanent settlements and slight but important explorations was introduced, which continued until the transfer of Alaska to the United States. During this time the English contributed much toward a knowledge of Arctic Alaska through the surveys made by their Franklin relief expeditions. Mackenzie's famous journeys across the continent to the Arctic Ocean pointed out the way to lucrative fur trade to the English, and brought them to Alaska from the east. Their explorations on the upper Yukon were linked with those of the Russians below by the journey of Kennicott, Dall, and their associates of the telegraph survey.

After Alaska became a United States possession there was a lull in explorations within its borders, though the Coast Survey began to chart the coast line. Except for Raymond's trip up the Yukon and the efforts of Petrof and of fur traders and prospectors no attempt was made at an extension of geographic knowledge in the interior until Schwatka made his trip down the Lewes and Yukon. This was followed by the less generally known though no less important explorations in the northern part by officers of the Navy, the Revenue-Marine Service, and the Coast Survey. Since Alaska attracted public notice through its placer gold resources important and extensive surveys and explorations have been carried on by the Geological Survey.

Alaskan surveys and explorations have never been and never will be easy. Throughout its history the geographic investigation has been a tale of hardship and suffering and not infrequently of death. Let those who are not personally familiar with the character of the difficulties not judge it too harshly. If the results have not always been commensurate with the expenditure of money, time, and even of human life, it should be remembered that the conditions of travel in the past have not been so favorable to the explorer as in some of the more temperate regions. The task is not yet complete. Reconnaissance surveys have been effected in but one-fifth of the territory, leaving large areas which are still practically unexplored.

[a] Nome, the Yukon, Tanana, and Copper River valleys are now connected with Dawson and with Valdez by telegraph. Dawson has outside telegraph connections through Canadian territory with the United States and to the coast at Skagway, Alaska. Skagway, Seward, and Valdez, all on the Pacific coast, are connected by cable with Seattle.

CLIMATE.

By Cleveland Abbe, Jr.

INTRODUCTION.

No discussion of the geography of a region is complete without some mention of the climate, for while on one hand climate is determined in a large measure by the relief of the earth's surface, on the other hand the surface features are the resultants of the atmospheric forces working upon the rocks of the earth's crust. The interest in climate does not end here, however, for the climatic conditions, as much as the topography and geographic position, determine the occupation and development of a region by man. Temperature and precipitation are as important as geographic features and natural resources. The relation of climate to animal and vegetable life, and hence to man's occupation of any portion of the earth's surface, is too evident to need special mention.

The following pages will be chiefly devoted to the climatic problems which are of special import to the settler, prospector, and miner, but it is hoped that the data compiled and the conclusions reached may not be without interest to the student of North American meteorology.

Ignorance of Alaska's varied climates has been widespread and has led to not a few blunders, both in the administration of the territory and also in plans for its investigation and development. Had accurate information been in the possession of the public at the time of its purchase, concerning its varied climatic provinces, which in a large measure control its animal and vegetable life and conditions of travel, a different feeling would have prevailed concerning that much-criticised transaction. The subsequent development of its resources might have been accomplished with a far smaller expenditure of time, money, and even of human life.

Though Alaska has been in our possession for nearly forty years, and part of its area has been known to whites for upward of two centuries, the mass of the public is profoundly ignorant of its climatic features. Even well-informed people still speak of it as a land of ice and snow, and there are few who realize that a part of its Pacific coastal province has a temperate climate.

METEOROLOGIC OBSERVATIONS.

During the Russian occupation, except in a few instances, there seem to have been no systematic efforts made to record accurate meteorologic observations. The best records during this period were kept by the Russian missionaries at their mission stations, Unalaska (Iliuliuk) and Ikogmut, and by the Russian Government officials at Sitka. Other records of less extent were made by the many explorers, travelers, and traders who visited the region. After the transfer of the territory to the United States the surgeons at United States army posts kept meteorologic records in connection with the post hospitals.

In 1878 and 1879, soon after the organization of the United States Weather Bureau, first under the Signal Corps of the army, later as a bureau of the Department of Agriculture, a few first-class observing stations, together with several voluntary stations of lower order, were established in Alaska. Most of these have been located along the coast or on the neighboring islands, and records of the great interior region have been dependent on the more or less incomplete data gathered by exploring and surveying parties and by voluntary observers, including traders and missionaries. The most important records from transient stations are those kept by the "International Arctic Expedition" (1882–83) at Utkiavi on Cape Smyth, by the two Coast and Geodetic Survey parties sent out (1880–1891) to determine the intersections of the one hundred and forty-first meridian with the Yukon River, by the Western Union Telegraph Company Expedition (1865–1867), and by the Geological Survey exploring parties (1898–1903). The demand for study of the agricultural possibilities of Alaska led to the establishment in 1898 of a special Alaska division of the experiment-station service of the Department of Agriculture, and since that year reliable observations in the district have been multiplying.

SOURCES OF MATERIAL.

The observations made up to the end of 1877 have already been summarized by Dall and Baker, and published, together with a very full bibliography, by the Coast and Geodetic Survey.[a] The results of observations made at six United States army posts, from 1861 to 1871, and the continuous series of Russian and American observations at Sitka, from 1847 to 1874, have been summarized by C. A. Schott,[b] and published in two volumes by the Smithsonian Institution. They form valuable supplements to the earlier monograph by Dall and Baker.

In the following pages will be summarized the most important results of the observations made subsequent to the publication of Dall and Baker's work, and features of most interest to those concerned in the economic development of the country will be particularly emphasized.

The material summarized in the accompanying tables was taken from the manuscript records covering the period from 1868 to the present time, in the custody of the United States Weather Bureau. Thanks to the courtesy of the Chief of the Weather Bureau, and the chief of the records division of the Weather Bureau, the writer was able to consult all the records now collected by the Bureau and deposited in its vault. These records were made by observers who may be grouped in four classes—post surgeons at regular United States army posts, regular Signal Service or Weather Bureau observers, voluntary observers supplied by the Weather Bureau with instruments, and members of various expeditions.

METHODS OF OBSERVATION.

The accuracy of the observations here used and the methods of making them may be most conveniently discussed for each of the elements.

TEMPERATURES.

The temperatures recorded by the army post surgeons were observed by means of standard instruments (type not known), three observations being made daily, 7 a. m., 2 p. m., and 9 p. m. These stations seem also to have been supplied in some cases with self-registering maximum and minimum thermometers, but the

[a] Dall, W. H., and Baker, M., Pacific Coast Pilot, Coast and Islands of Alaska, Appendix I, Meteorology and Bibliography, 2d series, Washington, 1879.

[b] Schott, Charles A., Tables, distribution, and variations of the atmospheric temperature in the United States, etc.: Smithsonian Contrib. Knowl., vol. 21, No. 277, Washington, 1876, pp. 10, 11, 124. Tables and results of the precipitation of rain and snow in the United States, etc.: Ibid., vol. 24, No. 353, Washington, 1881, 2d ed., pp. 11, 113.

records of such thermometers in the only case where their use was noted were so out of harmony with the tri-daily observations that they have not been used in this compilation. These observations record the temperature to two decimal places. Since most of the other records record temperature to the first decimal place only, the temperatures, as here published, have all been reduced to the nearest whole degree for the sake of uniformity. The maximum and minimum temperatures from the stations occupied by army posts represent only the maximum and minimum observed temperatures, and are indicated in the tables by (*). Concerning the exposure of the thermometers at army posts in Alaska, the following quotation from Dall and Baker is all that has been learned. They say,[a] "The observations [at Sitka] recorded in the Manuscript Meteorological Register U. S. Army were made in front of the hospital, which, facing southeast, fronts on Eastern Harbor. The instruments hung in an open latticework box of the ordinary construction for the reception of meteorologic instruments and at an elevation of 13½ feet above the level of the sea."

The temperature observations at Signal Service or Weather Bureau stations, whether at a regular station or by voluntary observers, are always made with standardized instruments issued by the central office in Washington, and have been accepted as correct, so far as the instruments were concerned. The instruments were presumably exposed in the standard Weather Bureau instrument shelter, and the observing hours were, during the early years, 7 a. m., 2 p. m., 9 p. m., but for the records of the voluntary observers, which were made by means of self-registering maximum and minimum thermometers, only one observation daily, made usually at 8 a. m., was required. In some cases, where the one or the other of the registering thermometers was broken, the missing extreme temperatures were supplied by observations at noon or at 7 a. m. When these latter observations seemed to be approximately true extreme temperatures they were admitted as part of the material for the table, but always with a note indicating at what hours they were made. Observations made by the voluntary observers of the Weather Bureau are made by means of standard instruments issued to those observers. These instruments are always accurately compared and corrected before being issued, and a card of corrections furnished, but in few, if any, cases is information at hand as to whether the proper corrections have been applied. It is believed, however, that all the results presented in the accompanying tables are reliable to within ½° F.

METHODS OF OBSERVING PRECIPITATION.

The precipitation data obtained from the Government army posts were presumably based upon observations made with the so-called conical De Witt gage,[b] which was issued by the Army to post hospitals. This gage, which is in the shape of an inverted cone, was recommended[c] to be exposed by cutting a hole in a board of sufficient diameter to allow the conical gage to come down just flush with the upper surface of the board. Such an exposure might cause these gages to be classed among "shielded rain gages," and would be very favorable to an accurate registration of rainfall if the board with its gage were exposed

[a] Pacific Coast Pilot, p. 60.

[b] De Witt, S., Description of the nine-inch conical rain gage: Am. Jour. Sci., New Haven, 1st ser., vol. 22, 1832, pp. 321-324 (fig.).

[c] Schott, C. A., Smithsonian Contrib. Knowl., vol. 24, No. 353, p. xi.

at a sufficient distance from surrounding objects. As to the actual exposure of the gages at Alaskan posts nothing is known. The rainfall was measured at army posts at the close of each storm, or more frequently if necessary to prevent the gage overflowing before it was read. Usually the time of beginning and ending of the rainfall was given, but only one measurement was made, namely, at the close of the storm, so that the given amounts of precipitation in the records often were for rainfalls extending over two or three days. In some cases, however, readings were made at 9 a. m. daily, as well as at the end of the storm, so that it was possible to determine the daily rainfalls more readily. The table on pages 162–165 shows the mean total rainfall for each month to midnight of the last day of the month. In the original army records a rainfall extending over the last day or two of one month and the first day or two of the next month was often not recorded until the end of that rainfall. In the earlier averages, published by Schott and Dall, no account was taken of this overlapping of the rainfall records. In the present work an attempt has been made to redistribute the rainfall so that that portion of it falling in the preceding month should be credited to that month and not to the following month. This redistribution was made according to the following plan: When the hours of beginning and ending of rainfalls or showers were given in the records the total rainfall was divided by the number of hours, and thus the amount of rain on each day was determined. When daily readings were made and no times of beginning and ending were recorded the readings were always allowed to stand as they were given. From the daily rainfalls as thus estimated was selected the greatest of each month for entering in the table on pages 166–167. The redistribution of rainfall just described became of particular importance in calculating the maximum daily rainfall for any month, since the daily measurements of rainfall are not usually given in the army records.

In cases of rainfall records made by voluntary or regular observers of the Weather Bureau, the instructions required the observer to record the rainfall every day, and it has not been necessary, in any case, to redistribute the rainfall among the days on which it did fall, or is supposed to have fallen. It has, however, been necessary in several cases to carefully study the records in order to determine whether or not the snowfall, as measured, was melted and included in the given total precipitation for the day, and for the month. The records, as they were found at the Weather Bureau, did not always seem to have made this inclusion, but where the necessary data were available, they were always corrected by the writer, so that the totals include rain and melted snow. In several cases it was not possible to make these corrections, because of the insufficiency or inaccuracy of the data, but these cases have not been used in compiling the present totals. It should, furthermore, be stated that the totals on rainfall are based only upon records for whole months, any incomplete months having been omitted in making up the means there given. In compiling the table of maximum daily rainfall (pp. 166–167), however, the incomplete monthly records have been used when the record for an incomplete month included a maximum figure.

In conclusion, it may be stated that the means given are based upon a series of observations of such varying lengths from station to station that they should be used only with the greatest caution. Only means based upon a series of observation extending over the same years, or means reduced to the same series of years, should be used in making any accurate comparative study of climate or for making any accurate estimates, plans, etc., for water resources.

The variation in rainfall, both daily, monthly, and annual, is so great at any station that only after a long series of observations have been obtained are we justified in drawing any definite conclusions concerning the rainfall to be expected. Unfortunately, the records for most stations in Alaska extend over short periods of years, and in many cases do not include even one complete year. This incompleteness of most of the records is expressed by the last column of the table on page 167, where the years and months of the record are given. In the column headed "years," the number of whole years is given; in the column headed "months," the number of scattered months over which the record stretches are given. In many cases, the number of months of record often exceeds the number of months in a year, but this simply indicates that the records are based upon observations made in many scattering months. The record at Eagle furnishes a good illustration of this, where we find that the record covers fifty-two months but *no* years.

The rainfall data from Weather Bureau and voluntary stations are based upon observations made daily by means of the standard Weather Bureau cylindrical gage, and with one or two exceptions are believed to include melted snowfall as well as rain.

The rainfall records kept by the commercial companies have not been incorporated in the accompanying tables, because no information has been received concerning the type of gage used by them.

RECORDS OF FROST AND ICE.

Records of the dates of occurrence of first and last frosts in fall and spring and the dates of first and last killing frosts were made very sporadically until the establishment of the experiment stations. The records show many gaps and omissions. The table presenting the results of these observations shows their character better than verbal description.

Dates of opening and closing of streams and harbors have also been kept intermittently by various volunteer observers, and their results have been incorporated in a separate table. Since observations on frosts and stream ice require no apparatus, they are perhaps, so far as they are given, worthy of more confidence than some of the instrumental observations, for many voluntary observers were without special preliminary training.

DESCRIPTION OF THE SYNOPTIC TABLES.

The results of the climatologic observations are presented in general tables, and figures for the monthly rainfall at the individual stations are added.

Locations of stations.—The following table presents an alphabetical list of the stations from which records have been obtained. For each station is given the latitude and longitude, the elevation above mean sea level, when known, the limiting dates of the period over which the observations extended, the number of whole years and months during which observations were carried on, and organizations by which the records were made (see also Pl. XVIII).

The latitudes and longitudes were first taken from the official records of the United States Weather Bureau and from Dall's Pacific Coast Pilot. They were then compared with the large scale maps of the Coast and Geodetic Survey and the

United States Geological Survey, and in some instances with maps of special districts of Alaska published by the United States Geological Survey.

Alaskan meteorologic stations, with location and length of record at each.

Reference number.	Station.	Latitude (north).	Longitude (from Greenwich).	Elevation.	Length of record.				Observations by—	Authority for latitude and longitude.
					Limiting dates.		Yrs.	Mos.		
					From—	To—				
		° ′	° ′	*Feet.*						
43	Anvik	62 37	160 08 W.	R. 40	Sept., 1882	Mar., 1891	0	44	S. S.; W. B. V	
20	Atka Island	52 15	174 15	15	May, 1879	Aug., 1886	3	16	S. S	
22	Attu Island	52 58	172 26	8	July, 1880	May, 1881	0	11	S. S	
23	Bering Island	52 12	165 55 E.	20	May, 1882	May, 1886	3	13	S. S	
26	Bethel Mission	60 58	161 52 W.	....	Nov., 1885	Feb., 1886	0	4	W. B. V.?	U. S. G. S., 1898.
38	Camp Colonna	67 25	140 59	650	Oct., 1889	July, 1890	0	10	C. and G. S	C. and G. S., 1896.
35	Camp Davidson	64 41	140 54	....	May, 1890	June, 1891	0	14	C. and G. S.	C. and G. S., 1896.
25	Carmel Mission	58 57	158 21	....	Jan., 1902	July, 1902	0	6	W. B. V	U. S. G. S., 1898.
37	Circle	65 50	144 04	....	Nov., 1898	Aug., 1900	1	20	P. S	U. S. G. S., 1904.
17	Coal Harbor	55 20	160 38	30	Sept., 1889	Oct., 1902	10	28	W. B. V	U. S. G. S.
47	Copper Center	61 58	145 20	1,005	July, 1902	Dec., 1902	0	6	W. B. V	U. S. G. S., 1903.
36	Eagle (Fort Egbert)	64 45	141 10	573	Oct., 1882	Dec., 1902	0	28	W. B.; W. B. V	U. S. G. S., 1899.
24	Fort Alexander	58 57	158 21	....	Aug., 1881	June, 1886	2	25	S. S	U. S. G. S.
10	Fort Liscum	61 05	146 20	....	Jan., 1901	Dec., 1902	2	00	W. B. V	U. S. G. S., 1900.
34	Fort Reliance	64 10	139 30	R. 30	Sept., 1882	May, 1886	0	18	S. S	C. and G. S.
1	Fort Tongass	54 46	130 30	20 to 30	June, 1868	Sept., 1870	1	16	P. S	P. C. P.
2	Fort Wrangell	56 28	132 20	30 to 36	May, 1868	Aug., 1882	2	40	P. S.; S. S	C. and G. S., 1869
29	Gambell	63 50	171 25	30?	Oct., 1894	Sept., 1902	2	33	W. B. V	C. and G. S.
44	Holy Cross	62 16	159 50	500?	Oct., 1893	Aug., 1901	6	21	W. B. V	
45	Ikogmut	61 56	160 43	....	Aug., 1883	May, 1886	0	23	S. S. V	U. S. G. S., 1898.
4	Juneau (1)	58 19	134 28	....	June, 1881	Feb., 1897	2	39	S. S. V.; W. B. V.	
5	(2) (wharf)	58 19	134 28	....	Dec., 1898	Dec., 1902	4	1	W. B. V	
11	Kenai	60 32	151 19	80?	June, 1870	Dec., 1902	5	31	P. S.; S. S.; W. B. V.	P. C. P.
31	Kikiktak (Friends' Mission).	67 00	162 00	....	Sept., 1897	Dec., 1902	3	15	W. B. V	
3	Killisnoo	57 22	134 29	20±	May, 1881	Dec., 1902	16	43	S. S.; W. B. V	
21	Kiska Island	52 00	177 25 E.	20	May, 1885	Apr., 1886	0	12	S. S	C. and G. S.
13	Kodiak (1)	57 48	152 25 W.	50?	Oct., 1868	Nov., 1899	1	35	P. S.; W. B. V	C. and G. S.
14	(2) (Woody Island).	57 48?	152 25?	....	Jan., 1900	Dec., 1902	0	34	W. B. V	
46	Kolmakof	61 30	158 59	40, 80	July, 1882	May, 1886	0	41	S. S. V	U. S. G. S., 1898.
16	Mine Harbor	55 45	160 40	105	Aug., 1902	Sept., 1902	0	2	W. B. V	
18	Morzhovoi	55 03	163 10	50?	Nov., 1881	May, 1883	0	18	S. S	
8	Nuchek	60 23	146 40	60?	May, 1883	Aug., 1884	0	16	S. S	U. S. G. S., 1900.
42	Nulato	64 41	157 58	15?	Oct., 1882	Apr., 1896	0	16	S. S.; W. B. V	U. S. G. S., 1903.
28	Omalik (mine)	65 02	162 40	700	Jan., 1884	Apr., 1885	0	12	S. S	U. S. G. S.
9	Orca	60 35	145 40	....	Sept., 1899	Dec., 1902	1	20	W. B. V	C. and G. S.
32	Point Hope	68 25	166 38	26 to 28	Aug., 1894	July, 1896	1	12	W. B. V	C. and G. S.
39	Rampart	65 30	150 15	....	Sept., 1900	Jan., 1902	0	7	W. B. V	U. S. G. S., 1902.
27	St. Michael	63 28	162 10	30 to (?)	July, 1877	July, 1901	7	28	S. S.; W. B. V	
30	St. Paul Island	57 15	170 10	40	Oct., 1869	May, 1883	1	35	S. S	
7	Sitka	57 03	135 19	13 to 63	Nov., 1867	Dec., 1902	17	44	P. S.; S. S.; W. B., W. B. V.	
6	Skagway	59 28	135 20	....	Nov., 1898	Dec., 1902	0	31	W. B. V	
40	Tanana (1) (Fort Adams).	65 10	152 45	200	Aug., 1882	May, 1886	0	27	S. S	
41	(2) (Fort Gibbon).	65 12	152 00	....	Aug., 1901	Dec., 1902	0	13	W. B. V	U. S. G. S., 1899.
12	Tyonok	61 03	151 10	....	Nov., 1898	Dec., 1902	4	2	W. B. V	U. S. G. S., 1902.
15	Ugashik	57 35	157 50	25?	Aug., 1883	Jan., 1886	2	4	S. S. V	
19	Unalaska	53 52	166 31	10, 13, 15	Sept., 1878	May, 1886	4	28	S. S	
33	Utkiavi (Point Barrow).	71 17	156 40	17	Oct., 1881	Aug., 1902	1	23	S. S.; W. B. V	

NOTE.—In "Elevation" column "R" means above river level, instead of sea level.

Each station in this alphabetical list is preceded by a reference number which is used in the succeeding tables. As the stations are grouped in succeeding tables by climatologic provinces, the names are not in alphabetic order.

Table of extreme temperatures.—The table on page 159 shows the absolute maximum and absolute minimum temperatures which have been observed at each of the stations during the period of years indicated in the last two columns of the table and the appropriate remarks. In the column headed "Extremes," are given the highest and lowest temperatures observed at each station within the period indicated, and also the difference, expressed in degrees Fahrenheit, between the highest and the lowest temperatures. The "Extremes" column, therefore, shows the extreme temperatures that have been experienced at each station, but not the extremes that might be expected within any one year. The table is of particular interest, as it shows the extreme temperatures observed in each month at each station and gives some idea of the amount and distribution of the extreme ranges of temperature over Alaska. These temperatures, however, have rarely been attained twice at the respective stations. They show what must be provided against in extreme cases, rather than what may be expected in an average year.

Table of precipitation.—The table on page 162 shows the average monthly and annual precipitation, including melted snow, and also the average number of days having a precipitation of 0.01 of an inch or more. This table may be expected to give, as far as the lengths of the individual records permit, a fair idea of the geographic and seasonal distribution of rain and melted snow over Alaska. It also affords material for the estimation of the average intensity of the monthly and annual rainfalls, since the mean monthly rainfall divided by the mean number of days with rain in the month gives the average amount of rain for each rainy day. The same may also be said for the column headed "Year." Typical rainfalls are also shown graphically on Pl. XIX.

Table of heavy rainfalls.—The table on page 166 is supplementary to the last-mentioned table, and shows the absolute maximum recorded rainfall in twenty-four hours during each month of the period over which the observations extend. The chief interest of this table lies in the fact that it enables the heaviest rainfalls of short duration in Alaska to be located and compared. It should be of considerable interest to those interested in agriculture and water powers, since the character of the rainfall is very important in investigations in both those lines.

Table of rainy days.—The table on page 168 gives the maximum and minimum number of rainy days observed, for each month and year, and repeats the average number of rainy days for each month in the year, already given.

This table is particularly interesting, as it shows the extreme fluctuations in the raininess of any district; but its value varies according to the number of observations which have been made.

Table of dates of frosts.—In the table on page 171 are shown the dates of the earliest killing frost in the fall and the last killing frost in the spring for all those stations at which these data were attainable. This table is, therefore, of prime interest to those who are interested in mining or in agricultural pursuits, since it serves to give an approximate idea of the length of the working and the growing seasons.

Tables of stream and harbor ice.—On pages 174 to 176 observations on the occurrence of ice in streams and harbors have been brought together in tabular form, and will prove of most use to those who are interested in navigation. The tables also show the approximate times at which high water and low water may be expected.

CLIMATIC PROVINCES OF ALASKA.

The climate of Alaska is by no means so uniformly arctic as is usually believed, but is such as would naturally result from its geographic position, its extent, and its varied topographic features.

The mere fact that Alaska stretches through 20 degrees of latitude and 54 degrees of longitude would alone be sufficient to bring about marked climatic differences. The northernmost point is within 18 degrees of the pole, while the southernmost lies in about the latitude of Liverpool, England. Its easternmost part, lying under the shelter of the coast ranges of British Columbia and bathed by the warm waters of the Pacific, is 2,500 miles distant from the westernmost of the Aleutian Islands, in the vicinity of the Siberian coast and the cold Arctic current.

Three seas, each with its own conditions of temperature and ice-covering, border Alaska and contribute to the multiplicity of climatic provinces. On the south it is washed by the warm Pacific; on the west it fronts upon the Bering Sea, which is essentially a body of cold water, whose northern half is covered with ice during six months of the year; while its northern coast is for nine months of the year locked in the ice of the Arctic Ocean.

The two mountain ranges that traverse Alaska from east to west divide the country into districts which differ very sharply from one another, both in temperature and in precipitation.

Last, but not least, may be mentioned the fact that Alaska lies in the northwest corner of a great land area, the North American continent, and forms a portion of the north and east coast of a still greater water body. This fact alone is sufficient to render Alaskan climate of decided interest to all students of climatology, as well as to give it peculiar features.

Previous studies of the climate of Alaska, as well as the experience of travelers, showed that the region may be divided into climatologic provinces very closely coincident with the physical provinces already discussed in foregoing chapters. The latest observations do not materially modify these divisions, but permit a somewhat more detailed subdivision to be made of one or two of the provinces. Alaska is here divided into eight climatic provinces, whose names and boundaries are as follows:

Pacific coast climatic province.—The Pacific coast province reaches from Dixon Entrance to Kodiak Island and includes all the islands of southeastern Alaska and the region lying between the ocean and the first range of mountains along the coast from Cross Sound to the beginning of the Alaska Peninsula. This is essentially a temperate and humid region. (See Nos. 1–14, tables, pp. 158 et seq.)

Alaska Peninsula climatic province.—The Alaska Peninsula climatic province includes the stations of Ugashik, Mine Harbor (Herendeen Bay), Cold Harbor (Unga Island), and Morzhovoi. (See Nos. 15–18, tables, pp. 158 et seq.) The climate here differs but in degree from the first province. It is in general somewhat more humid and milder than in the Cook Inlet district, approaching more nearly that of the Sitka district. The temperature ranges are more nearly of the insular type.

Aleutian Islands climatic province.—The Aleutian Islands province includes the Aleutian Islands, to which, for the sake of comparison, Bering Island, of the Commander group, has been added. (See Nos. 19–23, tables, pp. 158 et seq.). The climate of this province is characterized by moderate temperatures, limited ranges in temperature, and moderate humidity.

Bering Sea coast climatic province.—The Bering coast province begins at Fort Alexander in the northeast corner of Bering Sea and includes all the Bering Sea coast to Cape Prince of Wales. (See Nos. 24–28, tables, pp. 158 et seq.). Its climate is characterized by greater temperature ranges than are experienced in the foregoing provinces, while the precipitation is considerably less.

Bering Sea Islands climatic province.—This province is evidently related to the Bering coast province, but differs slightly from it in ranges of temperature. It includes the islands of St. Lawrence (Gambell), St. Paul, St. George, and St. Matthew. (See Nos. 29 and 30, tables, pp. 158 et seq.).

Arctic coast climatic province.—The Arctic coast province includes the Arctic coast stations from Cape Prince of Wales northward to Point Barrow and beyond, and southward to the Rocky Mountains. It is characterized by a long period of cold weather, which prolongs the winter through two-thirds of the year, and by a precipitation of about the same amount as that prevailing over the arid areas of Nevada and Utah. (See Nos. 31–33, tables, pp. 158 et seq.).

Interior climatic province.—The Interior province includes the central plateau region between the Rocky Mountain system on the north and the Pacific Mountain system on the south. It is characterized by great extremes of temperature and a very moderate rainfall, such as prevail in eastern Oregon and Washington. Thirteen stations included in this province are listed as Nos. 34–46 in the climatic tables (pp. 158 et seq.). Of these stations, Fort Reliance, Camp Davidson, Eagle (Fort Egbert), Circle, and Camp Colonna are located in the eastern section; Rampart, Fort Adams (Tanana 1), and Fort Gibbon (Tanana 2) are in the central section; and Nulato (St. Peter Mission), Anvik, Holy Cross (mission), Ikogmut, and Kolmakof are in the western section.

Copper River Plateau climatic province.—The station of Copper Center, which is given as the last, is here classed under a provisional province, the Copper River Plateau, since it shows some features characteristic of the interior climate and some suggesting the Pacific coast climate. (See No. 47, tables, pp. 158 et seq.).

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Table of mean temperatures for certain

Station.	Latitude.		Longitude.		Elevation.	Jan.	Feb.	Mar.	Apr.	May.	June.
Coast.	°	′	°	′	*Feet.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*
Fort Tongass	54	46	130	30	20–30	37.8	36.9	42.4	46.3	53.0	57.8
Fort Wrangell	56	30	132	28	25–35	26.2	30.8	31.6	42.7	49.3	55.3
Sitka	57	3	131	19	63	31.4	32.9	35.6	40.8	47.0	52.4
Do						34.2	33.0	37.2	41.9	46.9	51.6
Juneau	58	19	134	28		27.5	24.7	33.5	40.1	47.7	53.6
Valdez						23.8	15.5	30.8	31.6	39.4	49.6
Tyonok	61	3	151	10		5.41	15.3	23.6	37.7	43.1	53.1
Kodiak	57	48	152	19		30.0	28.2	32.6	36.3	43.2	49.5
Unalaska	53	53	166	32	13	30.0	31.9	30.4	35.6	40.9	46.3
Do	53	43	166	24	13	33.5	30.5	32.6	35.2	40.4	45.9
St. Michael	63	28	161	48	30	7.4	−2.3	8.9	19.9	33.1	46.3
Port Clarence	65	20	166	30		−7	−7	5	13	32	42
Utkiavi (Point Barrow)	71	22	156	16	17	−17.5	−18.6	−11.8	−1.2	21.4	32.8
Interior.											
Holy Cross (mission)	62	16	159	50	500?	−6.4	5.8	15.6	26.0	40.9	51.5
Fort Yukon								1.6	17.4	33.2	58.6
Eagle	64	45	141	10	573	−24.8	−6.0	13.0	29.3	42.2	52.6
Foreign.											
Ottawa, Canada	45	30	76			11.9	12.2	17.6	41.5	63.6	66.9
Winnipeg, Canada	50		97			−11.0	−5.0	10.5	35.5	53.6	61.5
Port Angeles, Wash	48	10	123	30		34.7	36.7	41.7	45.6	50.6	54.0
Scotland						37.1	38.4	39.4	44.1	49.0	54.8
Christiania, Norway	60		10	9 E.		24.1	23.9	29.5	39.9	50.9	59.9
Helsingfors, Finland	60	20	25 E.			20.9	18.8	26.2	34.8	44.1	56.9

[a] Compiled by A. H. Brooks from the following publications: Dall, Wm. H., Coast and Islands of Alaska: Meteorology, Appendix 1, Coast and Geodetic Survey, 1879. Reports of United States Weather Bureau. Georgeson, C. C., Agriculture in Alaska: Dept. of Agriculture, Office of Experiment Stations, Bulls. 48, 62, 82, 94, and Ann. Rept. for 1901. Jackson, Sheldon, Reports on Introduction of Domesticated Reindeer in Alaska, U. S. Bureau of Education. Collier, Arthur J., Reconnais-

Alaskan and other stations.[a]

Station.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.	Length of record. Limiting dates. From—	To—	Yrs.	Mos.
Coast.	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*				
Fort Tongass	60.0	56.6	52.4	49.0	41.6	39.3	47.8	1869	......	1	......
Fort Wrangell	58.2	57.5	52.3	45.9	33.5	32.8	43.0	May, 1868	Aug., 1882	4	18
Sitka	55.4	55.9	51.5	44.9	38.1	33.3	43.3	Jan., 1828	Dec., 1876	45	2
Do	54.4	56.6	52.3	45.7	39.8	36.0	44.5	Apr., 1881	Sept., 1887	5	18
Juneau	56.6	55.0	49.9	41.9	31.2	29.3	40.9	May, 1883	Dec., 1896	2	28
Valdez	50.5	46.6	......	......	22.4	21.6	......	1899	......	......	10
Tyonok	58.7	56.4	49	35.4	29.2	17	......	......	......	1	......
Kodiak	54.7	55.2	50.0	42.3	34.7	30.5	40.6	Jan., 1869	Aug., 1896	8	54
Unalaska	50.6	51.9	45.5	37.6	33.6	30.1	38.7	Oct., 1827	Apr., 1868	6	20
Do	49.6	50.3	46.0	40.4	34.6	32.8	39.3	June, 1872	May, 1886	2	32
St. Michael	53.6	51.9	43.9	30.5	15.6	4.8	26.1	July, 1874	June, 1886	11	12
Port Clarence	51	49	41	36	8	0	22	July, 1850	June, 1852	......	......
Utkiavi (Point Barrow)	38.1	37.9	27.8	4.4	− 6.0	−15.4	7.7	Nov., 1894 Sept., 1852	July, 1896 Aug., 1883	3	10
Interior.											
Holy Cross (mission)	57.9	51.8	42.5	29.6	12.5	1.8	......	1899	1900	2	......
Fort Yukon	64.2	53.6	42.6	16.9	−10.8	−26.0	......	......	......	......	10
Eagle	56.9	49.1	40.4	20.1	−10.0	− 7.4	21.2	......	......	1	......
Foreign.											
Ottawa, Canada	70.4	68.7	57.7	43.1	34.5	17.8	42.1	......	......	1	......
Winnipeg, Canada	64.0	61.5	49.0	36.5	18.0	3.0	29.6	......	......	1	......
Port Angeles, Wash	56.6	56.8	52.7	47.7	42.4	38.2	46.1	......	......	1	......
Scotland	57.1	56.6	52.8	46.4	40.6	37.8	46.1	......	......	1	......
Christiania, Norway	62.6	60.6	52.7	41.9	32.1	25.6	41.9	......	......	1	......
Helsingfors, Finland	61.9	58.3	50.5	43.9	33.7	21.7	39.2	......	......	1	......

sance of the Cape Nome and Adjacent Gold Fields of the Seward Peninsula (by Brooks), U. S. Geol. Survey, 1901. Collier, Arthur J., Reconnaissance of the northwest part of the Seward Peninsula: Prof. Paper U. S. Geol. Survey No. 2. Schrader, F. C., Reconnaissance of a Part of Prince William Sound and the Copper River district: Twentieth Ann. Rept. U. S. Geol. Survey, part 7, pp. 369.

GENERAL CLIMATOLOGY OF ALASKA.[a]

The Alexander Archipelago and adjacent parts of the mainland forming southeastern Alaska have the most temperate and humid climate of the Territory. The moisture-ladened winds of the Pacific precipitate their waters in this belt, producing an annual rainfall averaging between 80 and 130 inches. Three-fourths of the precipitation occurs in the winter months, from November to March, inclusive, and is characterized by long, incessant rains and drizzle. Sitka, located on the outer shore of the archipelago and exposed to the full influence of the Pacific, has an annual rainfall of 88 inches. In general, this province has cool summers and comparatively warm winters; but it is essentially a region of cloudy and rainy weather, having on an average not more than one hundred clear days in the year, and these largely in the spring months. April to July includes the driest months, while the greatest precipitation is in the autumn. Foggy weather is also a characteristic of this coast and adds to the dangers of navigation. The snowfall is insignificant, many years showing none.

The temperature throughout southeastern Alaska is remarkably equable. The extremes recorded at Sitka show for August, the hottest month, an extreme range of from 35° to 87° F., and for the coldest month, February, a range of from 3° to 54° F. The mean temperature for January is 33°, and for August 56°, a range of only 23°.

Juneau, on the mainland, is less subject to the oceanic influence. In recent years the precipitation here has not been so great as at Sitka, and the mean annual temperature is several degrees lower, the difference being more marked in winter than in summer. The snowfall at Juneau at tide water is very small, but is heavy in the mountains near at hand.

In the southernmost part of this coastal zone the climate is warmer and even more humid than at Sitka. Records kept at Fort Tongass, located on Dixon Entrance and subject to the full influence of the ocean, show an average of 133 inches of rainfall and a mean annual temperature of about 48°. These records, however, embrace observations covering a period of only two years.

Sitka has a mean annual temperature only 2° colder than that of Port Angeles on Puget Sound, or of Scotland in the British Islands. Its rainfall, however, is about three times that of Puget Sound and twice that of Scotland (see pp. 162–165). Its average temperature is 2° warmer than the annual mean of Ottawa, Canada, and the climate does not show anything like the extremes of winter and summer, though its rainfall is nearly three times as great. It has a far more equable climate and a lower mean annual temperature than the populous cities of Winnipeg, Canada; Christiania, Norway; and Helsingfors, Finland.

The enormous precipitation along the coast has a great effect on vegetation. The seaboard of southeastern Alaska is densely timbered with forests chiefly made up of spruce and hemlock, with some red and yellow cedar and other species. Shrubbery and all other plant life grows rank. The dense foliage of the trees and shrubbery shields the ground from the sun's rays on the comparatively few clear

[a] Written in cooperation by A. H. Brooks and C. Abbe, jr.

days, and the moisture of the heavy rainfall is long preserved in the moss-covered, sponge-like soil. This dense growth of trees and shrubs is in strong contrast to the open forests of the interior and the treeless region of the barren grounds to the north.

There are few climatic records for the seaboard between Cross Sound and Cook Inlet. The outer coast line has probably a somewhat colder mean annual temperature than Sitka, with somewhat less rainfall. According to the reports from the Copper River, the spring and early summer months are usually bright and clear, and midsummer is sometimes quite hot. The fall months are rainy as a rule, while the winter is probably much more severe than in the southeast. July and August are probably rather free from frosts along the coast. In the Copper River Plateau region frosts are liable to occur at any time in the year, but are rare in June, July, and early August. The annual snowfall, which begins in October and November, averages from 2 to 4 feet, somewhat more than in the Yukon basin.

The inland fiords are decidedly colder than the outer coast line. Some incomplete observations at Valdez show that the winter months are on the average 10° and the summer months about 5° colder than the corresponding periods at Sitka, and the annual precipitation is probably 50 per cent less. Snow, said to amount to 7 or 8 feet annually, is reported to fall from November to May, when it gives place to the rain and fog which extend through early June. June and July are the clearest months in the year, while the fall is again rainy and foggy.

At Kodiak Island, which is in about the same latitude as Sitka and is fully exposed to the equalizing influences of the Pacific, the mean annual temperature is 4° lower than at Sitka and there is 20 per cent less rainfall. The Cook Inlet region, including the lower part of the Sushitna basin, though somewhat colder than that part of the seaboard which lies directly on the open ocean, has probably the most delightful climate of any portion of Alaska. While the winters are cold compared with southeastern Alaska, the upper part of the inlet being usually locked in ice from November to May, they are not so severe as those of Bering Sea. The charm of the Cook Inlet climate is its bright, clear weather in the spring and summer, when there is just enough rainfall to insure ample water for the growth of vegetation.

The shores of Cook Inlet and the lower slopes of the adjacent mountains are timbered with spruce, birch, cottonwood, willow, and alder, which latter grows in dense thickets along the water courses. The eastern side of Kodiak Island is sparsely forested, but the Alaska Peninsula and the Aleutian Islands are treeless, except for some stunted willows.

The Aleutian Islands, bathed on one side by the warm waters of the Pacific and on the other by the colder waters of Bering Sea, and far from the continental land mass, have a climate distinctly oceanic in character. The records show it to be colder than that of southeastern Alaska, with 5 to 10 per cent less rainfall. Precipitation at Unalaska, in the eastern part of the archipelago, is greater during the fall and winter months. The reported preponderance of clear days in January and February is not borne out by recent records in this region. The table on page 168 shows twenty-four rainy days in these months, against thirteen in May and June. Northerly and northwesterly winds prevail in the winter and southerly and southwesterly during the summer. The mean temperature for the winter months is but little colder than for the corresponding periods at Sitka, but the annual mean is lowered by the cooler summers. The extreme range is 73° at Unalaska, 90° at Sitka, and 102° at Skagway. The fogs which are ever hanging about these islands make the passage of the straits perilous to navigation. Though timber is absent, grass grows luxuriantly.

Bering Sea is a cold body of water, with a mean annual temperature of about 39° F. It is practically closed against the warm influence of the Pacific by the barrier of the Aleutian Islands, and its cold temperature, incident to the high latitude, is probably increased by some influx of cold waters of the Arctic Ocean through Bering Strait. Fogs are very prevalent throughout the open season and seriously hamper navigation. The winter ice extends from Bering Sea as far south as the mouth of the Kuskokwim, and usually blocks navigation from about November until the end of May (see pp. 174–176).

The climate of the eastern shore of Bering Sea is rigorous in winter, growing more so toward the north, but its summer temperature is only a few degrees cooler than at Sitka. St. Michael, near the mouth of the Yukon, has a mean annual temperature of about 26°, but a summer extreme of 77° and a winter extreme of −55° are on record, giving an extreme range of 132°. Sitka has but 90° range. The annual precipitation at St. Michael is only about 18 inches, and much of that falls in the form of rain from May to October.

In the Seward Peninsula, which forms the north shore of Bering Sea, June, July, and August can be counted the summer months. The snow has usually disappeared by the 1st of June and does not begin to fall again until September. In some years June and July are delightfully dry and pleasant months, but the colder rains, which are apt to begin in August and practically continue until snow flies, often accompanied by severe winds, are excessively trying. During 1901 the average temperature was 44° in July and August and 40° in September,[a] the number of rainy days during these months aggregating thirty-six. At Port Clarence two years' records[b] showed a mean annual temperature of 22°, with a minimum of −38° and a maximum of 77°. The precipitation of the only year in which a record was kept amounted to 5.58 inches. The ground is usually found to be frozen a foot or two below the surface throughout the year.

The climate of the Seward Peninsula during the late summer and early fall is probably the worst of any part of Alaska which is inhabited by white men, for at this season of the year it is essentially arctic in its character and similar to that of the Arctic province. The utter lack of timber makes it impossible for the traveler to find shelter and often hardly fuel. While the winter temperatures of the northern Bering Sea coast lines are usually not so low as those of the interior, the greater humidity of the atmosphere makes them harder to resist.

The Arctic province, which includes the seaboard of the polar sea, is similar in character to the northern part of Bering Sea, but colder. At Point Barrow, the northernmost cape of Alaska, the mean annual temperature is less than 8°, with a precipitation less than 8 inches. The extreme of summer heat recorded

[a] Prof. Paper U. S. Geol. Survey No. 2, p. 7.
[b] Reconnaissance of the Cape Nome and Adjacent Gold Fields of the Seward Peninsula, 1900, p. 163.

at this point is 65°, in July, and of cold −55°, in February, giving an extreme range of 120°. The summer extends from about the middle of June to the middle of August, when snow begins to fly. Shore ice begins to form along the north Arctic coast early in September and remains until July. The Arctic pack ice has been known to come in on shore as early as August 14, but on that occasion went off again on the 28th of the same month (1902). Inland the summer months are usually clear, but the sea is often mantled in fog. The arctic littoral of Alaska is part of the broad tundra or barren ground belt which encircles the polar sea. The surface is everywhere covered with a dense growth of moss and grass and abundant wild flowers, beneath which the ground is perpetually frozen. Along the watercourses willows are found in thick growths, clinging close to the ground to avoid the icy blasts of the arctic winds. Away from the watercourses there is no timber of economic value, though some stunted shrubbery is found. It is remarkable that the observed total precipitation in the Arctic province averages about one-half that of the dry interior, and is comparable with the conditions prevalent in northern Nevada.

The climate of the Alaskan interior is continental in its character, semiarid, with great extremes of heat and cold. On ascending the Yukon, one gradually passes out of a relatively humid coastal belt, and at the international boundary reaches a point where the annual rainfall, as far as recorded, is less than 10 inches. Here the average temperature for December to February is from 5° to 10°, with an extreme minimum of −76° to −80°, while in the summer months of June, July, and August, 50° to 60° is the mean; the maximum, 90°. Frosts may occur at any time during the year, though there is usually a period of about 30 days, from the middle of June to the middle of July, which is without frost. The heaviest precipitation is in July, August, and September, and is always moderate in amount, while the winter snowfall aggregates from 2 to 3 feet. At other points in the Yukon basin less reliable records place the snowfall at from 4 to 6 feet. The Yukon usually begins to break in May, by which time the winter accumulation of snow has disappeared from the lowlands. It freezes again in early November, but after the middle of September the ice begins to run and navigation is interrupted. In spite of the rigorous cold of winter, the climate is less trying to man than some less severe though humid regions. Even during the extremes of cold, traveling with dog teams is not impossible, unless the wind is blowing. The lowlands of the interior are usually well forested with spruce, cottonwood, birch, willow, and alder. Away from the rivers and streams the forest becomes more open, and ceases altogether 2,000 or 3,000 feet above sea level. The region nearly everywhere is covered with a coating of thick moss, except in the open lowland tracts, where grass takes its place, and a few inches below the surface soil the ground in many places remains frozen throughout the year.

In this connection it is interesting to note that there is only one instance on record where excavation in this northwestern region has gone below the zone of perpetual frost. Tyrrell[a] describes a shaft in the Klondike placer field which pierced the frozen ground to a depth of about 200 feet. In the Nome region a

[a] Tyrrell, J. B., A peculiar artesian well in the Klondike: Eng. Min. Jour., vol. 75, 1903, p. 188.

shaft 120 feet deep did not reach below the level of perpetual frost. It must not be supposed that there is a continuous incrustal of frozen soil, for the placer-mining excavations in many places fail to reveal any.

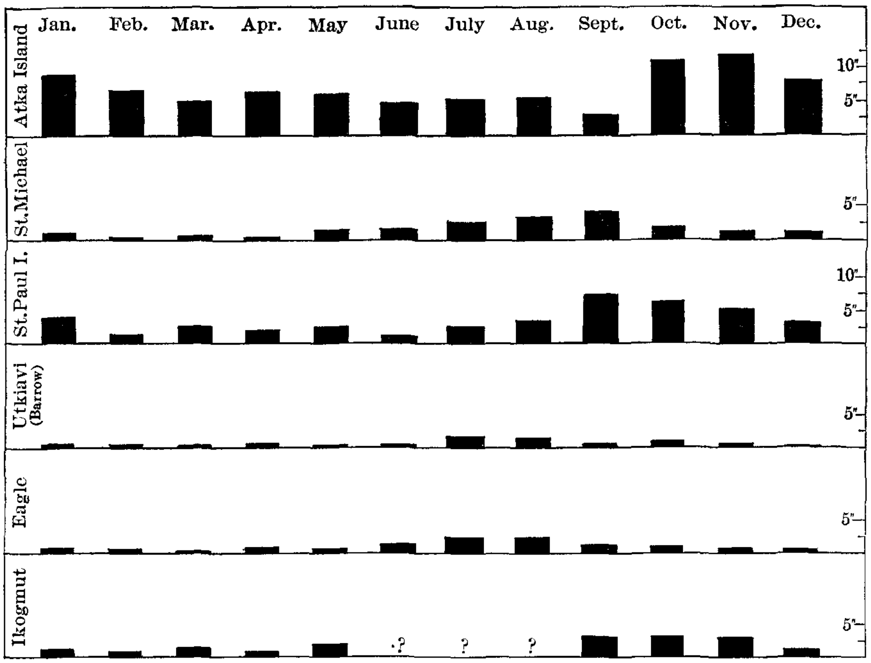
CLIMATIC FEATURES, BY PROVINCES.

PACIFIC COAST CLIMATIC PROVINCE.

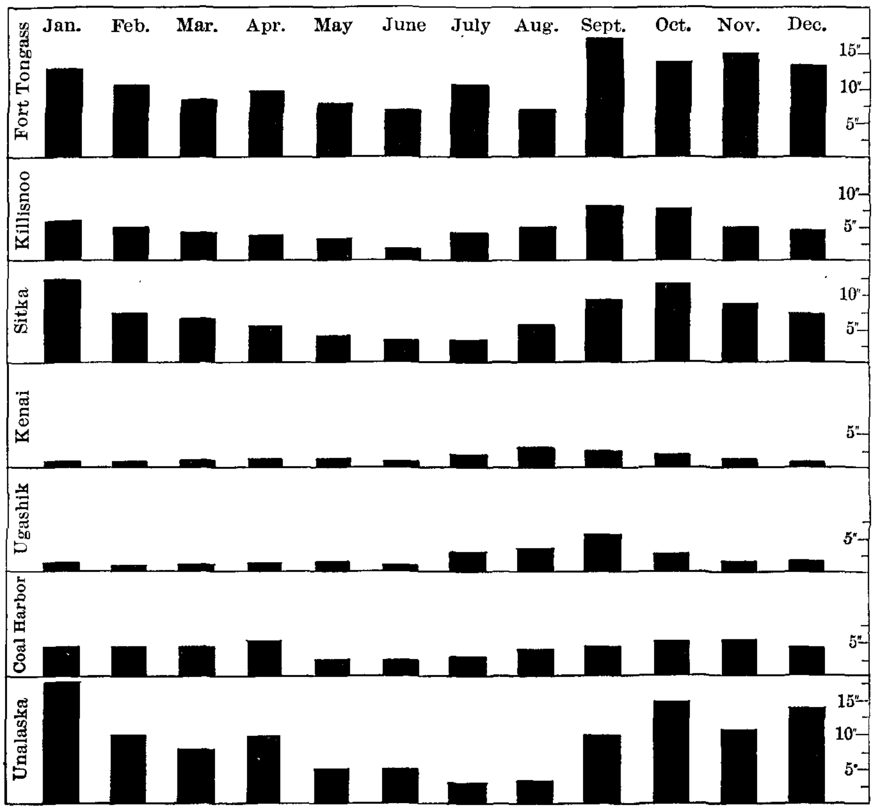
Rainfall.—The Pacific coast province, and more particularly the "panhandle," is well known for its heavy rainfall and cloudy weather. The tables on pages 162 et seq. and Pl. XIX show that this portion of Alaska, as well as the northwest coast of the States, has a rainfall comparable only to that of the Aleutian Islands, the immediately adjacent coastal portions of British America, and the coast of Washington and Oregon. In general, however, the precipitation within Alaska falls somewhat short of that recorded in the latter district. The heaviest annual rainfalls in this province occur at Nuchek (190.09 inches), Fort Tongass (133.10 inches), Orca (129.30 inches), Juneau (84 to 93 inches), Sitka (88.1 inches), and Fort Liscum (81.3 inches). Fort Wrangell, Killisnoo, and Kodiak stand next, with 50 inches or more, while Tyonok, Skagway, and Kenai have only between 15 and 25 inches.

Nearly all this precipitation falls as rain, and for the most part from September to January, both inclusive (Pl. XIX). During the other months a considerably smaller proportion of the annual rainfall is precipitated. The season of least rainfall, and consequently the one having the fewest number of rainy days, is generally from April to July. The table of annual and monthly rainfall (p. 162) shows Nuchek to be the only exception to this rule. At that station the heavy rains last until May and begin again in August. The table of rainy days (p. 168) shows that during the months of heavy rains there is scarcely a day without precipitation, the number of rainy days in a month running up to twenty, twenty-two, twenty-seven, and, in the case of Fort Liscum, even to twenty-eight and a half. On the other hand, the same table shows that even in the less rainy months the number of days per month on which rain falls is usually not less than ten, except at Skagway, Kenai, Fort Liscum, and Tyonok, where it is five or even less.

A feature of the local rainfalls which is often of economic importance is the maximum rainfall during a limited period of time—e. g., in twenty-four hours. If the material at hand were more complete and time allowed, a table of average maximum rainfalls would prove very valuable. In the absence of such a table the observed maximum rainfall in twenty-four hours for as many stations as possible have been collected in the table on page 166. From this table some idea of the intensity of the rainfall may be obtained. The table shows that the eastern portion of the Pacific coast province is subject to the most severe downpours, as a rule, the maximum amount of rain in twenty-four hours in that region being from 3 to 7 inches. The western stations have downpours generally less than 2 inches. Orca, however, has a record of over 7 inches of rain in twenty-four hours, which is the heaviest reported from any Alaskan station, and



(A)



(B)

TYPICAL MONTHLY RAINFALLS.

yet is more than 3 inches less than the heaviest daily rainfalls which have been recorded in the United States.

Generally the excessive rainfalls occurred during the characteristically rainy months, viz, in the fall and winter. Nuchek and Kodiak, however, again show variations from the general rule, as they have very heavy rains during May while Juneau has its heaviest rains in July and August.

Temperature.—The Pacific coast province, as shown by the table on pages 158–161, holds an intermediate position among the climatic provinces of Alaska so far as temperature is concerned. The extreme ranges observed in the province cover about 95° F., most of the stations showing a slightly smaller extreme range. Of course the average annual range is considerably less. An extreme maximum higher than 95° has not yet been recorded in the province, the highest being 92° at Skagway. On the other hand, every station except Nuchek and Orca has recorded a minimum temperature falling between —3° and —43° F. It is interesting to notice that the highest maxima and the highest minima occur in the "panhandle," while the lowest absolute maxima and minima occur on Kodiak Island and along Kenai Peninsula.

The greatest absolute ranges in temperature, 110° and 125°, occur in the Cook Inlet region, and are due to the fact that the minimum temperatures fall much lower than those in the eastern part. The most equable temperatures of the province seem to prevail at Nuchek and Orca, which lie between the waters of Prince William Sound and the Gulf of Alaska. Here the maximum has remained below 90° and the minimum above 0° F., resulting in an absolute extreme range of 60° for Nuchek and of 84° for Orca.

Growing season.—The dates of the last frosts in the spring and the first frosts in the autumn with the number of intervening days free from frost are given in the table on page 171, in as much detail as the records permit. From this table it appears that among the inlets and islands of the southern panhandle district the last frost comes during the latter half of April and the first fall frost the end of September or beginning of October. Thus there results a growing season in this region of about two hundred days. Farther north, from Sitka to Skagway, the last spring frost comes about the first of May and the first frost in the fall toward the middle of September, thus reducing the growing season to about one hundred and seventy-five days. In the Cook Inlet region the season becomes still shorter, as the last frost delays until May or even June while the fall frosts hurry in by the first week of September.

River and harbor ice.—The records of opening and closing of streams and harbors by the ice are very scanty among the meteorological records examined. They are given in the table on page 174. From the few found it would seem that the sea is free from ice by the middle of March at Unga Island, but that Cook Inlet does not usually open before the end of that month. Ice begins to form there late in the fall, perhaps the middle or last week in November. Within the Alexander Archipelago, however, the ice has been known to form as early as the end of October, and the bay at Fort Tongass has been closed during the first week in November.

ALASKA PENINSULA CLIMATIC PROVINCE.

Rainfall.—The province embracing the Alaska Peninsula and the islands to the south is characterized by less extremes of climate than the other portions of Alaska. The rainfall records from this province are not very complete, but they serve to show that the precipitation is much less than in the Pacific coast or Aleutian Islands province (see also Pl. XIX). Ugashik, on the west coast, has an annual rainfall of only 24.41 inches, while Unga Island, off the east coast, receives just about twice as much, 48.78 inches. The records at Morzhovoi, although not complete, indicate that the precipitation increases decidedly to the southwest toward Unalaska Island.

The seasonal distribution of rain is in general similar to that prevailing on the Pacific coast and among the Aleutian Islands. There is a rainier season from September to January and a drier one from February to August. The contrast between these two seasons is much less marked in this province, however, than it was seen to be in the Pacific coast province. This is shown by the larger number of rainy days in the year, and is also apparent from a brief examination of the table of monthly rainfalls (p. 162). This table shows that Coal Harbor has averaged from sixteen to seventeen rainy days in every month; Ugashik, on the west coast, ranges between fifteen and twenty-six rainy days, while the stations of the Pacific coast province have ranges running from nine or ten rainy days in the summer months up to twenty-six or twenty-eight days in the fall and winter.

The heaviest twenty-four-hour rainfalls of the province show interesting variations. Coal Harbor has the heaviest downpours, 1.25 to 5 inches, which are in excess of those occurring at most of the other stations in Alaska. Morzhovoi comes next with falls of from 0.40 to 2.07 inches. It is a peculiarity of these showers, however, that they seem to occur in any month except December, while at Coal Harbor the heaviest rains in twenty-four hours occur during the months from April to July. On the west coast Ugashik records seem to indicate that this portion of the province is rather exempt from such heavy rains. The recorded maximums lie between 0.22 and 1.20 inches. The season of heaviest rains in any twenty-four hours is from June to November.

Temperature.—As regards temperature ranges the Alaska Peninsula and the Pacific coast rank together between the two extremes found in Alaska. The extreme annual range is not so great as that of the interior nor so limited as that of the more isolated islands. The two stations on the east coast of the peninsula show an extreme annual range of 80° or 90°, practically the same as that prevailing about Dixon Entrance, but on the west coast the maximum range has extended through 124°. This contrast arises chiefly from the fact that much lower minimum temperatures are experienced on the west coast than on the east, and is not due to any important difference between the maximum temperatures of the two coasts. This contrast may be traced throughout the year. Each month the minimum at Ugashik falls lower than at Coal Harbor or Morzhovoi, while the maximum temperatures, reached during July and August on both coasts, almost coincide.

Growing season.—The dates of first and last frosts in this province (p. 171) show that on Unga Island the growing season includes about one hundred and fifty days, and lasts from the middle of May to the last week in September. The records from Ugashik are too scanty to permit any such estimate for that station, but judging from the records at Carmel Mission, on the delta of the Nushagak River, the number of days free from frost seems to be about one hundred and six, with a factor of uncertainty as to the occurrence of frosts in August.

River and harbor ice.—There are no records of the dates of opening and closing of streams and harbors.

ALEUTIAN ISLANDS CLIMATIC PROVINCE.

Rainfall.—The Aleutian Islands province ranks next to the Pacific coast province in amount of annual and monthly rainfall, but has a greater number of rainy days. Although complete records exist for Unalaska and Atka only, the other stations have sufficiently complete records to indicate that the average rainfall throughout the province will scarcely exceed 80 inches in a year. The greatest annual rainfall is at Unalaska, which also has the greatest number of rainy days. Indeed, this station has the greatest number of rainy days of any in Alaska, viz, 250.8, although heretofore Sitka has been considered as the rainiest point in the United States. Here, as on the Alaska Peninsula, the heaviest rainfall occurs during the fall and early winter, usually in October and November (see Pl. XIX). At Unalaska the season of heaviest monthly rains is somewhat longer than this, lasting from September until February, and the maximum occurs in January. The season of least rainfall at this station falls between June and August, yet even during this period the monthly rainfall averages very little under 3 inches. On the other islands of the province the season of minimum rainfall, so far as it may be determined from the insufficient records, occurs during the winter and early spring months. In general not less than 2 or 3 inches of rain fall in any month except February on Kiska Island, and the distribution of the rainfall throughout the year is unusually uniform. The same may be said of the distribution of rainy days as shown by the table on pages 168–170.

In amount of maximum daily rainfalls this province again stands next to the Pacific coast province. The seasonal variation of this factor is, however, less in the province under consideration, ranging from 5.58 inches at Unalaska to 1.75 inches at Unalaska and Atka. The maximum rainfalls in twenty-four hours observed on Kiska and Attu islands fall much below these figures. These heavy rains seem to characterize no one season on Unalaska, but to occur with equal frequency at any time between October and April. On the other islands they occur during July to January, but show some tendency to happen in the summer months as well.

Temperature.—The table on page 158 shows that the Aleutian Islands have characteristic island climate, so far as the ranges in temperature are concerned. The extremes are here closer together than anywhere else in Alaska. A maximum of 78° is the highest that has been recorded, and the lowest minimum was 5°, observed at Unalaska. On the other islands the lowest minimums are much higher, 15° and 11°. The warm season includes June, July, and August; the cold season is most severe during February and March.

Growing season.—Atka Island probably has the longest growing season, from the middle of February to the end of October, although this seems impossible. The partial record from Attu Island indicates that during that year the frost-free season lasted from early in May until the end of September, a period of about one hundred and thirty-five days. There is no evident reason why the growing season throughout the province should not be of about the same length as that just given for Attu Island.

River and harbor ice.—The records of frosts and of harbor ice are very incomplete.

BERING SEA COAST AND ISLANDS CLIMATIC PROVINCES.

Rainfall.—The precipitation in the Bering Sea coast and islands provinces is probably less than in the provinces to the southeast. The annual rainfall is heaviest about Fort Alexander, where it averages 33 inches, and it decreases in amount northward to an average of 18 inches at St. Michael. The precipitation of this province is thus shown to be comparable to that in the portion of the United States stretching from North Dakota and Minnesota on the north to Texas on the south. This moderate rainfall occurs within the relatively small number of one hundred and twenty-five to one hundred and sixty days.

The seasonal distribution of the rainfall (see Pl. XIX) seems to be quite different from that which prevails over the southern portions of Alaska, since the greatest amount of rain falls from July to October. Fort Alexander shows a distinct season of maximum rainfall limited to July, August, and September, and a very uniform monthly amount of from 4 to 5 inches during those three months. Farther north, at St. Michael, the average monthly precipitation increases regularly from 1.27 inches in June to 4.02 inches in September, and then takes a sudden drop to 1.70 inches in October. On St. Paul Island, however, the brief records show a much greater maximum, which occurs during the months of September, October, and November. This island has as many rainy days as Sitka—two hundred and seven—and one-half the precipitation—40.68 inches—from which it may be seen that the Bering Sea islands have a relatively drier climate than the coast. The table of rainy days (p. 168) brings out this difference even more strikingly, perhaps. It shows that, month for month during the rainy season, the islands have twice as many days with 0.01 inch or more of rain than does the coast. Strangely enough, however, these conditions are reversed during the months of June and July, as then the coast stations have twice as many rainy days as the islands.

In excessive rainfall in twenty-four hours this province (see p. 166) ranks next after the Aleutian Islands. On the coastal portion the heaviest daily rainfall occurs during the midsummer months, and ranges between 2 and 2.75 inches. On the island of St. Paul it seems to occur during the winter months, while during the summer this section receives the lightest of its maximum daily precipitation. As is apparent from the maxima just given, none of these twenty-four-hour quantities are very heavy, and the smallest which have occurred along the coast are very small indeed, even when compared with the scanty rainfalls of the interior province. The records containing these minima are from Omalik and are very incomplete—probably too faulty to warrant any conclusions at all to be drawn from them.

Temperature.—The extreme annual range in temperature of the Bering Sea coast province stands between that of the Pacific coast province and that of the interior. Although the maximum temperatures exceed those of the Aleutian Islands very little, the long winter, during which the sea is here covered with ice, suffers a fall in temperature which brings the minima far below those of the former province. The winter of the Bering Sea islands is also distinguished by these low temperatures. The reported extreme minima from the mainland range between $-30°$ at Fort Alexander to $-70°$ at Carmel Mission, and average about $-52°$. On the islands the lowest temperatures observed have been $-10°$ on St. Paul and $-31°$ on St. Lawrence. The extreme cold weather occurs during February and March, but the short record at St. Paul Island shows that its lowest temperature came in April. The greatest daily range in temperature lasts from September to March, thus including the periods of greatest cold. The season of least daily ranges lasts from May to October, with a warm season during June, July, and August.

Frosts.—The last frosts occur about the end of May and the fall frosts come toward the middle of September; thus the growing season for plant life is scarcely one hundred days in length.

Sea ice.—The sea in the vicinity of St. Lawrence Island is covered by ice from the first week in November until the end of April. The harbors along the coast do not open as early—at Carmel Mission clear water not appearing before the first week in May and at St. Michael Harbor usually not before the end of the first week in June.

ARCTIC COAST CLIMATIC PROVINCE.

Rainfall.—The precipitation along the Arctic coast of Alaska is probably the smallest in amount of any recorded there, averaging between 6 and 7.50 inches in a year. Most of the scanty winter precipitation is in the form of rather fine-grained snow, which drifts very badly under the influence of the storm winds of the season and is therefore very hard to measure accurately. On account of this low amount of moisture the climate may be classed as arid. It is comparable to that of the upper San Joaquin Valley in California and the Nevada-Utah deserts. The number of days with a measurable amount of rain is, of course, also the lowest for Alaska.

The greater portion of the scanty annual rainfall comes between July and December, the months from July to October generally having the greatest monthly totals (Pl. XIX). Another peculiarity about the rainfall here is the relatively great contrast between the small amount in December, January, and February and that which comes during July, August, and September. The former have monthly totals of 0.03, 0.05, and 0.19 inch; the latter have totals of 1.34, 1.02, and 1.48 inches, respectively. A study of the table on page 166 shows that most of the fall of any month may occur in one or two days only, leaving all the rest of the month without a measurable quantity to its credit. Indeed, cases are on record where the whole month's rain fell in less than one day. On the other hand, it has happened at Point Barrow that January, April, and May have passed without any rain or snow falling. The dryness of this province is still further shown by the table on page 168, from which it appears that the average number of rainy days per month is thirteen or lower. In no other province except the interior does the average number of rainy days fall below fifteen except during the dry season. Here in the rainy season the highest number of rainy days on record is eighteen, reached once. Four times the maximum number reached fifteen, while the minimum has been 0 four times and 0, 1, or 2 fourteen times.

Temperature.—The extreme annual range of temperature in the province (p. 158) is very nearly the same as that of the Bering Sea coast, but the extreme is here subject to much greater fluctuations. Except at Kikiktak, whose maximum temperature is 81°, the summer temperature shows distinctly the influence of the cold waters bounding this province on the north. The highest temperatures recorded at Point Hope or Barrow do not exceed 65°, a maximum which is also found on Bering Island. The maxima occur only during July and August. On the other hand, the minimum temperatures, while low, are not as severe as in the mountains to the south. The extreme low temperatures of the province have probably not gone lower than −55°, a temperature which has been equalled or exceeded at nearly every one of the interior stations. Evidently even the icebound Arctic Ocean exerts a moderating influence upon the winter temperatures of its coast. For the same reason the range in temperature is no greater at these higher latitudes than it is reported to be along the Bering Sea coast. While considering these minimum temperatures it is interesting to find that only in June, July, August, and September has the minimum temperature failed to fall below 0° F., while August at Point Hope is the only month in which the temperature has not fallen below 32° F. From these records it is clear why every month in the year seems to be subject to frost in this province.

The minimum temperatures and the greatest daily ranges of temperature occur during January, February, and March. The daily range decreases until the end of May, when it suddenly drops to its minimum, which it holds during June, July, and August. The season of minimum daily range at Barrow, however, seems to come from July to September, one month later than at the two stations on the more western coast of the province.

Frosts.—Unfortunately the growing season has not yet been carefully recorded in this region. Probably it does not begin before the end of June and ends on or before the middle of September. In 1902 a killing frost occurred at Barrow at the end of August, and if this happens every year or two the growing season there is likely to prove too short for human needs in spite of twenty-four hours of sunlight during the summer months.

INTERIOR CLIMATIC PROVINCE.

Temperature.—The geographic position of the interior province leads one to expect here the greatest extreme annual ranges of temperature and the greatest mean annual ranges. Indeed the extreme ranges here are from 120° to 162° F., and generally they are not less than 133°. The extreme monthly ranges naturally cover a smaller interval: the greatest of them were 112° and 110° in January, February, and March at Eagle and Tanana, respectively. It is probable that even at these stations such monthly ranges are rarely attained in any one year. The smallest extreme monthly ranges may be expected during June, July, and August, and even these greatly exceed the ranges which characterize these months in the other provinces of Alaska.

A brief examination of the table of temperatures of the interior province (p. 158) shows that extremely high temperatures are not characteristic. The maximum temperature recorded by properly sheltered instruments has not risen above 90° in the great Yukon basin, and the temperature of 94° at Copper Center, on the Copper River Plateau, is the highest that has been reported from any of the voluntary observing stations of the United States Weather Bureau. The writer is not unmindful that Dr. W. H. Dall makes the following statement:

"At Fort Yukon I have seen the thermometer at noon, not in the direct rays of the sun, stand at 112°, and I was informed by the commander of the post that several spirit thermometers, graduated up to 120°, had burst under the scorching sun of the Arctic midsummer."[a]

This passage leads one to infer that the temperature at Fort Yukon has been known to reach 120° F., but the writer doubts if such an inference is justified by our knowledge of the facts concerning the exposure of the thermometers which are reported to have burst under the heat. Since the Weather Bureau has been sending standard instrument shelters into the Alaska interior and has been receiving records from registering instruments exposed in them, no such temperature for the air as 112° has ever been reported. That it grows very hot in this province no one may deny. Doctor Dall, in the same book (loc. cit.), has characterized the summer heat thus:

"In midsummer on the upper Yukon the only relief from the intense heat, under which the vegetation attains an almost tropical luxuriance, is the brief space during which the sun hovers over the northern horizon, and the voyageur in his canoe blesses the transient coolness of the midnight air."

The air temperatures of the interior have sometimes been closely approximated by maximums in the Pacific coast province, but it is not probable that they are often even approached there, and surely the days as a whole must be much more bearable.

The minimum temperatures in this province fall much below those usually met with in any other portion of Alaska. The lowest recorded is −80° at Fort Reliance in January and the highest absolute minimum for any station is −49°, which was observed at Camp Davidson and Camp Colonna, on the international boundary. With the exception of these two stations the extreme minima decrease rather regularly as the Bering Sea coast is approached. The table shows that the great range in temperature which is experienced in the interior is due to the very low winter temperatures rather than to very extreme summer ones.

Growing season.—The growing season in the interior seems rather short in number of days, but when one remembers the length of time that the sun remains

[a] Dall, W. H., Alaska and its Resources, Boston, 1870, p. 437.

above the horizon and the consequent increase in the number of hours of insolation, the luxuriant and rapid growth of vegetation already referred to seems not so remarkable. The records at Camp Colonna show that the growing season during 1889-90 lasted from the end of April to the middle of October, making about one hundred and fifty days free from dangerous frosts. At Camp Davidson the record is more accurate and shows a much shorter season. Here the last killing frost occurred between the 3d and 27th of June, and the first killing frost came on August 13. At Eagle the records from 1883 to 1885 show that the last spring frost comes about May 15 and the first fall frost about the end of August, thus allowing a maximum growing period of perhaps one hundred and ten days. Fort Reliance has had frosts occur as early as the middle of August, with killing frosts before the end of September. Fort Yukon reports killing frosts by the first of September, and Holy Cross Mission, in the western interior, shows the average date of the last spring frosts to be the middle of May, and the first frost in the fall to happen by the end of August, or even earlier, so that the growing season there seems to last scarcely ninety days. In general, it may be concluded that the period of growth for the more tender vegetation of the interior province rarely exceeds fifty days in the eastern part, but increases in length up to perhaps one hundred and twenty days as the western coast is approached, lasting from the middle of June to the middle of August.

Rainfall.—The generally scanty rainfall of the interior is outclassed only by that of the Arctic coast. The most complete records of this element come from Eagle, where an average rainfall of 11.35 inches for the year has been observed. The fragmentary records from other interior stations indicate that Eagle probably has the smallest rainfall of the interior with the exception of Fort Reliance. As a whole, it is clear that the rainfall is least in the extreme eastern portion of the province and increases westward up to a maximum of probably not much over 25 inches in the year. This range in precipitation is also characteristic of that portion of the United States which lies between the Sierra Nevada and the Rocky Mountains north of the latitude of Salt Lake City. Similar conditions also prevail over northern Europe and north-central Asia, as well as most of Canada lying north of the Great Lakes.

The intensity of the rains in this province is much less than that found in the Pacific coast province, as is brought out in the low maximum rainfalls for any twenty-four hours. These rains rarely attain as high an amount as 2 inches, and most of the stations, particularly in the eastern and central portions, show only half of this amount or less. The variation in the maximum amount of rain observed in one day is considerable, ranging from 4.1 inches at Kolmakof down to 0.07 inch at Fort Reliance. This shows that these maximum falls in a day, like the average annual and monthly precipitation, decrease as distance from the coast increases.

The season of heaviest monthly rainfall lasts from June through August over the eastern portion of the province, and from August to November in the central and western areas. The largest number of rainy days occur during August and September, the average rising to sixteen or eighteen. The rain which falls during these months comes in the form of heavy showers and rarely stretches itself over more than twenty-four hours. The months of February and May show the lowest number of rainy days, the averages being from six to eight, and the season with the smallest maximum twenty-four hour rains seems to be from October to June. The incomplete character of the summer records in this province prevents any accurate study of the summer conditions, and the above summary may need very decided revision when better records shall be obtained.

River ice.—The opening and closing of the streams of the interior is best presented in the tabular statement on pages 174–176.

GENERAL CLIMATOLOGIC TABLES.

The following tables present in a compact form some of the results of observations on temperature, frost, rain and snowfall, and the movements of river and harbor ice at forty-six stations in Alaska. In these tables the stations have been grouped by geographic provinces, so that the observations relating to each province may all be under the eye at one time. The geographic coordinates of each station, the organization or organizations under which the observations were made, and other general information are given in the table on page 138, where the stations are arranged in alphabetical order.

Extreme temperatures and

No.	Stations.	January. Max.	January. Min.	January. R.	February. Max.	February. Min.	February. R.	March. Max.	March. Min.	March. R.	April. Max.	April. Min.	April. R.
	Pacific coast.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
1	Fort Tongass	47*	6*	41	45*	23*	22	59*	*− 2**	61	60*	33*	27
2	Fort Wrangell	47*	− 4*	51	58*	2*	56	54*	*−10**	64	64*	24*	40
3	Killisnoo	52	− 2	54	50	*−10*	60	52	− 2	54	63	15	48
4	Juneau (1)	50	*− 4*	54	50	*− 4*	54	50	10	40	63	13	50
5	Juneau (2) (wharf)	44	4	40	50	4	46	61	*− 5*	66	61	28	33
6	Skagway	42	− 4	46	44	− 9	53	63	*−10?*	73	61	16	45
7	Sitka	51*	*− 2**	53	54*	− 3	57	65	− 1	66	70*	19*	51
8	Nuchek (Fort Constantine)	48	20	28	47	16	31	45	27	18	54	27	27
9	Orca	43	5	38	46	8	38	57	*2*	55	64	25	39
10	Fort Liscum	45	*−14*	59	42	−12	54	52	− 8	60	52	2	50
11	Kenai	45	−40	85	45	−32	77	52	−34	86	58	4	54
12	Tyonok	38	*−27*	65	49	−17	66	58	− 9	67	59	1	58
13	Kodiak (1)	51	− 1	52	52	*−10**	62	64	11	53	61	20*	41
14	Kodiak (2) (Woody Island)	49	− 5	54	58	4	54	55	5	50	59	9	50
	Alaska Peninsula.												
15	Ugashik	46	−27	73	51	*−38*	89	55	−36	91	59	11	48
16	Mine Harbor (Herendeen Bay)	....	....	....	....	....	....	....	....	....	....	....	....
17	Coal Harbor (Unga Island)	47	− 9	56	51	*−12*	63	53	−11	64	65*	4	61
18	Morzhovoi	47	12	35	45	6	39	45	*− 3*	48	49	14	35
	Aleutian and Commander islands.												
19	Unalaska	52	16	36	51	9	60	51	*5*	46	59	18	41
20	Atka Island	45	20	25	46	*12*	34	46	21	15	50	21	29
21	Kiska Island	35	17	18	44	*15*	29	43	18	25	50	21	29
22	Attu Island	42	17	25	41	17	24	41	*11*	30	52	26	26
23	Bering Island	37	3	34	43	3	40	39	1	38	40	1	39
	Bering Sea coast.												
24	Fort Alexander	40	−27	67	39	*−30*	69	46	−15	61	48	8	40
25	Carmel Mission (Nushagak)	42	−41	83	....	....	....	62	*−70*	132	47	−15	62
26	Bethel Mission	41	−39	80	35	−29	64	....	....	....	....	....	....
27	St. Michael	44	−47	91	40	*−55*	95	44	−39	83	46	−26	72
28	Omalik (mine)	43?	−33	76	36	*−52*	88	43	−36	79	55	−24	79
	Bering Sea islands.												
29	Gambell (St. Lawrence Island)	32†	−27	59	35*	*−31*	66	**35**	*−31*	66	42*	−18	60
30	St. Paul Island	40*	13	27	39	− 1	40	43*	− 9	52	49*	*−10*	59
	Arctic coast.												
31	Kikiktak (Friends' Mission)	44	< *−50?*	94	34	−45	79	40	−36	76	40	−27	67
32	Point Hope (mission at Tikira)	23	−34*	57	6*	*−41*	47	38*	−39	77	35	−32	67
33	Utkiavi (Cape Smyth)	20	−49	69	24	−53	77	26	−51	77	32	−35	67
	Interior stations.												
34	Fort Reliance	20	*−80*	100	27	−72	99	45	−36	81	59	−10	69
35	Camp Davidson	25	*−49*	74	21	−39	60	30	−30	60	46	− 5	51
36	Eagle (Fort Egbert)	23	*−75*	98	38	−74	112	56	−56	112	59	−12	71
37	Circle	28	*−55*	83	28	*−55*	83	38	*−55*	93	48	−22	70
38	Camp Colonna	19	*−49*	68	35	−47	82	33	−48	81	51	−28	79
39	Rampart	19	*−68*	87	42	−48	90	....	....	....	....	....	....
40	Tanana (1) (Fort Adams)	34	*−76*	110	38	−60	98	46	−38	84	53	−14	67
41	Tanana (2) (Fort Gibbon)	....	*−63*	....	....	*−11*	....	....	*−43*	....	....	*−15*	....
42	Nulato (St. Peter Mission)	23	*−62*	85	29	−60	89	44	−33	77	50	−23	73
43	Anvik	35	−39	74	37	*−53*	90	46	−43	89	46	−25	71
44	Holy Cross (mission)	41	−55	96	41	*−57*	98	47	−55	102	50	−31	81
45	Ikogmut	39?	−48	87	36	−49	85	49	−35	84	53	−16	69
46	Kolmakof	43	*−58*	101	42	−44	86	44	−36?	80	49	−12	61
	Copper River Plateau.												
47	Copper Center	....	....	....	....	....	....	....	....	....	....	....	....

NOTE.—Italic figures denote minimum observed for station; heavy faced, maximum observed.

ranges in Alaska Territory.

No.	Stations.	May. Max.	May. Min.	May. R.	June. Max.	June. Min.	June. R.	July. Max.	July. Min.	July. R.	August. Max.	August. Min.	August. R.
	Pacific coast.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
1	Fort Tongass	70*	38*	32	**75***	43*	32	**91***	52*	39	81*	47*	34
2	Fort Wrangell	78*	35*	43	**86***	38*	48	82*	44	38	84	43	41
3	Killisnoo	76	24	52	76	33	43	**84**	38	46	81	36	45
4	Juneau (1)	71	26	45	82	38?	44	**88**	38	50	82	38	44
5	Juneau (2) (wharf)	69	29	40?	80	36	44	**86**	40	46	71	39	32
6	Skagway	79	25	54	90	34	56	**92**	39	53	80	32	48
7	Sitka	80	28	52	80*	33	47	**87***	35	52	82*	39	43
8	Nuchek (Fort Constantine)	58	30	28	**70**	39	31	69	47	22	**70**	46	24
9	Orca	64	28	36	77	35	42	**86**	33	53	78	40	38
10	Fort Liscum	62	25	37	**79**	32	47	77	32	45	70	30	40
11	Kenai	63	20	43	79	26	53	**82**	30	52	73	28	45
12	Tyonok	68	22	46	82	33	49	**83?**	38	45	73	31	42
13	Kodiak (1)	62	20*	40	76	34	42	**82**	40*	42	75	41	34
14	Kodiak (2) (Woody Island)	71	20	51	**82**	37	45	**82**	40	42	77	41	36
	Alaska Peninsula.												
15	Ugashik	63?	20?	43	83	29	54	78	31	47	**86**	32	54
16	Mine Harbor (Herendeen Bay)	....	....	....	....	....	....	....	....	....	62	42	20
17	Coal Harbor (Unga Island)	67*	12	55	71	15	56	**79**	37	42	75*	33	42
18	Morzhovoi	>51?	<25?	26?	....	....	....	**78**	37?	41?	68	42	26
	Aleutian and Commander islands.												
19	Unalaska	60	24	36	68	34	34	**78**	37	41	**78**	36	42
20	Atka Island	65	24	41	72	28	44	**76**	35	41	72	39	33
21	Kiska Island	50?	37?	13	**70**	35	35	67	38	29	64	38	26
22	Attu Island	....	....	....	....	....	....	....	....	....	**66**	38	28
23	Bering Island	56*	23	33	61*	31	30	**63**	36	27	63	37	26
	Bering Sea coast.												
24	Fort Alexander	67	7	60	**78**	32?	46	69	36	33	**78**	42	36
25	Carmel Mission (Nushagak)	65	23	42	**81**	35	46	78	38	40	....	....	....
26	Bethel Mission	....	....	....	....	....	....	....	....	....	....	....	....
27	St. Michael	56	− 3	59	66	22	44	**77**	33	44	69	32	**37**
28	Omalik (mine)	63	16	47	....	....	....	....	....	....	....	....	....
	Bering Sea islands.												
29	Gambell (St. Lawrence Island)	45	3	42	**62**	15	47	59	30	29	59	25	34
30	St. Paul Island	52*	19	33	**63***	31	32	59	35	24	56	40	16
	Arctic coast.												
31	Kikiktak (Friends' Mission)	61	−15	76	72	27	45	**81**	32	49	67	26	41
32	Point Hope (mission at Tikira)	55*	−12	67	58*	21	37	56*	26	30	**62***	36*	26
33	Utkiavi (Cape Smyth)	42	−14	56	61	18	43	**65**	27	38	59	26?	33?
	Interior stations.												
34	Fort Reliance	**76**	16	60	....	....	....	....	....	....	....	....	....
35	Camp Davidson	74	8	66	84	30	54	**87**	35	52	74	31	43
36	Eagle (Fort Egbert)	82	10	72	**87**	26	61	82	31	51	80	24	56
37	Circle	78	6	72	84	32	52	88	39	49	**90**	26	64
38	Camp Colonna	68	15	53	79	26	53	**85**	36	49	....	....	....
39	Rampart	....	....	....	....	....	....	....	....	....	....	....	....
40	Tanana (1) (Fort Adams)	72	11	61	....	....	....	....	....	....	**79**	28	51
41	Tanana (2) (Fort Gibbon)	....	22	....	....	....	....	....	....	....	....	36?	....
42	Nulato (St. Peter Mission)	**71**	7	64	....	....	....	....	....	....	....	....	....
43	Anvik	**67**	14	53	....	....	....	....	....	....	65?	40	25
44	Holy Cross (mission)	65	− 4	69	81	24	57	**83**	31	52	75?	30	45
45	Ikogmut	72	14?	58	....	....	....	....	....	....	**76?**	29?	47
46	Kolmakof	56?	19	47	....	....	....	67	35	32	**(75)**	17	58
	Copper River Plateau.												
47	Copper Center	....	....	....	....	....	....	**94**	38	56	85	28	57

Extreme temperatures and ranges

No.	Stations.	September.			October.			November.			December.		
		Max.	Min.	R.	Max.	Min.	R.	Max.	Min.	R.	Max.	Min.	R.
	Pacific coast.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.
1	Fort Tongass	67*	38*	29	58*	37*	21	51*	32*	19	47*	24*	23
2	Fort Wrangell	73	38*	35	67*	31*	36	53	4*	49	52*	− 3*	55
3	Killisnoo	69	27	42	60	25	35	53	1	52	54	1	53
4	Juneau (1)	85	31	54	66	20	46	60	− 1	61	45	1	44
5	Juneau (2) (wharf)	65	34	31	65	23	42	56	10	46	54	8	46
6	Skagway	76	30	46	60	16	44	51	7	44	57	− 4	61
7	Sitka	74*	32	42	67*	25	42	59*	5*	54	59	7*	52
8	Nuchek (Fort Constantine)	....	....	....	65	22	43	45	*10*	35	41	13	28
9	Orca	74	31	43	59	25	34	48	11	37	48	7	41
10	Fort Liscum	64	25	39	53	18	35	45	0	45	41	−13	54
11	Kenai	65	16	49	60	−10	70	44	−26	70	45	*−43*	88
12	Tyonok	70	25	45	61	10	51	44	13	31	49	−21	70
13	Kodiak (1)	68?	36	32	59	30	29	53	15	38	50	− 6	56
14	Kodiak (2) (Woody Island)	72	36	36	66	22	44	54	9	45	49	*−12*	61
	Alaska Peninsula.												
15	Ugashik	75	22	53	56	0	56	46	−27	73	46	−26	72
16	Mine Harbor (Herendeen Bay)	62	32	30	....	....	....	....	....	....	....	....	....
17	Coal Harbor (Unga Island)	72*	10	62	60	15	45	59	14	45	50	− 2	52
18	Morzhovoi	61	36	25	51	28?	23	50	23	27	46	10	36
	Aleutian and Commander islands.												
19	Unalaska	68	33	35	62	26	36	54	19	35	50	12	38
20	Atka Island	62	34	28	54	28	26	49	22	27	45	*12*	33
21	Kiska Island	62	29	33	54	24	30	47	18	29	42	18	24
22	Attu Island	58	36	22	49	30	19	46	25	21	44	22	22
23	Bering Island	59*	30	29	51	18	33	44	7	37	41	*− 1*	42
	Bering Sea coast.												
24	Fort Alexander	71	21	50	65	9	56	47	−12	59	43	−29	72
25	Carmel Mission (Nushagak)	....	....	....	....	....	....	....	....	....	....	....	....
26	Bethel Mission	....	....	....	....	....	....	35	−38	73	35	*−51*	86
27	St. Michael	69	21	48	60	6	54	43	−22	65	45	−43	88
28	Omalik (mine)	....	....	....	36?	− 2	38?	32?	−29	61?	....	−29	....
	Bering Sea islands.												
29	Gambell (St. Lawrence Island)	50	21	29	44†	12	32	36	−19	55	33†	−16?	49?
30	St. Paul Island	54	31	23	56*	25	31	43	18	25	42	4	38
	Arctic coast.												
31	Kikiktak (Friends' Mission)	63	11	52	45	−14	59	38	−26	64	29	−40	69
32	Point Hope (mission at Tikira)	60*	29	31	39	− 1	40	34	−21	55	28*	−36	64
33	Utkiavi (Cape Smyth)	52	20	32	42?	−22	64?	30	−36	66	14	*−55*	69
	Interior stations.												
34	Fort Reliance	67	12	55	55	−11	66	36	−50	86	34	−69	103
35	Camp Davidson	66	14	52	52	4	48	34	−35	69	17	*−49*	66
36	Eagle (Fort Egbert)	78	8	70	68	−28	96	39	−52	91	39	−68	107
37	Circle	84	2	82	(38)	(−12)	50	28	−52	80	32	−53	85
38	Camp Colonna	....	....	....	34	− 6	40	35	−36	71	17	−43	60
39	Rampart	....	(22?)	....	45	−12	57	28	−52	80	30	−53	83
40	Tanana (1) (Fort Adams)	72	12	60	54	−21	75	36	−53	89	17	−68	85
41	Tanana (2) (Fort Gibbon)	....	23	....	53	− 9	62	15	−45	59	25	*−64*	89
42	Nulato (St. Peter Mission)	....	....	....	47	−13	60	28	−36	64	31	−54	85
43	Anvik	66	11	55	51	−18	69	41	−35	76	25	−44	69
44	Holy Cross (mission)	68	14	54	57	−14	71	44	−25	69	48	−50	98
45	Ikogmut	68?	24	44	50	− 5	55	41	−34	75	42	*−53?*	95?
46	Kolmakof	68	5	63	59	−14	73	39	−41	80	41	−53	94
	Copper River Plateau.												
47	Copper Center	68	19	49	66	1	67	32	−46	78	34	*−53*	87

in Alaska Territory—Continued.

No.	Stations.	Length of record. Years.	Mos.	Dates of records.
	Pacific coast.			
1	Fort Tongass	2	4	June, 1868, to Sept., 1870.
2	Fort Wrangell	1	51	June to Aug., 1868; Apr., 1869, to Sept. 26, 1870; Feb., 1875, to June 14, 1877; Aug. 25 to Dec., 1881; Feb. to Mar., June to Aug., 1882.
3	Killisnoo	17	32	May, 1881, to Feb., 1885; June to Oct., 1885; Mar. to Dec., 1886; Jan. to Mar., Sept. to Dec., 1888; Jan., 1889, to Dec., 1902.
4	Juneau (1)	2	38	June, 1881, to Mar., 1882; May, 1883, to Oct., 1884; Nov. 13, 1889, to Jan., 1892; Nov. 16, 1894, to Jan., 1895; June 17–Sept., 1895; Sept., 1896, to Feb., 1897.
5	Juneau (2) (wharf)	4	1	Dec., 1898, to Dec., 1902.
6	Skagway	0	31	Nov., 1898, to July, 1899; Sept., 1899, to Aug., 1900; Sept., Oct., 1901; May to Dec., 1902.
7	Sitka	17	44	Nov., 1867, to May, 1877; Apr., 1881, to Sept., 1887; July, 1898, to Feb., 1899; May, 1899, to Dec., 1902.
8	Nuchek (Fort Constantine)	0	11	Oct., 1883, to Aug. 31, 1884.
9	Orca	0	31	June, 1899, to May, 1900; Oct. 7, 1900, to Mar., 1901; July, 1901, to Mar., 1902; Sept. 17 to Dec., 1902.
10	Fort Liscum	2	0	Jan., 1901, to Dec., 1902.
11	Kenai	4	12	May to Aug. and Oct. to Dec., 1899; Jan., 1900, to Dec., 1902. (Min. also Jan., 1885, to May, 1886.)
12	Tyonok	4	2	Nov., 1898, to Dec., 1902.
13	Kodiak (1)	0	23	Nov., 1895, to Aug., 1896, and Nov., 1898, to Nov., 1899.
14	Kodiak (2) (Woody Island)	0	22	Jan., 1900, to Dec., 1902; missing are Sept., 1900, and Oct., 1902.
	Alaska Peninsula.			
15	Ugashik	2	3	Nov. 11, 1883, to Dec. 13, 1885; Aug., 1883.
16	Mine Harbor (Herendeen Bay)	0	2	Aug. and Sept., 1902.
17	Coal Harbor (Unga Island)	10	26	Sept., 1889, to Sept., 1890; Aug., 1891, to Sept., 1902.
18	Morzhovoi	0	18	Nov., 1881, to May 7, 1882; July, 1882, to May 24, 1883.
	Aleutian and Commander islands.			
19	Unalaska	4	10	July, 1881, to Apr., 1886.
20	Atka Island	3	16	May 7, 1879, to Aug., 1879; Oct., 1881, to May 12, 1885; May, 1886 to Aug., 1886.
21	Kiska Island	0	11½	May 13, 1885, to Apr. 30, 1886.
22	Attu Island	0	9	Aug., 1880, to Apr. 30, 1881.
23	Bering Island	2	24	June, 1882, to May, 1886.
	Bering Sea coast.			
24	Fort Alexander	2	25	Aug., 1881, to June, 1883; June 15, 1884, to June 12, 1886.
25	Carmel Mission (Nushagak)	0	6	1902.
26	Bethel Mission	0	4	Nov., 1885, to Feb., 1886.
27	St. Michael	7	27	Aug., 1877, to Dec., 1878; July, 1880, to June, 1886; Oct., 1899, to July, 1901.
28	Omalik (mine)	0	12	Jan. 20 to May, and Oct. 18 to Dec., 1884; Jan. to Apr. 16, 1885.
	Bering Sea islands.			
29	Gambell (St. Lawrence Island)	2	32	Oct., 1894, to Sept., 1897; Nov., 1898, to June, 1899; Oct., 1901, to Sept., 1902.
30	St. Paul Island	1	31	Oct., 1869, to June, 1870; May 1–15, 1878, to May, 1879; June, 1881, to May, 1883.
	Arctic coast.			
31	Kikiktak (Friends' Mission)	3	9	Sept. 1?, 1897, to May, 1901.
32	Point Hope (mission at Tikira)	1	12	Aug., 1894, to July, 1896.
33	Utkiavi (Cape Smyth)	1	22	Oct. 17, 1881, to Aug. 6, 1883; Sept., 1901, to Aug., 1902.
	Interior stations.			
34	Fort Reliance	0	18	Sept., 1882, to May 8, 1883; Sept. 17, 1885, to May 29, 1886.
35	Camp Davidson	0	13	May, 1890, to May, 1891.
36	Eagle (Fort Egbert)	0	58	Oct., 1882, to May 9, 1883; Aug. 22, 1884, to May 12, 1885; Aug. 16, 1885, to May 19, 1886; Aug. 15, 1899, to Dec., 1900; Nov. and Dec., 1901; Feb. to Dec., 1902.
37	Circle	1	20	Dec. 15, 1896, to June, 1898; Nov., 1898, to Sept., 1899; July, Aug., 1900.
38	Camp Colonna	0	10	Oct. 13, 1889, to July 14, 1890.
39	Rampart	0	6	Oct. 1 to 23 and Nov., 1900, to Feb., 1901; Jan., 1902; (22?) is for Sept. 25 to 30, 1901 only.
40	Tanana (1) (Fort Adams)	0	27	Aug., 1882, to May 22, 1883; Sept., 1883, to Mar., 1884; Aug. 18, 1885, to May, 1886.
41	Tanana (2) (Fort Gibbon)	0	13	Aug., 1901, to May, 1902; Oct. to Dec., 1902.
42	Nulato (St. Peter Mission)	0	12	Oct., 1894, to May, 1895; Jan. to Apr., 1896.
43	Anvik	0	28	Sept., 1882, to May, 1885.
44	Holy Cross (mission)	6	20	Oct., 1893, to June, 1894; Sept., 1894, to Aug., 1901.
45	Ikogmut	0	25	Aug. 18, 1883, to May, 1884; Aug. 16 to 31, and Nov. 9, 1884, to May, 1885; Sept., 1885, to May, 1886.
46	Kolmakof	0	30	Aug., 1883, to Aug. 8, 1884; Aug. 25, 1885, to May 14, 1886.
	Copper River Plateau.			
47	Copper Center	0	5½	July 18 to Dec. 31, 1902.

* Indicates record from observations at 7*a*, 2*p*, 9*p*. † Indicates record from observations at 8*a*, 8*p*.

Mean precipitation, including melted snow, and the mean number of

No.	Stations.	January.		February.		March.		April.	
		Days.	Mean total.	Days.	Mean total.	Days.	Mean total.	Days.	Mean total.
	Pacific coast.								
1	Fort Tongass	18.5	12.92	21.5	10.79	17.5	8.21	19.0	9.57
2	Fort Wrangell	17.6	6.07	20.0	8.11	12.6	*2.89*	16.6	4.11
3	Killisnoo	18.0	5.98	14.9	4.96	15.0	4.04	11.0	*a3.50*
4	Juneau (1)	18.1	10.61	11.2	*4.85*	18.7	6.62	15.0	5.25
5	Juneau (2) (wharf)	20.0	8.77	11.7	4.38	14.2	4.62	17.0	7.04
6	Skagway	7.5	0.90	2.5	*0.57*	3.0	0.64	10.5	2.39
7	Sitka	16.8	**12.17**	15.9	7.47	18.0	6.70	16.2	5.61
8	Nuchek (Fort Constantine)	23.0	**27.07**	8.0	9.15	21.0	18.02	18.0	16.92
9	Orca	16.0	12.66	8.3	6.40	11.0	11.08	b22.0	b16.35
10	Fort Liscum	17.5	9.67	5.0	1.04	14.5	5.54	9.0	4.50
11	Kenai	5.3	0.78	4.4	*0.70*	7.4	0.97	6.4	0.83
12	Tyonok	7.7	2.15	5.7	0.65	4.5	0.71	4.0	0.88
13	Kodiak (1)	16.0	4.82	14.0	4.44	11.0	4.17	14.0	2.92
14	Kodiak (2) (Woody Island)	12.7	3.15	14.7	4.26	14.7	5.21	10.5	*2.93*
	Alaska Peninsula.								
15	Ugashik	14.0	1.44	7.0	*0.49*	16.0	1.04	14.0	1.14
16	Mine Harbor (Herendeen Bay)	......	......	......	......	......	......	......	......
17	Coal Harbor (Unga Island)	14.5	3.96	d13.0	d4.23	14.0	4.26	13.2	5.12
18	Morzhovoi	13.0	7.51	6.5	2.94	4.0	2.20	5.0	1.47
	Aleutian and Commander islands.								
19	Unalaska	26.8	**17.94**	21.0	9.82	22.2	7.76	24.8	9.69
20	Atka Island	21.5	9.05	15.5	6.47	12.0	5.22	15.2	6.66
21	Kiska Island	10	2.06	7	*0.93*	9	3.40	11	2.25
22	Attu Island	24	5.29	15	3.01	22	2.60?	16	*2.16*
23	Bering Island	15.7	*0.70*	13.0	1.59	12.5	0.91	11.5	1.13
	Bering Sea coast.								
24	Fort Alexander	14.2	**3.19**	7.5	*1.07*	14.5	3.06	10.5	1.67
25	Carmel Mission (Nushagak)	8	1.98	......	......	11	......	8	......
26	Bethel Mission	6	......	6	......	......	......	......	......
27	St. Michael	8.1	0.85	5.5	*0.24*	7.4	0.52	7.8	0.36
28	Omalik (mine)	3	0.40	3	0.32	3.5	0.15	4	0.07
	Bering Sea islands.								
29	Gambell (St. Lawrence Island)	8	......	8.6	......	11.0	......	10.8	......
30	St. Paul Island	21.0	3.62	15.0	1.59	16.5	2.45	15.5	1.87
	Arctic coast.								
31	Kikiktak (Friends' Mission)	......	......	......	......	......	......	......	......
32	Point Hope (mission at Tikira)	2.0	0.05	1.5	*0.03*	3.0	0.49	5.0	0.27
33	Utkiavi (Cape Smyth)	3.7	*0.19*	5.3	0.36	6.6	0.23	6.6	0.32
	Interior stations.								
34	Fort Reliance	5.5	**1.00**	6.5	0.76	4.5	0.23	2.5	*0.07*
35	Camp Davidson	16	0.59	14	0.86	6	*0.22*	9	0.61
36	Eagle (Fort Egbert)	6.2	0.43	5.8	0.55	4.8	*0.39*	8.6	0.76
37	Circle	......	......	......	......	......	......	......	......
38	Camp Colonna	14	0.68	16	**2.08**	12	0.81	4	*0.12*
39	Rampart	......	......	......	......	......	......	......	......
40	Tanana (1) (Fort Adams)	11.0	1.69	8.6	0.85	13.0	0.68	3.5	*0.44*
41	Tanana (2) (Fort Gibbon)	......	......	......	......	......	......	......	......
42	Nulato (St. Peter Mission)	5.0	0.68	7.0	0.91	12.5	**1.46**	>2	*>0.16*
43	Anvik	15.6	1.33	6.0	*0.37*	15.3	1.44	7.6	0.54
44	Holy Cross (mission)	8.0	......	6.6	......	10.6	......	7.4	......
45	Ikogmut	13.0	1.02	7.3	*0.57*	14.7	1.32	11.0	0.63
46	Kolmakof	10.3	1.29	6.0	*0.52*	14.0	1.18	9.3	0.88
	Copper River Plateau.								
47	Copper Center	......	......	......	......	......	......	......	......

a For 13 years only. b For 1900 only. d For 8 years.

NOTE.—Italic figures, minimum for year; heavy faced, maximum for year.

days with 0.01 inch or more precipitation, for each month and the year.

No.	Stations.	May.		June.		July.		August.	
		Days.	Mean total.	Days.	Mean total.	Days.	Mean total.	Days.	Mean total.
	Pacific coast.								
1	Fort Tongass	15.5	7.70	10.3	*6.66*	16.6	10.58	9.6	6.71
2	Fort Wrangell	18.6	3.71	13.7	3.56	15.8	3.69	14.3	3.07
3	Killisnoo	12.3	3.38	9.9	*2.36*	11.7	4.19	16.5	4.90
4	Juneau (1)	16.7	7.36	14.6	4.99	15.5	5.59	15.6	7.53
5	Juneau (2) (wharf)	15.5	4.28	12.7	*3.09*	11.0	3.96	20.2	9.39
6	Skagway	4.7	0.77	5.0	0.60	5.7	1.73	8.5	1.51
7	Sitka	16.1	4.11	13.6	*3.31*	14.9	3.55	16.8	5.84
8	Nuchek (Fort Constantine)	18.5	18.92	10.5	*4.17*	18.5	9.93	13.0	14.13
9	Orca	[b]20.0	[b]13.70	[b]11.0	[b]4.59	11.0	*4.34*	20.5	19.13
10	Fort Liscum	9.9	2.26	8.0	*0.68*	14.5	4.21	28.5	12.38
11	Kenai	6.4	1.01	5.1	0.73	8.9	1.69	13.4	**3.31**
12	Tyonok	3.7	*0.44*	4.2	0.61	8.2	2.09	17.7	4.71
13	Kodiak (1)	14.0	4.97	9.0	2.11	7.0	*0.80*	10.0	2.37
14	Kodiak (2) (Woody Island)	15.0	5.21	8.7	3.13	11.3	4.02	17.3	4.64
	Alaska Peninsula.								
15	Ugashik	[c]17.0	[c]1.50	11.5	1.14	25.5	2.90	23.5	3.51
16	Mine Harbor (Herendeen Bay)								
17	Coal Harbor (Unga Island)	11.8	*2.49*	10.4	*2.49*	10.6	2.81	13.6	3.74
18	Morzhovoi	[e]8.0	[e]5.56			[f]5.0	[f]2.67	11.0	5.02
	Aleutian and Commander islands.								
19	Unalaska	17.2	5.20	11.2	4.94	14.8	*2.97*	15.2	3.39
20	Atka Island	15.8	6.14	13.6	4.50	12.6	5.28	14.6	5.67
21	Kiska Island	6?	3.94?	10	3.38	12	6.39	13	**8.10**
22	Attu Island							13	4.62
23	Bering Island	8.5	0.96	12.5	1.67	15.7	2.46	16.0	2.09
	Bering Sea coast.								
24	Fort Alexander	14.2	2.43	13.0	1.88	16.7	4.13	14.0	4.49
25	Carmel Mission (Nushagak)	10	1.30	2	0.40	14	3.00		
26	Bethel Mission								
27	St. Michael	9.1	1.27	10.4	1.45	13.6	2.53	16.7	3.27
28	Omalik (mine)	2	*0.02*						
	Bering Sea islands								
29	Gambell (St. Lawrence Island)	6.8		6.0		8.0		11.3	
30	St. Paul Island	21.3	2.12	8?	*1.13*	10.0	2.77	14.0	3.39
	Arctic coast.								
31	Kikiktak (Friends' Mission)								
32	Point Hope (mission at Tikira)	3.5	0.21	3.5	0.51	8.0	0.88	11.5	1.02
33	Utkiavi (Cape Smyth)	*6.6*	0.25	9.0	0.47	11.6	**1.34**	10.0	*0.97*
	Interior stations.								
34	Fort Reliance	6.0	0.69?						
35	Camp Davidson	7	0.56	11	2.21	14	1.74	16	**2.96**
36	Eagle (Fort Egbert)	6.5	0.76	9.5	1.36	13.0	**2.22**	13	1.99
37	Circle			4	0.54	8.5	1.98	9	**2.72**
38	Camp Colonna	4	0.60	5	0.27				
39	Rampart								
40	Tanana (1) (Fort Adams)	12.0	1.51					16.0	2.16
41	Tanana (2) (Fort Gibbon)								
42	Nulato (St. Peter Mission)	4	0.36						
43	Anvik	7.0	0.63					[h]13	[h]**2.75**
44	Holy Cross (mission)	5.1		8.7		12.0		18.6	
45	Ikogmut	9.0	1.79					8.5	
46	Kolmakof							19.0	**7.36**
	Copper River Plateau.								
47	Copper Center							12.0	1.08

[b] For 1900 only. [c] For 26 days only. [e] May 1 to 24, 1883. [f] July 8 to 31, 1882. [h] August, 1883.

Mean precipitation, including melted snow, and the mean number of days with

No.	Stations.	September.		October.		November.		December.	
		Days.	Mean total.	Days.	Mean total.	Days.	Mean total.	Days.	Mean total.
	Pacific coast.								
1	Fort Tongass	19.3	**17.66**	20.0	14.11	27.0	15.46	19.0	13.33
2	Fort Wrangell	17.2	6.63	13.2	7.36	17.8	**11.27**	22.5	10.41
3	Killisnoo	19.3	7.79	22.3	**7.92**	16.9	5.16	17.6	4.81
4	Juneau (1)	18.4	**12.19**	19.8	10.05	18.4	10.47	19.8	8.16
5	Juneau (2) (wharf)	20.5	11.39	20.0	**11.47**	15.0	7.51	17.6	8.37
6	Skagway	13.5	3.47	12.0	3.22	8.0	2.17	11.7	**3.78**
7	Sitka	19.5	9.67	21.7	11.96	19.5	9.80	18.9	7.88
8	Nuchek (Fort Constantine)	19.0	22.96	22.0	21.50	13.0	10.51	19.0	16.81
9	Orca	16.5	20.81	20.2	**21.98**	12.7	9.21	13.5	11.05
10	Fort Liscum	22.5	14.22	22.0	**14.25**	11.5	6.63	13.0	5.95
11	Kenai	11.7	2.46	10.0	2.06	7.4	1.13	6.0	0.88
12	Tyonok	14.2	**4.86**	12.2	4.15	6.5	0.88	7.2	1.31
13	Kodiak (1)	12.0	1.95	18.0	6.31	18.0	**6.52**	18.0	5.72
14	Kodiak (2) (Woody Island)	10.0	5.98	21.0	**8.95**	9.5	3.55	15.0	7.91
	Alaska Peninsula.								
15	Ugashik	24.0	**5.52**	23.0	2.70	15.5	1.42	16.5	1.61
16	Mine Harbor (Herendeen Bay)	......	......	......	......	......	......	......	......
17	Coal Harbor (Unga Island)	15.9	4.58	16.4	5.33	14.4	**5.51**	13.8	4.31
18	Morzhovoi	13.0	7.51	a 15.0	a **10.26**	17.0	7.92	8.5	1.45
	Aleutian and Commander islands.								
19	Unalaska	23.2	9.85	26.4	14.58	23.4	10.95	24.6	13.99
20	Atka Island	19.0	*3.01*	21.2	10.32	18.0	**11.58**	17.2	7.77
21	Kiska Island	7.0	4.31	19	7.67	22	6.28	17	2.55
22	Attu Island	15	4.06	15	**8.91**	20	6.46	22	6.52
23	Bering Island	13.5	2.50	17.7	2.60	16.5	**2.96**	17.0	1.62
	Bering Sea coast.								
24	Fort Alexander	18.5	**4.98**	11.0	1.99	11.5	2.84	9.0	1.36
25	Carmel Mission (Nushagak)								
26	Bethel Mission	......	......	......	......	4	......	5	......
27	St. Michael	18.5	**4.02**	11.4	1.70	11.4	1.15	6.9	0.75
28	Omalik (mine)	......	......	......	0.23	3?	**0.45**	3?	0.18
	Bering Sea islands.								
29	Gambell (St. Lawrence Island)	11.5	......	6.6	......	10.8	......	12.0	......
30	St. Paul Island	19.5	**6.91**	22.0	6.06	22.7	5.39	21.5	3.38
	Arctic coast.								
31	Kikiktak (Friends' Mission)	......	......	......	......	......	......	......	......
32	Point Hope (mission at Tikira)	13.0	1.48	7.0	0.25	2.5	0.75	3.5	**1.63**
33	Utkiavi (Cape Smyth)	10.5	0.61	7.0	0.75	6.3	0.39	4.3	0.26
	Interior stations.								
34	Fort Reliance	5.0	0.80?	3.5	0.37	8.0	0.73	5.0	0.43
35	Camp Davidson	16	2.41	6	*0.22*	13	0.72	7	0.33
36	Eagle (Fort Egbert)	9.8	1.07	7.8	0.80	7.0	0.57	5.7	0.45
37	Circle	......	......	......	......	......	......	......	......
38	Camp Colonna	......	......	......	......	8	*0.41*	14	**1.17**
39	Rampart	......	......	......	......	......	......	......	......
40	Tanana (1) (Fort Adams)	14.0	1.48	16.0	**2.49**	12.5	2.33	10.0	0.82
41	Tanana (2) (Fort Gibbon)	......	......	17	1.57	2	0.14	14	1.36
42	Nulato (St. Peter Mission)	......	......	8	1.36	6	1.20	8	1.42
43	Anvik	11	2.04	12.6	1.19	13.3	1.43	......	......
44	Holy Cross (mission)	16.3	......	13.3	......	9.8	......	11.0	......
45	Ikogmut	18.0	3.07	22.0	**3.67**	15.0	3.10	11.5	1.07
46	Kolmakof	17.7	3.70	15.0	1.58	13.0	2.82	9.3	1.80
	Copper River Plateau.								
47	Copper Center	7	0.73	8	2.02	4	1.50	2	0.20

a October 1 to 27, 1882.

0.01 inch or more precipitation, for each month and the year—Continued.

No.	Stations.	Year. Days.	Year. Mean total.	Length of record. Years.	Length of record. Months.	Limiting dates.
	Pacific coast.					
1	Fort Tongass	213.8	133.10	2	4	June, 1868, to Sept., 1870.
2	Fort Wrangell	199.9	70.88	0	40	June to Aug., 1868; Apr., 1869, to Sept., 1870; Feb., 1875, to May, 1877; Sept., 1881, to Aug., 1882.
3	Killisnoo	185.4	58.97	13	11	Jan., 1889, to Dec., 1902.
4	Juneau (1)	201.8	93.06	2	35	June, 1881, to Mar., 1882; May, 1883, to Oct., 1884; Dec., 1889, to Jan., 1892; Dec., 1894, to Jan., 1895; July to Sept., 1895; Sept., 1896, to Feb., 1897.
5	Juneau (2) (wharf)	195.4	84.27	4	1	Dec., 1898, to Dec., 1902.
6	Skagway	92.6	21.75	0	30	Nov., 1898, to July, 1899; Sept., 1899, to Aug., 1900; Oct., 1901; May to Dec., 1902.
7	Sitka	207.9	88.10	17	42	Sept., 1867, to May, 1877; Apr., 1881, to Sept., 1887; July, 1898, to Dec., 1902.
8	Nuchek (Fort Constantine)	203.5	**190.09**	0	16	May, 1883, to Aug., 1884.
9	Orca	*b* 175.0	*b* 129.31	1	18	Oct., 1899, to Mar., 1901; July, 1901, to Mar., 1902; Oct. to Dec., 1902.
10	Fort Liscum	175.0	81.33	2	0	Jan., 1901, to Dec., 1902.
11	Kenai	92.4	16.55	5	26	Sept., 1882, to May, 1886; May, 1899, to Dec., 1902; June, 1884, and Sept., 1899, missing.
12	Tyonok	95.8	23.44	4	2	Nov., 1898, to Dec., 1902.
13	Kodiak (1)	161	>45.00	0	13	Nov., 1898, to Nov., 1899.
14	Kodiak (2) (Woody Island)	160.4	58.94	0	17	Jan. 5, 1900, to Aug., 1900; Nov., 1900, to Mar., 1901; May, 1901, to Aug., 1902.
	Alaska Peninsula.					
15	Ugashik	207.5	24.41	2	0	Jan., 1884, to Dec., 1885.
16	Mine Harbor (Herendeen Bay)	....	....	....	....	
17	Coal Harbor (Unga Island)	161.6	48.78	9	0	Jan., 1894, to Dec., 1902.
18	Morzhovoi	106	....	....	17	Nov., 1881, to Apr., 1882; July 8, 1882, to May 24, 1883.
	Aleutian and Commander islands.					
19	Unalaska	**250.8**	111.08	4	10	July, 1881, to Apr., 1886.
20	Atka Island	196.2	81.67	3	14	June, 1879, to Aug., 1879; Oct., 1881, to Apr., 1885; May to Aug., 1886.
21	Kiska Island	143	>60.30	0	11½	May 13, 1885, to Apr., 1886.
22	Attu Island	....	....	0	9	Aug., 1880, to Apr., 1881.
23	Bering Island	170.1	21.19	2	23	June, 1882, to Apr., 1886.
	Bering Sea coast.					
24	Fort Alexander	154.6	33.09	2	23	Aug., 1881, to June, 1883; July, 1884, to May, 1886.
25	Carmel Mission (Nushagak)	....	....	0	6	Jan., and Mar. to July, 1902.
26	Bethel Mission	....	....	0	4	Nov., 1885, to Feb., 1886.
27	St. Michael	126.8	18.11	7	6	Aug., 1877, to Dec., 1878; July, 1880, to June, 1882; Sept., 1882, to June, 1886.
28	Omalik (mine)	....	....	0	9½	Feb. to May, and Oct. 18 to Dec., 1884; Jan. to Mar., 1885.
	Bering Sea islands.					
29	Gambell (St. Lawrence Island)	116.4	....	2	32	Oct., 1894, to Sept., 1897; Nov., 1898, to June, 1899; Oct., 1901, to Sept., 1902; days with rain are recorded.
30	St. Paul Island	207.0	40.68	1	29	Oct., 1869, to June, 1870; Oct., 1878, to May, 1879; June, 1881, to May, 1883.
	Arctic coast.					
31	Kikiktak (Friends' Mission)	....	....	....	....	
32	Point Hope (mission at Tikira)	64.0	7.57	1	12	Aug., 1894, to July, 1896.
33	Utkiavi (Cape Smyth)	*87.5*	*6.14*	1	21	Nov., 1881, to July, 1883; Sept., 1901, to Aug., 1902.
	Interior stations.					
34	Fort Reliance	....	>5.08	....	16	Sept., 1882, to Apr., 1883; Oct., 1885, to May, 1886.
35	Camp Davidson	....	>13.43	....	13	May, 1890, to May, 1891.
36	Eagle (Fort Egbert)	97.7	11.35	0	52	Oct., 1882, to Apr., 1883; Sept., 1884, to Apr., 1885; Sept., 1885, to Apr., 1886; Sept., 1899, to Dec., 1900; Nov. and Dec., 1901; Feb. to Dec., 1902.
37	Circle	....	....	0	5	June, 1897; June, 1898; July, 1897; July, 1900; Aug., 1900.
38	Camp Colonna	....	>6.14	0	8	Nov., 1889, to June, 1890.
39	Rampart	....	....	....	....	
40	Tanana (1) (Fort Adams)	....	>15.45	0	26	Aug., 1882, to Apr., 1883; Sept., 1883, to Mar., 1884; Sept., 1885, to May, 1886.
41	Tanana (2) (Fort Gibbon)	....	....	0	3	Oct., to Dec., 1902.
42	Nulato (St. Peter Mission)	....	>7.55	0	10	Oct., 1894, to May, 1895; and Jan. 3 to Mar., 1896.
43	Anvik	....	>11.72	0	26	Sept., 1882, to May, 1885; June, July, and Aug., missing, except Aug., 1883.
44	Holy Cross (mission)	127.4	21.0±	6	11	Oct., 1893, to June, 1894; Sept., 1894, to Sept., 1896; June, 1897, to May, 1899; Aug., 1899, to Aug., 1901.
45	Ikogmut	....	>16.24	0	22	Sept., 1883, to May, 1884; Sept. to Oct., 1884; Jan. to May, 1885; Oct., 1885, to May, 1886.
46	Kolmakof	....	>21.13	0	24	Aug., 1883, to July, 1884; Sept., 1885, to Apr., 1886. (Very incomplete.)
	Copper River Plateau.					
47	Copper Center	....	>5.53	0	5	1902.

b For 1900 only.

Maximum precipitation, in

No.	Station.	January.	February.	March.	April.	May.	June.	July.
	Pacific coast.							
1	Fort Tongass	3.58	*1.02*	1.50	1.80	1.30	2.16	1.60
2	Fort Wrangell	1.50	**3.70**	*1.00*	1.99	2.03	1.70	1.66
3	Killisnoo	1.80	2.30	*1.10*	1.30	1.85	1.20	**2.50**
4	Juneau (1)	2.55	2.44	1.93	1.57	*1.41*	>1.75?	1.87
5	Juneau (2) (wharf)	3.17	1.60	1.60	2.58	*1.02*	1.10	2.00
6	Skagway	*0.21*	0.52	0.90	0.90	0.45	0.35	0.92
7	Sitka	3.84	5.00	3.14	4.40	3.04	2.23	*1.31*
8	Nuchek (Fort Constantine)	5.18	4.59	3.07	*2.95*	4.00	3.49	4.49
9	Orca	2.60	2.70	5.24	[a] 1.75	[a] 2.33	[a] *1.45*	2.08
10	Fort Liscum	1.85	0.70	2.54	1.30	1.59	*0.21*	1.93
11	Kenai	0.70	*0.61*	1.12	0.76	1.01	0.55	0.84
12	Tyonok	1.00	*0.50*	0.64	0.75	0.63	0.70	0.85
13	Kodiak (1)	0.84	0.77	1.29	0.57	**1.38**	0.76	*0.37*
14	Kodiak (2) (Woody Island)	1.00	1.40	**1.50**	1.00	**1.50**	*0.88*	1.00
	Alaska Peninsula.							
15	Ugashik	0.37	*0.22*	0.41	0.25	[b] 0.46	0.54	0.65
16	Mine Harbor (Herendeen Bay)							
17	Coal Harbor (Unga Island)	1.42	1.80	*1.25*	**5.00**	2.00	2.00	2.00
18	Morzhovoi	1.75	1.64	1.45	1.20	[c] 1.50		[d] 1.10
	Aleutian and Commander islands.							
19	Unalaska	**5.58**	4.66	3.86	4.16	3.28	3.19	2.49
20	Atka Island	2.20	*1.75*	2.40	1.80	2.60	2.15	**3.35**
21	Kiska Island	0.54	*0.28*	1.80	0.35	1.65?	0.80	**2.00**
22	Attu Island	0.66	0.68	*0.22?*	0.44			
23	Bering Island	*0.40*	1.05	0.86	0.59	0.66	0.47	**1.55**
	Bering Sea coast.							
24	Fort Alexander	1.14	0.72	1.17	0.81	0.85	0.82	0.93
25	Carmel Mission (Nushagak)	0.50		0.65	**0.74**	0.35	*0.28*	0.67
26	Bethel Mission							
27	St. Michael	0.79	0.27	0.39	*0.21*	0.86	0.80	1.47
28	Omalik (mine)	0.22	0.20	**0.08**	0.08	*0.01*		
	Bering Sea islands.							
29	Gambell (St. Lawrence Island)							
30	St. Paul Island	**1.90**	0.75	0.55	0.75	0.64		[e] 0.53?
	Arctic coast.							
31	Kikiktak (Friends' Mission)							
32	Point Hope (mission at Tikira)	*0.04*	*0.04*	0.54	0.17	0.14	0.42	0.47
33	Utkiavi (Cape Smyth)	0.19	0.19	*0.12*	0.21	0.14	0.24	**0.69**
	Interior stations.							
34	Fort Reliance	0.31	0.30	0.17	*0.07*	0.21		
35	Camp Davidson	0.11	0.20	*0.09*	0.23	0.24	0.59	0.29
36	Eagle (Fort Egbert)	*0.30*	0.47	0.43	0.41	0.39	0.64	0.52
37	Circle						0.30	0.65
38	Camp Colonna	0.21	**0.93**	0.17	*0.08*	0.55	0.16	
39	Rampart							
40	Tanana (1) (Fort Adams)	1.00	0.84	0.18	*0.11*	0.36		
41	Tanana (2) (Fort Gibbon)							
42	Nulato (St. Peter Mission)	0.38	0.45	0.42	0.24	*0.12*		
43	Anvik	**1.10**	*0.13*	0.47	0.28	0.37	0.25?	
44	Holy Cross (mission)	1.11	0.60?	0.98	0.45	*0.36*	**1.60?**	0.71
45	Ikogmut	0.28	*0.18*	0.54	0.23	>0.67?		
46	Kolmakof	0.66	1.03	*0.35*	0.50	0.64		0.47
	Copper River Plateau.							
47	Copper Center							

[a] For 1900 only. [b] For 26 days only. [c] For May 1 to 24, 1883. [d] For July 8 to 31, 1882. [e] For 29 days, July, 1876.

inches, in twenty-four hours.

No.	Station.	August.	September.	October.	November.	December.	Length of record. Years.	Months.
	Pacific coast.							
1	Fort Tongass	3.20	3.10	**5.15**	2.15	1.70	2	4
2	Fort Wrangell	1.08	2.00	3.12	3.15	**2.11**	0	40
3	Killisnoo	1.35	1.90	2.15	2.20	1.60	13	11
4	Juneau (1)	**3.95**	2.37	2.00	>3.10?	2.01	2	35
5	Juneau (2) (wharf)	1.94	**4.00**	2.30	2.97	2.41	4	1
6	Skagway	0.53	0.90	1.00	0.63	**1.72**	0	30
7	Sitka	4.79	3.79	**6.55**	5.05	2.82	17	42
8	Nuchek (Fort Constantine)	3.60	3.35	4.37	3.50	3.15	0	16
9	Orca	3.42	6.70	**7.41**	3.02	3.25	1	18
10	Fort Liscum	1.60	2.08	2.05	**3.80**	1.66	2	0
11	Kenai	1.20	*0.64*	**1.77**	0.83	0.93	5	25
12	Tyonok	**2.00**	1.10	1.90	0.88	1.40	4	2
13	Kodiak (1)	0.68	0.48	**1.38**	1.35	0.84	0	13
14	Kodiak (2) (Woody Island)	*1.00*	1.05	*1.35*	*0.80*	1.25	0	17
	Alaska Peninsula.							
15	Ugashik	1.11	**1.20**	0.55	0.53	0.40	2	0
16	Mine Harbor (Herendeen Bay)	....	....	....	....	....	....	....
17	Coal Harbor (Unga Island)	1.90	1.90	2.05	2.07	1.35	9	0
18	Morzhovoi	1.60	**2.07**	*f* 1.75	2.00	*0.40*	0	17
	Aleutian and Commander islands.							
19	Unalaska	*1.98*	2.65	5.38	4.73	5.56	4	10
20	Atka Island	1.95	2.16	2.30	3.20	2.95	3	14
21	Kiska Island	1.58	1.15	**2.00**	1.30	0.85	0	11½
22	Attu Island	1.14	1.36	**1.93**	1.08	0.72	0	9
23	Bering Island	**1.12**	0.94	1.13	1.17	0.65	2	23
	Bering Sea coast.							
24	Fort Alexander	**2.72**	1.16	0.79	1.28	*0.66*	2	23
25	Carmel Mission (Nushagak)	....	....	....	....	....	0	6
26	Bethel Mission	....	....	....	....	....	0	4
27	St. Michael	**2.65**	1.95	1.85	0.95	1.14	7	6
28	Omalik (mine)	....	....	....	**0.22**	0.12	0	9½
	Bering Sea islands.							
29	Gambell (St. Lawrence Island)	....	....	....	....	....	2	32
30	St. Paul Island	....	*0.50*	1.62	0.65	1.61	1	29
	Arctic coast.							
31	Kikiktak (Friends' Mission)	....	....	....	....	....	....	....
32	Point Hope (mission at Tikira)	0.39	0.73	0.14	1.33	**1.75**	1	12
33	Utkiavi (Cape Smyth)	0.30	0.29	0.53	0.20	0.21	1	21
	Interior stations.							
34	Fort Reliance	....	**0.35?**	0.17	0.30?	0.30?	0	16
35	Camp Davidson	0.75	**1.05**	*0.08*	0.16	0.10	0	13
36	Eagle (Fort Egbert)	**0.75**	0.47	0.47	0.35	*0.23*	0	52
37	Circle	**0.80**	....	....	....	....	0	5
38	Camp Colonna	....	....	....	0.14	0.28	0	8
39	Rampart	....	....	....	....	....	....	....
40	Tanana (1) (Fort Adams)	0.37	1.13	**3.05**	1.98	1.06	0	26
41	Tanana (2) (Fort Gibbon)	....	....	0.23	*0.10*	0.34	0	3
42	Nulato (St. Peter Mission)	....	....	**0.61**	0.31	0.42	0	10
43	Anvik	*g* 0.44	0.71	0.26	0.42	0.27?	0	26
44	Holy Cross (mission)	1.43	1.20	1.40?	0.71	1.03?	6	11
45	Ikogmut	>0.70?	>**1.29?**	0.98	0.75	0.42	0	22
46	Kolmakof	2.03	1.10	0.59	*h* **4.10**	3.03	0	24
	Copper River Plateau.							
47	Copper Center *i*	0.38	0.27	0.45	**1.20**	*0.10*	0	5

f For October 1 to 27, 1882. *g* For 1883 only. *h* From November, 1882. *i* For 1902 only.

Maximum, minimum, and mean number of rainy days (i.

No.	Stations.	January.			February.			March.			April.			May.		
		Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean
	Pacific coast.															
1	Fort Tongass	22	15	18.5	26	17	21.5	18	17	17.5	23	15	19.0	16	15	15.5
2	Fort Wrangell	21	16	17.6	25	13	20.0	17	7	*12.6*	21	13	16.6	25	12	18.6
3	Killisnoo	25	9	18.0	23	7	14.9	27	7	15.0	21	3	*11.0*	19	6	12.3
4	Juneau (1)	30	9	18.1	14	6	*11.2*	24	15	18.7	17	11	15.0	25	11	16.7
5	Juneau (2) (wharf)	23	16	20.0	17	8	11.7	18	10	14.2	23	13	17.0	18	12	15.5
6	Skagway	8	7	7.5	3	2	*2.5*	4	2	3.0	8	13	10.5	7	3	4.7
7	Sitka	24	6	16.8	26	7	15.9	29	9	18.0	24	10	16.2	26	6	16.1
8	Nuchek	......	......	23	......	......	*8*	......	......	21	......	......	18	22	15	18.5
9	Orca	16	16	16	11	4	*8.3*	22	1	11.0	......	......	[b] **22**	......	......	[b] 20
10	Fort Liscum	......	......	17.5	......	......	*5.0*	......	......	14.5	......	......	9.0	......	......	9.0
11	Kenai	9	0	5.3	9	1	*4.4*	14	3	7.1	11	4	6.4	9	2	6.4
12	Tyonok	9	6	7.7	9	3	5.7	6	2	4.5	6	2	4.0	5	1	*3.7*
13	Kodiak (1)	......	......	16	......	......	14	......	......	11	......	......	14	......	......	14
14	Woody Island	......	......	12.7	......	......	14.7	......	......	14.7	......	......	10.5	......	......	15.0
	Alaska Peninsula.															
15	Ugashik	......	......	14.0	......	......	*7.0*	......	......	16.0	......	......	14.0	......	......	17.0
16	Mine Harbor	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
17	Coal Harbor	20	9	14.5	[e] 19	[e] 6	[e] 13.0	20	9	14.0	20	6	13.2	19	6	11.8
18	Morzhovoi	......	......	13.0	......	......	6.5	......	......	*4.0*	......	......	5.0	......	......	[g] 8.0
	Aleutian and Commander islands.															
19	Unalaska	28	26	**26.8**	26	15	21.0	25	18	22.2	27	19	24.8	24	11	17.2
20	Atka Island	27	19	**21.5**	20	11	15.5	19	7	*12.0*	27	11	15.2	22	12	15.8
21	Kiska Island	......	......	10	......	......	7	......	......	9	......	......	11	......	......	*6?*
22	Attu Island	......	......	**24**	......	......	15	......	......	22	......	......	16	......	......	......
23	Bering Island	20	12	15.7	19	8	13.0	15	10	12.5	18	7	11.5	13	10	*8.5*
	Bering Sea coast.															
24	Fort Alexander	23	5	14.2	12	0	*7.5*	18	10	14.5	16	5	10.5	18	11	14.2
25	Carmel Mission	......	......	8	......	......	......	......	......	11	......	......	8	......	......	10
26	Bethel Mission	......	......	6	......	......	6	......	......	......	......	......	......	......	......	......
27	St. Michael	13	2	8.1	12	0	*5.5*	14	1	7.4	16	1	7.8	14	5	9.1
28	Omalik (mine)	......	......	3	......	......	3	......	......	3.5	......	......	4	......	......	2
	Bering Sea islands.															
29	Gambell	12	4	8.0	15	3	8.6	18	7	11.0	23	4	10.8	12	2	6.8
30	St. Paul Island	25	19	21.0	19	12	15.0	16	12	16.5	21	7	15.5	26	10	21.3
	Arctic coast.															
31	Kikiktak	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
32	Point Hope	2	2	2.0	2	1	*1.5*	3	3	3.0	9	1	5.0	7	0	3.5
33	Utkiavi (Cape Smyth)	6	0	*3.7*	12	2	5.3	12	1	6.6	11	0	6.6	15	0	6.6
	Interior stations.															
34	Fort Reliance	9	2	5.5	10	3	6.5	7	2	4.5	4	1	*2.5*	6	6	6.0
35	Camp Davidson	......	......	16	......	......	14	......	......	*6*	......	......	9	......	......	7
36	Eagle (Fort Egbert)	8	3	6.2	9	0	5.8	8	2	*4.8*	13	6	8.6	7	6	6.5
37	Circle	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
38	Camp Colonna	......	......	14	......	......	**16**	......	......	12	......	......	*4*	......	......	*4*
39	Rampart	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
40	Fort Adams	14	5	11.0	11	5	8.6	13	6	13.0	6	1	*3.5*	12	12	12.0
41	Fort Gibbon	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
42	Nulato	5	0	5.0	8	6	7.0	16	9	**12.5**	>3	2	*>2*	......	......	4.0
43	Anvik	22	8	**15.6**	9	3	*6.0*	20	13	15.3	15	4	7.6	8	6	7
44	Holy Cross (mission)	14	1	8.0	11	2	6.6	14	5	10.6	13	3	7.4	11	2	*5.1*
45	Ikogmut	17	9	13.0	9	5	*7.3*	17	13	14.7	16	5	11.0	14	8	9.0
46	Kolmakof	18	2	10.3	11	3	*6.0*	20	8	14.0	17	4	9.3	......	......	......
	Copper River Plateau.															
47	Copper Center	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......

number of days with rain or melted snowfall ≧0.01 inch).

No.	Stations.	June.			July.			August.			September.			October.		
		Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean
	Pacific coast.															
1	Fort Tongass	15	7	10.3	22	13	16.6	18	4	*9.6*	23	9	19.3	22	18	20.0
2	Fort Wrangell	18	6	13.7	20	8	15.8	20	10	14.3	24	14	17.2	17	10	13.2
3	Killisnoo	16	3	*9.9*	21	4	11.7	28	1	16.5	26	14	19.3	28	16	**22.3**
4	Juneau (1)	17	11	14.6	19	13	15.5	20	8	15.6	26	13	18.4	27	8	**19.8**
5	Juneau (2) (wharf)	20	9	12.7	13	7	*11.0*	25	16	20.2	25	16	**20.5**	26	15	20.0
6	Skagway	11	1	5.0	10	3	5.7	17	[a]0	8.5	17	10	**13.5**	16	9	12.0
7	Sitka	20	6	*13.6*	23	8	14.9	28	8	16.8	26	13	19.5	28	13	**21.7**
8	Nuchek	12	9	10.5	23	14	18.5	16	10	13.0			19			22
9	Orca			[b]11	13	9	11.0	22	19	20.5	19	14	16.5	14	25	20.2
10	Fort Liscum			8.0			14.5			**28.5**			22.5			22.0
11	Kenai	11	1	5.1	12	5	8.9	19	8	**13.4**	21	5	11.7	14	3	10.0
12	Tyônok	7	0	4.2	9	5	8.2	20	17	**17.7**	16	11	14.2	15	7	12.2
13	Kodiak (1)			9			*7*			10			12			**18**
14	Woody Island			*8.7*			11.3			17.3			10			**21**
	Alaska Peninsula.															
15	Ugashik			11.5			**25.5**			23.5			24.0			23.0
16	Mine Harbor															
17	Coal Harbor	21	3	*10.4*	15	6	10.6	21	8	13.6	23	11	15.9	20	11	**16.4**
18	Morzhovoi						[c]5.0			11.0			13.0			[c]15.0
	Aleutian and Commander islands.															
19	Unalaska	13	8	*11.2*	18	10	14.8	18	12	15.2	27	19	23.2	30	23	26.4
20	Atka Island	18	10	13.6	20	4	12.6	17	12	14.6	23	16	19.0	23	20	21.2
21	Kiska Island			10			12			13			7			19
22	Attu Island									*13*			15			15
23	Bering Island	20	5	12.5	20	12	15.7	19	11	**16.0**	16	10	13.5	23	12	**17.7**
	Bering Sea coast.															
24	Fort Alexander	14	12	13.0	21	12	**16.7**	15	13	14.0	21	15	18.5	17	4	11.0
25	Carmel Mission			*2*			**14**									
26	Bethel Mission															
27	St. Michael	19	5	10.4	22	5	13.6	25	10	16.7	22	9	**18.5**	23	6	11.4
28	Omalik (mine)															
	Bering Sea islands.															
29	Gambell	13	2	*6.0*	13	5	8.0	20	11	11.3	13	10	11.5	9	3	6.6
30	St. Paul Island	12	3	*8.0?*	15	5	10.0	15	12	14.0	21	18	19.5	29	17	22.0
	Arctic coast.															
31	Kikiktak															
32	Point Hope	4	3	3.5	11	5	8.0	18	5	11.5	15	11	**13.0**	9	5	7.0
33	Utkiavi (Cape Smyth)	10	7	9.0	12	11	**11.6**	15	5	10.0	15	6	10.5	12	2?	7.0
	Interior stations.															
34	Fort Reliance										5	5	5.0	5	2	3.5
35	Camp Davidson			11			14			**16**			**16**			*6*
36	Eagle (Fort Egbert)	13	6	9.5	13	13	**13.0**	16	10	**13.0**	14	7	9.8	10	6	7.8
37	Circle			4			8.5			9						
38	Camp Colonna			5												
39	Rampart															
40	Fort Adams							16	16	**16**	12	8	14.0	20	6	**16.0**
41	Fort Gibbon															17
42	Nulato															8
43	Anvik									[c]13	19	4	11.0	24	5	12.6
44	Holy Cross (mission)	12	6	8.7	18	6	12.0	29	6	**18.6**	20	11	16.3	19	6	13.3
45	Ikogmut									>8.5?	23	7?	18.0	30	3?	**22.0**
46	Kolmakof									**19**	22	12	17.7	27	2	15.0
	Copper River Plateau.															
47	Copper Center									12			7			8

Maximum, minimum, and mean number of rainy days (i. e., number of days with rain or melted snowfall ≧ 0.01 inch).

No.	Stations.	November.			December.			Means.	Length of record.	
		Max.	Min.	Mean.	Max.	Min.	Mean.		Years.	Months
	Pacific coast.									
1	Fort Tongass	27	27	**27.0**	23	15	19.0	213.8	2	4
2	Fort Wrangell	24	13	17.8	27	17	**22.5**	199.9	0	40
3	Killisnoo	28	6	16.9	23	10	17.6	185.4	13	11
4	Juneau (1)	30	4	18.4	24	18	**19.8**	201.8	2	35
5	Juneau (2) (wharf)	18	12	15.0	24	8	17.6	195.4	4	1
6	Skagway	10	4	8.0	20	6	11.7	92.6	0	30
7	Sitka	29	13	19.5	28	9	18.9	207.9	17	42
8	Nuchek (Fort Constantine)			13			19	203.5	0	16
9	Orca	16	7	12.7	15	12	13.5	[b]175.0	1	18
10	Fort Liscum			11.5			13.0	175.0	2	0
11	Kenai	13	4	7.4	12	4	6.0	92.4	5	26
12	Tyonok	7	3	6.5	8	3	7.2	**95.8**	4	2
13	Kodiak (1)			**18**			**18**	[c]161.0	0	13
14	Kodiak (2) (Woody Island)			9.5			15	160.4	0	17
	Alaska Peninsula.									
15	Ugashik			15.5			16.5	[d]207.5	2	0
16	Mine Harbor (Herendeen Bay)									
17	Coal Harbor (Unga Island)	23	6	14.4	22	6	13.8	[f]161.6	9	0
18	Morzhovoi			**17.0**			8.5	106.0?	0	17
	Aleutian and Commander islands.									
19	Unalaska	25	22	23.4	26	23	24.6	[k]**250.8**	4	10
20	Atka Island	22	15	18.0	21	10	17.2	196.2	3	14
21	Kiska Island			**22**			17	[l]>143	0	11½
22	Attu Island			20			**22**	[m]>162	0	9
23	Bering Island	18	13	16.5	25	8	**17.0**	[n]170.1	2	23
	Bering Sea coast.									
24	Fort Alexander	16	7	11.5	14	5	9.0	154.6	2	23
25	Carmel Mission (Nushagak)								0	6
26	Bethel Mission			4			5		0	4
27	St. Michael	19	3	11.4	15	2	6.9	126.8	7	6
28	Omalik (mine)			3?			3?		0	9½
	Bering Sea islands.									
29	Gambell (St. Lawrence Island)	22	5	10.8	15	9	**12.0**	116.4	2	32
30	St. Paul Island	27	15	**22.7**	26	19	21.5	207.0	1	29
	Arctic coast.									
31	Kikiktak (Friends' Mission)									
32	Point Hope (mission at Tikira)	3	2	2.5	5	2	3.5	64.0	1	12
33	Utkiavi (Cape Smyth)	11	2?	6.3	7	2	4.3	87.5	1	21
	Interior stations.									
34	Fort Reliance	11	5	8.0	8	2	5.0		0	16
35	Camp Davidson			13			7		0	13
36	Eagle (Fort Egbert)	11	4	7.0	8	4	5.7	97.7	0	52
37	Circle								0	5
38	Camp Colonna			8			14		0	8
39	Rampart									
40	Tanana (1) (Fort Adams)	14	5	12.5	12	2	10.0	>116	0	26
41	Tanana (2) (Fort Gibson)			2			14		0	3
42	Nulato (St. Peter Mission)			6			8		0	10
43	Anvik	15	11	13.3				>101.4	0	26
44	Holy Cross (mission)	16	5	9.8	16	5	11.0	127.4	6	11
45	Ikogmut	19	11	15	13	10	11.5	>130	0	22
46	Kolmakof	19	7	13	12	7	9.3	>113.6	0	24
	Copper River Plateau.									
47	Copper Center			4			2		0	5

a A trace fell on 4 days.
b For 1900 only.
c Nov., 1898, to Nov., 1899.
d Jan., 1884, to Dec., 1885.
e For 8 years.
f Jan., 1894, to Dec., 1902.
g May 1 to 24, 1883.
h July 8 to 31, 1882.
i Oct. 1 to 27, 1882.
k July, 1881, to Apr., 1886.
l May, 1885, to Apr., 1886.
m Aug., 1880, to Apr., 1881.
n June, 1882, to Apr., 1886.
o For 1883 only.

Last and first frosts at Alaska stations.

Station and year.	Last killing frost.	Last frost.	First frost.	First killing frost.	Growing days.
Pacific coast province.					
Metlakatla:					
1891			Sept. 30		
1892		Apr. 15	Oct. 14	Nov. 17	225
1893	Apr. 6	May 1	Oct. 19	Oct. 30	207
Fort Tongass:					
1868			Nov. 6	Dec. 19	
1869		Mar. 19	Sept. 29	Dec. 17	210
1870		Mar. 14			
Fort Wrangell:					
1869			Sept. 20	Oct. 15	
1875	Mar. 14	Apr. 20	Oct. 5	Oct. 29	229
1876	Apr. 30	June 5	Sept. 14	Oct. 29	182
1882			Oct. 2	Oct. 8	
Juneau:					
1889			Nov. 18		
1890		Mar. 29	Oct. 6		191?
1891		May 2	Sept. 20		141?
1895			Sept. 10	Sept. 19	
1899			Sept. 4		
1900				Sept. 22	
Chilkoot (Portage Bay):					
1881			Oct. 11		
1882			Sept. 6		
Skagway:					
1899		May 9		Sept. 4	117?
1900	Apr. 9				
1902		July 7	Aug. 27		50?
Howkan:					
1882			Sept. 26		
Killisnoo:					
1884			Sept. 13		
1885			Sept. 28	Oct. 12?	
1888			Oct. 15		
1891		May 6	Sept. 27		>143
1892		Mar. 31	Oct. 14		>197
1893		May 2	Oct. 18		>169
1895			Sept. 3	Sept. 12	
1897			Sept. 27		
Sitka:					
1868		Apr. 21			
1869			Sept. 19		

Last and first frosts at Alaska stations—Continued.

Station and year.	Last killing frost.	Last frost.	First frost.	First killing frost.	Growing days.
Pacific coast province—Continued.					
Sitka—Continued.					
1870			Oct. 19		
1871				Oct. 31	
1872				Oct. 7	
1873	May 27		Nov. 5		>162
1881		May 8			
1900	June 1		Aug. 25	Oct. 1	122
1901				Nov. 1	
Fort Liscum:					
1901				Sept. 29	
Nuchek (Port Etches):					
1883			Oct. 5		
Kenai:					
1883			Sept. 14		
1884			Sept. 24		
1899		June 9		Aug. 25	77?
1900			Aug. 14	Aug. 24	
1901			Aug. 18	Nov. 24?	
1902		June 21	Sept. 1	Sept. 15	86?
Kodiak:					
1899			Sept. 6	Oct. 6	
Woody Island (Kodiak):					
1901			Sept. 2		
Alaska Peninsula.					
Coal Harbor (Unga Island):					
1893			Sept. 15		
1894	May 12	June 8	Sept. 17		>128
1895	May 16	June 12	Sept. 18	Oct. 13	150
1896	May 31			Sept. 10	102
1897				Oct. 24	
1898	May 8		Sept. 8		>123
1899				Sept. 17	
1900	May 29		Sept. 10	Sept. 15	109
1901		June 29			
1902			Sept. 22		
Morzhovoi:					
1881			Oct. 29		
Ugashik:					
1884	Apr. 25			Nov. 3	202
1885				Aug. 19	

Last and first frosts at Alaska stations—Continued.

Station and year.	Last killing frost.	Last frost.	First frost.	First killing frost.	Growing days.
Aleutian Islands.					
Unalaska:					
1879		Feb. 14	Oct. 30		
1881			July 21		
Attu Island:					
1880			Sept. 20		136?
1881		May 7			
Bering Sea coast province.					
St. Michael:					
1877			Sept. 13		
1878			Sept. 2	Sept. 30	
1880			Sept. 18		
1881	May 31?		Sept. 14		106?
1900			Sept. 21		
Carmel Mission:					
1902	May 14	May 28?			
Gambell (St. Lawrence Island):					
1895			Aug. 11	Sept. 5	
1902			Sept. 29		
Arctic Ocean coast.					
Point Hope:					
1894			Sept. 13	Oct. 16	
1895				Oct. 15	
Interior province.					
Fort Reliance:					
1885			Aug. 16	Sept. 27	
Camp Colonna:					
1889				Oct. 17	171?
1890		Apr. 29			
Camp Davidson:					
1890	June 27			Aug. 13	47?
1891	June 3				
Eagle:					
1882			Sept. 1		
1884				Aug. 28	
1885	May 11?			Sept. 1	112?
Circle:					
1898				Nov. 28?	
1899			Aug. 19		
Fort Yukon:					
1899				Sept. 1	
1900			Oct. 4	Oct. 6	

Last and first frosts at Alaskan stations—Continued.

Station and year.	Last killing frost.	Last frost.	First frost.	First killing frost.	Growing days.
Interior province—Continued.					
Holy Cross Mission:					
1894			Oct. 3	Oct. 7	
1895			Sept. 7	Sept. 26	
1899			Aug. 3	Sept. 19	
1900	Apr. 30			Aug. 12	104
1901	May 30			Aug. 31	93
Kolmakof:					
1883			Aug. 23		
1884			Aug. 29	Oct. 12?	
1885			Sept. 20		

Dates of opening and closing of certain Alaska streams.

River and station.	Ice began running.	River clear.	Ice began running.	River closed.
Yukon River.				
Fort Reliance:				
1882			Oct. 22	Nov. 2
1883	May 6			
1885			Oct. 17	Nov. 9
1886	May 15			
Eagle:				
1882			Oct. 13	Nov. 5
1883	May 4	May 9		
1884			Oct. 5	Oct. 10
1885	May 8	May 12	Nov. 9	
1886	May 16	May 19		
1902			Oct. 21	Nov. 19
Circle:				
1898	May 13[a]			
Fort Yukon:				
1899			Oct. 3	Oct. 26
1901	May 20			
1902	May 6	May 20		
Fort Gibbon:				
1902			Oct. 25	Nov. 6
Mouth of the Tanana:				
1882			Oct. 15	Oct. 30
1883	May 10	May 13	Oct. 25	Nov. 4

[a] Yukon River opened 13th of May. Water enough for sluicing on Deadwood; also on Mastodon, 20th of May.

Dates of opening and closing of certain Alaska streams—Continued.

River and station.	Ice began running.	River clear.	Ice began running.	River closed.
Yukon River—Continued.				
Mouth of the Tanana—Continued.				
1885			Oct. 14	Nov. 29 [a]
1886	May 18	May 29		
Nulato:				
1894 [b]				Oct. 16
1895	May 22			
Anvik:				
1882			Oct. 26	Oct. 27
1883	May 15	May 22	Oct. 25	Nov. 7
1884	May 17	May 26	Oct. 5	Oct. 12
1885	May 16	May 22		
Anvik River.				
Anvik:				
1882				Oct. 14
1883	May 12		Oct. 24	
1884	May 14	May 16	Sept. 29	Oct. 1
1885	May 8	May 10		
Yukon River.				
Holy Cross Mission:				
1893	May 19			
1894	May 23	June 1	Oct. 14	Oct. 24
1895	May 22	May 30		
1896	May 27	May 29?	Oct. 10	Nov. 3
1897	May 19	May 21?		Oct. 19
1898	Apr. 30?			
1899			Oct. 5	Oct. 29
1900	Apr. 29	May 20	Oct. 16	Oct. 25
1901	June 1	June 3?		
Ikogmut (Russian mission):				
1885			Oct. 15	Oct. 30
1886	May 26	June 6		
Kuskokwim River.				
Kolmakof:				
1883			Oct. 24	
1884			Oct. 12?	
1885		Apr. 28		Nov. 6
1886	May 11	May 18		
Fort Wrangell River.				
Fort Wrangell:				
1882			Oct. 10	

[a] Nov. 9, water rising on Yukon.

[b] Main channel open until Oct. 24.

Dates of opening and closing of certain Alaska streams—Continued.

River and station.	Ice began running.	River clear.	Ice began running.	River closed.
Kenai River.				
Kenai:				
1899			Dec. 4	Dec. 14
1900	Mar. 18	Mar. 29		
Fish River.				
Omalik:				
1884	May 21			Sept. 25
1885	May 9			

Dates of opening and closing of bays and harbors.

Station.	Bay opened.	Bay closed.	Station.	Bay opened.	Bay closed.
Fort Tongass:			St. Michael—Continued.		
1868		Nov. 6	1885	June 30	Nov. 5
Kenai:			1886	June 5	Nov. 13
1883	Feb. 7		1887	June 14	Nov. 2
1889		Dec. 27	1888	June 8	Nov. 18
1900	Mar. 29		1889	June 23	Nov. 16
Coal Harbor (Unga I.):			1890	June 5	Nov. 11
1899	Mar. 13	Dec. 9	1891	June 9	Nov. 14
Carmel:			1892	June 11	Nov. 7
1902	May 8		1893	June 10	Nov. 5
Gambell (St. Lawrence I.):			1894	June 23	Nov. 1
1901		Nov. 9	1895	June 18	Dec. 7
1902	Apr. 22		1896	June 25	Nov. 21
St. Michael:			1897	June 22	Oct. 25
1874		Dec. 3	1898	June 13	Oct. 31
1875	May 25	Nov. 20	1899	June 10	Nov. 7
1876	June 8	Nov. 6	1900	June 8	Nov. 22
1877	June 13	Nov. 15	1901	July 3	Nov. 2
1878	June 15	Nov. 15	Friends' Mission: [a]		
1879	June 9	Nov. 9	1897		Oct. 1
1880	June 27	Dec. 6	1898	June 7	Oct. 20
1881	June 11	Dec. 7	Point Hope: [b]		
1882	June 9	Nov. 25	1894		Nov. 19
1883	June 8	Nov. 21	1895	July 17	
1884	June 10	Oct. 10	1896	Aug. 1	

[a] At Kikiktak, Kotzebue Sound.

[b] Near Tikira. "Usually clear from July 1."

SPECIAL CLIMATOLOGIC TABLES.

OBJECT OF TABLES.

The accompanying special tables relating to Killisnoo, Sitka, and Coal Harbor (Unga Island), pages 179–188, are designed to show certain interesting and important features of the respective local climates, which can be studied only after a continuous record extending over a considerable number of years is available. The immediate purpose is to bring out the most frequently recurring values of certain climatic elements and facilitate their comparison with the so-called "mean values," which are the values usually asked for and presented in climatologic papers.

"SCHEITELWERTE."

The "Scheitelwerte" is defined by Prof. J. Hann as the "Temperature which recurs most frequently within a given period of time."[a] From his discussion of this element the following has been extracted:

"Formerly it has been tacitly assumed that these two quantities [Scheitelwerte and mean value] are the same, as is true in the case of the arithmetical mean of observations or measurements of a quantity whose magnitude is always constant, but the observations are subject to accidental errors. Closer investigation, however, has shown that this is not the case with meteorologic data * * * The frequency of the various temperature groups must be counted from many years of observations, however, before one is able to determine the most frequent group with any degree of certainty. * * * The calculation of the frequency of occurrence of definite temperature groups forms a valuable extension and specialization of our knowledge of the temperature conditions of any locality. The briefest expression of such conditions is given in the means, and the 'Scheitelwerte' can not be substituted for them."[b]

MANNER OF CONSTRUCTING TABLES.

A simple table of this class is presented on page 179, which shows the frequency of various maximum temperatures in each month at Killisnoo. The table as printed consists of a series of 12 columns, one for each month, and a series of horizontal lines, to each of which is assigned a given temperature. To construct this table one proceeds as follows:

Having determined all the observed maximum temperatures by months and years, the number of times each maximum temperature has occurred in any month at a station is then entered on the corresponding lines and proper month column of the table. Thus, it was found that the maximum temperature in January reached 42° in six different years, so this fact was recorded by writing the figure 6 on the line numbered 42° and in the column headed January. This procedure is repeated until the number of times of occurrence of every recorded maximum for each month has been entered. The complete table then presents the appearance of the table on page 179.

[a] Hann, J., Lehrbuch der Meteorologie. Wien, 1902. pp. 113-115.
[b] Hann, J., op. cit., pp. 113-114.

USE OF TABLES.

The usual maximum temperature for any month at Killisnoo during the period covered by the table is shown opposite the largest figure in the column for the proper month.

The table shows also at a glance the highest and the lowest maximum temperatures for the months and for the year and furnishes a basis for judging how frequently these extremes have been reached or even approached. By comparing the number of times of occurrence with the number of years of observation one is enabled to judge more accurately of the chances of a given maximum temperature occurring again. Thus the chances seem to be two to one that the maximum temperature at Killisnoo in January would be 42° rather than 40°. Again, the table shows that in July there is an even chance of the maximum temperature being 71°, or lying between 73° and 74°; whereas the chances of the maximum lying between 71° and 74° far exceed the chances that it will lie between 79° and 80°, and the chances of the temperature again reaching the observed extreme maximum of 84° is seen to be very small.

Tables of similar construction show the frequency of the various minimum temperatures and of the various numbers of rainy days in each month at Killisnoo and at Coal Harbor, and the frequency of various numbers of rainy days at Sitka.

DISCUSSION OF THE FREQUENCY TABLES FOR KILLISNOO.

FREQUENCIES OF MAXIMUM TEMPERATURES.

The table on page 179 shows the following general features: During the period covered by the table the highest temperature reached was 84°, in the month of July, and this once only. The most frequent yearly maximum is seen to have been 71°, characteristic of five years out of the nineteen recorded; but a maximum of either 74° or 75° was reached during seven years out of nineteen. Hence it may be inferred that the maximum for any year is more likely to fall between 74° and 75° than to hit upon 71°.

Some months show the magnitude of the individual frequencies and the magnitude of the sum of several frequencies; the more frequent temperatures tend to fall within certain limits, e. g., 46° to 49° in November. Other months seem characterized by the low magnitudes of the individual frequencies and also by a scattering of them over a greater range, e. g., May. It seems to be a fair and logical interpretation of these features to conclude that future temperature maxima (or minima) will exhibit much the same characters as those of the past, and that one may expect to find the future temperatures coming close to those which in the past have been most often attained. In the case of a month like May at Killisnoo, on the other hand, the table gives no ground for expecting the maximum to fall, with even a moderate degree of certainty, within a group of limited range. Taken month by month the table shows that January is most likely to have a maximum temperature between 39° and 42° (eleven times), preferably 42° (six times), but that there is an almost equal chance for the maximum

Table of frequencies of absolute maximum temperatures at Killisnoo.

[Period covered: May, 1881, to February 23, 1885; June 8, 1885, to October 31, 1885; March–December, 1886; January–March, September–December, 1888, and January 1, 1889, to December 31, 1902.]

° F.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
85													
84							1						1
83													
82													
81								1					
80							1						1
79							2						2
78													
77													
76					1	2							
75							1	2					3
74						3	2	1					4
73							2						
72						1	3	4					1
71					1	2	4	2					5
70						2	1	3					1
69					1	1	1	1	1				
68					1	3		3					1
67							1		2				
66					1		1	1					
65					2	2		1	1				
64					2				3				
63				1	1	1		1	4				
62				1	1				3				
61					2				2				
60					2	2			3	1			
59									1				
58				1					1				
57										2			
56				1	2					3			
55				2	1					3			
54					1					4		1	
53				1						1	1	1	
52	2		1	2						3	1		
51			1							2	2		
50		1	2							2			
49			2								4	1	
48				4							1		
47	2	1		1							5	1	
46			2	2							2		
45		4	3	1							1	2	
44	1	2	2								1	2	
43	1		4								1	2	
42	6	3	2								1	2	
41		5										5	
40	3											3	
39	2	1											
38	1	2											
37	1												
Years observ'd	19	19	19	17	19	19	20	20	21	21	20	20	19

to lie between 37° and 40° (seven times). In February the maximum has most frequently fallen between 41° and 42° (eight times), and almost as frequently (six times) between 44° and 45°, while the extreme of 50° has been reached but once. During March the maximum temperature has occurred by far the largest number of times (thirteen) between 42° and 45°, and has shown very little preference for 43° (four times), while the highest temperature, 52°, has been reached but once. In April the maximum is seen to fall more frequently in the interval between 45° and 48° (eight times) than in any other similar interval. There seem to be two secondary groups, however, with a frequency of three each at 52°–53° and 55°–56°. The extreme maximum of 63° was reached but once. The table shows a very decided rise (12°) in the absolute values of the most frequent maximum temperature on passing from April to May. In the latter month these temperatures show only a moderately developed tendency to group themselves together; the most frequent single maxima occurred only twice each in nineteen years, and these were five in number. The frequency numbers show their strongest grouping (ten times) between 60° and 65°, with a slight tendency to subdivide at 60° to 61° and 64° to 65° (each four times). The extreme maximum was 76° (once).

From June on the maximum temperatures draw together again into more limited and more sharply defined groups. For June they are distinctly grouped between 68° and 71° (eight times), but the most frequent single temperature within the group, viz, 68° (three times), is matched by an isolated maximum of 74° and almost equaled by the extreme maximum, 76° (two times).

The highest maximum temperature for the period of the table was 84°, and occurred in July (once), but the most frequent maxima for this month lie between 71° and 74° (eleven times), with a distinct preference for 71° and 72° (seven times together).

The extreme maximum of August, 81°, is several degrees lower than that for July, as is the grouping of the most frequent maximum, viz, 68° to 72° (thirteen times). The grouping of the frequencies within the latter limits does not show so great a difference from those for July. In August the most frequent single maximum was 72° (four times), 1° higher than that for July, while the general preference seems to have been for the interval 70° to 72° (nine times), or 1° lower than that for July.

The more frequent maximum temperatures now again begin to decrease rapidly. In September they are well grouped between 60° and 64° (fifteen times), with some preference for 63° (four times), and but one occurrence of an extreme maximum of 69° only, and one each of 58° and 59°.

In October the frequencies are not so closely grouped. They come between 57° and 50° (twenty times), with a concentration between 54° (four times) and 55° (three times). The extreme maximum was 60° (once).

November was characterized by a slight scattering of the maxima, shown by the fact that the grouping between 46° and 49° (twelve times) includes little more than one-half the total occurrences for the month. The occurrences outside this group usually have frequencies of only 1, and inside the group are distinctly concentrated at 47° (five times) and 49° (four times).

December shows a somewhat greater scattering of the maxima, the total range being from 54° (once) to 40° (three times), but does not match January in this respect. The table shows, however, that the December maximum has a well-developed tendency to fall between 45° and 40° (sixteen times), with a marked concentration of frequencies at 41° (five times) and 40° (three times).

FREQUENCIES OF MINIMUM TEMPERATURES AT KILLISNOO.

The table of frequencies of absolute minimum temperatures at Killisnoo (p. 182), was constructed on the same principle as the foregoing one. It has somewhat more interest for the farmer since it is the unexpected occurrence of extremely low temperatures which most often plays havoc with his crops.

The column headed "Year" shows that in every one of the twenty years of record the extreme minimum temperature fell as low as 11°, and in fifteen years fell as low as 4° or even lower. The most frequent extreme minimum fell between 4° and 2° (eight times) but this proportion of the total number of years, 40 per cent, is not a sufficient basis for any very positive expectations. The fact of chief importance is that the extreme minimum temperature is sure to fall as low as 11°.

A study of the individual months is best left to the reader, but a few important features may be pointed out. The first feature to attract attention is the marked scattering and small magnitude of the frequencies shown by the minimum temperatures in the winter months, contrasting strongly with the marked grouping and higher magnitudes shown in the summer months. This indicates that the probable extremes of the next winter can not be closely estimated; they have been too uncertain in the past; while the much more important summer minimum can be more closely predicted.

The table shows clearly that all of July and August may be counted upon as safe growing months, for their minimum temperatures very rarely fall below 40° and usually remain closer to 42°. In the spring it is apparent that temperatures injurious to growing plants are sure to be met with through April, and that May is very subject to freezing temperatures, the minimum of this month usually falling between 34° and 29° (fifteen times in nineteen years), and often reaching 32° to 34° (nine times).

Passing to the fall months, the grouping of the minima within well-defined limits during September and October is at once striking. During September the minimum falls most frequently in the group between 37° and 34° (eleven out of twenty-one times), but has also shown preference for 31° (six times); while in October there are two well-defined groups, viz, 32° to 30° (eight times) and 28° to 25° (thirteen times). From these facts it is evident that September is not likely to favor crops for more than half its days, and that October is sure to put a stop to the further maturing of all crops.

Table of frequencies of the absolute minimum temperatures at Killisnoo.

[Periods: May 1, 1881, to February 28, 1885; June 8, 1885, to October 31, 1885; March to December, 1886; January to March and September to December, 1888; and January 1, 1889, to December 31, 1902.]

°F.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
47							1						
46							1						
45							2	1					
44							2						
43							1						
42							6	4					
41						1	1	6					
40						1	4	5					
39						2	1	1					
38						3	1	2	1				
37						3			2				
36						4		1	4				
35						3			3				
34					3	2			2				
33				1	1	1							
32					5					2			
31					2				6	4			
30					2				1	2	1		
29				1	2				1				
28										4		1	
27				3					1	3			
26				4	2					3		1	
25					1					3	1		
24			2	2	1						1	1	
23	1		2	2							1		
22			1	1									
21	1			1							2	1	
20												1	
19		1		1							2		
18			1								3		
17	1		1										
16			1								1	2	
15			3	1							1	1	
14			1								1		
13	2										1	2	
12	1		1								1		
11	2	2											1
10	1	3	1								2	2	1
9	1	2										2	1
8			1									3	1
7		2											1
6	1		1									1	1
5	1												
4	2	2	1										5
3	1	1											1
2		2										1	2
1	2	1									1	1	1
0	1	1	1										1
−1													
−2	1		1										2
−3													
−4													
−5													
−6													
−7													
−8													
−9		1											1
−10		1											1
Years observed	19	19	19	17	19	20	20	20	21	21	19	20	....

FREQUENCIES OF RAINY DAYS AT KILLISNOO.

The foregoing tables deal with the frequency of occurrence of various temperatures, but as no average or mean maximum and minimum temperatures had been calculated there was no opportunity to compare these values, which are the ones usually given, with the most frequently recurring temperatures. In the following table of frequencies of numbers of rainy days at Killisnoo, direct comparison may be made between the most frequent number of rainy days in each month and the "Mean numbers" which are given in the last line of the table.

Table of frequencies of the number of days having 0.01 inch or more of rain at Killisnoo.

[From January 1, 1889, to December 31, 1902. The asterisk (*) indicates mean number of days with rain.]

No. of days.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
31												
30												
29												
28								1		1	1	
27			1							1		
26			1						1	1		
25								1	2	2		
24								1			1	
23	1	2								**3**		2
22	1								1	*1		
21	1		1	1			1			1	2	**3**
20	**3**							1		1		1
19	1	1			1			1	***3**			**3**
18	*1	**3**	1	1				1	**3**		2	*
17	2	1	**2**	1	**2**			**2**	1	1	*	1
16				1	1	1	1	*	1	2	**3**	
15	1	*	*1		**2**	**2**	2		1		2	2
14					1			**2**	1			1
13	1	1	1	**4**			1	1				
12	1	2	**2**		*	**2**	*1				1	
11		1		*		1	**4**				1	
10		1	1		**2**	**2**	1	1				1
9	1				1	*1		1				
8		1	1	1	1		1					
7		1	**2**	2	1	**2**	1					
6				1	1	1					1	
5												
4						1	1	1				
3				1		1						
2												
1												
0												
Years observed	14	14	14	13	14	14	14	14	14	14	14	14
Mean number of days	18.0	14.9	15.0	11.0	12.3	9.0	11.7	16.5	19.3	22.3	16.9	17.6

The table shows two facts very clearly, viz, that the same number of rainy days in a given month recurs much less frequently than does a maximum or a minimum temperature; and second, that the mean number of rainy days does not necessarily coincide with the most frequently recurring number of rainy days. Concerning these relationships between means and "Scheitelwerte" or most frequently recurring values, Professor Hann says[a] that when temperature "Scheitelwerte" for each ten years of observations, or even larger periods, are compared with the corresponding means, there is found to be "extraordinary variations among the 'Scheitelwerte' and a marked coincidence among the means." In April the most frequently recurring number of rainy days is thirteen, while eleven is the mean number of rainy days as calculated in the usual way from the individual observations. According to the usual custom, April of next year should be expected to have about eleven rainy days. A study of the April column, however, in this table shows that one-third of all the observations in April have shown thirteen rainy days as characteristic of April, whereas April has never had eleven rainy days, but has in four years had numbers of rainy days lying between six and eight. Then from the frequencies, as shown in this table, it would seem fair to conclude that the best chance for any given succeeding year is for April to have thirteen rainy days, and that the second best chance is for April to have a number of rainy days lying between six and eight, probably seven, and that there would apparently be no chance for April to have ten, eleven, or twelve rainy days, the number of rainy days lying closest to the so-called mean number of rainy days. We may illustrate this feature of these tables again by considering the number of rainy days in December. The mean, calculated in the usual way, assigns to December 17.6 rainy days. The table of frequencies, however, shows that the most frequent number of rainy days in December lies between nineteen and twenty-one, with preponderating values for nineteen and twenty-one. In other words, the chance would seem to be more in favor of December having twenty rainy days rather than seventeen rainy days at Killisnoo.

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[a] Hann, J., Lehrbuch der Meteorologie, Wien, 1902, p. 115.

FREQUENCY TABLE FOR SITKA.

FREQUENCIES OF RAINY DAYS.

A table similar in character to the last one for Killisnoo has also been constructed for Sitka as follows:

Table of frequencies of the number of days having 0.01 inch or more of rain at Sitka.

[Periods: Nov. 1, 1867, to May 31, 1877; Apr. 1, 1881, to Sept. 30, 1887, and July 1, 1898, to Dec. 31, 1902. The asterisk (*) indicates mean number of days with rain.]

Number of days rain.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
31												
30												
29			1								1	
28								1		2		1
27								1		2		
26		1			1				1	1		
25		1	2					1	2	1	1	**4**
24	1			1					1	1	2	2
23	1						1		1	1	3	1
22	2	1	2	1				1		*1		1
21	1	2	1	1			2	2	2		1	2
20	1	1	1	**3**	**5**	1	2		2	**5**	***4**	
19	**3**	1	**4**	1	1		2	2	**3**	2	1	*1
18	1		*1	1		2			*1		1	1
17	*1	2		**3**	2	1		3	1	1		
16	**3**	*	1	*	***4**	**5**	2	*	**3**		1	1
15		2	1	**3**	1	2	***3**		1	2	2	1
14		2		1	2	*2	2	**4**	2		**3**	1
13	**3**	**3**	1		2	1	1	1	1	1	1	1
12			1	**3**			1	3				
11			1	2	2							1
10	2	1		1			2	1				2
9		1	2			2						1
8						2	2	1				
7		2										
6	1				1	2	1					
5												
4												
3												
2												
1												
Years observed	20	20	19	21	21	20	21	21	21	20	21	21
Mean number of days	16.8	15.9	18.0	16.2	16.1	13.6	14.9	16.8	19.5	21.7	19.5	18.9

This table is for a period of twenty-one years, which coincides in part with the period of fourteen years used in the Killisnoo period. Here, again, the difference between the average number or rainy days and the most frequent number in each month may be seen most clearly in the case of December, but also in October and March.

FREQUENCY TABLES FOR COAL HARBOR, UNGA ISLAND.

Similar tables, compiled for Coal Harbor, are given below:

Table of frequencies of the absolute maximum temperatures at Coal Harbor, Unga Island.

[Occurrence: During the intervals Sept., 1889, to Sept., 1890; and Aug., 1891, to Oct. 15, 1902.]

°F.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
79							1						2
78							1						1
77													
76							*1						1
75								*1					
74													
73							1						1
72							2	1	*1				2
71						1		1					
70								*1					
69						1	2	3					3
68						3	1	1					1
67					*1			1	1				
66						1	1		3				
65				*1		2	1	1	2				1
64								1	3				
63									1				
62					1	1		1	2				
61						1							
60						1		1	*1	1			
59				1						1	1		
58					2					1			
57					4	1							
56											1		
55					1					4			
54					1					3			
53			1	1						2			
52													
51		1									1		
50			1	4	1						2	1	
49		3	1								1		
48		1	5	2						1	3	1	
47	1			1							2	1	
46	2		1	1							*1	3	
45	3	1	1	1	1							1	
44	1	1	1									1	
43		3											
42	4	1		1								1	
41												*1	
40			1									2	
39													
38													
37													
36		1											
35													
34	1												

*Occurrences marked thus indicate temperatures from daily readings at 7 a. m., 2 p. m., and 9 p. m. All others were obtained from self-registering instruments.

Frequencies of absolute (or observed) minimum temperatures at Coal Harbor, Unga Island.

[Periods: Sept. 1, 1889, to Sept. 31, 1890, and Aug. 1, 1891, to Sept. 31, 1902. The asterisk (*) indicates values from daily observations at 7 a. m., 2 p. m., 9 p. m.]

° F.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
50								*1					
45													
44													
43								1					
42							1	**3**					
41													
40							**4**	**3**					
39							3	2					
38						1	3	2					
37						2	1						
36						2			1				
35									**6**				
34									2				
33						1		1	2				
32					1	**3**			2				
31										2			
30						1							
29					**2**	1				1			
28					**2**					2			
27										1			
26										1			
25				1	1					**2**	1		
24					1					2			
23					1								
22				1	1						*1		
21											1	1	
20					1								
19											1	1	
18		1									**3**	1	
17		2		1							2		
16		1		1							2	1	
15			1	1	1	1				1		1	
14											1	1	
13			*1									1	
12			1	**2**	1								
11	1												
10	1		1	1					1				
9			1										
8	*1			*1								1	
7	1		1										1
6		*1		*1								1	
5	1		1	1								1	
4		*1	1	1									
3		2											1
2	1		1										
1	*1											*1	
0	1	1	1										1
− 1													
− 2	1	1										1	2
− 3													
− 4													
− 5	1												
− 6	1		*1										2
− 7													
− 8													
− 9	1												1
−10		1											
−11			1										1
−12		1											1

Table of frequencies of days having 0.01 inch rain or melted snow in each month, and the year, at Coal Harbor, Unga Island.

[From Jan. 1, 1894, to Dec. 31, 1902.]

Number of days.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
25												
24								1				
23									1		1	
22												1
21						1						
20	1		1	1						2		
19		2	2		1					1		1
18	2								2	1	2	
17				1					1	1	1	1
16				1		1		1	1	1	1	
15				1	1		2	1	1		1	1
14	2	2	1	1	3		2	2		1		
13	2	1	1	1				1	1	1		1
12	1	1	1			1			1			1
11			1			2			1	1		1
10				1	1	1	1	1				
9	1		2					1			1	1
8				1	1			1			1	
7		1					3					
6		1		1	2	1	1				1	1
5												
4						1						
3						1						
2												
1												
0												
Mean number days	14.5	13.0	14.0	13.2	11.8	10.4	10.6	13.6	15.9	16.4	14.4	13.8

RAINFALL AT ALASKA STATIONS.

In the rainfall tables the following abbreviations and symbols are used: ( ) inclose figures not used in compiling synoptic tables; ? signifies figures whose accuracy is doubted; $\frac{5\text{–}31}{0.30}$ indicates that the 0.30 inch fell on the days from 5th to 31st, both inclusive; > indicates that the sum following is, from the original records, evidently too small; < indicates that the sum following is probably too large; $\frac{25\text{ da.}}{0.75}$ indicates that the given sum (0.75 inch) is from 25 observations only during the month and therefore incomplete; $^{R}2.65$ indicates that the number shows only *rainfall*, snowfall *not* included; [0.73], an interpolated mean. Where the fragments of two successive years overlap by one or more months, as in the case of Nuchek, the averages only of the duplicating months were used in determining the annual rainfall.

Summary of records of precipitation (in inches) at stations in Alaska.

ANVIK.

[Lat. 62° 37′ N. Long. 160° 08′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1882	......	......	......	......	......	......	......	......	(12 da / 0.48)	0.86	2.20	(20 da / 0.17)	......
1883	1.27	0.26	29 da 1.70	0.40	27 da 0.51	......	......	(11-31 / 2.75)	3.33	2.43	1.40	(18 da / 0.30)	......
1884	2.10	0.34	0.83	0.25	0.91	(1-9 / 0.46)	......	......	4-30 2.31	0.29	0.68	(1-17 / 0.56)	......
1885	0.32	0.52	1.78	0.98	0.47	......	......	......	......	......	......	......	......

ATKA ISLAND.

[Lat. 52° 15′ N. Long. 174° 15′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1879	......	......	......	......	7-31 4.49	1.76	4.25	8.01	......	......	......	......	......
1881	......	......	......	......	......	......	......	......	......	6.30	10.90	13.46	......
1882	11.45	8.20	8.40	5.40	4.47	4.40	4.63	5.43	9.16	12.18	8.87	2.52	85.11
1883	7.65	3.43	3.60	4.86	8.19	4.20	3.88	4.83	9.71	10.05	14.72	8.85	83.97
1884	8.01	10.31	7.14	5.97	6.46	5.10	11.62	3.78	8.20	12.74	11.85	6.26	97.44
1885	9.10	3.94	1.76	10.41	(1-12 / 2.56)	......	......	......	......	......	......	......	......
1886	......	......	......	......	7.08	7.07	2.01	6.30	......	......	......	......	......

ATTU ISLAND.

[Lat. 52° 58′ N. Long. 172° 26′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1880	......	......	......	......	......	......	(22-31 / 0)	4.62	4.06	8.91	6.46	6.52	......
1881	5.29	3.01	2.60?	2.16	(1-12 / 1.20)	......	......	......	......	......	......	......	......

BERING ISLAND.

[Lat. 52° 12′ N. Long. 165° 55′ E.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1882	......	......	......	......	(22-31 / 0)	2.07	1.45	1.07	1.32	3.29	2.23	2.21	......
1883	0.61	2.98	0.61	1.03	0.38	2.71	2.09	3.43	3.67	2.52	2.16	1.72	23.91
1884	0.94	1.49	1.44	1.38	1.31	0.26	2.27	1.71	1.70	3.26	3.39	0.96	20.11
1885	0.58	0.39	0.25	0.86	1.19	1.63	4.05	30 da 2.15	3.32	1.34	4.08	1.61	21.45
1886	0.66	1.50	1.33	1.25	(1-6 / 0)	......	......	......	......	......	......	......	......

CAMP COLONNA.

[Lat. 67° 25′ N. Long. 141° 00′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1889	......	......	......	......	......	......	......	......	......	(13-31 / 0.17)	0.41	1.17	......
1890	0.68	2.08	0.81	0.12	0.60	0.27	(1-14 / 0.01)	......	......	......	......	......	......

Summary of records of precipitation (in inches) at stations in Alaska—Continued.

CAMP DAVIDSON.

[Lat. 64° 40′ N. Long. 141° 00′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1890					0.63	2.21	1.74	2.96	2.41	0.22	0.72	0.33	13.42
1891	0.59	0.86	0.22	0.61	0.48	$\left(\frac{1-21}{0.48}\right)$							

CARMEL MISSION (NUSHAGAK).

[Lat. 58° 57′ N. Long. 158° 21′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1902	1.98		2.17?	>2.11	1.30	0.40	3.00						

CHERNOFSKI.

[Lat. 53° 25′ N. Long. 167° 14′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1881										7.24	6.76	>6.50	

CHILKAT (PYRAMID HARBOR).

[Lat. 59° 20′ N. Long. 135° 25′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1883					0.84	2.66	1.60	2.19	5.11	1.98	4.79	6.89	
1884	3.30	4.90	5.75	[a]0.98	2.94	1.05	1.14	1.52	2.44	2.58	7.17	5.23	39.00
1885	0.68	0.93	1.80	0.71	0.08	0.32	0.01	0.31	0.45	3.36	1.14	1.51	11.30
1886	0.76	4.99	0.21	0.09	0.32	0.12							

CHILKOOT (PORTAGE BAY).

[Lat. 59° 26′ N. Long. 136° 28′ W. Station probably located near the present Haines Mission.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1881									$\left(\frac{18-31}{2.28}\right)$	7.63	5.95	7.68	
1882	8.77	18.99	1.34	3.04	1.55	2.45	1.95	2.94	8.00	7.55	10.31	5.52	72.41
1883	1.29	5.48	5.93	1.13									
1886							0.22	0.29	0.85	1.07	0.70	0.18	

CIRCLE.

[Lat. 65° 50′ N. Long. 144° 04′ W. The accuracy of queried values is doubtful; they are one-tenth of recorded snowfalls.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1897	(1.53?	0.10?	0. ?	1.10?	1.45?)	0.70	2.30	(1.50?	1.65?	1.15?	0.10?	0.40?)	
1898	(0.20?	0.40?	1.60?	0.75?	0.75?)	0.39					(0.50?	0.40?)	
1899	(0.41?	0.10?	0.20?)										
1900							1.66	2.72					

COAL HARBOR, UNGA ISLAND.

[Lat. 55° 20′ N. Long. 160° 38′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1893												5.94	
1894	3.05	1.56	2.74	0.91	5.20	4.40	0.88	5.17	4.21	4.48	5.89	5.55	44.04
1895	2.94	3.68	5.42	8.00	2.09	1.69	2.46	3.17	2.03	8.15	7.30	4.46	51.39
1896	1.02	6.08	4.80	1.69	2.74	2.15	3.93	6.79	11.41	5.23	2.60	3.79	52.23
1897	4.90	5.00?	2.88	3.85	0.71	2.35	1.70	1.46	3.76	6.82	12.90	6.82	53.15
1898	6.59	1.39	8.70	3.21	2.02	7.08	3.59	2.23	1.07	0.73	0.64?	3.71?	40.96
1899	3.30	3.77	4.28	1.82	3.72	0.39	6.51	4.42	4.99	5.06	1.91	1.25	41.42
1900	3.37	5.41	2.22	18.28	2.24	1.88	2.91	5.74	4.65	5.36	7.98	3.21	63.25
1901	3.95	6.57	1.99	3.55	0.67	2.21	1.64	1.63	2.80	7.45	3.54	8.87	44.87
1902	6.54	4.64	5.34	4.77	2.98	0.33	1.70?	3.05	5.88	4.74	6.87	1.20	48.04

[a] The exposure of the rain gage changed on the 1st of this month.

Summary of records of precipitation (in inches) at stations in Alaska—Continued.

COPPER CENTER.

[Lat. 61° 58′ N. Long. 145° 20′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1902	...	...	...	...	...	...	$\left(\frac{18\text{–}31}{0.90}\right)$	1.08	0.73	2.02	1.50	0.20	...

EAGLE.

[Lat. 64° 45′ N. Long. 141° 10′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1882	...	...	...	...	...	...	...	...	...	0.58	0.38	0.69	...
1883	0.74	0.45	1.01	0.44	$\left(\frac{1\text{–}9}{0}\right)$	...	...	...	...	...	...	...	...
1884	...	...	...	...	...	...	...	$\left(\frac{22\text{–}31}{0.36}\right)$	1.65	0.27	0.87	0.40	...
1885	0.28	0.70	0.41	0.92	$\left(\frac{1\text{–}12}{0.21}\right)$	...	...	$\left(\frac{16\text{–}31}{0.48}\right)$	0.96	1.32	1.27	0.22	...
1886	0.19	1.23	0.36	1.19	$\left(\frac{1\text{–}19}{0.47}\right)$	...	...	...	...	...	...	...	...
1899	...	...	...	...	...	...	...	$\left(\frac{16\text{–}31}{1.63}\right)$	0.39	0.65	0.52	0.26	...
1900	0.52	0.39	0.02	0.42	0.84	1.57	1.88	2.71	1.72	1.23	0.21	0.77	12.28
1901 [a]	...	...	...	...	...	...	...	...	...	...	0.24	0.19	...
1902 [a]	...	T.	0.17	0.84	0.64	1.15	2.56	1.28	0.65	0.77	0.62	0.51	(>9.19)

FORT ALEXANDER.

[Lat. 58° 57′ N. Long. 158° 21′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1881	...	...	...	...	...	...	...	2.86	3.75	1.91	3.38	1.44	...
1882	4.80	1.42	2.72	0.47	1.76	1.18	2.86	3.90	5.33	3.58	6.53	2.10	36.65
1883	6.63	1.24	4.21	1.49	2.46	2.24	...	...	...	...	...	...	} 35.05
1884	...	...	...	...	...	$\left(\frac{15\text{–}30}{0.10}\right)$	6.10	2.19	6.69	0.33	1.04	0.43	}
1885	0.26	0.00	2.45	3.41	3.12	2.21	3.43	8.99	4.16	2.13	0.43	1.46	32.05
1886	1.06	1.63	2.85	1.31	2.39	$\left(\frac{1\text{–}12}{0.62}\right)$	...	...	...	...	...	...	...

FORT LISCUM.

[Lat. 61° 05′ N. Long. 146° 20′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1901	9.40	0.80	6.38	6.20	1.45	1.13	4.77	16.20	12.72	10.31	6.28	7.47	83.11
1902	9.94	1.28	4.70	2.80	3.08	0.24	3.65	8.56	15.72	18.20	6.98	4.43?	79.58

FORT RELIANCE.

[Lat. 64° 10′ N. Long. 139° 30′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1882	...	...	...	...	...	...	...	...	0.80	0.26	0.75	0.44	...
1883	1.61	0.27	0.32	0.07	$\left(\frac{1\text{–}8}{0.00}\right)$	...	...	...	...	...	...	...	...
1885	...	...	...	...	...	...	...	...	$\left(\frac{17\text{–}30}{\text{T.}}\right)$	0.48	0.71	0.42	...
1886	0.39	1.24	0.14	0.08	$\left(\frac{1\text{–}29}{0.69}\right)$	...	...	...	...	...	...	...	...

[a] Records kept at Fort Egbert military post.

Summary of records of precipitation (in inches) at stations in Alaska—Continued.

FORT TONGASS.

[Lat. 54° 46′ N. Long. 130° 30′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1868	......	......	......	......	......	1.81	8.45	0.45	2.78	8.68?	17.92	10.40	......
1869	12.00	9.98	5.75	9.87	5.30	6.89	5.87	6.44	12.51	19.54	13.00	16.26	123.41
1870	13.84	11.61	10.58	9.28?	10.10	4.63	6.85	6.53	18.84	......	......	......	......

FORT WRANGELL.

[Lat. 56° 28′ N. Long. 132° 20′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1868	......	......	......	......	(11–31 / 0.90)	1.90	4.20	1.00	......	......	......	......	......
1869	......	......	......	7.27	5.11	5.06	4.60	3.50	6.66	11.13	3.69	7.39	} 56.00
1870	3.43	2.26	1.25	2.94	2.63	3.90	2.35	3.05	(1–26 / 14.02)	......	......	......	}
1876	......	......	......	......	......	[3.56]	2.56	4.91	5.16	5.76	11.75	12.36	} 76.75
1877	8.71	12.92	3.54	2.13	3.39	(1–14 / 1.85)	......	......	......	......	......	......	}
1881	......	......	......	......	......	......	......	(25–31 / 0.13)	8.06	5.19	18.37	11.49	......
1882	......	9.14	3.87	(8 da / 1.39)	(21 da / 1.48)	3.40	4.76	2.91	......	......	......	......	......

FORT YUKON.

[Lat. 66° 34′ N. Long. 145° 18′ W. This record seems to be of doubtful accuracy.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1899	......	......	......	......	......	......	......	......	16–30 / 0.10	0.60?	0.27?	0.47?	......
1900	0.36	T	0.42?	0.05?	......	1.19	0.32	30 da / 1.47	28 da / 0.74	0.60	0.51	0.24	......
1901	1.95?	0.03	0.38?	0.56	0.46	0.41	......	......	......	......	......	......	......
1902	0.88?	0.01?	0.05?	0.58?	0.01?	......	......	0.74?	1.51?	2.37?	1.60?	0.75?	......

GAMBELL (ST. LAWRENCE ISLAND).

[Lat. 63° 50′ N. Long. 171° 25′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1895	......	......	......	......	0.14?	0.59	26 da / 0.42	1.08	1.92	0.48?	......	......	......
1896	>0.60	......	......	......	......	>1.26	0.89	3.63	>2.66	>0.75?	......	......	......
1897	......	......	>0.60?	......	>0.35	0.59	0.42	1.67	1–25 / 1.56?	......	......	......	......
1898	......	......	......	......	......	......	......	......	......	......	>2.50?	......	......
1902	......	......	......	......	......	29 da / 0.72	2.13	25 da / 1.75	26 da / 1.23	......	......	......	......

Summary of records of precipitation (in inches) at stations in Alaska—Continued.

HOLY CROSS MISSION.

[Lat. 62° 16′ N. Long. 159° 50′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1893										5.08	0.67	3.57	
1894	3.53	0.56	1.81	0.52	0.21	1.75			1.79	2.12	0.55	2.40	
1895	0.79	1.03	1.37	0.11	0.37	0.99	2.19	2.65	1.71	0.69	2.23	0.59	14.72
1896	0.01	29 da 1.07?	1.34	1.67	0.20	1.93	2.63	3.90	1.83				17.37
1897						0.46	1.14	[a]22 da >2.18	[a]25 da 1.66?	1.45	1.04	1.79	
1898	1.94?	1.07?	>3.29	>1.21	0.20	2.89?	3.34	2.96	2.43	0.23	1.19?	1.15?	>21.90?
1899	0.51?	1.05?	1.49?	0.97?	0.33			3.67	4.40	1.17?	0.49	1.00	
1900	0.74?	29 da 0.57	0.50	0.50	0.92	1.67	1.44	5.76	6.69	3.34	1.98	4.49?	28.60?
1901	1.46	2.46	1.[illegible]6?	0.55	0.13	0.85	0.92	4.50					

HOWKAN.

[Lat. 54° 45′ N. Long. 132° 30′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1882										25 da 18.56?	26 da 14.21?	28 da 19.63?	

JUNEAU (1).

[Lat. 58° 19′ N. Long. 134° 28′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1881						23 da 3.37	6.65	3.03	14.61	8.00	12.95		
1882	9.50	4.55	5.25										
1883					7.46	8.98	9.41	11.23	8.42	8.74	9.93	12.05	107.65
1884	10.94	29 da 5.40	9.64	4.49	13.11	4.04	6.32	8.03	13.30	11.39			
1889											(13–30 8.15)	5.40	
1890	3.22	6.55	5.89	4.94	4.85	6.37	5.51	2.21	17.11	11.31	18.46	6.86	93.28
1891	20.51	2.68	5.68	6.32	4.01	2.22	2.37	13.01	10.30	11.19	10.44	7.03	95.76
1892	13.67												
1894											(16–30 3.27)	7.22	
1895	5.80					(17–30 3.63)	3.23	7.66	7.53				
1896									14.08	9.70	0.58	10.39	
1897		5.08											

JUNEAU (2) (WHARF).

[Lat. 58° 19′ N. Long. 134° 28′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1898												8.10	
1899	4.22	4.92	1.58	4.28	4.68	5.63	1.06	4.88	9.10	11.90	6.71	8.42	67.38
1900	8.52	4.19	3.06	11.37	5.00	2.21	5.19	6.57	10.84	10.91	12.45	7.87	88.18
1901	9.57	6.32	8.19	8.19	3.47	2.13	1.98	14.04?	11.41	16.50	3.52	13.33	98.65
1902	12.76	2.08	5.64	4.34	3.99	2.41	7.60	12.10	14.24	6.57	7.38	4.26	83.37

[a] These values not used in computing total for 1896–97.

Summary of records of precipitation (in inches) at stations in Alaska—Continued.

IKOGMUT (Russian mission).

[Lat. 61° 56′ N. Long. 160° 43′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1883								(18–31 / 2.85)	27 da / 5.17	5.69	3.94	1.50	
1884	1.46	29 da / 0.55	0.81	0.81	(7–31 / 0.81)			(16–31 / 0.98)		9–31 / 0.09	1.30	0.65	
1885	0.58	0.40	1.48	0.71	1.42				5–30 / 0.98	1.53	1.07	(1–18 / 0.91)	
1886	(23–31 / 0.00)	0.20	1.68	0.31	5–31 / 3.13								

KENAI.

[Lat. 60° 32′ N. Long. 151° 19′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1882									(12 da / 1.33)	27 da / 0.92	1.99	0.31	
1883	0.71	0.66	1.30	0.39	1.47	1.88	2.21	1.56	0.80	2.85	2.53	0.95	**17.31**
1884	1.15	29 da / 0.96	0.85	27 da / 0.37	1.18	[0.73]	1.42	2.79	2.54	0.41	0.63	0.58	**>13.61**
1885	0.66	0.62	1.98	1.43	0.54	0.60	2.62	4.80	1.16	1.37	1.14	1.61	**18.53**
1886	T	1.87	1.50	1.24	2.98								
1899					0.82	0.68	1.36	2.34		4.32	0.32	0.67	
1900	1.47	0.31	0.31	0.52	0.37	0.55	0.86	3.92	3.34	2.19	0.90	1.15	**15.89**
1901	0.64	0.07	0.32	0.85	0.30	0.06	1.66	4.85	2.23	1.69	0.64	0.19	**13.50**
1902	0.84	0.44	0.50	1.03	0.42	0.59	1.71	2.92	4.69	2.73	0.86	1.55	**18.28**

KETCHIKAN.

[Lat. 52° 25′ N. Long. 131° 38′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1902					23–31 / 2.79	3.31	5.62						

KILLISNOO.[a]

[Lat. 57° 22′ N. Long. 134° 29′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1881					20 da / 5.00	1.36	2.68	2.09	29 da / 3.79	3.03	7.13	7.97	
1882	6.38	7.01	1.51	1.88	2.47	2.02	2.78	2.38	3.44	25 da / 0.55	21 da / >1.10	3.19	**[94.1]**
1883	1.69	1.01	3.25	1.17	0.82	2.47	30 da / 2.44	4.87	3.70	28 da / 2.85	1–16 / 2.88		
1884				0.50?	3.81	>1.29	0.87	4.13	3.49	6.61	22 da / 6.39	3.67	
1885	29 da / 1.85					8–30 / 0.49?	1.00?	2.05?	4.89?	6.29?			
1886	[5.6]	[5.0]	3.36	0.48	28 da / 0.64	7–30 / 0.57	1.54	4.05	5.85	9.85	8.25	5.55	**[51.0]**
1887	(Records existed for this year, but could not be found.)												
1888	2.05	29 da / 4.15	2.30						7.35	10.78	8.55	3.85	
1889	4.45	3.35	3.45	3.40	2.95	1.85	1.85	6.40	5.75	4.70	4.75	2.40	**44.80**

[a] The values on pp. 162–165 are based on the years 1889 to 1902 only.

Summary of records of precipitation (in inches) at stations in Alaska—Continued.

KILLISNOO—Continued.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1890	2.05	4.60	4.20	0.90	2.40	0.30	6.02	1.95	12.80	7.55	8.80	3.00	54.57
1891	8.35	2.70	7.05	5.95	4.40	0.40	3.35	6.65	8.25	7.95	3.24	5.20	63.49
1892	8.40	29 da / 7.30	9.30	[3.50]	3.25	4.60	5.95	6.75	9.55	12.45	9.80	13.25	[94.10]
1893	8.10	3.70	3.65	3.30	5.35	2.85	8.15	9.90	8.35	9.60	4.10	4.95	72.00
1894	5.85	8.25	7.70	4.20	2.85	3.15	3.95	5.60	5.05	6.15	5.35	4.05	62.15
1895	3.25	7.30	2.50	4.20	1.70	3.35	3.35	6.95	6.45	8.45	4.45	8.55	60.50
1896	7.50	29 da / 8.25	2.30	0.65	0.80	3.25	2.05	3.40	8.95	10.55	1.30	8.25	57.25
1897	5.45?	3.40	2.70	4.35	8.40	1.50	5.30	4.65	13.15	11.95	4.25	4.60	69.70
1898	4.40	3.80	2.45	6.80	2.90	1.05	4.30	1.30	6.35	5.90	6.50	6.95	52.70
1899	6.41	4.80	2.00	1.60	1.40	3.20	0.90	1.95	7.40	30 da / 5.95	6.30	3.45	45.36
1900	5.55	29 da / 3.35	2.40	6.85	2.20	4.30	8.45	2.30	4.25	6.00	7.05	6.50	59.20
1901	6.95	6.05	5.40	1.15	4.00	1.60	1.40	5.95	5.50	9.10	3.55	5.30	55.95
1902	29 da / 6.95?	2.65	1.50	2.10	4.70	1.60	3.80	4.80	7.20	4.60	2.75	2.90	45.55

KISKA ISLAND.

[Lat. 52° 00′ N. Long. 177° 25′ E.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1885	......	......	......	......	13–31 / 3.94	3.38	6.39	8.10	4.31	7.67	6.28	2.55	>51.26
1886	2.06	0.93	3.40	2.25	......	......	......	......	......	......	......	......	

KODIAK (1).[a]

[Lat. 57° 48′ N. Long. 152° 25′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1868	......	......	......	......	......	......	......	......	......	......	......	[R]12.65	......
1869	[R]2.65	[R]4.11?	[R]9.83	6.86	8.68	7.15	0.79?	3.89	5.94	7.14	6.61	9.90	73.55
1870	8.01	3.31	10.60	5.08	3.16	2.90	1.49	3.53	1–16 / 0.84	......	......	......	......
1898	......	......	......	......	......	......	......	......	......	......	7.38	5.72	47.11
1899	4.82	4.44	4.17?	2.92	4.97	2.11	0.80	2.37	1–29 / 1.95	6.31	29 da / 5.67	......	

KODIAK (2) (WOODY ISLAND).

[Lat. 57° 48′ N. Long. 152° 25′ ? W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1900	5–31 / 2.95	6.19	7.46	29 da / 2.60	6.62	3.35	30 da / 6.64	2.64	......	(25 da / 1.86)	2.28	4.73	......
1901	2.62	0.30	3.85	(19 da / 4.20?)	3.45	4.50	3.56	5.13	5.98	8.95	4.82	11.10	......
1902	3.89	6.29	4.33	3.26?	5.55	1.55	1.87?	6.15?	(25 da / 3.13?)	......	(24 da / 0.75)	(27 da / 4.20)	......

[a] The values on pp. 162–165 are for 1898–99 only.

Summary of records of precipitation (in inches) at stations in Alaska—Continued.

KOLMAKOF.

[Lat. 61° 30′ N. Long. 158° 59′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1882	......	......	......	......	......	......	(10 da / 0.11)	(21 da / 3.85)	27 da / 2.43	1.14	(19 da / 10.97)	27 da / 3.65	......
1883	1.34	1.08	(22 da / 0.56)	(27 da / 0.60)	(18 da / 0.07)	......	......	30 da / 7.36	4.54	3.53	4.14	1.11	......
1884	2.30	29 da / 0.29	1.41	1.08	(22 da / 1.27)	......	(6–31 / 2.30)	(17 da / 1.47)	4.12	(20 da / 0.94)	(21 da / 0.93)	(1–5 / 0.29)	......
1885	(17–31 / 0.39)	0.42	(8–31 / 1.05)	1.39	......	......	......	(17 da / 5.67)	(18–30 / 0.03)	30 da / 0.06	1.50	0.63	......
1886	0.22	0.30	0.95	0.18	(1–11 / 0.68)	......	......	......	......	......	......	......	......

METLAKATLA.

[Lat. 55° 10′ N. Long. 131° 30′ N.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1891	......	......	......	......	......	......	......	......	......	......	14.31	18.00	......
1892	15.48	6.45	9.79	6.52	5.90	4.27	4.73	9.37	8.38	30 da / 18.75	9.70	12.79	112.13
1893	14.81	8.97	4.88	3.41	10.84	2.50	7.18	6.87	8.09	12.81	9.69	13.04	103.09
1894	7.48	16.03	8.10	10.56	5.22	2.53	7.97	[8.2]	[8.2]	[15.8]	[11.2]	[14.6]	[115.9]

MORZHOVOI.

[Lat. 55° 03′ N. Long. 163° 10′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1881	......	......	......	......	......	......	......	......	......	......	8.38	2.31	......
1882	11.78	4.04	2.05	2.45	(1–7 / 0.90)	......	8–31 / 2.67	5.02	7.51	1–27 / 10.26	7.47	0.60	......
1883	3.25	1.85	2.35	0.49	1–24 / 5.56	......	......	......	......	......	......	......	......

NOME.

[Lat. 64° 30′ N. Long. 165° 25′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1900	......	......	......	......	......	......	......	13–31 / 0.60	7.00	......	......	......	......

NUCHEK.

[Lat. 60° 23′ N. Long. 146° 40′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1883	......	......	......	......	13.00	6.47	8.72	10.81	22.96	21.50	10.51	16.81	190.09
1884	27.07	29 da / 9.15	18.02	16.92	24.84	1.88	11.14	17.46	......	......	......	......	

NULATO.

[Lat. 64° 41′ N. Long. 157° 58′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1882	......	......	......	......	......	......	......	......	......	2.62	3.76	(1–16 / 0)	......
1894	......	......	......	......	......	......	......	......	......	1.36	1.20	1.42	......
1895	0.68	1.09	0.89	0.16	0.36	(1–8 / 0.24)	......	......	......	......	......	......	......
1896	3–31 / T	29 da / 0.73	2.03	(1–19 / 0.27)	......	......	......	......	......	......	......	......	......

Summary of records of precipitation (in inches) at stations in Alaska—Continued.

OMALIK.

[Lat. 65° 02′ N. Long. 162° 40′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1884	(20–31 / 0.57)	29 da / 0.23	0.09	0.07	0.02	....	....	....	....	0.23?	0.45?	0.18?	....
1885	0.40?	0.40?	>0.21?	(1–16 / 0.32?)	....	....	....	....	....	....	....	....	....

ORCA.

[Lat. 60° 35′ N. Long. 145° 40′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1899	....	....	....	....	....	....	....	....	(13–30 / 14.30)	17.87	13.02	9.95	....
1900	9.73	9.93	15.74	16.35	13.70	4.59	5.06	11.25	15.32	9.78	4.72	13.09	129.31
1901	16.17	1.21	16.91	....	....	....	30 da / 3.62	30 da / 27.02	26.36	24.71	8.02	9.75	....
1902	12.02	8.05	0.60	....	....	....	....	....	(17–30 / 12.71)	35.56	11.10	11.40	....

POINT HOPE (NEAR TIKIRA).

[Lat. 68° 25′ N. Long. 166° 38′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1894	....	....	....	....	....	....	....	28 da. / 1.59	1.19	0.42	1.37	3.22	....
1895	0.05	0.03	0.42	0.04	0.43	0.19	0.27	30 da. / 0.45	1.77	0.09	0.13	0.05	3.92
1896	0.05	29 da. / 0.04	0.57	0.51	0.00?	0.83	1.49	....	....	....	....	....	....

ST. MICHAEL.

[Lat. 63° 28′ N. Long. 162° 10′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1877	....	....	....	....	....	....	(15–31 / 0.67)	2.48	2.23	0.27	0.52	0.11	....
1878	0.11	0.12	0.12?	0.44	2.59	1.40	3.48	2.16	2.29	0.66	0.95	1.86	16.18
1880	....	....	....	....	....	....	0.65	4.05	5.61	2.38	1.48	1.31	[20.1]
1881	0.06	0.00	0.01	0.39	2.66	0.65	0.89	4.43	3.40	2.14	1.75	0.23	16.61
1882	1.88	0.40	0.28	0.04	0.18	0.25	(1–16 / 0.17)	(27–31 / 0.17)	1.70	1.74	1.27	0.12	[13.66]
1883	2.63	0.34	0.96	0.50	0.63	1.84	3.13	3.80	4.48	1.66	1.06	0.70	21.73
1884	0.57	29 da / 0.17	0.78	0.26	0.25	0.77	4.00	1.40	5.04	1.46	0.60	0.20	15.50
1885	0.38	0.31	1.07	0.77	1.04	3.51	3.06	4.56	3.39	1.62	0.42	0.75	20.88
1886	0.43	0.34	0.46	0.12	1.53	1.77	....	....	....	....	....	....	[18.1]

Summary of records of precipitation (in inches) at stations in Alaska—Continued.

ST. PAUL ISLAND.

[Lat. 57° 15′ N. Long. 170° 10′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1869 [a]	......	......	......	......	......	......	......	......	......	1.92?	2.40?	1.70?	......
1870 [a]	1.00?	1.02?	0.82?	1.10?	0.88?	0.14?	......	......	......	......	......	......	......
1876	......	......	......	......	......	......	29 da. / 2.73	......	......	......	......	......	......
1878	......	......	......	......	......	......	......	......	(20–30 / 1.23)	9.89	4.92	8.14	......
1879	7.32	3.00	1.92	4.58	3.82	......	......	......	......	......	......	......	......
1881	......	......	......	......	......	2.22?	2.10?	4.49?	7.94	5.88	7.81	3.04	......
1882	......	1.86	2.88	1.71	1.68	1.02	3.49	2.30	5.89	6.55	6.44	0.66	} 36.59
1883	2.54	0.48	4.18	0.51	2.10	......	......	......	......	......	......	......	
1892 [b]	......	......	......	......	......	......	......	......	3.88	2.91	2.84	3.13	......
1893 [b]	1.62	2.86	3.79	3.28	1.85	1.76	2.55	1.96	1.35	R >1.49	2.71?	>2.99?	>28.21?
1894 [b]	>2.46?	2.23?	>4.23	2.29?	>3.06?	>2.22?	>1.99?	>1.93	......	......	......	......	......

SITKA.

[Lat. 57° 03′ N. Long. 135° 19′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1867	......	......	......	......	......	......	......	......	......	......	14.62	3.24	......
1868	7.00	29 da. / 4.35	5.72	2.27	7.55	1.93	4.20	4.01	6.81	7.27	9.38	6.69	67.18
1869	10.14	14.80	6.30	8.99	6.87	4.99	3.20	3.84	7.62	9.50	7.12	10.84	94.21
1870	9.97	6.05	6.00	4.51	3.35	4.94	2.44	6.39	9.16	9.46	11.58	7.55	81.40
1871	3.00	3.22	4.74	4.00	1.90	6.00	2.79	13.33	7.70	14.54	5.36	3.54	70.12
1872	5.84	29 da. / 2.07	8.59	>2.38	3.18	3.70	3.43	2.65	6.13	8.85	6.58	5.97	59.37
1873	8.40	7.96	3.87	2.83	1.67	2.67	1.54	7.54	5.09	17.98	9.02	5.75	74.32
1874	2.74	5.87	2.27	2.23	2.04	3.43	3.40	2.50	15.70	14.84	4.84	10.27	70.13
1875	3.06	7.90	5.94	11.81	1.69	3.14	3.57	5.30	10.43	13.84	5.41	11.66	83.75
1876	9.03	29 da. / 2.89	4.29	3.72	3.19	2.62	3.12	5.52	6.36	9.82	9.15	17.97	77.68
1877	9.98	8.76	1.97	4.35	2.45?	......	......	......	......	......	......	......	......
1881	......	......	......	4.21	3.10	1.54	4.40	1.98	12.11	5.04	13.50	10.52	......
1882	14.20	16.35	3.53	4.21	2.89	3.71	6.68	6.33	9.67	9.64	11.47	13.58	102.26
1883	4.69	6.92	16.00	4.78	3.70	4.13	6.38	9.16	8.13	13.31	10.63	14.54	102.37
1884	14.01	29 da. / 6.15	11.05	2.76	10.35	3.77	4.78	6.91	13.20	14.56	16.31	7.09	110.94
1885	10.42	9.86	12.10	13.42	3.55	2.36	3.85	4.00	8.33	13.55	9.65	11.70	102.79
1886	7.36	18.84	10.08	7.67	3.68	4.53	3.27	10.72	25.52	24.82	20.51	3.26	140.26
1887	7.83	4.92	7.38	6.64	7.30	5.01	7.62	9.38	10.55	(1–8 / 1.61)	......	......	......
1898	......	......	......	......	......	(15–31 / 1.39)	3.97	3.92	5.98	8.22	13.47	10.99	......
1899	5.75	10.38	[6.70]	8–30 / 3.76	4.02	4.99	2.27	8.35	8.52	9.85	7.02	6.94	[78.7]
1900	8.71	3.49	2.62	12.09	4.56	3.13	3.77	7.92	28 da. / 7.82	10.73	9.39	6.59	80.82
1901	9.33	6.38	7.80	7.17	4.86	1.26	0.45	10.03	8.82	15.59	6.16	10.18	88.03
1902	11.92	2.25	5.39	4.93	6.10	1.87	7.35	14.96	13.43	8.25	6.19	5.93	88.57

[a] These observations were recorded, in cubic centimeters (cc), and have been converted to depth of rainfall in inches by multiplying by $\frac{2}{100}$. This factor was obtained by assuming the rain gage to have been a De Witt conical 9-inch gage, with 5-inch aperture, such as was regularly supplied to the U. S. Army post hospitals, and by assuming that the rainfall was poured from the gage into a glass graduate reading in cubic centimeters.

[b] The records for these years not used in compiling the synoptic tables.

Summary of records of precipitation (in inches) at stations in Alaska—Continued.

SKAGWAY.

[Lat. 59° 28′ N. Long. 135° 20′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1898											2.56	7.85	
1899	0.94	0.88	0.13	0.66	1.07	1.29	0.59		5.28	2.99	2.72	1.44	[>17.99]
1900	0.86	0.26	1.15	4.12	0.12	0.20	1.70	T					
1901									$\left(\frac{14\text{–}30}{1.22}\right)$	4.92			
1902					0.13	0.30	2.89	3.03	1.66	1.75	1.24	2.06	

TANANA (FORT ADAMS).

[Lat. 65° 10′ N. Long. 152° 45′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1882								2.16	1.72	0.50	0.82	0.46	
1883	1.72	1.22	0.40	0.40	$\left(\frac{1\text{–}22}{0.67}\right)$				1.10	2.59	2.75	0.86	
1884	3.16	1.03	0.97										
1885								$\left(\frac{18\text{–}31}{0.23}\right)$	1.53	4.40	3.42	1.15	
1886	0.20	0.31	0.66	0.04	1.51								

TANANA (FORT GIBBON).

[Lat. 65° 12′ N. Long. 152° 00′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1902										1.57	0.14	1.36	

TELLER (REINDEER STATION).

[Lat. 65° 20′ N. Long. 166° 30′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1901									T				
1902	0.06?	0.01	0.09	0.20?	0.00?	0.12?	2.98	1.18					

TYONOK.

[Lat. 61° 03′ N. Long. 151° 10′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1898											1.85	1.41	
1899	1.29	1.35?	0.65	1.23	1.05	1.20	1.69	2.72	5.51	4.70	0.58?	0.73?	22.70
1900	2.69	0.52	0.47	0.60	0.29	0.72	1.05	4.94	4.22	2.53	0.60	1.54	20.17
1901	1.55	0.20	0.62	1.00	0.04	0.53	2.68	5.77	3.16	4.42?	0.45	1.13	21.55
1902	3.08	0.52	1.09	0.71	0.38	0.00	2.93	5.40	6.56?	4.96	0.94	1.72	28.29

UGASHIK.

[Lat. 57° 35′ N. Long. 157° 50′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1883								(5.19)			$\left(\frac{11\text{–}30}{0.80}\right)$	(0.91)	
1884	1.66	29 da. 0.34	1.00	0.53	$\frac{28\text{ da.}}{1.26}$	0.21	2.72	2.26	7.05	2.99	2.07	1.12	23.21
1885	1.22	0.65	1.08	1.75	$\frac{1\text{–}26}{1.74}$	2.08	3.08	4.77	3.99	2.41	0.78	2.11	25.66
1886	$\left(\frac{1\text{–}18}{2.53?}\right)$												

Summary of records of precipitation (in inches) at stations in Alaska—Continued.

UNALASKA.

[Lat. 53° 52′ N. Long. 166° 31′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1878	....	....	....	....	....	....	....	....	2.59	3.97	3.79	9.92	....
1879	2.88	1.35	3.26	1–28 2.93	....	....	....	....	17–31 0.37	6.98	6.56	2.68	....
1880	4.11	3.32	3.28	1.18	....	....	....	....	....	....	....	....	....
1881	....	....	....	....	....	....	2.60	2.12	9.16	27.30	11.82	12.70	....
1882	14.30	7.97	5.84	2.19	4.51	3.84	2.12	1.88	11.48	10.00	9.30	7.37	80.80
1883	17.78	2.88	10.36	5.77	10.85	1.48	1.70	4.74	9.75	6.15	5.02	13.64	90.12
1884	11.93	29 da. 26.19	9.44	14.00	3.97	12.41	4.31	4.90	11.23	11.85	19.89	28.17	158.29
1885	29.87	4.42	8.42	12.40	1.47	2.03	4.15	3.34	7.64	17.60	8.75	8.08	108.17
1886	15.82	7.64	4.74	14.09	(1–22 3.71)	....	....	....	....	....	....	....	....

UTKIAVI (GOVERNMENT STATION NEAR POINT BARROW).

[Lat. 71° 17′ N. Long. 156° 40′ W.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1881	....	....	....	....	....	....	....	....	....	(17–31 0.96)	0.73	0.44	....
1882	0.45	0.04	0.51	0.41	0.44	0.63	1.47	1.46	1.10	1.09	0.34	0.24	8.18
1883	0.14	0.84	0.14	0.54	0.31	0.31	1.04	....	....	....	....	....	....
1901	....	....	....	....	....	....	....	....	0.13?	0.42?	0.10?	<0.10?	3.45
1902	T	<0.20	<0.05	T	T	0.46	1.51	0.48	....	....	....	....	

GEOLOGY.

INTRODUCTION.

This report as first projected was to include descriptive geography only, and no geology; but as the work advanced it led to a consideration of the origin, as well as the distribution and form of the topographic features. Once having entered this borderland between the two sciences, references to the bed-rock geology multiplied, and a systematic presentation of the purely geologic aspect of the problems seemed desirable. As no summary of Alaskan geology has been published in recent years, it will be necessary to cover the entire field. In such a brief review only general results can be presented, and the details must be sought in the reports which will be referred to. It is hoped that a short account of the geology may not only lead to a better understanding of the physiography, but may also serve a useful purpose in presenting a résumé of the progress of geologic investigation in this important section of North America.

Though geologic investigation can be said to have been begun by Steller, who, as a member of the Bering expedition in 1741 (p. 107), was the first naturalist to land on the Alaskan coast, only within the last decade have systematic researches been undertaken. Most of the exploring expeditions, of which an account has been given elsewhere in this report (pp. 104–133), were accompanied by naturalists, who usually noted the rocks and minerals encountered and collected fossils. Chamisso, the German poet-naturalist, in 1816 accompanied Kotzebue on his voyage of discovery, and was one of the earliest contributors in this field.

As the coast became better known these observations multiplied, and the collections which found their way to European museums gave the stratigrapher some clue to the character and age of the bed-rock terranes; but at best these notes were scattering and were often by untrained observers. In 1848, Grewingk[a] admirably summarized all this early work in a compilation based on an exhaustive study of the literature, and not only assembled all the facts conveniently in one volume, but also presented some suggestive correlations and generalizations. This was the first attempt at a systematic treatment of the geology, and the results even at the present day are not without value. Grewingk must be credited with the first geologic map of any part of this province, and he seems also to have been the first to obtain any true conception of the relation of the orographic features of Alaska to those of the rest of North America.

A quarter of a century elapsed after Alaska passed into the hands of the United States before the casual notes of the naturalist were supplemented by systematic geologic investigations, though meanwhile the accumulation of data continued. Dall, during the Russian régime, had made a geologic reconnaissance of the lower Yukon Valley and of a part of the Norton Bay region, and after the transfer spent a number of years in seaboard explorations under the auspices of the Coast Survey. Blake, too, contributed notes on the coastal geology, and later Russell and Hayes made inland journeys, while the Canadians, Dawson and McConnell, made important contributions to the geology of the adjacent regions. The Alaskan glaciers were studied by Muir, Russell, Wright, Reid, and others, in whose publications are found occasional references to bed-rock features.

At best these investigations were little more than the observation of isolated facts which, though not without value, in only rare instances offered a sufficient groundwork for general conclusions.

An appropriation by Congress for the investigation of the mineral resources of Alaska enabled the Geological Survey in 1895 to dispatch its first regular party to the Pacific coastal belt, and in the following year a second was sent into the interior. These were the precursors of the many to follow. Systematic surveys were begun in 1898, and in the last seven years twenty-odd expeditions have investigated this field, some visiting its remotest parts. Explorations have been the objects of most of these journeys, for during many of them even the geologic reconnaissance mapping was forced to give way to random notes on such phenomena as were encountered in the direct route of travel. Alaskan exploration demands of the geologist only too often that he abandon for a time all research and give himself entirely to overcoming the physical obstacles that beset his progress. Such interruptions may be of hours, of days, or even weeks; may mean a long, weary portage between watercourses, rafting a turbulent glacial river, building a causeway through a swamp, chopping a trail through an interminable forest, or scudding before a storm on an exposed sea coast, but they always leave a hiatus in the

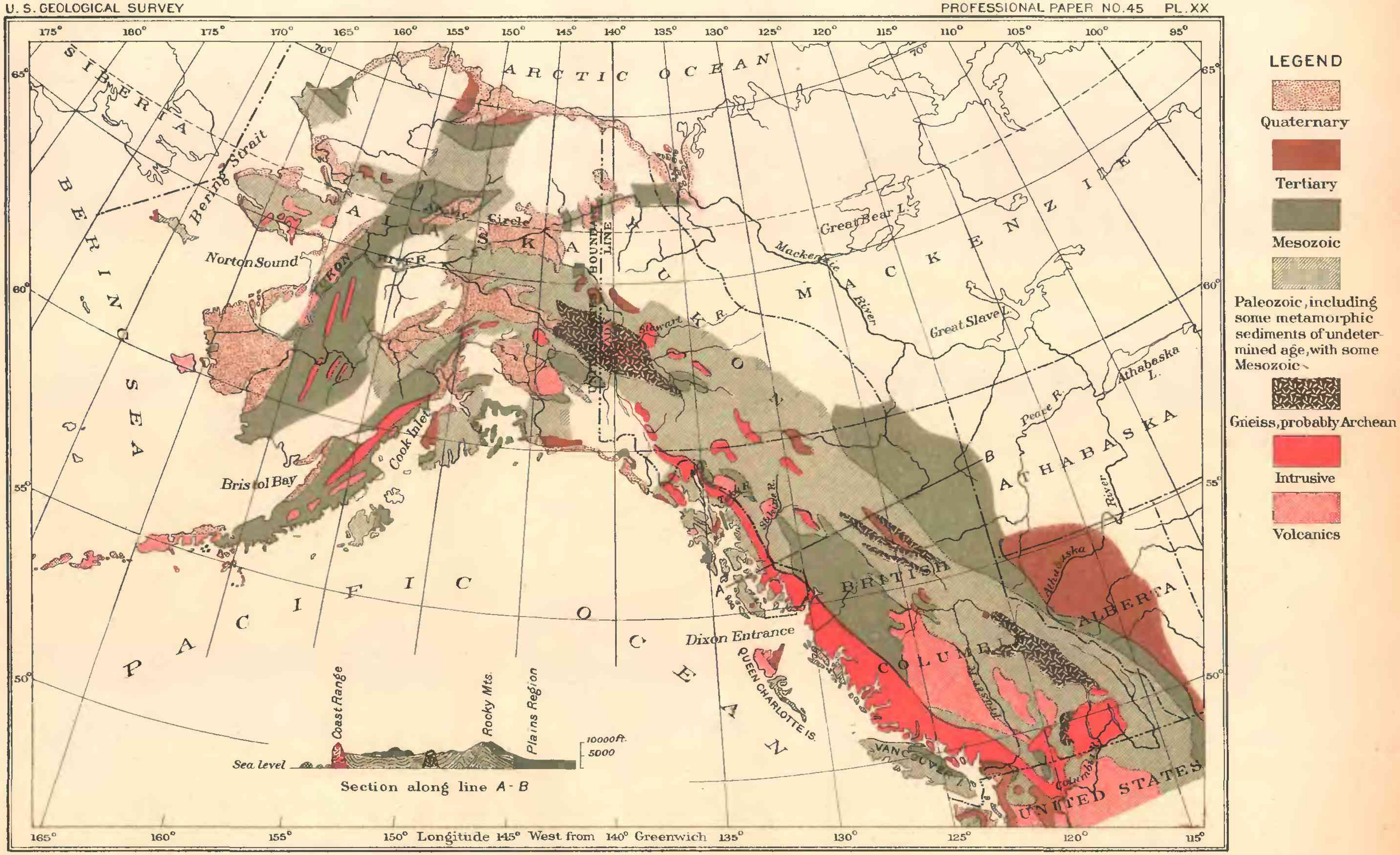
[a] Grewingk, C., Beiträge zur Kentniss der orographischen und geognostischen Beschaffenheit der Nord-west Küste Amerikas, mit den anliegenden Inseln (with geologic and other maps). St. Petersburg, 1850.

geologic notes that may prove fatal to correct generalizations. A personal knowledge of the conditions of work alone can show why the results have often been so meager, and at what cost of toil and exposure these investigations have been made.

Nor do the physical conditions of this field permit of a rapid determination of the bed-rock geology, for here are no such opportunities for geologic observation as are found in the plateau region of the western United States, with its deep canyons and bare rocks. Alaska is mantled by a heavy growth of moss and other vegetation, and the traveler may journey for days with hardly a clue to the character of the bed rock except the gravels in the stream beds, and though in the mountain ranges exposures are usually better, here again the structure is often so intricate as to defy solution during a rapid journey. Many of the problems will require the most detailed and painstaking study, and few can be solved by rapid reconnaissance work, as have been many of those of the western cordillera of the United States.

If, then, the researches in the geology of this field of the past decade have as yet left no landmarks like the exhaustive monographs which resulted from the explorations of the trans-Mississippian region, there is reason for it in the difficulties of the field. Furthermore, the immediate results aimed at, besides exploration, have been the development of the mineral resources, and in many instances the purely geologic studies have been made entirely subordinate to this object. The progress on the general structural and stratigraphic problems may appear to have been very slow to those unfamiliar with the conditions and purposes of the survey; if, however, it is borne in mind that ten years ago practically nothing was known of the geology of this area of nearly 600,000 square miles, except along parts of the coast, it will be manifest that the results achieved are commensurate with the time that has been devoted to them.

The terranes of Alaska range in age from crystalline schists, probably Archean, to recent deposits of unconsolidated material. The stratigraphic position and distribution of some horizons have been fairly well established in the areas which have been surveyed, but there are many more beds of which little or nothing is known. Igneous rocks are widely distributed both horizontally and vertically, and occur in many varieties, both as intrusives and extrusives. The sedimentary and igneous rocks have passed through many recurrent epochs of disturbances, some of which have brought about flexures and dislocations, while others were of the nature of broad orogenic movements, which have uplifted or depressed large areas in their relation to sea level, with little or no plications. The epirogenic movements or periods of faulting and folding have induced the complex relations of the rock strata or masses of various parts of the province; but these deformations, even where they have affected considerable areas, were usually intensified along certain zones which have a general parallelism to the dominant physical features. Though something is known of the dynamic history of the region, most of its problems remain to be solved.



GEOLOGIC SKETCH MAP OF NORTHWESTERN NORTH AMERICA

Compiled from publications of U.S. Geological Survey and Geological Survey of Canada by Alfred H. Brooks

Scale
100 0 100 200 300 400 500 600 700 miles

1904

JULIUS BIEN & CO. N.Y.

CORRELATION WITH WESTERN UNITED STATES AND CANADA.

Any connection that can be established between the stratigraphy of Alaska and that of better-known regions will lead to a better understanding of the geology. Correlations between localities separated by hundreds if not thousands of miles must be of a very general character, unless the intervening area has been carefully mapped, or paleontologic evidence furnishes definite proof. Of the latter there is in this case little, for up to the present time but few collections of fossils have been made, and most of the age determinations have been based on very fragmentary material. The interpretation of Alaskan stratigraphy has been aided by the work of the Canadian Geological Survey, which for over a quarter of a century has been actively mapping western Canada, so that now the general sequence and distribution of the larger divisions of the time scale are fairly well established. The results, in a large measure to be credited to Dr. George M. Dawson and Mr. R. G. McConnell, have been embodied in a geologic map[a] of western Canada, on which is shown the distribution of the larger divisions of the stratigraphic column known as "systems," and which has been used as a basis for the accompanying geological sketch map (Pl. XX), which is intended to express, in a general way, the relation of the geology of Alaska to that of western Canada and the United States.

As the physiographic provinces of Alaska are continuations of those of the western United States and Canada, and as they are in a measure but an expression of the bed-rock geology, it would be inferred that the same general horizons which form the cordillera of western United States and Canada extend into Alaska. Such has been found to be the case.

The trend of the structure is northwest, parallel to shore line and the mountain ranges. It is thus northwest-southeast in southeastern Alaska, and then southwest-northeast. The parallelism of the structural features of the Paleozoic and older rocks makes it evident that this marked change of direction of the axes has dominated the deformation of this province since very early geologic time.

Dawson[b] has stated that there is a marked continuity and lithologic uniformity along the strike of the various terranes in this cordilleran belt, and as to a certain extent this holds true in Alaska, it is possible to delineate on the map some of the larger geologic features throughout the entire province.

Several areas of gneissoid rocks, including gneisses, mica-schists, and igneous intrusives, with probably some altered sediments, are provisionally referred to the Archean, though their pre-Cambrian age is open to question.

The sedimentary rocks on this map (Pl. XX) have been divided into four groups, in the oldest of which are placed the beds which have been more or less metamorphosed, and which are probably, for the most part, Paleozoic, though it is known to include some Triassic. All the rocks of this division, which embraces a number of unconformable series, were closely folded and considerably altered before the deposition of the second group which embraces the higher terranes of the Mesozoic and are chiefly Cretaceous, though it includes some Jurassic. The beds of

[a] Geological map of the Dominion of Canada. Western Sheet, No. 783 Geol. Survey Canada.

[b] Geological record of the Rocky Mountain region Canada; Bull. Geol. Soc. America, vol. 12, p. 60.

JULIUS BIEN & CO LITH. N.Y.

this second group have also been subjected to stresses and are closely folded, but not to anything like the extent of the underlying metamorphic terranes. Beds of Tertiary age, probably chiefly Eocene, form the third of these large subdivisions and rest unconformably on the two older series. These also have been deformed, but in most cases to a much less extent than the Mesozoic. The Pleistocene unconsolidated gravels, sands, and silts are the highest of the groups and also the best defined; but as they were not indicated on the Canadian map their occurrences in this part of the province is necessarily omitted on the accompanying sketch (Pl. XX).

The igneous rocks fall into two groups, the intrusives and extrusives. The extrusives are especially abundant in the southern part of the field and decrease to the north, though evidences of recent volcanic activity are far from being absent in Alaska. The igneous complex of the Coast Range is the only extensive area of intrusive rocks in the field. Intrusive rocks are, however, very common throughout the province, especially in the areas of metamorphic terranes.

In general the rocks are distributed as follows (see map, Pl. XX): A belt of metamorphic sediments, chiefly Paleozoic, but with some Triassic, skirts the shore of the Pacific and is the bed rock of the islands of British Columbia and of southeastern Alaska, as well as part of the mainland. This is bounded on the east by the great zone of Coast Range intrusives. East of the Coast Range is a second belt of metamorphic terranes, probably chiefly Paleozoic, of irregular form, about 300 miles in width and stretching from Washington to the northwest into Alaska, a distance of 1,000 miles, and occupying in a general way the intermontane belt between the Rocky Mountains on the east and the Pacific Mountains on the west. This zone is interrupted by a number of elongated gneissic areas (Archean?), which have a roughly linear arrangement along a northwest-southeast axis, and by irregular areas of intrusives, of Mesozoic sediments, and of Tertiary lavas.

A belt of Mesozoic sediments forms the eastern boundary of the metamorphic rocks south of the sixtieth parallel of latitude. These include not only the undisturbed Mesozoic beds which underlie the Tertiary of the Great Plains region to the east, but also some older terranes of this system, which, infolded with Paleozoic sediments, make up the Rocky Mountains.

Tracing these groups northward, it is found that the western belt of metamorphics skirts the coast line, and, following the bend at Prince William Sound, is continued in the Kenai Peninsula. The Coast Range complex is extended to the north by a series of intrusives along the axis of the Alaska Range. The interior belt of metamorphic sediments broadens into a fan-shaped area in Alaska, but is interrupted near Bering Sea by extensive areas of Mesozoic rocks. The eastern belt of Mesozoic and Tertiary rocks of British Columbia finds its counterpart in the rocks of similar age in the Arctic slope region.

GEOLOGIC RECONNAISSANCE MAP.

Though much of Alaska is still unsurveyed, the general distribution of some of the larger subdivisions of the time scale is known sufficiently well to be indicated on the accompanying map (Pl. XXI), which is a graphic summary of what has been learned of the geology. While the blanks in the map represent unsurveyed areas, it must not be supposed that the colored portions represent results of equal value. Areas like the Seward Peninsula and the Copper River basin have been surveyed in considerable detail; others, like the Kuskokwim and Tanana valleys, have been covered by only the most hurried reconnaissance work. In some mountain regions the geologic coloring has been extended to cover areas almost entirely unexplored, but only where topographic continuity between geologic sections pointed to probable geologic continuity. For example, the geology of the central part of the Alaska Range is inferred from the three cross sections at the Skwentna, the Cantwell, and Delta river valleys. The relative value of the geologic coloring in different parts of the map will be further brought out in the discussion.

Ten subdivisions are indicated on the map (Pl. XXI); seven are sedimentary, two igneous, and one metamorphic. The so-called Archean is made up of gneisses and crystalline schists and possibly some sediments which are in part undoubtedly basal, but very likely are in part deformed igneous rocks of a later date. A succession of more or less highly altered sediments, embracing many different formations and believed to be largely Paleozoic, but also known to include some lower Mesozoic terranes, occupies the largest areas in the province. The areas of Silurian are small, because it is only where fossils have been found that they could be differentiated from the other metamorphic terranes. Lack of detailed knowledge makes it necessary on the map to throw the Devonian and Carboniferous into one group, while over much the larger part of the field it has been found impossible to make any subdivisions in the Paleozoic.

Though all the subdivisions of the Mesozoic have been recognized in Alaska, the data are yet too fragmentary to permit of mapping them separately, and only two groups are recognized. The one embraces the Triassic and Jurassic, as well as the undifferentiated Mesozoic, and the second the Cretaceous. The reason for this apparently arbitrary division lies in the fact that the distribution of the Cretaceous is better known because it is usually fossiliferous. The Mesozoic indicated in the Alaska Peninsula probably includes some Tertiary beds.

The Tertiary, undifferentiated on the accompanying map, is almost entirely Eocene, for Miocene and Pliocene beds have been found in considerable areas only on the north coast and along the southwest slope of the St. Elias Range.

The Pleistocene coloring has been extended to only the larger areas and has perforce been made to include the recent alluvium. Most of the rivers, except those that traverse the Coast Range, are bordered by Pleistocene silts and gravels.

Of the intrusives the scale of the map permitted the representation of only the larger stocks, and even these have been omitted in the Archean areas, where the gneisses and igneous rocks are not always easily differentiated. The distribution of the Recent and Tertiary volcanics is shown throughout the regions surveyed, but many smaller areas were omitted because of the scale of the map.

The general facts of the geology, as already indicated, are a belt of metamorphosed sediments, chiefly Paleozoic, skirting the Pacific coast, bounded on the north and west first by intrusives, and then beyond the great bend by Mesozoic rocks. Inland of these lies a second belt of altered sediments, in part Paleozoic, and these give way north of the Rockies to Mesozoic and Tertiary beds. The intermontane zone of Paleozoics is interrupted by Pleistocene deposits and by a broad belt of Cretaceous rocks, which stretches northeast from Bering Sea to the base of the Rockies. Volcanic rocks are widely distributed, and in the Alaska Peninsula, Mount Wrangell region, and in the Bering Sea littoral cover considerable areas.

CORRELATIONS.

The correlation table (opposite) is based on a study of the literature as well as on a personal knowledge of much of the field. Though many of these correlations are by those who did the field work, the writer has not hesitated to express in the table his own interpretations of the succession, even though they are at variance with those of the original investigators.

It is not to be inferred that because two formations appear as equivalents in the table they are considered exactly synchronous, for in few instances have the stratigraphic studies been made in sufficient detail to permit the determination of exact equivalencies between the terranes of different regions. Furthermore, the stratigraphic units of Alaska maps and reports vary greatly in definition, and range in thickness from 50 feet to many thousands of feet. While in some cases a name may designate a well-defined horizon, whose position is established by stratigraphic and paleontologic evidence, in others, a heterogeneous aggregate of strata, of whose thickness, stratigraphic relations, distribution, and age almost nothing is known, has been grouped together as a "series." The Carboniferous rocks in the upper Copper River and in northern Alaska are cases in point. In the first district the Carboniferous terranes have been divided into two distinct formations, the "Suslota" (Lower Carboniferous) and "Mankomen" (Permian), on paleontologic and stratigraphic evidence; in the second, a great complex of schists, conglomerates, etc., has been assembled under the name "Fickett series," and assigned to the Carboniferous on very scant evidence. Though all of these formations appear as Carboniferous in the table the definite correlation between them is yet to be established.

It has not been possible to include all of the formations mentioned in the literature, for Alaskan stratigraphy is rather overburdened with names, in view of the lack of detail in the field studies. There are now upward of one hundred different names which have been given to various stratigraphic subdivisions of Alaska, and probably half of these have been applied to very ill-defined units. Some of these have already been relegated to oblivion by the workers in this field, and many more will follow, but it is exceedingly difficult to eliminate these from the literature. Effort has been made to include in the table chiefly those which promise to become fixed in the nomenclature, but for the sake of clearness others are inserted which will probably not be retained. In the text practically all of the formation names which have appeared in print will be discussed. The writer feels less hesitancy in making this criticism of the redundancy of stratigraphic nomenclature because he is himself responsible for part of it.

Dawson's generalized section of British Columbia and Yukon Territory forms the first column of the table, and as it is based on closer field studies than most of the sections for Alaska, it may be used as a general standard of comparison. The other sections are arranged, as far as possible, geographically from south to north.

The second column, which indicates the succession in southeastern Alaska, is largely the writer's own work, but he has received helpful suggestions from Spencer, whose recent geologic work in the Juneau district is not yet published. Use has also been made of the unpublished notes of F. E. and C. W. Wright.

The work of Schrader, Spencer, and Mendenhall has made the geology of the southern Copper River basin fairly well known, though the relation of this area to the Chugach Mountains and Prince William Sound regions is still undetermined. Their results are embodied in the third column and indicate the succession in the Chitina Valley and the south slope of the Wrangell Mountains.

Mendenhall and Schrader have mapped the northern and western slope of the Wrangell Mountains, together with an area stretching northward to the Tanana, and the succession determined by them is given in the fourth column. The writer has reconnoitered the adjacent region to the north and east, where there still remain many unsolved important stratigraphic problems.

The fifth column indicates the succession in the Alaska Range, near the Skwentna-Kuskokwim divide, as determined by Spurr and the writer. In this district, though the horizons seem well defined, both lithologically and paleontologically, lack of detailed mapping has rendered it impossible to subdivide the Paleozoic on the west side of the range, though Ordovician and Devonian fossils have been found.

The succession in the middle and lower Yukon region is probably better known than any other part of the field, thanks largely to Collier's detailed studies, though others have made important contributions. The results are presented in the sixth column of the table. Though the sequence of the strata is fairly well known, there has been no areal mapping, and as the horizontal extent of the section is probably a thousand miles, errors have probably crept in, because of the variation of individual strata, which in the absence of paleontologic evidence might lead to faulty correlations.

Schrader's reconnaissance across the Rocky Mountains in northern Alaska furnished a general key to the stratigraphic succession, but so rapid was the journey and so beset by difficulties that the sequence can hardly be regarded as definitely established. The sixth column of the table is largely based on this work of Schrader's, but use has also been made of his previous investigation in the Chandlar and Koyukuk basins and of Mendenhall's reconnaissance from the Yukon to Kotzebue Sound.

The reconnaissance mapping of the entire Seward Peninsula was completed at the close of the field season of 1903, and the general succession, as indicated in the table, is probably correct. The geology is, however, complex, and further studies will be needed before the details and structure of the metamorphic rocks can be learned. The sequence as presented does not differ greatly from that determined by the writer in 1900, but Collier's results of later years have been incorporated.

STRATIGRAPHIC SUCCESSION.

OUTLINE.

The general sequence of strata is presented in the table facing p. 206, and the distribution of some of the large subdivisions of the geologic section is shown on the geologic map (Pl. XXI). The geologic succession in different districts will now be discussed in some detail, and the facts presented on which the correlations are based. It is believed that this section of the paper will be made clearer by divorcing from it all consideration of structure, and avoiding as far as possible references to the dynamic history of the province. These subjects will therefore be taken up later.

A brief survey of the geologic sequence may serve as outline for the more detailed discussion to follow. The gneisses and crystalline schists, provisionally referred to the Archean, are regarded as the basal member of the stratigraphic column. These are succeeded by a great complex of metamorphic sediments, intruded by many igneous rocks whose age and stratigraphic relations are often undetermined. Though they have been subdivided into many formations many of them are very ill defined, and much more detailed evidence will be required before the succession is definitely established. Ordovician and Silurian fossils have been found in some of the lower members of this great complex, and Devonian fossils in some of the higher. In the Yukon basin there seems to be an unconformity near the base of the Devonian, below which the rocks are much more highly metamorphosed. These older and more highly crystalline sediments are likely to prove of Silurian, Ordovician, or Cambrian, or possibly pre-Cambrian age. The metamorphosed clastics of southeastern Alaska include Devonian, Carboniferous, and possibly Triassic beds, but it has not yet been possible to subdivide the metamorphic series. Elsewhere in the province recognizable Devonian and Carboniferous terranes also find place in the stratigraphic succession.

The Triassic and Jurassic have thus far been recognized only in the Copper River basin and in southwestern Alaska. The lower Cretaceous is more widely distributed, and includes the youngest beds known to have suffered any considerable alteration. A marked unconformity is believed to separate the lower and upper Cretaceous horizons. The upper Cretaceous is well represented in the lower Yukon basin and north of the Rockies, and has also been recently found by Wright at Kuiu Island.

Of the Tertiary horizons the Eocene coal-bearing beds are the only ones which have been found widely distributed, and these occupy no considerable areas. The Miocene and Pliocene seem to have a relatively small development. The Pleistocene is represented throughout the province by gravels, sands, and silts, and in the regions which have been occupied by ice by various forms of glacial deposits.

PRE-PALEOZOIC.

ARCHEAN.

It is a long-established practice that a complex of crystalline schists should be assigned to the Archean, unless there is proof that it is younger. More detailed studies of the so-called Archean often lead to quite different conclusions, and in Alaska the areas assigned to the "Archean" and "Basal granite" are being reduced in size, if not entirely eliminated. For instance, in the Yukon-Tanana region Prindle's[a] recent studies have shown that if the Archean rocks are present at all they are in much smaller areas than indicated on some of the earlier maps. McConnell,[b] too, has shown that some of the granites of the same general region which have been called basal are in fact intrusive in the sedimentary rocks. With all these eliminations there still seems to remain gneisses, gneissoid granites, and crystalline schists, which probably form a basal complex and will provisionally be assigned to the Archean.

A number of belts of gneissoid rocks of lenticular outline stretch from southern British Columbia[c] into Alaska (Pl. XX), with a roughly linear arrangement, and with these Dawson grouped his "Shuswap series," composed not only of gneisses and crystalline schists, but also of crystalline limestones and quartzites. Dawson pointed out its lithologic and structural similarity to the Greenville[d] series of eastern Canada, and provisionally assigned them to the Archean. It appears that such age criteria of crystalline schists can have no great value, though the conclusion that they are a part of a basal complex of western Canada is supported by their general structural relations and lithologic character.

The northernmost of these gneissoid areas crosses into Alaska between the Tanana and the Yukon and is well exposed along the lower White River, where it comprises a complex[e] of gneisses and mica-schists, with igneous intrusives, both massive and schistose, and both basic and acid. The belt seems to stretch 100 miles to the west of the White River, where it probably pitches under the younger sediments. The writer is prepared to believe that sediments may be included in these areas of gneiss and that the results of detailed studies may lead to the assignment of the entire series to a higher horizon than is here given them.

Another belt of crystalline schists lies to the west in the extension of the axis of the White River gneissic area, and the basal character of these is attested by better, though not by any means conclusive, evidence. The writer in the course of an exploration[f] crossed this belt of gneisses south of the Tanana and near the head of the Cantwell, but there was no opportunity to examine the rocks in detail. The rocks are typified by a coarse augen-gneiss similar to that of the gneissic complex of the upper Tanana. This augen-gneiss appears to grade upward into a feldspathic conglomerate which seems to form the basal member of the metamorphic sediments. If such are the facts, these gneisses would appear to be a basal complex. This would also suggest that the other gneissic areas lying to the southeast are Archean, as they all appear to belong to the same belt.

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[a] Prindle, L. M., The Fortymile, Birch Creek, and Fairbanks gold placers: Bull. U. S. Geol. Survey No. 251.

[b] McConnell, R. G., The so-called basal granite of the Yukon: Am. Geol., vol. 30, 1902, pp. 55–62.

[c] Dawson, George M., Geological record of the Rocky Mountain region in Canada: Bull. Geol. Soc. America, vol. 12, 1901, pp. 62–64; Geological Map Dominion of Canada (Western Sheet No. 783), Geological Survey of Canada.

[d] Dawson, G. M., ibid., p. 63.

[e] Brooks, A. H., Reconnaissance of the White and Tanana river basins: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 460–466.

[f] Report is in preparation. An abstract entitled "Reconnaissance in the Mt. McKinley region, Alaska," was published in Science, new ser., vol. 16, 1902, pp. 985–986.

Schrader[a] observed a few outcrops of gneissoid granites and mica-schists in the lower Chandlar Valley north of the Yukon and assigned them to the Archean. As the evidence presented by him makes it almost equally probable that these may be sheared granitic rocks, intrusive in his Lake schists (sedimentary), they are not differentiated from the metamorphosed sediments on the geologic map (Pl. XXI). In this connection it is worthy of note that the older sedimentary terranes of the region sometimes contain crystalline schists and sheared eruptives, which render lithologic evidence of Archean age of relatively little value.

Gneisses are reported by Spurr[b] in the Kuiu Mountains east of the lower Yukon, and by Collier west of the Yukon, near the mouth of the Melozi River, but their Archean age remains to be proved.

The only other rocks which have been referred to as basal granite are near the western margin of the upper part of the Alaska Peninsula. These, described by Spurr,[c] were assigned by him to the pre-Jurassic, but had previously been called Archean. They appear to be an igneous complex of early Mesozoic age (Pl. XXI).

PALEOZOIC.

GENERAL STATEMENT.

The base of the sedimentary succession is not yet known, but it must be sought in the belts of metamorphic clastics, where few structural and age determinations have been made. One such zone (see Pl. XXI) stretches through the Alexander Archipelago and probably continues northward into the St. Elias Range. A second forms a broad belt in the intermontane region and is continuously traceable from the international boundary north and west to Bering Strait except where mantled by younger beds. It is a complex of metamorphic sediments and eruptives, including rocks of very diverse lithologic types, and ranges in age from probably Cambrian, possibly pre-Cambrian, to Devonian, though it is chiefly pre-Devonian. Some lower Mesozoic terranes may also be included with these metamorphic sediments, as outlined on the map, for what appears to be the same series in the Queen Charlotte Islands to the south includes both Triassic and Carboniferous beds, and as both these series have been subjected to about the same degree of metamorphism they can be separated only by detailed mapping, which has not yet been done.

As little has yet been accomplished toward differentiating and mapping this complex series, it is indicated, for the most part, as a cartographic unit (Pl. XXI). In northern Alaska, where the horizons are somewhat less altered, there is some paleontologic[d] evidence of Devonian, Carboniferous, and Silurian terranes, and Devonian and Carboniferous fossils have also been found on the Yukon;[e] Lower Silurian organic remains occur in the Seward Peninsula,[f] and Ordovician[g]

[a] Schrader, F. C., A reconnaissance along Chandlar and Koyukuk rivers: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 471-472.

[b] Spurr, J. E., Reconnaissance in southwestern Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 234-235.

[c] Ibid., pp. 234-235.

[d] Schrader, F. C., Reconnaissance in northern Alaska: Prof. Paper U. S. Geol. Survey No. 20, 1904, pp. 55-71.

[e] Collier, A. J., The coal resources of the Yukon: Bull. U. S. Geol. Survey No. 218, 1903, pp. 16 and 17.

[f] Collier, A. J., A reconnaissance of the northwestern portion of the Seward Peninsula: Prof. Paper U. S. Geol. Survey No. 2, 1902, pp. 20-21.

[g] Brooks, A. H., An exploration in the Mt. McKinley region (in preparation).

and Devonian forms have been found along the western front of the Alaska Range. A few Silurian,[a] Devonian, and Carboniferous forms have been collected from the metamorphic rocks of southeastern Alaska.

These facts indicate that the metamorphic complex, which must have a thickness measured by thousands if not tens of thousands of feet, is probably chiefly Paleozoic. Over much of the province the series is so complex that reconnaissance surveys have yielded but scant results, but in some districts the general succession is fairly well known and forms the basis of the correlations which have already been epitomized in the table facing page 206.

The table does not reveal any close analogy between the Paleozoic succession of western Canada and of any part of Alaska, for the metamorphism seems to have been much greater in Alaska than in Canada, or, in other words, seems to increase to the northwest. Dawson[b] reports 40,000 feet of Cambrian strata in Canada. The equivalents of these rocks are probably present in Alaska, but they lie in the part of the metamorphic series which has not yet yielded fossil remains. All the post-Cambrian systems of western Canada have been found in some parts of Alaska.

Though on the map (Pl. XXI) the Paleozoic areas are largely undifferentiated, for reasons already given, all that is known of the succession will here be summarized. The rocks believed to be the oldest sediments, even though their stratigraphic position is very much in doubt, and the Silurian and Ordovician terranes will be discussed under the heading "Lower Paleozoic." The Devonian and Carboniferous will receive separate consideration.

LOWER PALEOZOIC.

The discussion of the presence or absence of Cambrian and Silurian terranes must be deferred until the succession of the older sedimentaries in various parts of the province has been presented.

The metamorphic rocks of southeastern Alaska include what seems to be a more or less well-defined belt[c] of white crystalline limestone and phyllites stretching through the westernmost islands of the Alexander Archipelago to Glacier Bay, where they have yielded a few Silurian fossils.[d] Silurian fossils have also been found at Freshwater Bay on Chichagof Island. The name "Wales series" has been given to some limestones and phyllites on Prince of Wales Island that appear to lie in the southern extension of this belt. Though metamorphic rocks appear to be abundant in this district, this is the only terrane which has been assigned to the lower Paleozoic. The strike of these rocks to the northwest would carry them into the unexplored St. Elias Range, where the only clues to the geology are a few random notes.[e] For nearly 200 miles the

[a] Brooks, A. H., A reconnaissance of the Ketchikan mining district: Prof. Paper U. S. Geol. Survey No. 1, 1902, pp. 19, 21, and 43. Also unpublished notes of F. E. and C. W. Wright.

[b] Geological record of the Rocky Mountain region of Canada: Bull. Geol. Soc. Am., vol. 12, 1901, p. 62.

[c] Brooks, A. H., op. cit., pp. 19-24 and 41-45.

[d] These organic remains were at first assigned to the Carboniferous, but were subsequently proved to be of Silurian age. Op. cit. p. 19-20. It is very unfortunate that the assignment of this limestone to the Carboniferous should again have appeared in print (Harriman Alaska Expedition, vol. 4, p. 20) two years after the correction had been made.

[e] Brooks, A. H., A reconnaissance from Pyramid Harbor to Eagle City, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 356-373.

region where these terranes might be expected to outcrop is entirely unknown, but near Yakutat Bay Russell[a] found a metamorphic terrane of unknown age, called by him the "St. Elias schists," which may represent the same horizon. One hundred miles farther west in the same strike are crystalline limestones and schists called by Schrader the "Klutina"[b] series and assigned to the pre-Devonian, because of their lithologic similarity to the Fortymile series, which occurs in an entirely different province, 300 miles to the north. Schrader's "Valdez series," of this same district, will be discussed with the Mesozoic terranes.

Mendenhall[c] mapped a small area of highly altered schistose rocks on the southern flank of the Wrangell Mountains, under the name "Dadina schists," and provisionally assigned them to the Silurian. Little is known of their stratigraphic relations, except that they are probably older than the Permian, and in many ways resemble the Klutina rocks.

The name "Tanana schists," first applied by the writer[d] to some metamorphosed, fine-grained, argillaceous, and calcareous rocks of the upper Tanana Valley, was extended by Mendenhall[e] to more highly altered sediments in the Alaska Range, which seem to be an extension of the rocks of the type locality. Mendenhall has again applied this name to the metamorphic schists of the Alaska Range in his later report already cited. In the type locality the Tanana schists are known to be older than the Carboniferous, and are probably older than the Devonian. On the Copper River they are overlain unconformably by beds which are probably Devonian, and it is likely that the Tanana schists are lower Paleozoic or pre-Cambrian. There is, however, further evidence, for the schists of the Alaska Range have been identified again 100 miles to the southwest, where they are well exposed in the gorge of the Cantwell, and appear to extend to the southwest with decreasing metamorphism, and to merge with the closely folded cherts and slates which carry Ordovician fossils and limestones and which are traceable along the western front of the Alaska Range.[f] This latter group of sediments includes a great thickness of Paleozoic terranes, varying in age from at least the Ordovician to the Devonian. The writer, unable to differentiate these, mapped them as a unit, as Spurr had previously done under the name Terra Cotta series.[g] Spurr, who named the series and provisionally assigned it to the Jurassic, recognized its unconformable relation to the overlying beds (Tordrillo series), which he had assigned to the Cretaceous, but which have since been proved to be Jurassic (p. 231). This evidence points to the conclusion that the Terra Cotta may in a general way be synchronous with the Tanana and that both belong to the lower Paleozoic.

[a] Russell, I. C., Expedition to Mount St. Elias: Nat. Geog. Mag., vol. 3, 1891, p. 173-174.

[b] Schrader, F. C., A reconnaissance of a part of Prince William Sound and the Copper River district, in 1898. Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 408-410. Schrader, F. C., and Spencer, A. C., Geology and mineral resources of a portion of the Copper River region, U. S. Geol. Survey, 1901, pp. 34-37.

[c] Mendenhall, W. C., The geology of the central Copper River region: Prof. Paper U. S. Geol. Survey No. 41, 1905, pp. 27-30.

[d] Brooks, A. H., A reconnaissance in the White and Tanana river basins: Twentieth Ann. Rept. U. S. Geol. Survey pt. 7, 1900, pp. 468-470.

[e] Mendenhall, W. C., A reconnaissance from Resurrection Bay to the Tanana River: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 313-314.

[f] Brooks, A. H., An exploration in the Mount McKinley region (in preparation).

[g] Spurr, J. E., A reconnaissance in southwestern Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 156-157.

The oldest sediments of the Yukon-Tanana region include a great thickness of closely folded siliceous schists, phyllites, and quartzites, associated with crystalline limestones. The basal member of this series is believed to be an arkose conglomerate (see p. 209), and to have been derived from the erosion of the gneisses, which would indicate an unconformity at the base of the sediments. According to Spurr,[a] the conglomerate is succeeded by Birch Creek schists (Birch Creek series), typified by highly altered arenaceous sediments, often carrying graphite. Spurr's estimate of the thickness as 25,000 feet is probably much too great, for Prindle's[b] more detailed studies in the same field have shown that the folding is so complex as to almost defy accurate measurements of thickness.

The arenaceous sediments merge gradually upward into calcareous rocks and finally into the crystalline limestones interbedded with quartzites, which Spurr[c] called "Fortymile series." This series is typically made up of marbles and quartzites, with some hornblende and garnetiferous and sometimes graphitic schists. Prindle and Hess in 1904 found fossils of either Silurian or Devonian age in a white crystalline limestone in the headwater region of Birch Creek and Tolovana River. Both the Birch Creek schists and the Fortymile series contain abundant intrusives and are cut by many quartz veins, some of which are metalliferous and form the source of the placer gold. These two formations are unconformably overlain by the Rampart series (Devonian), and are therefore of lower Paleozoic or pre-Cambrian age.

McConnell's[d] determinations of the stratigraphy of the Klondike region, made in considerable detail, are briefly summarized in the following table:

Stratigraphy of the Klondike region.

System.	Formation.	Lithologic character.
Stratified and foliated rocks, mostly Paleozoic	Moose Hide group	Green igneous rocks, both massive and schistose.
	Klondike series	Micaceous and feldspathic schists, probably altered eruptives.
	Hunker series	Graphite-schists, some limestones, dolomites, and green schists.
	Indian River series	Slates and quartz-schists, passing into mica-schists, with some limestone.

While there is not the close correspondence which might be expected between this sequence and that determined by Spurr in the adjacent regions to the west, yet there is some similarity. McConnell's basal rocks, the Indian River series, similar

[a] Spurr, J. E., The geology of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1900, pp. 140-145.
[b] Prindle, L. M., Gold placers of the Fortymile, Birch Creek, and Fairbanks regions: Bull. U. S. Geol. Survey No. 251.
[c] Spurr, J. E., op. cit., pp. 145-554.
[d] McConnell, R. G., The Klondike region: Ann. Rept. Geol. Survey Canada, vol. 12, new series, 1899, pp. 18A-20A.

to the Birch Creek schists, are overlain by the Hunker series, not unlike the Fortymile series. No equivalent of the Klondike series has been recognized to the west, and though the highest of McConnell's metamorphic rocks are of igneous origin, they are not very similar to the Rampart series (Devonian).

Some white crystalline limestones, with phyllites, seem to overlie the gneisses on the lower White River. They were called the "Nasina[a] series," and provisionally correlated with the Fortymile rocks. McConnell[b] has adopted the name "Nasina series," and in a personal letter states that he has traced it far to the south and inclines to the belief that it is the equivalent of the sediments included by Dawson in his Shuswap series.

Since the above was written, Prindle and Hess have spent a field season in the Yukon-Tanana region. Their results have not yet been digested, but the following table presents in concise form their provisional conclusions:

Stratigraphy of the Yukon-Tanana region.

System.	Formation.	Relation.	Lithologic character.
Pennsylvanian, perhaps Permo-Carboniferous.	....	(?)	Gray, green, and black shales, and thin siliceous beds.
Devonian	Rampart formation	(?)	Limestone, shales, slate, grit, quartzite, conglomerate, chert, and greenstone partly tuffaceous.
Older than Devonian	Fortymile formation	Uncomformity ?	Schists and crystalline limestones.
Older than Devonian	Birch Creek schists	Conformity ?	Quartzite and schists.

The succession in the older metamorphic terranes north of the Yukon is hardly as well established as might be inferred from the multiplicity of formation names. Schrader's first account[c] of the geology, based on an exploration in the Chandlar and Koyukuk basins, gave the sequence of pre-Devonian rocks about as follows:

The Rapid schist, regarded as the base of the sedimentary rocks, is a biotite-schist, often carrying garnet and other metamorphic minerals, but the published description does not show any marked difference between it and the schists associated with Schrader's so-called "basal granite" already referred to. The second horizon, termed "amphibolite-schist," is described as fine grained and pale green in color, but as it also is made to include a quartz-mica-schist, it would not seem to be very different from the older Rapid schists, or the younger Lake quartzite schists, and its green facies might be an altered intrusive. The Lake quartzite

[a] Brooks, A. H., Reconnaissance in Tanana and White river basins: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, 465-466.

In another report, entitled "A reconnaissance from Pyramid Harbor to Eagle City" (Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 357 and 358) the writer grouped all the gold-bearing rocks together under the name Kotlo series, which would include the Birch Creek, Fortymile, and Rampart series, but now that more detailed studies have been made, the name "Kotlo" can be entirely eliminated from the stratigraphic nomenclature.

[b] Summary Rept. Geol. Survey Canada for 1900, p. 41.

[c] Schrader, F. C., A reconnaissance along Chandlar and Koyukuk rivers: Twenty-first Ann. Rept. U. S. Geol. Survey, pt 2, 1900, pp. 472-476.

schists, the next younger horizon, is apparently essentially a mica-schist, and mineralogically does not differ from the two older formations except in the presence of graphite. These three formations are lithologically so similar and their succession seems so much in doubt that it appears they can here be grouped together. They form a broad belt of highly metamorphosed sediments, with some intrusives, which are succeeded on the north by heavily bedded crystalline limestone and mica-schists, termed the "Bettles series," and there is some evidence that the latter may rest uncomformably on the older rocks.

In Schrader's[a] second journey he studied a section parallel to and 100 miles to the west of his first section. This yielded far more definite results, but unfortunately he was able to correlate only in part the formations in the two sections. The Skagit formation, made up of heavily bedded crystalline limestones and mica-schists, is placed at the base. This yielded some obscure organic remains which indicate that it is not older than the upper Silurian. Some mica-schists and quartz-mica-schists outcropping south of the Skagit were called the "Totsen series." The contact between these rocks and the Skagit was not exposed, but Schrader[b] appears to have regarded the Totsen as the younger, though his statements[b] on this point are not entirely in accord. The evidence presented might almost equally well be interpreted as indicating that the Totsen underlies the Skagit, and might be correlated with the Rapid and Lake schists which lie to the east in the extension of the strike, a correlation made by Schrader in his table.[c] If this proves to be the case, the two crystalline limestone horizons, the Skagit and the Bettles, are probably equivalent. The correlation of Schrader's parallel sections, borne out by lithologic similarity and by structure, is suggested to be as follows: In both sections mica-schist, quartz-mica-schist, and greenstone, or amphibolite-schist, are succeeded to the north by heavy-bedded white crystalline limestone with intercalated schist layers. If the writer's interpretation be correct, the equivalency of Schrader's pre-Devonian terranes would be thus:

(Upper Sil.?) Skagit formation=Bettles series.
Totsen series and greenstone schist=Rapid, Lake, and amphibolite schists.

It will be evident that this succession resembles that of the oldest sediments of the Yukon-Tanana region, for the lower horizon of mica- and quartz-schist is similar to the Birch Creek schists, while the upper, consisting of crystalline limestones and mica-schists, is not unlike the Fortymile rocks.

Some metamorphic beds are exposed along the John River Valley and in the heart of the Endicott Mountains, but these Schrader believes to be younger than the terranes which have been described, and places in his "Fickett series" (Carboniferous). Schrader's "Stuver series" is probably Devonian or younger, and will be described below.

Nothing is known of the westward extension of these metamorphics, except in the area studied by Mendenhall[d] during his exploration of the Alatna and Kobuk

[a] Schrader, F. C., A reconnaissance in northern Alaska: Prof. Paper U. S. Geol. Survey No. 20, 1904, pp. 55–62.
[b] Ibid., pp. 58, 59, 65, and 97.
[c] Ibid., p. 97.
[d] Mendenhall, W. C., A reconnaissance from Fort Hamlin to Kotzebue Sound: Prof. Paper U. S. Geol. Survey No. 10, 1902, pp. 31-36.

valleys. He was unable to subdivide the semicrystalline rocks which he encountered in his rapid journey and grouped them together as a "metamorphic complex." The members of this great group include schists of various types, limestones, quartzites, and greenstones, and resemble lithologically the older terranes of other parts of Alaska. Mendenhall traced these rocks westward to Kotzebue Sound, and indicated that in a general way they were the equivalent of the metamorphic terranes of the Seward Peninsula.

The accumulation of geologic data regarding the Seward Peninsula has gone on intermittently since 1899, and the close of the season of 1903 saw the completion of the reconnaissance surveys throughout the peninsula. The facts here presented are based on the writer's own field work in 1900,[a] but are modified by the facts learned by Collier, who extended the reconnaissance work in 1901[b] and again in 1903.[c] Other contributors have been Mendenhall,[d] who made a reconnaissance in the Norton Bay region in 1900 and in 1901[e] touched the northern coast during an exploration already referred to, and Moffit,[f] who completed the reconnaissance mapping of the northeastern portion of the peninsula in 1903.

Most of the bed-rock series is probably older than the Devonian, and the terranes vary from highly crystalline schists to those which are but little altered, as the metamorphism seems to have been of a rather local character. The stratigraphic succession is now fairly well determined, though only one formation has on paleontologic evidence received a definite assignment in the time scale. Beginning with the oldest, the general succession is as follows: Mica-schist and crystalline limestone (Kigluaik series), graphitic quartzites (Kuzitrin series, unconformably overlain by mica-schists), then massive limestones overlain by mica-schists (Nome series). The massive limestone of the Nome series, called the Port Clarence limestone, has yielded Silurian fossils.

As first defined, the Kigluaik series is made up of highly crystalline limestones and mica-schists cut by many massive granite dikes. It is typically exposed in the Kigluaik Mountains. Collier's late studies have shown that the series also includes some gneissoid rocks and some highly graphitic schists. They are apparently conformably overlain by the Kuzitrin series, which is typically made up of a highly graphitic quartzite. As the Kuzitrin series has not been recognized throughout the area it may have been in part removed by erosion before the deposition of the succeeding beds of the Nome series, which are apparently unconformable.

The Nome series, the next horizon, is a group of rocks of great diversity of lithologic character. A considerable thickness of mica-schists, containing quartz and some albite, forms the basal member. Above this is massive limestone, locally semicrystalline, called the Port Clarence limestone. The first fossils found in this

[a] Brooks, A. H., A reconnaissance of the Cape Nome and adjacent gold fields of Seward Peninsula, in a special publication, U. S. Geol. Survey, entitled Reconnaissances in the Cape Nome and Norton Bay regions, Alaska, 1900, pp. 27-41.

[b] Collier, A. J., A reconnaissance of the western portion of the Seward Peninsula: Prof. Paper U. S. Geol. Survey No. 10, pp. 16-24.

[c] Results not published.

[d] Mendenhall, W. C., A reconnaissance in the Norton Bay region, Alaska, in 1900, contained in a special publication of the U. S. Geol. Survey, entitled Reconnaissances in the Cape Nome and Norton Bay regions, pp. 199-205.

[e] Collier, A. J., op. cit.; Prof. Paper U. S. Geol. Survey No. 10, 1902.

[f] Moffit, F. H., The Fairhaven gold placers, Seward Peninsula, Alaska: Bull. U. S. Geol. Survey No. 247.

horizon were thought to be of lower Silurian age, but more complete collections have shown them to be upper Silurian. The Port Clarence limestone in places is overlain by schistose rocks, which constitute the upper member of the Nome series. In the southern part of the peninsula these schists are lithologically identical with those occurring below the limestone member, but to the north they are represented, in part at least, by calcareous schists and with some mica and chloritic schists. The whole series has been penetrated by many dikes and sills which are chiefly basic rocks.

In the first description of the Nome[a] series it was pointed out that it might include some Mesozoic beds because of certain obscure fossils collected by Mendenhall in the Fish River Valley. The paleontologists were convinced that these fossils were Mesozoic forms, though the stratigraphic work had led to the correlation of the limestone in which they occurred with the limestone in which Silurian forms had been found in the Port Clarence region. This made it necessary to believe that the "Nome series" included beds as widely separated in the geologic time scale as the Mesozoic and Silurian. More complete collections from the same locality have shown the error of the first determination, and the organic remains are now all assigned to the Silurian.

Recently a limestone near Cape Prince of Wales yielded a small collection of fossils, which may be Devonian or Carboniferous. If more perfect specimens show that the age of these fossils has been correctly determined, it is quite possible that some upper Paleozoic beds have been included in the Nome series.

The presence of Carboniferous beds at Cape Lisburne, 300 miles to the north, is attested by abundant fossil[b] evidence, but the occurrence of Silurian in this locality is based on fossils collected and identified more than half a century ago. Schuchert, who makes mention of Silurian fossils from this locality in a brief summary of the Alaska[c] Paleozoic, published in 1896, has informed the writer that as the later collections have revealed no Silurian forms he thinks the determinations published by Grewingk[d] may be in error.

It has been shown that the oldest sedimentary terranes are usually highly altered, and that the stratigraphic sequence is only imperfectly known. Ordovician fossils have been found only on the west side of the Alaska Range and Silurian only in southeastern Alaska and in the Seward Peninsula. A third locality in northern Alaska has yielded a few obscure fossils, which have been provisionally assigned to the Silurian. In southeastern Alaska the Silurian beds appear to lie near the base of the sedimentary series, and the same probably is true of the Ordovician horizon in the Alaska Range. The Silurian of the Seward Peninsula overlies a great sedimentary series, as does the supposed Silurian of northern

[a] Brooks, A. H., Reconnaissance of Cape Nome and adjacent gold fields of Seward Peninsula: Reconnaissances in the Cape Nome and Norton Bay regions in 1900 (special publication U. S. Geol. Survey), 1901, p. 31.

[b] Collier, Arthur J., unpublished notes.

[c] Schuchert, Charles, Report on Paleozoic fossils from Alaska: Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, pp. 898-906.

[d] Grewingk, C., Beiträge zur Kentniss der orographischen und geognostichen Beschaffenheit der Nordwest Küste Amerikas mit den anliegenden Inseln: Verhandl. der Russ. K. Mineral. Gesell. zu St. Petersburg, 1848-49. Also separate 1850.

Alaska. The fossils of all three of the Silurian localities occur in a massive limestone, with some intercalated beds of mica-schists or phyllites. Both in northern Alaska and in the Seward Peninsula a great series of mica-schists or phyllites occurs immediately beneath the Silurian limestone. These facts suggest that these limestones belong to the same horizon, but as some of its occurrences are a thousand miles apart the correlation is advanced only as a tentative hypothesis.

The white limestone of the Yukon region (Fortymile series), known to be of pre-Devonian age, like the Silurian fossil-bearing limestone, which it closely resembles, also overlies a schist and phyllite series, and this suggests a further correlation of this Fortymile series with the other Silurian limestones. The correlations suggested would make the Wales (southeastern Alaska), Fortymile (Yukon), the Skagit (Koyukuk Valley), and Nome (Seward Peninsula) series approximately equivalent in age and show a very extensive development of the Silurian. It is of interest to note that these horizons are all mineralized and gold bearing.

Below the Silurian there are no paleontologic data, with the exception of the Ordovician in the Alaska Range, and of this little is known. The similarity of the Birch Creek, Lake, Rapid, Totsen, and Kuzitrin series in lithology, degree of metamorphism, and stratigraphic position below the supposed Silurian limestone suggests that these formations may belong to the same horizon. Here again all of these terranes are mineralized. A necessary corollary of these conclusions is that the Kigluaik series of the Seward Peninsula is the oldest sedimentary horizon of Alaska.

There is no clue to the age of these schistose rocks. They may be of Lower Silurian, Ordovician, Cambrian, or pre-Cambrian age. The fact that Dawson[a] estimates the Cambrian rocks in British Columbia to have a thickness of 25,000 to 40,000 feet makes it plausible to regard these rocks as in part, as least, of Cambrian age.

Igneous rocks are often associated with these metamorphic sediments, but the laws of their local distribution are not known. The intrusives are of several ages, the more recent ones being entirely massive, while the older have often been as much sheared as the schists with which they are associated. The quartz veins seem to be concomitants of the igneous rocks, and, as they are the source of the placer gold, the distribution of the intrusives is a matter of economic importance.

DEVONIAN.

The geologic map (Pl. XXI) does not indicate the very wide distribution of the Devonian horizons, for they are included in part with the Carboniferous and in part with the undifferentiated Paleozoic. Several rock groups have been assigned to the Devonian, but only one is definitely known to find place in it. This, a siliceous blue limestone, with usually an abundant coral fauna of middle Devonian types, has been identified in nearly all parts of the province which have been visited by geologists. The Devonian rocks are usually much less metamorphosed than the older Paleozoic sediments, to which they seem to bear an unconformable relation. Siliceous limestones (middle Devonian fossils) and slates, which

[a] Geological record Rocky Mountain region Can.: Bull. Geol. Soc. America, vol. 12, 1901, pp. 64-68.

outcrop in a small area in the southern part of the Alexander Archipelago, were called the "Vallenar[a] series," and seem to rest unconformably on the Wales series (Silurian ?). The same horizon probably occurs at Kuiu Island and at Glacier[b] Bay, and probably has a rather wide distribution in southeastern Alaska.

The Nikolai greenstone in the Copper River region, probably of Devonian or Carboniferous age, comprises a series of volcanic[c] flows, usually of diabasic character, and conformably overlain by the Chitistone limestone (Permian ?) provisionally assigned to the Carboniferous. The age of the Nikolai is uncertain, but it is worthy of note that its lithology and probable stratigraphic position are similar to the Rampart series (Devonian), to be described below.

The Wellesley[d] formation, which is composed of a basal member made up of heavy conglomerate, and an upper member, largely of clay slates, has been recognized in only a small area in the upper Tanana and White river basins, where it rests unconformably on greenstone schists. A few fragmentary fossil remains led to its assignment to the Carboniferous or Devonian, and as the known occurrences of the former in the immediately adjacent region are all limestones, the Wellesley is probably Devonian.

Mendenhall[e] found a similar formation in the Copper River basin, about 150 miles to the west, and called it the "Chisna group." It consists of conglomerates, quartzites, arkoses, with some calcareous beds and an abundance of tufaceous material and igneous rocks. Though Mendenhall provisionally assigns this to the Carboniferous, the evidence seems equally strong that it may be Devonian, and in any event the Wellesley and Chisna are probably synchronous deposits and may represent the base of the Devonian. Eldridge's[f] "Cantwell conglomerate," a series composed of conglomerate and coarse sandstone, may be a western extension of the Chisna. A heavy conglomerate,[g] sometimes associated with tufaceous deposits, outcrops along the western front of the Alaska Range and overlies unconformably the more highly altered sediments (Silurian or Ordovician ?). This formation resembles the Chisna and Wellesley, but the correlations are of doubtful value, because a similar conglomerate occurs in association with a Mesozoic or Tertiary coal-bearing horizon of this district. The "Stuver series," which occurs 500 miles to the northwest, near the Arctic front of the Rocky Mountains, is also largely made of a conglomerate, and may be of the same horizon. It is described below.

In detached areas along the western front of the Alaska Range,[h] a blue siliceous limestone yielded middle Devonian fossils at several localities, but is so closely infolded with older rocks, that it had to be mapped with the undifferentiated Pale-

[a] Brooks, A. H., Preliminary report on the Ketchikan mining district: Prof. Paper U. S. Geol. Survey No. 1, 1902, pp. 42-43.

[b] Ibid., p. 21.

[c] Schrader, F. C., and Spencer, A. C., The Geology and Mineral Resources of a Portion of the Copper River District, U. S. Geol. Survey, 1901, pp. 40-43.

[d] Brooks, A. H., A reconnaissance in the Tanana and White river basins: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 470-472.

[e] Mendenhall, W. C., Geology of the central Copper River region, Alaska: Prof. Paper U. S. Geol. Survey No. 41.

[f] Eldridge, G. H., A reconnaissance in the Sushitna basin and adjacent territory: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, p. 16.

[g] Brooks, A. H., An exploration in the Mount McKinley region, U. S. Geol. Survey. (In preparation.)

[h] Ibid.

ozoic. Fifty miles to the west Spurr[a] found a considerable area of gray limestone, to which he gave the name Tachatna series. These rocks are generally thin bedded, with calcareous, carbonaceous, and chloritic slates and some fine-grained arkoses, and yielded middle Devonian fossils. They are unconformably overlain by lower Cretaceous beds.

The Rampart series, which thus far has proved the best defined stratigraphic unit of the Paleozoic in the central region, seems to reach its greatest development in the district roughly defined by the Yukon on the north and west, the Tanana on the south, and the international boundary on the east. Spurr,[b] who named this formation, characterized its rocks as dark green, rather massive volcanic diabases, with diabase tuffs and intercalated beds of slate and impure limestone. Later studies by Collier, Prindle, and the writer show that the Rampart series contains also considerable blue siliceous limestone. Spurr assigned the Rampart to the Paleozoic, and the discovery of fossils in the limestone shows that it is Devonian and is probably a part of the middle Devonian terrane, found elsewhere in Alaska. The Rampart series bears an unconformable relation to the older Fortymile series (Silurian?) and Birch Creek schists, as well as to younger Carboniferous rocks.

Northwest of the Yukon is an igneous complex which Mendenhall[c] has described under the term Kanuti series. These rocks are in many ways very like the Rampart series with which he provisionally correlated it. The Kanuti, as defined by him, contains no sediments except some hornstone, and appears to include more intrusive material than the typical Rampart. The basal members are greenstone and hornstone, which are intruded by basic igneous rocks, succeeded by basalts, tuffs, and diabases.

Devonian beds have not been definitely recognized in northern Alaska, for the Lisburne horizon, assigned to this system by Schrader, proves, as will be shown below, to be Carboniferous (Pennsylvanian). The Stuver[d] series, made up of conglomerate and quartzites, underlies the Lisburne unconformably along the upper part of the Anaktuvuk Valley and may be of Devonian age. Schrader seems to have been in doubt as to the true stratigraphic position of the Stuver series, for in one table of the report cited (p. 53) he places it at the base of his sedimentary series (pre-Silurian), while in another (p. 97) he puts it well up in the Paleozoic, and correlates it with the Lake quartz-schists, a formation which it appears in no way to resemble. Its possible correlation with the Chisna and Wellesley formations has already been indicated. The degree of metamorphism, as well as other facts presented by Schrader, might lead to the inference that the Stuver series represented some infolded Mesozoic beds had he not definite proof of its being older than the Lisburne. The Fickett series, which occurs to the south, provisionally assigned by Schrader to the Carboniferous, contains conglomerates[e] which are in every way identical with those of the Stuver, and had there been opportunity for closer studies it seems possible that they might prove to be of the same horizon.

[a] Spurr, J. E., A reconnaissance in southwestern Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 157-159.

[b] Spurr, J. E., The geology of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 155-169.

[c] Mendenhall, W. C., A reconnaissance from Fort Hamlin to Kotzebue Sound: Prof. Paper U. S. Geol. Survey No. 10, 1902, pp. 37-38.

[d] Schrader, F. C., Reconnaissance in northern Alaska: Prof. Paper U. S. Geol. Survey No. 20, 1904, pp. 60-62.

[e] Ibid., p. 68.

Reference has already been made to the Bettles series, which, according to Schrader, is probably Devonian, but is here correlated with Skagit (Silurian?). The only evidence of Devonian rocks in the Chandlar basin is furnished by fossils collected by Schrader[a] from the stream gravels of the Chandlar River, but these organic remains are obscure and may prove to be Carboniferous. At Cape Lisburne, Collier found a series of sandstones and slates whose thickness aggregates more than 2,000 feet, overlain conformably by Carboniferous (Mississippian) beds (p. 224). These he has provisionally assigned to the Devonian.

McConnell[b] found limestones carrying fossils, probably of Devonian age, at the lower ramparts of the Porcupine, which suggests that the Devonian occurs to the east. The fragmentary fossils found near Cape Prince of Wales, which may be Devonian, have already been referred to.

The region east of the Rocky Mountains, in the Mackenzie basin, was one of extensive deposition during Devonian times. McConnell[c] here recognized three subdivisions in the Devonian: An upper limestone and dolomite formation containing extensive coral remains, and having a thickness of about 300 feet, several hundred feet of shales with some limestone, and a lower member, consisting of at least 2,000 feet of limestone and dolomite with some quartzite. The last was not found to be fossiliferous and may include beds older than the Devonian.

To summarize briefly, the Devonian is represented by limestones and slates in southeastern Alaska, and by siliceous limestones and calcareous shales in the Kuskokwim region. In the upper Tanana and Copper River basins a heavy conglomerate, quartzite, and slate and tufaceous series is provisionally assigned to the Devonian, while near the Yukon River this period is represented by a great series of volcanic flows, with some siliceous limestones. The presence of Devonian rocks in northern Alaska is not yet established on Paleontologic evidence. At Cape Lisburne there is a great thickness of sandstones and slates which are probably Devonian, but which have yielded no fossils. In the Colville basin a heavy conglomerate and quartzite series (Stuver) may be Devonian, though on the accompanying table they are included in the Carboniferous.

Though igneous rocks are closely associated with the Devonian beds of the Yukon—the Kuskokwim basin and southeastern Alaska—they seem to be entirely lacking in the beds of this age in the northern part of the Territory.

CARBONIFEROUS.

On the geologic map (Pl. XXI) the distribution of the Carboniferous is not indicated, for it is in part included in the undifferentiated Paleozoic, in part in the Devonian. At least two distinct Carboniferous horizons are present. The one, Permian, has been traced in a general way from southeastern Alaska into the Copper River basin, and is found again on the Yukon; the other, Lower Carboniferous, outcrops in the Copper River basin, on the Yukon, and in northern Alaska.

In southeastern Alaska the presence of Carboniferous is attested by fossils from Kuiu[d] and Admiralty islands.

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[a] Schrader, F. C., Reconnaissance in northern Alaska: Prof. Paper U. S. Geol. Survey No. 20, 1904, p. 66.

[b] McConnell, R. G., Report on an exploration in the Yukon and Mackenzie basins, N. W. T.: Ann. Rept. Geol. Nat. Hist. Survey Canada, new series, vol. 4, 1890, p. 133D.

[c] Ibid., pp. 14D–18D.

[d] Brooks, A. H., A reconnaissance of the Ketchikan mining district: Prof. Paper U. S. Geol. Survey No. 1, 1902, p. 21.

The Ketchikan series, consisting of argillites, with some greenstones and limestones, may be of Carboniferous age,[a] but may also include some infolded Triassic beds. Spencer, who has recently studied in the Juneau region what seems to be a northern extension of the Ketchikan belt of rocks, however, found obscure fossils at Taku Harbor, which have been provisionally assigned to the Carboniferous. Wright[b] found doubtful Permian fossils in what appeared to be the same horizon 100 miles to the north, in the Porcupine gold district. It appears then that there is a fairly well-defined belt of rocks, in part, at least, Carboniferous, skirting the mainland of southeastern Alaska, and there may be other occurrences of this horizon in the islands to the west.

The northwest strike of this series would carry it into the unexplored St. Elias Range, but in the White and Copper River basins Permian rocks are known to occur. In 1899 the writer[c] found a heavy bed of southerly dipping white semicrystalline limestone outcropping along the northern base of the St. Elias Range and traced it almost continuously from the Kashaw River, a tributary of the West Fork of the Alsek, to the Nabesna, a distance of nearly 200 miles, but at only one locality, Kletsan Creek (White River basin), did it yield well-preserved fossils, a few of which were collected and referred by Schuchert to the Carboniferous, but, with a more complete knowledge of the fauna from collections from adjacent regions, he has been able to definitely assign this horizon to the Permian. The field notes were too meager to permit the differentiation of this limestone from the Nutzotin series, a subdivision now abandoned, but intended to include the Carboniferous and Devonian. This Permian limestone of the White River is succeeded conformably by black slates, which are probably Triassic.

Schrader, three years later, after a more detailed examination of the upper Tanana region, found a much larger area of the Carboniferous rocks and collected both Permian and lower Carboniferous fossils. The Permian beds he has called the Suslota limestone, and the lower Carboniferous the Nabesna limestone.

Still farther west, in the southern foothills of the Alaska Range, Mendenhall[d] found Permian beds which are composed of 6,000 and 7,000 feet of sandstones, shales, and limestones, with intrusive sheets with some pyroclastics, and which he termed the Mankomen group. Fossils are sufficiently widely distributed throughout the section to justify assigning the entire succession to the Permian. Such a great development of Permian is unknown in adjacent areas, and the determination might be open to question were it not based on a carefully measured section and on more detailed studies than have been made anywhere else in the province. Similar close work is likely to disclose Permian horizons in other districts. The Mankomen is not found in association with any younger beds, and as it is cut off on one side by a fault with a throw of thousands of feet, its stratigraphic relations to other horizons are unknown.

On the south side of the Wrangell Mountains the Carboniferous may be represented by the Chitistone limestone which rests conformably on the Nikolai

[a] Brooks, A. H., A reconnaissance of the Ketchikan mining district: Prof. Paper U. S. Geol. Survey No. 1, 1902, p. 44.

[b] Wright, C. W., The Porcupine placer district: Bull. U. S. Geol. Survey No. 236, 1904.

[c] Brooks, A. H., A reconnaissance from Pyramid Harbor to Eagle City: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 359.

[d] Mendenhall, W. C., The geology of the central Copper River region: Prof. Paper U. S. Geol. Survey No. 41.

greenstone (Devonian?), and is succeeded conformably by beds of known Triassic age. This formation is a very massive limestone, probably 2,000 feet thick. No fossils have been found in it, and its age determination rests solely on correlation with the Permian on the north side of the mountains.

North and west of the Copper River basin the reconnaissance surveys have not disclosed any Carboniferous beds as far as the Yukon near the Arctic Circle. At the so-called Calico Bluffs, Collier found a series of closely folded semi-crystalline limestones and black slates, which yield lower Carboniferous fossils. A few miles below these rocks are unconformably overlain by a conglomerate limestone and slate series which carries Permian fossils. This is an interesting locality because it makes known an erosional interval within the Carboniferous which has not been recognized elsewhere in Alaska. Spurr[a] included both these groups of Carboniferous in his so-called Tahkandit series, which was intended to embrace both the Carboniferous and the Devonian. Prindle and Hess have recently found Carboniferous fossils in limestone which occurs about 50 miles east of Fort Hamlin.

During his exploration of the Anaktuvuk, in northern Alaska, Schrader traversed a belt of phyllites, chloritic schists, limestones, slate, sandstone, quartzite, grit, and conglomerates, about 50 miles in width. In spite of the heterogeneity of these rocks and the uncertainty of their interrelations, the hasty character of the field observation made it necessary to group them in one formation, the Fickett[b] series. The only fossils encountered were in the stream gravels and were evidently derived from beds in this series, and on this evidence the entire succession was provisionally assigned to the Lower Carboniferous. The Fickett overlies the Skagit (Silurian?) on the south by an unconformable overlap, and on the north it is cut off by a fault from the Lisburne (Carboniferous). Schrader states that the Fickett and Lisburne series bear an unconformable relation.

The Fickett series, which may have a thickness of 8,000 to 10,000 feet, has a basal member made up of shale, slate, and limestone, succeeded by quartzite, grit, and conglomerate, and then by slate and micaceous sandstone. It is in this part of the section that the limestone is supposed to occur which yielded the Carboniferous fossils of the stream gravels. A still higher member includes sandstone, limestone, quartzite, schists, slate, and conglomerate, succeeded by quartz-schists and green chloritic schists, the latter often cut by quartz veins. It is not made clear why the most highly altered members should occur at the top of the series, for while it is true that these metamorphosed rocks lie near one of the axes of intense folding it would be expected that the same metamorphic effect would have been noted at the northern limit of the section where another locus of extreme deformation was observed.

Schrader, fully realizing the incompleteness of his field notes, states that possibly beds of Mesozoic age may have been included in his Fickett series. From the standpoint of historical geology the foregoing adds little to stratigraphic knowledge except the mere fact of the presence of a Carboniferous horizon in this thin area.

The so-called Lisburne series, forming a second horizon in the Carboniferous of northern Alaska, is made up of crystalline[c] limestones and intercalated shales.

[a] Spurr, J. E., Geology of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 169-175.
[b] Schrader, F. C., A reconnaissance in northern Alaska: Prof. Paper U. S. Geol. Survey No. 20, 1904, pp. 67-72.
[c] Ibid., pp. 62-67.

Schrader, who defined this series, recognized it in the Colville basin and also 400 miles to the west at Cape Lisburne. He assigned it to the Devonian, primarily on the basis of fossil evidence, but the more complete collections from the Cape Lisburne locality made by Mr. Collier indicate that these rocks are Carboniferous and probably younger than the Fickett series. In the Colville basin the Lisburne rocks on the south rest on the Stuver series (Carboniferous or Devonian?) and on the north at the base of the range give way to Lower Cretaceous beds.

Mr. Collier measured the following section of Carboniferous rocks at Cape Lisburne:

Stratigraphy at Cape Lisburne.

System.	Formation.	Thickness, etc.	Lithologic character.
Carboniferous (Pennsylvanian).	Lisburne series	3,000′±	A—Massive limestones interstratified with white cherts. Extensive coral and bryozoan fauna.
		Conformity 1,000′±	B—Thinly bedded shales, slates, cherts, and limestones. Fauna includes brachiopods, trilobites, cephalopods, and lamellibranchs.
		Conformity 500′±	C—Thinly bedded black shales, slates, and limestones; several coal beds; lower Carboniferous flora, brachiopods, and coral fauna.
Devonian?		Conformity 2,000′+	Calcareous sandstones and slates. No fossils found.

The lowest member of the Carboniferous here indicated carries fossils which are probably of the same horizon as those found by Schrader in his Fickett series. No exact equivalency between the two horizons can, however, be established because the Fickett appears to include a vast thickness of very heterogeneous beds, whose age determination must await further investigations.

Collier has found Carboniferous fossils in the limestones which are exposed on the east flank of Cape Mountain near the western end of the Seward Peninsula, and these are provisionally correlated with the Lisburne series. The same horizon probably also occurs on St. Lawrence Island where one Carboniferous fossil has been found by Collier.

To summarize briefly: A belt of Carboniferous rocks (probably Permian) has been fairly well traced throughout southeastern Alaska; the continuation of the strike of these would carry them into the White, Tanana, and Copper River basins, where there is a very extensive development of Permian beds and also some lower Carboniferous rocks; Permian beds have also been found on the Yukon, near the Arctic Circle, resting unconformably on strata of lower Carboniferous age. In northern Alaska the presence of two Carboniferous horizons is established by fossil evidence, though there is little definite knowledge of their extent or stratigraphic and structural relations. In all except this northern field igneous intrusives are found cutting the Carboniferous rocks, and in southeastern

Alaska it is probable that some of the associated greenstone schists are ancient lava flows. In the Copper River basin volcanic rocks are characteristic accompaniments of the sediments referred to the Permian.

Of the adjacent provinces the Mackenzie seems to contain no Carboniferous, or at least it was not recognized by McConnell in his explorations. In British Columbia, however, Dawson[a] has found this period well represented, chiefly by limestones. These limestones he has traced northward into the Yukon Territory, but not to the Alaskan boundary. They are in places accompanied by a large amount of volcanic material and resemble the rocks of the Mankomen group. These rocks are generally thin bedded, with calcareous, carbonaceous, and chloritic slates, and some fine-grained arkoses and yielded middle Devonian fossils. They are unconformably overlain by Lower Cretaceous beds.

MESOZOIC.

GENERAL STATEMENT.

The Mesozoic is well represented in Alaska, where all three of its larger subdivisions have been recognized. The Triassic and Jurassic have been identified only in the Pacfic Mountain province and near Cape Sabine, in northern Alaska, but Cretaceous rocks are found not only at these localities, but also in the Yukon basin and in the Arctic slope region.

Three large areas of Mesozoic terranes are indicated on the geologic map (Pl. XX). One stretches along the western shore of the Pacific, extending in somewhat broken belts northeast into the Copper River basin, north into the heart of the Alaska Range, and southwest into the Alaska Peninsula, the larger part of which is composed of Mesozoic rocks. A second area of Mesozoic lies in the lower part of the Kuskokwin Valley and stretches northwestward to the Yukon and up its tributary, the Koyukuk, to the base of the Rocky Mountains, where it overlaps unconformably on the Paleozoics. The southern belt is composed of Triassic, Jurassic, and Lower Cretaceous rocks, while the northern is probably largely made up of Cretaceous beds. A third area of Mesozoic rocks, which includes Jurassic and Lower and Upper Cretaceous terranes, forms an east-west belt north of the Endicott Range, and has been identified in the Colville basin and again at Cape Lisburne. The eastward extension of this belt is found in the Cretaceous rocks exposed along the watershed between Porcupine and Mackenzie rivers. Besides the above large belts some small areas of Mesozoic rocks occur in southeastern Alaska.

In the following pages the undifferentiated Mesozoic, the Triassic, and Jurassic will be discussed together, and will be followed by an account of the Upper and Lower Cretaceous. This grouping under distinct headings is justified by the fact that the Cretaceous horizons are usually found to be fossiliferous, and their distribution is, therefore, more definitely established than either the Triassic or Jurassic. Then, too, the Cretaceous is usually not as highly deformed and metamorphosed as the lower subdivisions of the Mesozoic. The same grouping has been followed on the map (Pl. XX), where the undifferentiated Mesozoic, Triassic, and Jurassic are indicated by one color and the Upper and Lower Cretaceous by another.

[a] The geological record in the Rocky Mountain region in Canada: Bull. Geol. Soc. America, vol. 12, 1901, pp. 69-72.

TRIASSIC AND JURASSIC.

Dawson's "Vancouver[a] series" includes a great but undetermined thickness of volcanic material, intercalated with argillites and limestones, which carry Triassic fossils and which occupy large areas on Vancouver Island and on the Queen Charlotte Islands. As the Vancouver beds are not always easily separated from the underlying Carboniferous, in reconnaissance mapping it has been found impossible to indicate them as distinct stratigraphic units.

It is to be expected that this Triassic series will be found in the adjacent parts of Alaska, but up to the present time it has not been positively identified. It has been shown that certain metamorphic terranes carry Permian fossils, and it is quite possible that Triassic beds may be infolded with these, as is the case with the Carboniferous of Queen Charlotte Islands. This view is borne out by some obscure fossils (probably Mesozoic) which have recently been found by Prindle near Fort Wrangell. While reconnoitering the southern part of the Alexander Archipelago a succession of conglomerates, black shales, and slates was encountered and called the Gravina[b] series, from the name of the island where they occur. These rocks are closely infolded with the Vallenar series (Devonian), but the two formations are probably separated by an unconformity. So little was learned of the distribution and structural relations of this horizon that the wisdom of giving it a distinct name now seems open to question. The Gravina was correlated with Dawson's Queen Charlotte group (Cretaceous), but on reviewing the evidence its identity with the Vancouver series (Triassic) seems equally probable. In 1904 Wright found a conglomerate and slate series on Admiralty Island which yielded Lower Cretaceous or Jurassic forms.

In the same insular region there are large areas of massive, basic, igneous rocks, chiefly of effusive origin, which were grouped together under the name Kasaan[c] greenstone, and were provisionally assigned to the Mesozoic. On the Queen Charlotte Islands to the south rocks of similar character occur in both the Triassic and in the Cretaceous, and the Kasaan effusives may belong to either period, but in the report cited were provisionally placed in the Cretaceous and correlated with the rocks of the Queen Charlotte group.

Emerson,[d] who spent two months in skirting the Alaska coast from Dixon Entrance to Bering Strait as a member of the Harriman party, has made some important contributions to Alaska geology, but some of his correlations appear hardly justified on the scant evidence obtained. Emerson extends Dawson's Vancouver series to include not only the Triassic but also the Jurassic and then assigns to it extensive areas of sedimentary and igneous rocks, of whose stratigraphic position little or nothing is known. The inclusion of supposed Jurassic beds in the Vancouver seems particularly unfortunate in view of the fact that it already probably embraces a part of the Carboniferous. On this point Dawson[e] says: "It [Vancouver series] is associated often with very similar rocks of the Carboniferous period, already

[a] Dawson, G. M., The geological record in the Rocky Mountain region of Canada: Bull. Geol. Soc. America, vol. 12, 1901, pp. 57-92.

[b] Brooks, A. H., A reconnaissance of the Ketchikan mining district: Prof. Paper U. S. Geol. Survey No. 1, 1902, p. 45.

[c] Ibid., pp. 49-50.

[d] Emerson, B. K., Harriman Alaska Expedition, vol. 4, pp. 11-54.

[e] Geological record in the Rocky Mountain region of Canada: Bull. Geol. Soc. America, vol. 12, 1901, p. 73.

referred to as existing in the same orographic belt, and it yet remains to draw a distinct line between the two series." Moreover, the close of the Triassic seems to have been marked by a dynamic revolution which sharply differentiated the Triassic from the Jurassic.

Emerson includes in the Vancouver the metamorphic sediments adjacent to the Coast Range intrusives, near Fort Wrangell, and in part at least Paleozoic, and the much less altered sediments of Sitka. These latter may be Mesozoic, but seem to offer no stratigraphic tie point with the schists at Fort Wrangell or with the Triassic of Vancouver Island. It is of great value to the stratigrapher to know that the Yakutat formation, near Mount St. Elias, the Orca series of Prince William Sound, and some sedimentary rocks at Wood Island are synchronous deposits, but the correlation of these supposed Jurassic beds with the Vancouver series (Triassic), whose nearest known outcrops are at least 600 miles away, appears but to add confusion to stratigraphic nomenclature. This is not by any means the most sweeping correlation contained in this work, for, on the basis of a seemingly hasty examination, outcrops on the east shore of Port Clarence, in the Seward Peninsula, which are most likely Silurian, are also assigned to the Vancouver series, though the nearest known Vancouver is nearly 1,500 miles distant. The writer feels impelled to make these criticisms in the interests of stratigraphic nomenclature, especially as the opinion of the author of the volume under discussion will undoubtedly have great weight among geologists.

On the west side of Baranof Island near Sitka there is a series[a] of conglomerates, feldspathic sandstones, and slates, with some tuffs and intrusives, whose stratigraphic position is unknown. On the basis of a very hasty examination of a few outcrops, in 1901, the writer suggested that these beds might be of Tertiary[b] age, but results of the examination by Emerson and other members of the Harriman party and more recently that of F. E. Wright show them to be more highly altered than the Tertiary of this province, and they may therefore provisionally find place in the Mesozoic.

Two hundred miles to the west is the deep indentation of the coast line called Yakutat Bay, and some knowledge of the geology of this region is furnished by the explorations of Russell[c] and by the more recent observations of Gilbert and other members of the Harriman party, who spent a few days on the inlet. Russell gave the name Yakutat system to a succession of gray and brown sandstones, which in places are coal bearing, but he was not able to establish their age. In his first report he was inclined to place them above his Pinnacle system, in the upper part of which he found Pliocence or Pleistocene fossils, but as both formations included indurated and highly folded and faulted beds the assumption of Pleistocene age seemed hardly warranted. During the second journey Russell was able to prove that the Pleistocene fossils came from morainic material and probably were in no way connected with the bed rock. While this discovery was of great importance in its bearing on the physiographic history, it left the Yakutat and Pinnacle systems,

[a] Harriman Alaskan Expedition, vol. 4, pp. 47 and 48.

[b] Prof. Paper U. S. Geol. Survey No. 1, 1902, p. 26.

[c] Russell, I. C., An expedition to Mount St. Elias, Alaska: Nat. Geog. Mag., vol. 3, 1890, pp. 167-175; Second expedition to Mount St. Elias, Thirteenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1893, pp. 7-91.

which are not unlike in lithology and may be of the same age, without any stratigraphic tie points. In this region the Harriman party collected some obscure fossils which have been assigned to the Jurassic by Ulrich.[a] If this age determination is correct, it shows an extensive development of the beds of Jurassic age along the southern flank of the St. Elias Range.

One hundred miles to the west, near Controller Bay, where the presence of petroleum has led to some geologic investigations, Martin[b] found a series of slightly metamorphosed sandstone, limestone, and shale, characterized by colors varying from gray to dull red and green. He was unable to assign any more definite place to this series than probably pre-Tertiary; but as the rocks lie in the strike of the Yakutat series and accord with it in lithology and structure, it is fair to assume that they represent a western extension of the same group and are of Mesozoic age.

In Prince William Sound, 100 miles to the west, the same series appears to be well represented by arkoses, sandstones, and shales, with some black limestones and occasional beds of conglomerate, together with considerable diabase or basalt. These beds are closely folded and jointed, are very similar to those of the Controller Bay region, and were first described by Schrader[c] under the name Orca series. A few obscure plant remains pointed to a Tertiary or Mesozoic age, and the formation was provisionally assigned to the former. Some more knowledge of the Orca resulted from the investigations of Schrader[d] and Spencer two years later, but its age would have still remained in doubt had not the Harriman party[e] here again found the organic remains that are so characteristic of Yakutat rocks. This discovery was made known in sufficient time to be inserted in the Schrader and Spencer report,[f] and the Orca was there referred to the Jurassic.

To the west of Prince William Sound the rocks of the Chugach Mountains bend sharply to the south and find their continuation in the highlands of the Kenai Peninsula. This change of strike seems to carry the Orca series into the peninsula and to Kodiak Island. This is probably the case, for Mendenhall's[g] Sunrise series, a succession of arkoses, sandstones, and slates, was traced by him from the western part of Prince William Sound into the Kenai Peninsula. The identity of a part of the Sunrise with the Orca can not be doubted, though the former may quite possibly include a part, if not the whole, of the Valdez formation. Moffit,[h] who has recently studied this region, describes these rocks as follows:

"The eastern portion of Kenai Peninsula and the region about the head of Turnagain Arm present a succession of rocks, which, as a whole, are of remarkably uniform appearance and composition. They are of sedimentary origin and consist

[a] Ulrich, E. O., Fossils and age of the Yakutat formation: Harriman Alaska Expedition, vol. 4, 1902, pp. 125–146.

[b] Martin, G. C., The petroleum fields of the Pacific coast of Alaska: Bull. U. S. Geol. Survey No. 250, pp. 12–13.

[c] Schrader, F. C., A reconnaissance in the Prince William Sound and Copper River region: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 404–408.

[d] Schrader, F. C., and Spencer, A. C., The Geology and Mineral Resources of a part of the Copper River region: U. S. Geol. Survey, 1901, pp. 37–40.

[e] Harriman Alaska Expedition, vol. 4, 1902, pp. 49–50.

[f] The apparent contradictions in this report as to the age of the Orca were not the fault of the authors, as the changes were made during their absence on field duty.

[g] Mendenhall, W. C., A reconnaissance from Resurrection Bay to the Tanana River: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 305–307.

[h] Moffit, F. H., The gold placers of Turnagain Arm: Bull. U. S. Geol. Survey No. 259, 1905, p. 93.

chiefly of fine-grained gray and bluish-black slates and gray arkoses. Interstratified with these, but in far less amount, are quartzose beds and occasional thin conglomerates In a few places north of Turnagain Arm this series of rocks, called by Mendenhall [a] the Sunrise series, is cut by dikes of igneous rocks of an aplitic or granitic character."

In 1898 Dall [b] found obscure fossils, assigned provisionally to the Triassic, in a much-contorted slate and sandstone series on Woody Island near Kodiak, a locality which he,[c] in company with the other geologists of the Harriman party, again visited in 1899; the fossils then collected led to the definite assignment of these beds to the same horizon as the Yakutat and Orca series. The determination of the Yakutat and Orca series and the beds on Woody Island as synchronous deposits is the most important geologic result of the Harriman party, even though the absolute position of these terranes in the geologic column must, in the opinion of the writer, be still open to doubt.

A closely folded series of rocks, consisting of constant repetitions of arkoses and sandstones or graywackes and shales, underlie the Orca, and occupy a large area north of Prince William Sound. These beds were described as the Valdez formation by Schrader,[d] who, much perplexed as to their true stratigraphic position, placed them in every system of his table of correlations from the Devonian to the early Tertiary. In his second season's work, made with the collaboration of Spencer, but little more was learned of the age of the Valdez, but it was then provisionally assigned to the Silurian.[e]

The stratigraphic relations of the Valdez rocks present one of the most difficult problems which has been met with in Alaska geology. Briefly, the facts are as follows: The Chugach Mountains, which border the Copper River basin on the south, are largely built up of closely folded sediments of rather uniform composition, embracing feldspathic sandstones, or graywackes, and shales, or slates, which are generally schistose, but have been subjected to a somewhat varying degree of metamorphism. On the south the Valdez rocks are probably everywhere cut off from the sea by the sandstone and shales of the Orca series, which they are supposed to underlie. In most instances they continue northward to the alluvial-floored basins of the Chitina and Copper rivers, but in a few localities they have been found resting on the metamorphic limestones and schists of the Klutina series (Paleozoic?). Across the Chitina Valley, and only a few miles from the northernmost outcrops of the Valdez formation, occurs the Chitistone limestone (Carboniferous?), succeeded by Triassic and Jura-Cretaceous beds, which are but little altered. The Valdez, then, on the one hand differs but little from the Orca series (Jurassic?) in structure, lithology, or degree of metamorphism, but on the other in no way resembles the less folded and unaltered Triassic and Jura-Cretaceous beds which outcrop within a few miles of them on the north.

Though the Valdez and Orca rocks have been regarded as distinct series, the published statements fail to reveal any direct evidence of a structural break between

[a] Mendenhall, W. C., A reconnaissance from Resurrection Bay to the Tanana River, Alaska, in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1898, p. 305.

[b] Dall, W. H., The coal and lignite of Alaska: Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, pp. 871-872.

[c] Harriman Alaska Expedition, vol. 4, 1902, pp. 51-53.

[d] Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 408-410

[e] The Geology and Mineral Resources of the Copper River Region, p. 33.

them, nor is their lithology very unlike. When Schrader and Spencer placed the Valdez rocks well down in the Paleozoic, it was before the Orca series had been assigned to the Mesozoic. The writer would interpret the facts as showing that the Valdez beds are in part at least the stratigraphic equivalents of the Mesozoic rocks of the Wrangell Mountains. He is quite prepared to believe, however, that some older sediments may have been included in the Valdez series.

Since the Copper River report was written, facts have accumulated which indicate that Mesozoic beds of the adjacent region are often considerably altered. Northwest of Cook Inlet the Alaska Range is largely made up of Mesozoic sediments, which are intensely folded, more or less altered, and in many ways closely resemble the Valdez rocks. In the Nutzotin Mountains, north of the Wrangell volcanic group, Schrader has reported an extensive series of closely folded and considerably altered sediments, which resemble the Valdez series, and yet yield Mesozoic fossils. These two occurrences, to be described in greater detail, are here cited to show that the deformation and metamorphism of the Valdez are not safe criteria for age determination.

The Wrangell Mountains are built up of a great series of Tertiary and Recent lavas, which rest on a base of gently folded Jura-Cretaceous rocks, which in turn overlie a considerable thickness of calcareous sediments carrying Triassic fossils. In the Triassic[a] of the Chitina Valley is a lower member of thin-bedded limestone and black shale, having a thickness of about 1,000 feet, and resting conformably on the Chitistone limestone (Carboniferous). It carries no fossils, but corresponds very closely with the rocks, observed by the writer, overlying the Permian limestone in the upper White River basin. The upper member of the Triassic includes at least 3,000 feet of black shales, with occasional bands of fossiliferous limestone. An attempt was made by Rohn,[b] who, under the auspices of the War Department, made a reconnaissance of this field, to divide the Triassic into the McCarthy Creek shales and the Kuskulana shales, but this subdivision was abandoned after more detailed studies had been made. As no fossils have been found in the lower member, it is possible that it may belong with the Chitistone, from which it is not separated by any structural break.

The Triassic, which is closely folded, is succeeded unconformably by the Kennicott[c] formation of Jura-Cretaceous age, consisting of conglomerates[d] and overlain by sandstones, limestones, and shales. This same horizon seems to occur about 100 miles to the west in Mendenhall's[e] "Matanuska series," which is made up of conglomerate (a thickness of 1,000 feet was measured) and sandstones, but more typically red, green, and black shales, with some intercalated limestone beds, which yield Jura-Cretaceous fossils.

The rugged Nutzotin Mountains forming the southern wall of the upper Tanana Valley were explored by the writer in 1899, and found to be made up of a series of closely folded slates, graywackes, and impure limestones, with some igneous

[a] Geology and Mineral Resources of the Copper River Region, pp. 46-47.

[b] Rohn, Oscar, A reconnaissance of the Chitina and Skolai Mountains, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, pp. 423, 424, 426, 427, 433.

[c] Named by Rohn, op. cit., pp. 428, 431, 433.

[d] The Geology and Mineral Resources of the Copper River Region, pp. 48-49.

[e] Mendenhall, W. C., A reconnaissance from Resurrection Bay to the Tanana River: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 307-309.

rocks along the valley of the Nabesna River. This series, lying between the Devonian (Wellesley) on the north and the Permian on the south, seemed an integral part of the upper Paleozoic beds, which were grouped together under the name Nutzotin[a] series, a stratigraphic subdivision since abandoned. Schrader, who mapped this country in more detail in 1902, found enough fossils to make it evident that most of the rocks of the Nutzotin Mountains are of Mesozoic age, though he was able to make no subdivisions of them.

Mesozoic rocks seem to have their greatest development in the Alaska Peninsula and northward into the Alaska Range. The Pacific shore of the peninsula and the western shore of Cook Inlet have been known for upward of half a century as a source of Mesozoic fossils, but up to very recent years almost nothing was known of the stratigraphy of the region. An account of the early investigations in this district is to be found in Dall's[b] summary, which shows that Mesozoic fossils, ranging in age from the Triassic to the upper Jurassic or Lower Cretaceous, had been found. Spurr[c] mapped as Jurassic a broad belt of rocks, stretching from near the upper end of Cook Inlet southwestward to the limits of his map, near the fifty-eighth parallel, and notes their probable continuance as far south as Port Moller. He gives the name Naknek series to some arkoses and conglomerates of this belt, which carry Jura-Cretaceous fossils. A part of the area covered by Spurr's map has recently been examined in some detail by Martin,[d] who investigated the oil fields of the vicinity and reported about 1,600 feet of sandy shales, with some conglomerates, sandstones, and limestones, with Jurassic fossils, to which he gave the name Enochkin formation. These rocks rest uncomformably on an igneous complex to the west, and are succeeded to the east by about 2,000 feet of volcanic flows and agglomerates, with some shale, probably of Cretaceous age. At Cold Bay, 100 miles to the southwest, Martin found Triassic overlain by Jurassic arkose sandstone, with some limestone and dark shale.

In 1904 Martin and Stanton continued the stratigraphic study of the Alaska Peninsula.[e] Their results are summarized in the table which follows.

[a] Brooks, A. H., A reconnaissance from Pyramid Harbor to Eagle City: Twenty-first Ann. Rept., U. S. Geol. Survey, pt. 2, 1900, p. 360.

[b] Dall, W. H., Report on coal and lignite of Alaska: Seventeenth Ann. Rept., U. S. Geol. Survey, pt. 1, 1896. pp. 866-871.

[c] Spurr, J. E., A reconnaissance in southwestern Alaska: Twentieth Ann. Rept., U. S. Geol. Survey, pt. 7, 1900, pp. 235-236. Map, pl. 14.

[d] Martin, G. C., The petroleum fields of the Pacific coast of Alaska: Bull. U. S. Geol. Survey No. 250.

[e] Stanton, T. W., and Martin, G. C., The Mesozoic section on Cook Inlet and the Alaska Peninsula: Bull. Geol. Soc. America, vol. 16, 1905, pp. 391-410.

Stratigraphy of the Alaska Peninsula.

Age.	Name of formation.	Lithologic character and thickness.	Geographic distribution.
Upper Cretaceous		Sandstone and shale, 2,000 feet.	A few scattered localities on the Alaska Peninsula.
Upper Jurassic	Naknek formation	Arkose, volcanic detritus and flows, conglomerate, sandstone, and shale, 5,000 feet.	West shore of Cook Inlet and south shore of Alaska Peninsula.
Middle Jurassic	Enochkin formation	Shale, sandstone, a little limestone and conglomerate, 3,000 feet.	West shore of Cook Inlet and south shore of Alaska Peninsula.
Lower Jurassic		Tuffs, sandstone (?), and possibly lavas.	South shore of Kachemak Bay.
Upper Triassic		Limestone, chert, and shale, 2,000? feet.	Kamishak Bay and south shore of Alaska Peninsula.
Lower Triassic? or Paleozoic?	Yakutat-Vancouver-Kodiak slates.	Black slates	Kodiak.

A section across the southern end of the Alaska Range, through the basin of the Skwentna, shows a complex of volcanic and intrusive rocks, forming the foothills of the mountains on the east. The stratigraphic position of these rocks, first described by Spurr, under the name Skwentna[a] series, and later studied by the writer, is much in doubt. Lithologically they resemble somewhat the igneous complex at Enochkin Bay, and like them they are succeeded unconformably by Mesozoic sediments. On the accompanying map (Pl. XXI) they are included in the Mesozoic and may be provisionally assigned to the Triassic.

The Mesozoic rocks to the west of this complex include a great thickness of closely folded sandstones, graywackes, slates, and some limestones, aggregating a thickness of probably many thousand feet. This is Spurr's Tordrillo[b] series, which he assigned to the Cretaceous, but, as shown by fossils determined by Stanton, it is in part at least middle Jurassic.[c] These rocks are, in many ways, similar to both the Valdez series and the Mesozoic beds of the Nutzotin Mountains, and the latter rocks lie in the extension of the strike of the Tordrillo series.

Coal-bearing rocks have long been known to occur near Cape Lisburne[d] on the northwest coast of Alaska, and a few fossil plants collected from these beds were determined as Mesozoic. The rocks associated with the coal are sandstones, arkoses, with some conglomerate, and in places shale and impure limestone, and they carry Jurassic plant remains. Schrader called them the Corwin[e] series and indicated that they are older than any of the Mesozoic of the Colville basin.

[a] Spurr, J. E., A reconnaissance in southwestern Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 149-152.

[b] Ibid., pp. 153-156.

[c] An exploration in the Mount McKinley region: Prof. Paper U. S. Geol. Survey, No. —. (In preparation.)

[d] Brooks, A. H., The coal resources of Alaska: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1901, pp. 530-553 and 561-563.

[e] Prof. Paper U. S. Geol. Survey No. 20, pp. 72-74.

Collier,[a] who had much better opportunities for detailed studies in this field than any of the previous investigators, has published the following statement in regard to the Mesozoic stratigraphy:

"The Mesozoic rocks occur on the coast, about 3 miles east of Cape Lisburne, and extend beyond the limits of the area covered by this investigation. They consist of two members, of which the older is coal bearing while the younger is not only destitute of coal but also of fossils.

"The coal-bearing member, which has been called the Corwin formation, begins on the coast line about 26 miles east of Cape Lisburne and about 2 miles west of Corwin Bluff. From this point it extends eastward to and beyond Cape Beaufort, the eastern limit of the area comprised in this investigation. This formation consists of rather thin-bedded shales, sandstones, and conglomerates. The shales which form the greater part of the section, vary from greenish-brown calcareous to black carbonaceous beds, and in texture from mudstones to fine-grained sandy shales.

"The sandstones occur at infrequent intervals through the formation, in beds usually less than 10 feet in thickness. Their outcrops form low ridges, which are easily traceable over eroded areas. The conglomerates are made up mainly of quartz and chert pebbles, ranging in diameter from one-half to 4 inches. A conglomerate bed about 15 feet thick, which reaches the coast at Corwin Bluff, makes a distinct ridge from 100 to 200 feet high, which has been traced southeastward for about 15 miles, giving a definite key to the stratigraphy of a portion of the field.

"The thickness of the Corwin formation exposed along the coast near Corwin Bluff is not less than 15,000 feet. The base of the formation has not been observed, but it probably rests unconformably on the Paleozoic rocks.

"Fossil plants collected from it indicate that the age is Jurassic.

"The structure consists of several broad synclines and anticlines, the dips of the beds varying from 0° to 60°. There is no evidence of faulting other than minor shearing movements parallel with the bedding planes.

"The Corwin formation is conformably overlain by a more arenaceous series of sandstones and shales in which neither coal beds nor fossils have been found. The contact of these rocks with the Corwin rocks may be seen about 2 miles west of Corwin Bluff, whence it extends southeastward for several miles to the limit of the area investigated. The western limit of the formation is a well-defined fault line extending southeastward from a point on the coast 3 miles east of Cape Lisburne, where the formation is in contact with the Paleozoic, which is overthrust. The structure of this formation increases in complexity from its base at the top of the Corwin formation as this fault is approached; there are intense crumpling and numerous minor thrust faults. For this reason it is impossible to estimate the thickness of the formation, but the evidence obtained indicates that its minimum thickness is not less than 5,000 feet."

Practically nothing is known of the geology east of the Colville, until the portage route is reached, which crosses the Rocky Mountains and connects the Porcupine with the Mackenzie waters. Here McConnell[b] has made some geologic observations. He showed that no rocks older than Mesozoic (probably Cretaceous)

[a] Collier, A. J., Coal fields of the Cape Lisburne region: Bull. U. S. Geol. Survey No. 259, pp. 175–176.

[b] McConnell, R. G., A report on an exploration in the Yukon and Mackenzie basins: Ann. Rept. Geol. and Nat. Hist. Survey Canada, new ser., vol. 4, 1888–89, pp. 21D and 119D–120D.

were exposed, and that these consisted of quartzites, sandstones, and shales, and that the entire thickness of beds referred to the Cretaceous is probably 5,000 feet.

It has been demonstrated that Mesozoic beds are extensively developed in the Pacific seaboard of Alaska, and while many of the rocks along the coast are of undetermined age, Triassic, Jurassic, Jura-Cretaceous, and Upper Cretaceous fossils have been found. In the Mount Wrangell region the systems are sharply differentiated. Mesozoic rocks, probably of Jurassic age, have been traced paralle to the coast from Yakutat Bay to Kodiak Island, while in the Alaska Peninsula the Triassic and Cretaceous have been recognized at a few localities, and the Jurassic occurs extensively and is continued northward into the Alaska Range. Though the known Triassic and Jurassic beds are not greatly altered in this district, there is evidence that some partly metamorphosed sediments, such as those of the Chugach and Nutzotin mountains, are Mesozoic. One measured section in the Wrangell Mountains revealed 4,000 to 5,000 feet of Triassic, succeeded by several thousand feet of Jura-Cretaceous. While here the middle and lower Jurassic are entirely wanting, these have been found in the adjacent region with a thickness of at least several thousand feet. In the Alaska Peninsula Stanton and Martin found Triassic and Jurassic sediments aggregating a thickness of at least 10,000 feet. In northern Alaska, near Cape Lisburne, Mesozoic beds, which are probably chiefly Jurassic, have been found to a thickness of probably 20,000 feet.

CRETACEOUS.

As it is an open question as to where the division between the Lower Cretaceous and the upper Jurassic terrane should be made, certain formations like the Kennicott are referred to the Jura-Cretaceous. If the unconformity at the base of the Kennicott is found to be a widespread feature, it may eventually serve as a convenient line of demarcation. The following paragraph presents this matter briefly:

"Rocks [a] which have been referred to the Cretaceous have a wide distribution in Alaska and adjacent portions of Canada. These have been described in different localities under various formation names and have usually been assigned to the Lower Cretaceous. The paleontologic evidence obtained as yet is but fragmental, and according to Doctor Stanton, consists mainly of the identification of a single species *Aucella crassicollis* Keyserling, which has been found rather widely distributed in Alaska. This species marks a definite horizon in the Knoxville beds of the Lower Cretaceous of California, and also occurs in the Lower Cretaceous of Russia, but the genus *Aucella* occurs abundantly in the upper Jurassic as well as the Lower Cretaceous, and the identification of a single species of that genus represented by a few imperfect and fragmentary specimens can not safely be depended on for separating Jurassic from Cretaceous rocks. It is probable that all the Alaska beds from which *Aucella crassicollis* has been reported are Lower Cretaceous, though part of them may be Jurassic."

For convenience these *Aucella*-bearing beds will here be included in the Cretaceous, with the reservation that they may ultimately find a place in the

[a] Brooks, A. H., The coal resources of Alaska: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1901, pp. 527-528.

Jurassic. An exception has been made in case of the Kennicott and Matanuska terranes, of this *Aucella* horizon, because they were so intimately associated with the Triassic and Jurassic beds that their description was included with them. These *Aucella*-bearing beds have also been found at Herendeen[a] Bay on the Alaska Peninsula, which indicates the presence in this district of Mesozoic terranes varying in age from Triassic to Jura-Cretaceous.

The recent studies of Wright[b] have revealed the presence of the *Aucella*-bearing beds along the eastern coast of Admiralty Island in a series of conglomerates, graywackes, and slates. Stanton makes the following statement in regard to the fossils from these beds:

"The specimens of *Aucella* from Pybus Bay, Admiralty Island, are apparently referable to species that in California and adjacent States are characteristic of the Lower Cretaceous, *Aucella piochii* occurring in a lower zone than *Aucella crassicollis*. The Alaskan specimens probably also come from the Lower Cretaceous, although strict correlation is rendered somewhat hazardous by the fact that the genus *Aucella* with similar specific forms ranges down into the upper Jurassic."

Wright has also found a conglomerate sandstone and shale series on Kupreanof Island, a few miles south of Admiralty Island, which carries plant remains assigned to the Upper Cretaceous. Knowlton reports as follows on these fossils:

"These plants indicate beyond question that the age is Cretaceous, and I would place them in the lower part of the Upper Cretaceous, or approximately of Cenomanian age."

It appears that these Upper Cretaceous beds are discordant to *Aucella*-bearing terranes of the adjacent region, and that they are conformably succeeded by the Kenai (Eocene) rocks, with which they are lithologically identical.

Spurr,[c] in his reconnaissance along the upper Yukon, grouped together some conglomerates, sandstones, carbonaceous shales and limestones, and assigned them to Jurassic and Cretaceous. Though a part of these are Cretaceous, yet the name Mission Creek series—proposed by Spurr—will have to be abandoned, for it was applied to beds as widely separated as the Carboniferous and the Tertiary. Collier[d] found Lower Cretaceous fossils (*Aucella*) in a series of closely-folded black slates, with some limestones and calcareous conglomerates which outcrop along the Yukon for nearly 80 miles, at a locality which can be identified on the map (Pl. XXI) by noting the point of intersection of the one hundred and forty-second meridian.

An extensive area of Cretaceous beds is represented on the map stretching northeast from near Bering Sea to the base of the Rocky Mountains in the upper Koyukuk basin. This belt is known to be interrupted by both older and younger terranes, but within it Cretaceous rocks are believed to predominate. Lower Cretaceous beds alone have been identified in the southern part of the area, but as the evidence is purely negative it is quite possible that higher members of the Cretaceous may yet be found. To the north of the Yukon the Cretaceous rocks belong to the middle or upper part of the system, while still

[a] Brooks, A. H., The coal resources of Alaska: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1901, pp. 528–529.
[b] Wright, C. W., A reconnaissance of Admiralty Island. (In preparation.)
[c] Spurr, J. E., Geology of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 169–175.
[d] Collier, Arthur J., The coal resources of the Yukon: Bull. U. S. Geol. Survey No. 218, pp. 15–17, 1903.

farther north the lowest members are again exposed, overlapping the metamorphic sediments at the base of the range.

Spurr[a] subdivided the Mesozoic rocks of the Kuskokwim Valley into three series, all Cretaceous, of which the Holiknuk and Kolmakof series are supposed to be synchronous, while the stratigraphic relation of the third—the Oklune series, which is Jura-Cretaceous—to the others is unknown. The Holiknuk series is made up of alternating sandstones, argillaceous and siliceous limestone containing fragmentary Cretaceous fossils, and shale and arkose, all thrown up in broad open folds. An unconformity determined the line of demarcation between these beds and the underlying Tachatna series (Devonian).

A succession of volcanic rocks of various types occurs to the southwest, and these, together with some intercalated tuffs, shales, impure limestones, and arkoses, form Spurr's Kolmakof series, supposed to be synchronous with the Holiknuk beds. A group of sediments, including shales, impure limestones, with some arkoses, received the name "Oklune series" from the mountains where they are typically exposed. These beds are referred to the Jura-Cretaceous on the evidence of some fragmentary fossils. As far as the facts presented can be interpreted, all three of these series may belong to the same horizon. All three exhibit about the same amount of deformation and are intruded by igneous rocks of various kinds. If they are not of the same age, it is probable that the Holiknuk belongs to the Jurassic or the Triassic and that the others are younger.

Cretaceous rocks outcrop almost without break on the lower Yukon from the mouth of the Melozi River to the head of the delta and northward into the basin of the Koyukuk River. In this part of the Yukon Valley Dall made the first geologic observations in the interior of Alaska over forty years ago. In his summary of Alaskan[b] geology, made many years after, he assigned some coal-bearing beds to the Kenai (Eocene) and reported that they were succeeded by marine fossil-bearing sandstones. Spurr[c] corroborated Dall's observations, and, accepting Eocene as the age of the underlying coal-bearing beds, assigned the succeeding strata to the Miocene under the name Nulato sandstone. This conclusion seemed to be further supported by fossils from sandstone which were determined as Miocene. The stratigraphic position of the coal-bearing beds of the Yukon will be considered below, but it will be noted that so-called Kenai of the Yukon embraces beds as divergent in age as the Upper Cretaceous and the Upper Eocene. The stratigraphic work of Collier,[d] in 1902, followed by that of Hollick, in 1903, and the studies of their collections by Stanton and Knowlton have yielded ample proof of the Upper Cretaceous age of both the Nulato sandstone and the underlying coal-bearing beds. These results have not yet appeared in print, but are briefly referred to in Collier's report on the coal resources of the Yukon.[e] In short, near Nulato there seems to be exposed a conformable series, consisting of sandstones, shales, and conglomerates, which represent continuous sedimentation from the middle of the Cretaceous to the Upper Eocene.

[a] Spurr, J. E., A reconnaissance in southwestern Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 159–169.

[b] Dall, W. H., and Harris, G. H., Neocene correlation papers: Bull. U. S. Geol. Survey No. 84, pp. 347–348.

[c] Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, p. 196.

[d] Bull. U. S. Geol. Survey No. 213.

[e] Bull. U. S. Geol. Survey, No. 218, p. 17.

Schrader's Koyukuk[a] report makes mention of Lower Cretaceous fossils in an impure limestone, associated with volcanic rocks, which outcrop near the sixty-sixth parallel, and to the south of these of an impure limestone which carried Upper Cretaceous fossils, but assigned the Nulato sandstone to the Miocene. During his second journey in this region he was able to add considerable data regarding the Cretaceous rock, and gave the name Koyukuk series to beds consisting of impure limestone, slate, and some sandstone associated with igneous rocks. This formation carries the typical Jura-Cretaceous fossil, *Aucella crassicolis* Keyserling.

Between the northern limit of the Koyukuk and the base of the mountains is a broad belt of sandstone and shale, resting on a basal member of conglomerates, whose pebbles are derived from the metamorphic sediments (Paleozoic?) which lie to the north. These Schrader[b] called the Bergman series, and in his second report provisionally assigned to the Cretaceous, but in his first publication he had called them Eocene (Kenai), because they are lignite bearing. The Bergman is supposed to overlie the Koyukuk, but, as the contact was not seen, the relations may be reversed, and the Bergman might be Jurassic or Upper Cretaceous. The presence of the coal would suggest their correlation with the Upper Cretaceous coal-bearing beds of the Nulato region; but this is not a safe criterion, for the coal, which is lignite, resembles that of the Kenai (Eocene) rather than that of the Cretaceous, and the series may be chiefly lower Mesozoic, with some infolded Kenai beds.

A third extensive development of Cretaceous forms a broad east-west zone across northern Alaska, in the Arctic slope province. These rocks Schrader[c] divided into two unconformable groups—the Anaktuvuk series (Lower Cretaceous) and the Nanushuk series (Upper Cretaceous). The Anaktuvuk is made up of fine, heavy-bedded sandstones, or arkose—sometimes a grit, with little conglomerate—the whole aggregating at least 2,000 feet. Resting unconformably on these are sandstone, impure limestone, slate, quartzite, and chert, which make up the Nanushuk series. The Anaktuvuk carries *Aucella crassicolis* Keyserling, making it Jura-Cretaceous, while the Nanushuk has yielded Upper Cretaceous fossils. The Nanushuk, like the Upper Cretaceous of the lower Yukon, contains coal seams of excellent quality.

The following brief summary may be made in regard to the Cretaceous: The lowest member (possibly in part Jurassic) is found widely distributed from southeastern to northern Alaska. It is developed in the Yukon, Kuskokwim, and Koyukuk valleys and in the Arctic slope region. Its composition varies from sandstones to limestone, but its basal member is usually a conglomerate. The Upper Cretaceous has been recognized on Kupreanof Island, in the Alaska Peninsula, on the lower Yukon, and in the Colville basin.

CENOZOIC.

TERTIARY.

Tertiary rocks cover no considerable areas in Alaska, though widely distributed in isolated patches, many of which are too small to find a place on a map (Pl. XXI) of this scale. These are in part remnants of larger areas dissected by erosion; in part deposits laid down in distinct basins.

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[a] Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 476-477.
[b] Prof. Paper U. S. Geol. Survey No. 20, 1904, pp. 77-78.
[c] Ibid., pp. 74-76 and 79-81.

The so-called Kenai group (Upper Eocene or Oligocene) is the lowest and also the most widely distributed horizon of this system. The fact that the Kenai is coal-bearing has led to its recognition in many locations even by untrained observers, but it must be admitted that this apparent easy method of age determination has tended toward the conclusion that all the coal-bearing terranes are of one horizon. The deformation of the Kenai group seems to represent the last considerable epirogenic movements in this province. Of the other divisions of the Tertiary the Miocene seems to be rather widely distributed along only the Pacific coast, and beds of Pliocene age have been found only on the Yukon and north of the Rocky Mountains.

The Tertiary will be discussed under the two headings: "Eocene" and "Miocene and Pliocene." Though the stratigraphy of this epoch would seem to present fewer difficult problems than the older terranes, it is but very imperfectly known, owing chiefly to the lack of adequate collections of its fossils.

EOCENE.

Probably all the Eocene of Alaska belongs to the Kenai series, which has been variously called Oligocene and Arctic Miocene, but is now generally regarded as chiefly Upper Eocene, with possibly some Lower Eocene beds. The type locality is on the western side of the Kenai Peninsula, where the Kenai group, as first defined by Dall,[a] consists of bluish shales, sandstones, conglomerates, lignite seams, with abundant terrestrial and fresh-water plant remains, and occasional intercalated beds of limestones. Dall named an upper member of the group, consisting of conglomerate and sand layers, Unga beds.

At the type locality the Kenai is made up of only slightly indurated or entirely unconsolidated beds. The same terrane has, however, been identified in much more highly altered rocks which carry plant remains and also coal, such as those of Controller Bay, Mantanuska River, and Cantwell River. These facts are difficult to reconcile, and it appears that the deciphering of the Alaska Tertiary stratigraphy must await further investigation. It seems at least possible that the Kenai series of the Pacific littoral may include horizons younger or older than the Upper Eocene, and in any event that all the coal-bearing beds of the Pacific coast province are not synchronous deposits. The fact that the coals of adjacent parts of British Columbia are Upper Cretaceous makes it probable[b] that this horizon is present in the Pacific coastal region of Alaska, as has already been found to be the case on Kupreanof Island.

Coarse, sandy beds, with some conglomerate, considerable volcanic material, with seams of lignite of Tertiary[c] age, occur on Graham Island, as well as on all the islands of the Queen Charlotte group. In the same region are sandstones containing marine Miocene or Pliocene fossils and also lignite seams.

Slightly indurated beds of feldspathic conglomerates, sandstones, and shales, carrying more or less lignitic coal, have been found at various localities[d] in the

[a] Dall, W. H., and Harris, G. B., Correlation papers: Bull. U. S. Geol. Survey No. 84, pp. 232–249.
[b] Geol. Nat. His. Survey Canada, 1872–73, pp, 1-100; 1878–79, pp. 1B-100B.
[c] Dawson, G. M., Queen Charlotte Islands: Geol. Nat. Hist. Survey Canada, 1878–79, pp. 84B–94B.
[d] Dall, W. H., The coal and lignite of Alaska: Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, pp. 775–783.

Alexander Archipelago and the adjacent parts of the mainland of Alaska. They probably do not exceed a few hundred feet in thickness. On Admiralty Island they are intimately associated with lava flows, which are of a basaltic and andesitic character. These same beds may be present at Lituya and Yakutat bays, where lignites are said to occur.[a] On Admiralty and Kuiu islands these beds have yielded plant[b] remains referable to the Kenai, and for this reason they have all been assigned to that formation, though, as has been shown, Wright found Cretaceous coals in southeastern Alaska, and on the adjacent islands of British Columbia coal seams occur in strata varying in age from Cretaceous to the Miocene.

At Controller Bay, Martin[c] has given the name Katalla formation to a series of argillaceous and carbonaceous shales, with occasional bands of sandstone, limestone, conglomerate, and tufa, which from the evidence of a few fossils are provisionally assigned to the Tertiary. These beds overlie a series of semialtered sandstones, limestones, and shales, which have already been correlated with the Orca and Yakutat series.

In the same district a group of indurated shales, feldspathic sandstones and coal seams, having a thickness of many hundred if not several thousand feet, was named the Kushtaka formation. The coal, which is of a bituminous character, is totally unlike that of the Kenai of Cook Inlet, and the general structure suggests that the Kushtaka overlies the Katalla.

Mention has already been made of Dall's description of the Kenai series of the type locality on the peninsula of the same name. Stone,[d] who recently made a detailed study of the coal measures in the Kachemak Bay region, describes the succession as follows:

"The Kenai formation as exposed in Kachemak Bay is composed of soft, light-gray sandstones and clay shales, with frequently interspersed coal seams. Four partial sections of the formation, aggregating 1,765 feet of strata, are given in the next chapter. These sections are represented diagrammatically on Pl. I, *A*, and show that coal seams from a few inches to 7 feet thick are distributed throughout the portion of the formation represented. It appears also that 350 feet at the top of the Falls Creek section, which is the highest geologically, have no sandstone, being composed entirely of shale and coal. It can not be said with certainty that the lower portion of the formation is characterized by an abundance of sandstone, and the upper portion by a lack of it, although there is a suggestion that this may be the case. The sandstones are medium grained, soft, light gray, sometimes iron stained, and occur in beds from a few inches to 30 feet thick. Cross-bedding was noted at one locality. Some portions of the heavier beds of sandstone occasionally are hard and weather out in nodular blocks. In these blocks the best preserved fossil plants are sometimes found. In one locality lenses of grit, or fine conglomerate, occur in a sandstone bed. The pebbles are smaller than a half-inch in diameter, and are mostly quartz. Sandstones at places grade into sandy shale. Dall[e] reports coarse

[a] Dall, W. H., The coal and lignite of Alaska: Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, pp. 783–784.
[b] Ibid., pp. 775–783.
[c] Martin, G. C., The petroleum fields of the Pacific coast of Alaska: Bull. U. S. Geol. Survey No. 250, pp. 13–15.
[d] Stone, R. W., Coal fields of Kachemak Bay and vicinity: Bull. U. S. Geol. Survey. (In preparation.)
[e] Dall, W. H., Coal and lignite of Alaska: Seventeenth Ann. Rept. U. S. Geol. Survey. pt. 1, p. 807.

conglomerates overlying the coal-bearing Kenai beds at Unga Island, but the writer did not find them at Kachemak Bay. They may occur farther inland, however.

"The shales of the Kenai formation on Kachemak Bay are all light-colored clay or mud rocks grading on one side into arenaceous shale and on the other into clay. They are soft and crumbly on the outcrop, and when wet become plastic. At the upper end of the bay they seem to be softer than at Bluff Point, which is a geologically lower horizon. Beds of clay that have been baked by the burning of a coal seam are red and hard. Small blocks of gray, hard limestone were found at one locality, and suggest that the formation may contain a small amount of calcareous sediments, but no limestone was found in place."

The Kenai rocks of this region are little disturbed, and rest unconformably on both Jurassic and Triassic beds which are much folded and faulted. Stone did not see the entire section of Kenai beds, but obtained measures showing 5,000 to 6,000 feet of strata, and estimated that they may aggregate a thickness of 10,000 feet.

Probably the same horizon occurs on the west shore of Cook Inlet, at Tyonok, where there is an outcrop of fine feldspathic sandstone, with seams of impure lignite, or fossil wood, together with some fine conglomerate. These, together with some similar beds found in the Beluga, Skwentna, Keechatna, and Sushitna River basins, of the same region, may be Kenai, or may, as suggested by Spurr, represent a younger horizon, to which he gave the name Hayes[a] River beds. Spurr, however, assigned to the Kenai his Yentna beds, consisting of coarse conglomerates, apparently the same horizon as Eldridge's Kenai[b] on the Sushitna. The writer, who has examined some of these locations, is inclined to regard all the lignite-bearing beds as synchronous deposits which may belong to the upper part of the Kenai, or may be of younger age, and thinks that their lithologic variations are due to their deposition in isolated basins.

Bituminous coal-bearing rocks carrying Eocene plants have recently been found in the Matanuska River Valley. These appear to be of the same character as those of Controller Bay.

On the Alaska Peninsula two distinct Eocene horizons have been recognized. The first is the widely distributed Kenai series, made of conglomerates, sandstones, and shales, and carrying plant[c] remains. The second terrane includes a lower member, composed of breccias, agglomerates, and tuffs, and an upper member made up of shales, soft sandstones, and grits. Palache,[d] who described these rocks, grouped them all together under the name Stepovak series. Marine fossils, assigned by Dall to the Middle Eocene, occur in some of the beds of the upper member. The Stepovak has not been recognized at any other locality, and its relation to the Kenai has not been established, but it is probably older.

Coal-bearing beds occur at a number of places and have been found in small, isolated areas along the eastern shore of the Alaska Peninsula and on the adjacent islands, and these Dall[e] has correlated with the Kenai, some on definite paleontologic, but some only on general stratigraphic evidence. It is not impossible that

[a] Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, p. 172.
[b] Ibid., pp. 16 and 17.
[c] Knowlton, F. H., Fossil plants from Kukak Bay, Harriman Alaska Expedition, vol. 4, pp. 149-162, New York, 1904.
[d] Palache, Charles, Geology about Chichagof Cove, Stepovak Bay, Harriman Alaska Expedition, vol. 4, pp. 69-88.
[e] Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, pp. 797-811.

some of these terranes may prove to be older than the Kenai, for at Chignik Bay the coal horizon is known to be of Cretaceous age. In the Aleutian Islands,[a] as well as on the adjacent mainland, lignite-bearing beds have been reported, and referred to the Kenai.

The Wrangell volcanics occupy the most extensive area of any Tertiary rocks of the Copper River region, but though volcanism dominated during this epoch, some sediments were laid down during Kenai times, and could the extensive Pleistocene gravels be swept away, this horizon might be found to cover considerable areas. Mendenhall's Gakona[b] formation includes a basal bed of conglomerate about 500 feet thick, shales, and beds of slightly indurated gravels and lignites, with Kenai plant remains. In the Tanana Valley, about 100 miles to the north, some soft, friable sandstone and fine conglomerate, called Tok sandstone,[c] have been provisionally assigned to the Tertiary, and may be of Kenai age.

In the upper basin of the Cantwell River, a southerly tributary of the Tanana, the writer has found a well-defined series made up of a basal conglomerate several hundred feet in thickness, succeeded by at least 2,000 feet of reddish shales and sandstones. Some coal was found associated with the latter. These beds carry plant remains which Knowlton correlates with those of the Kenai. The rocks are, however, much more indurated and highly folded than the typical Kenai beds, but resemble the Eocene plant-bearing terranes of the Matanuska River Valley.

The Kenai was recognized in the Yukon Valley many years ago, but true stratigraphic relations have only recently been determined by the detailed studies of Collier and Hollick. The study of the material collected by them has not been completed, and but few of the results have been published. The paleobotanical investigations have fallen to Knowlton,[d] who has made the following preliminary statement of results to the Geological Society of Washington:

"Up to about 1900 the known fossil flora of Alaska numbered about 110 species, all of which has come from the coast region from Sitka to Cape Lisburne. With the exception of the Cape Lisburne forms, which were regarded as of Jurasso-Cretaceous age, practically all those known were Tertiary in age. The discovery of gold in the interior incited exploration, and soon small collections of plants were brought in, mainly from the upper rocks of the Yukon. As these agreed in Tertiary age with those previously known from the coast region, it came to be accepted that only Tertiary plants occurred throughout this vast area. The United States Geological Survey desired to establish a type section, and in 1902 Mr. A. J. Collier was delegated to make a trip down the Yukon, studying the stratigraphy and collecting fossils from as many points as possible. When the plants were studied, it was found that those from above Rampart were Tertiary (so-called Arctic Miocene) while below this point a very different condition was found. Near Nahoclatilten Mr. Collier obtained collections which appeared to be mixed; that is, a part of the material

[a] Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, pp. 811-814.

[b] Mendenhall, W. C., The geology of the central Copper River region: Prof. Paper U. S. Geol. Survey No. 41.

[c] Brooks, A. H., A reconnaissance in the Tanana and White river basins: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, p. 473.

[d] Science, new series, vol. 19, 1904, pp. 733-734.

seemed to be Tertiary and the remainder Middle or Lower Cretaceous. Undoubted Upper Cretaceous plants were obtained from a number of other localities, especially in the vicinity of Nulato, but so much interest attached to the Nahoclatilten localities that in 1903 Dr. Arthur Hollick was commissioned to duplicate Mr. Collier's trip. From the combination of the two collections it is possible to decide with certainty that all points above Rampart are Tertiary, while the plants below indicate that the age is either undoubted Cretaceous or doubtful Tertiary. The Cretaceous plants include cycads of several genera, conifers, and many dicotyledons, the combination resembling mostly the Middle and Upper Cretaceous flora of Bohemia."

It appears then that the Kenai of the Yukon falls into two geographic groups—that of the upper river, which lies unconformably on various horizons, including Lower Cretaceous and older metamorphic rocks, and that of the lower river, which rests conformably on Upper Cretaceous beds. It occurs in a considerable area in Canadian territory near Dawson, and again a few miles below the boundary, as well as in many isolated patches in various parts[a] of the basin. In the upper river region it is typically made of heavy conglomerate, sandstone, and shale, with lignitic seams, may locally reach a thickness of several thousand feet, and is often closely folded and faulted. The Kenai of the lower river has about the same lithologic character, but the conglomerates and sandstones are usually finer, and the beds are but little disturbed.

Dall[b] provisionally assigned some coal-bearing sandstones and shales which are found between the Yukon and Norton Bay to the Kenai, but these may also prove to be of Upper Cretaceous age, as have some of those of the lower Yukon. A few lignite-bearing beds have been found in isolated patches in the Seward Peninsula and in the Kobuk Valley. These are usually but slightly indurated, consist essentially of feldspathic sandstone, and rest unconformably on the metamorphic rocks.

Schrader has divided the Tertiary of northern Alaska into two formations,[c] which may be unconformable. The lower Colville is assigned to the Kenai, from the evidence of some fragmentary fossil plant remains, and from its position below beds carrying a Pliocene fauna. This horizon is about 150 feet thick, and consists essentially of partly consolidated silts, but its basal member is sandstone and shale, with lignite seams. There is little evidence of its extent, but it seems possible the same beds may be represented by the coal-bearing[d] horizon at Wainwright Inlet and Kuk River, which seems to be an entirely distinct occurrence from the coal horizon at Cape Lisburne.

MIOCENE AND PLIOCENE.

The reconnaissance work of the past few years has failed to show a wide distribution of Miocene or Pliocene beds in Alaska, for here little has been added to what Dall published ten years ago, except that Pliocene beds have been found in the Arctic slope province and some unconsolidated beds on the Yukon have been provisionally placed in one or the other of these epochs.

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[a] Compare the coal resources of the Yukon, by Arthur J. Collier, Bull. U. S. Geol. Survey No. 218.
[b] Bull. U. S. Geol. Survey No. 184, p. 246.
[c] Prof. Paper U. S. Geol. Survey No. 20, 1904, pp. 81-83.
[d] Brooks, A. H., The coal resources of Alaska: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1901, p. 563.

The most southerly locality in Alaska where Miocene beds have been found is at Lituya Bay, where Dall[a] found sandstones and conglomerates which carry Miocene fossils. Spurr[b] reports the occurrence of sandstones, thin-bedded limestones, and shales at Icy Bay, 200 miles west of Lituya Bay. Fifty miles west, on Kayak Island, Martin[c] found Miocene conglomerates, sandstones, and shales.

Some marine fossils were found by Dall[d] in isolated localities along the coast of the Alaska Peninsula and on the adjacent islands, including the Aleutians, and were provisionally referred to the Astoria group (Miocene). On the north shore of Bristol Bay are some slightly consolidated gravels, sands, arkoses, and clays, which are somewhat deformed and were called Nushagak beds and referred to the Miocene by Spurr.[e] The evidence of their age rests on their stratigraphic relation to the Pleistocene, and to the fact that Miocene fossils had been reported from this vicinity by Dall.

In the Yukon basin the Nulato sandstone, formerly supposed to be Miocene, now finds place in the Upper Cretaceous. (See p. 236.) Spurr's[f] Twelvemile beds exposed on Mission Creek and assigned to the Pliocene are probably Kenai, but his Palisade[g] conglomerate, consisting of a cemented gravel, with some lignite, together with associated silts, is probably of Miocene or Pliocene age.

The Tertiary of the Arctic slope is divided by Schrader into two series, of which the lower is probably of Kenai age, while the upper carries marine fossils, probably of Pliocene age. This horizon, called Upper[h] Colville, is made up of fine gray calcareous silts, in which the bedding planes are entirely undisturbed, while the underlying Lower Colville is considerably deformed, suggesting an unconformity between the two formations. Schrader states that the thickness of the Upper Colville is about 50 feet, and that the fossils came from near the top of the bed.

In considering the Miocene and Pliocene, the fact should not be lost sight of that some of the beds now classed with the Pleistocene may be older. In the Seward Peninsula the placer-mining operations have shown great local thickness of gravel deposits, and as little is known of the stratigraphic relations of the lower beds of these unconsolidated deposits it is by no means impossible that some of these may prove to be of Tertiary age, and if so will probably fall into the Pliocene.

SUMMARY OF TERTIARY STRATIGRAPHY.

The Kenai series, the oldest known Tertiary, has been referred to the Upper Eocene, but, as these are known to rest conformably on Upper Cretaceous, with which they form a continuous series without any stratigraphic break, it seems probable that the Kenai may include some Lower Eocene beds. The Kenai has been definitely recognized for nearly the entire length of the Yukon and at a number of localities in the Pacific coastal belt of Alaska. Its equivalent horizon in the

[a] Dall, W. H., Report on coal and lignite of Alaska: Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, pp. 783–784.
[b] Spurr, J. E., A reconnaissance in southwestern Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, pp. 263–264.
[c] Martin, G. C., The petroleum fields of the Pacific coast of Alaska: Bull. U. S. Geol. Survey No. 250, p. 15.
[d] Bull. U. S. Geol. Survey No. 84, pp. 252–259.
[e] Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 173–174.
[f] The Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pt. 196–197.
[g] Ibid., pp. 199–200.
[h] Prof. Paper U. S. Geol. Survey No. 20, 1904, p. 83.

Copper River basin is the Gakona formation, and in the Arctic slope region the lower Colville series. It is usually characterized by conglomerates, sandstones, shales, and lignite seams, and the fossil plant remains show a fresh-water origin for most of these beds. One locality alone, and that on the Alaska Peninsula, has yielded marine Eocene fossils.

The Miocene is represented by some marine deposits which are found along the Pacific coast as far north as Bristol Bay. To the Pliocene have been assigned the upper Colville, made up of silts, and, with less definite evidence, some cemented gravels on the Yukon.

QUATERNARY.

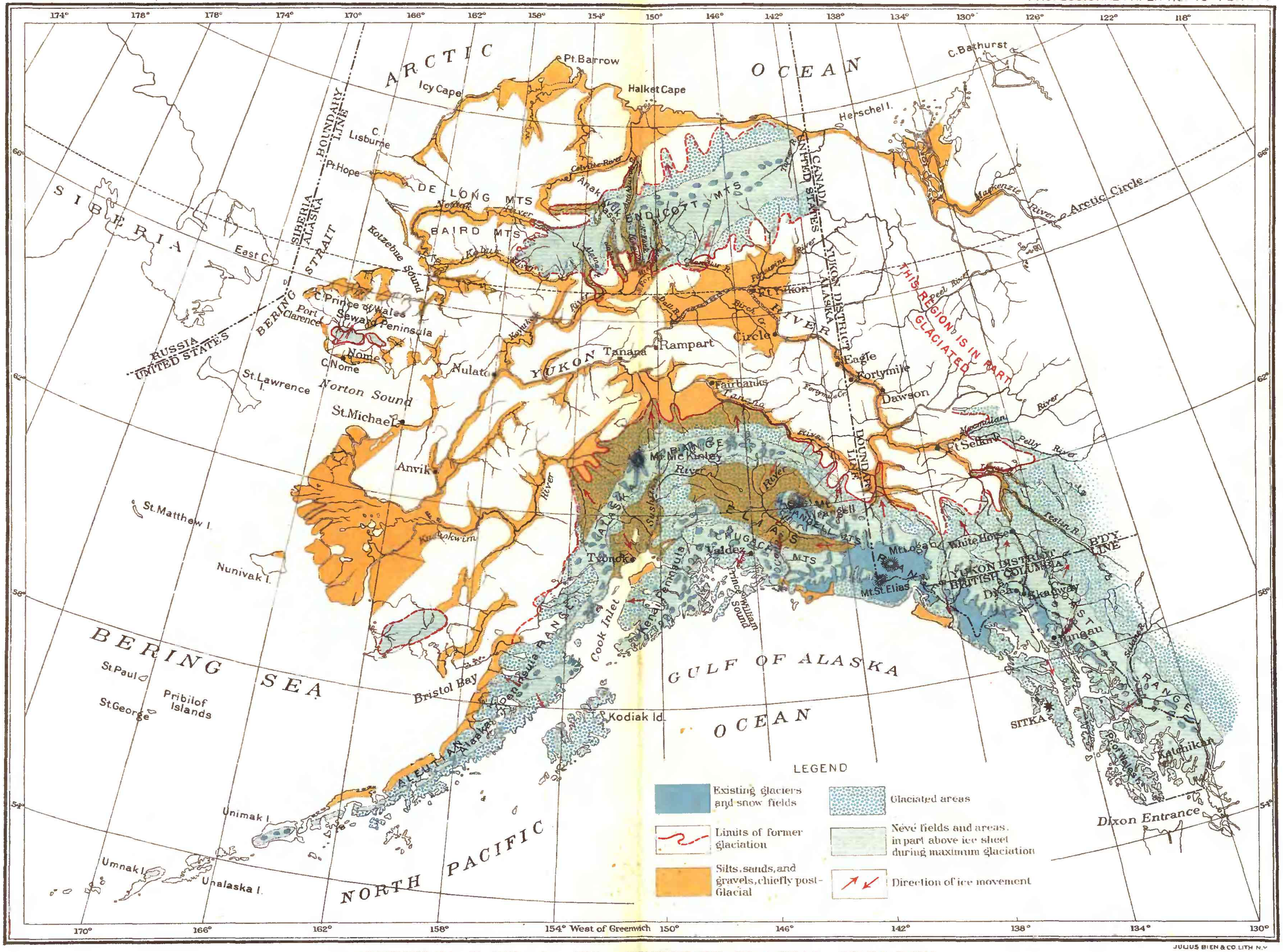
The Pleistocene and Recent terranes of this province are lithologically nearly identical, sometimes grading into each other, and geologic studies have in most cases not gone far enough to differentiate them. Therefore on the geologic maps (Pls. XX and XXI) the Quaternary is indicated as a stratigraphic unit. The Recent deposits, except the soil and ground ice, which are not mapped, cover relatively small areas, and the Quaternary of the map can be regarded as all Pleistocene except along the valleys, deltas, and seabeaches, where the younger sediments are included.

Much of the Pleistocene is directly or indirectly connected with the epoch of glaciation, and in a general way is divisible into the englacial deposits, which are the older, and extraglacial deposits, which are the younger. The englacial deposits include drifts, till, and a little morainic material, as well as other forms of washed gravel deposits; the extraglacial material is composed of the gravels, sands, and silts which were spread out as a mantle during the retreat of the ice. Though there are undoubtedly pre-Glacial Pleistocene deposits, the definite proof of their occurrence is still wanting. The Recent deposits are composed of fluvial and littoral sands, gravels, and silts of the present waterways, the ground ice, peat, muck, and soil, and the moraines of the existing glaciers, which are of relatively small import. In the following pages the present glaciers will receive first consideration, to be followed by an account of the former glaciation, as well as of the materials which were deposited during the advance and retreat of the ice, and the section will be closed by a brief reference to the Recent deposits.

PRESENT GLACIERS.

In the popular mind Alaska is not infrequently associated with limitless expanses of snow and ice, but glaciers and permanent snow fields are almost entirely limited to the Pacific Mountain system. (Pls. XII and XXII.) The existing glaciers have been mentioned in the systematic geography, and further details can be found in Gilbert's[a] report, for only a few broader features of their occurrence will here be noted. Gilbert[b] states that glacial ice now covers 15,000 to 20,000 square miles distributed over about three-tenths of Alaska, and is found only in the Pacific Mountain system. (Pls. XII and XXII.) It seems probable that this latter statement needs slight modification, for Schrader[c] reports the small remnant of a glacier in the John River basin

[a] Gilbert, G. K., Glaciers: Harriman Alaska Expedition, vol. 3. New York, 1904.
[b] Ibid., pp. 7-9.
[c] A reconnaissance in northern Alaska: Prof. Paper U. S. Geol. Survey No. 20, 1904, pp. 86 and 91.



SKETCH MAP OF ALASKA SHOWING GLACIAL GEOLOGY

COMPILED BY ALFRED H. BROOKS

Scale

0 100 200 300 400 500 miles

1904

of northern Alaska (Pl. XXIV, *B*), and on the authority of prospectors larger glaciers in the higher mountains to the northeast. Lingering remnants of glacial ice are also to be found in the Kigluaik[a] Mountains of the Seward Peninsula, while Spurr[b] also reports a dying glacier on the Ahklun Mountains near Bering Sea.

The large glaciers are on the seaward slope of the Pacific ranges, where they are fed by the extensive snow fields which find origin in the abundant precipitation from moisture-laden winds of the ocean. Many of the glaciers on the Pacific side reach far out from the mountains and some discharge directly into the sea, while those of the inland slopes are small and seldom reach the mountain fronts. (XXIII, *A* and *B*). A rough measure of the relative intensity of the glacial-producing conditions between the coast and inland faces of the ranges may be had by comparing the general altitude of snow line and ice fronts. According to Hayes[c] the névé line of glaciers on the seaward slope of the St. Elias Range has an altitude of 2,000 feet against 6,000 feet on the inland slope. Furthermore, while on the seaward side glaciers stretch into the sea, on the north side of the range they retreat rapidly at altitudes of 4,000 to 5,000 feet. A similar ratio of ice and snow line is found on the north and south slopes of the Wrangell Mountains, though here the altitudes on both sides are higher. On the south and east slope of the Alaska Range the snow line is between 4,500 and 5,000, and the ice fronts reach within 1,000 feet of sea level, while on the west and north slope the snow line is between 7,500 and 8,000 feet, and few of the glaciers reach even the front of the range, which stands at 2,500 feet.

FORMER GLACIATION.

The present glaciers of Alaska are but the remnants of far larger ice masses which mantled considerable areas but did not compare in extent with the former ice sheet of northeastern America, or even the present ice cap of Greenland. The accompanying map (Pl. XXII) expresses the general features of the glacial geology, though few of the details are yet known.

Four areas were in comparatively recent times in part covered by glacial ice, and each of these had a more or less central source in highlands, which furnished the névé fields from which the ice flowed in directions determined, to a large measure, by the pre-Glacial topography. The glaciation of Alaska is to be regarded rather as an extension of the present system of alpine and piedmont glaciers than as a continental ice sheet. Each high range was the locus of an accumulation of snow and ice, and from each radiated a distinct system of glaciers, which often did not leave the main lines of drainage. The present snow and ice fields of the St. Elias Range (Pls. XII and XXII), which fill the valleys and often no doubt cover divides and crest lines, and yet leave considerable areas not affected by ice, illustrate on a small scale the probable character of the former ice fields. The older glacial system was, however, far more extensive, and in southeastern Alaska approached the continental type.

On the map (Pl. XXII) the mountains, which furnished the névé fields and whose higher summits and crest lines towered above the snow and ice, are distinguished from the adjacent regions of lesser relief that were more completely

[a] Reconnaissance of the Cape Nome and Adjacent Gold Fields of Seward Peninsula, Alaska, p. 43.
[b] Spurr, J. E., A reconnaissance in southwestern Alaska: Twentieth Ann. Rept., U. S. Geol. Survey, pt. 7, 1900, p. 253.
[c] Hayes, C. W., An expedition through the Yukon district: Nat. Geog. Mag., vol. 4, 1892, p. 153.

covered by ice. Even in much of the regions of less relief the ice was confined to the valleys, and there were large uncovered areas. The lack of the detailed field observations and the small scale of the accompanying map has made it impossible to indicate the driftless areas within the glaciated region, about which some facts will be presented.

The advance and retreat of these ice sheets were probably, broadly speaking, synchronous throughout the province with the movements of the cordilleran glacier to the south. During the retreat the flood of waters, caused by the melting of the ice, carried a large amount of gravels, sands, and silts, which was deposited in broad mantles. There are now found in the gravel piedmont plateaus, and in the terraces, remnants of these deposits which are such prominent features of Alaska topography. This epoch of ice invasion from the highlands to the lowlands is of comparatively recent date, for the remnants of the larger ice sheet are still preserved in the many glaciers of the Pacific ranges of Alaska, and Pleistocene fossils are found in the overwash deposits.

The glacial geology is known only in its broader aspects, for no detailed mapping of these Pleistocene terraces has been carried on, but it is probable that the ice movements were not simply as have been outlined, but included a number of advances and retreats.

The great cordilleran ice sheet of northwestern America, which, according to Dawson,[a] swept north and south from its source in British Columbia, probably only reached into southeastern Alaska, where it passed through the Coast Range gaps, and, uniting with the local glaciers from these mountains, helped to scour out the extensive system of waterways of the Pacific shore and covered a good part of the Alexander Archipelago. The evidence of glacial erosion in this southeastern province indicates a great thickness of ice, and here, unlike other parts of Alaska, the ice overrode considerable altitudes. The large unmapped areas in the islands make it impossible to indicate the limits of the ice sheet, but it probably covered most of the archipelago and dumped its débris directly into the Pacific beyond. It is certain, in any event, that the larger channels, such as Chatham Strait and Lynn Canal, were occupied by glaciers (Pl. IV, *A*).

The northern front of the cordilleran ice[b] sheet formed a very irregular line extending northeast from the White River across the Yukon basin to the Rocky Mountains, for along the valleys of the larger river the ice extended north far beyond the general front as great tongues (map, Pl. XXII). It is probable that detailed studies may show even a still greater irregularity of ice front, for the glacial limit has been chiefly determined by journeys along the water courses, and it may be found that many of the interstream areas were never covered by the ice. Almost throughout this northern ice limit there is a striking absence of

[a] Dawson, G. M., On the later physiographical geology of the Rocky Mountain region in Canada: Trans. Roy. Soc. Canada, vol. 8, sec. 4, 1890.

[b] Dawson, G. M., Exploration in the Yukon district: Geol. Nat. Hist. Survey Canada, vol. 3, pt. 1., 1889; Report on the later physiographical geology in the Rocky Mountain region of Canada: Trans. Roy. Soc. Canada, vol. 8, sec. 4, 1890.

Russell, I. C., Notes on surface geology of Alaska: Bull. Geol. Soc. America, vol. 1, 1889, pp. 99-154.

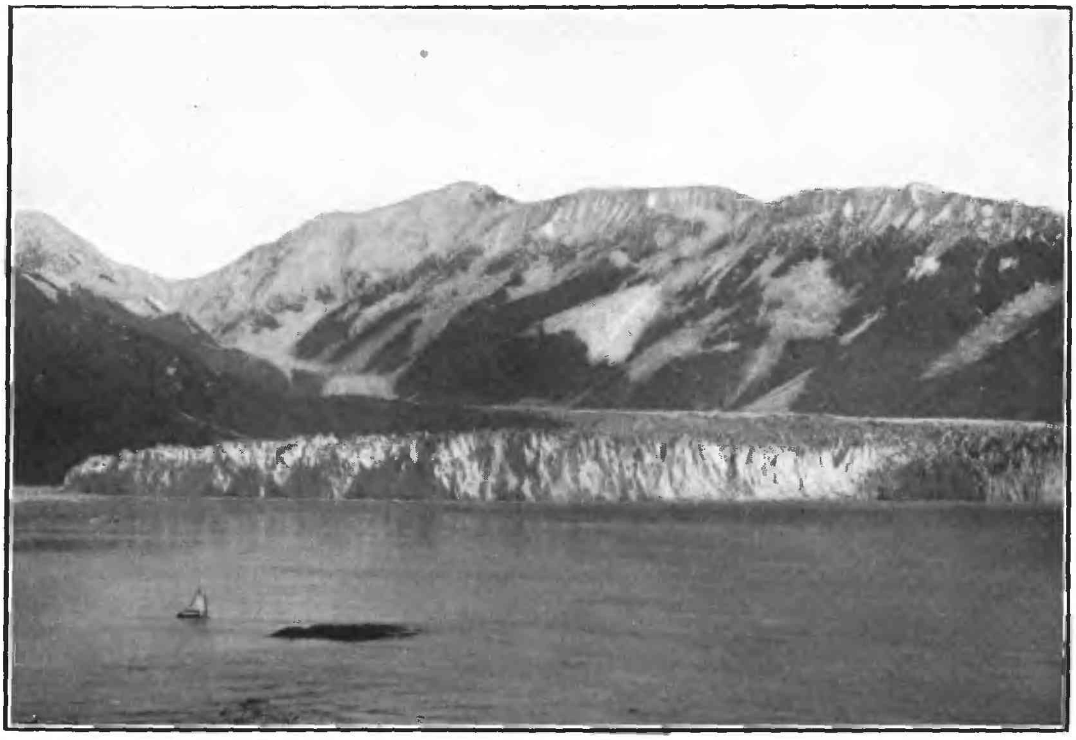
Hayes, C. W., An expedition through the Yukon district: Nat. Geog. Mag., vol. 4, 1892, pp. 117-162.

Tyrrell, J. B., Glacial phenomena in the Canadian Yukon district: Bull. Geol. Soc. America, vol. 10, 1898, pp. 193-198.

Brooks, A. H., A reconnaissance in the White and Tanana river basins: Twentieth Ann. Rept., U. S. Geol. Survey, pt. 7, 1900, pp. 429-494; Reconnaisance from Pyramid Harbor to Eagle City: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 331-391.

A. OCONNOR GLACIER FROM SLIMS RIVER VALLEY.

A typical valley glacier on the north slope of the St. Elias Range.



B. DALTON GLACIER, DISENCHANTMENT BAY.

A typical tide-water glacier from south slope of St. Elias Range.

morainic material, indicating the presence of a system of valley glaciers whose dumping ground was soon removed by the floods which accompanied the retreat.

The Pacific Mountains to the north had several centers of glaciation. The St. Elias Range sent one ice sheet northward, which probably united with the cordilleran glacier and another one southward which discharged into the Pacific.

Schrader and Spencer[a] have shown that all three of the ranges which bound the Copper River basin and plateau were foci for the accumulation of ice which eventually overrode the entire basin, and that the Chugach Mountains on the south poured down their seaward slope great masses of glacial ice which scoured out the fiords of Prince William Sound.

The Alaska Range to the northwest also contributed glacial ice which moved southward across the Copper River Plateau and down the Sushitna Valley and filled, in part at least, the upper end of Cook Inlet. On the north and west of the same range the glaciers stretched well out into the lowland of the upper Kuskokwim. In these mountains the upper limits of glaciation is between 4,000 and 5,000 feet.

During this epoch both slopes of the Aleutian Range were the breeding grounds of glaciers which discharged into the sea; their scouring helped to produce the irregularities of shore line of the Alaska Peninsula.

The higher valleys of the Ahklun Mountains near Bering Sea are U-shaped, and there is other evidence of their having been occupied by glaciers,[b] but this ice accummulation was evidently very local.

Throughout most of the interior plateau province glaciation was limited to the margin, but in the Seward[c] Peninsula the Kigluaik and Bendeleben mountains were the sources of comparatively small valley glaciers, some of which reached the sea.

The mountains of northern Alaska are less well known, but it is certain that their higher parts were the loci of ice accumulation, which stretched out from the base of both slopes. Schrader[d] found that this ice extended southward along some of the valleys nearly 50 miles from the base of the range. In the John (Pl. XXIV, *A* and *B*) and Chandlar valleys he noted the presence of till to a depth of 100 feet, but these glaciers, like those of the Pacific Mountains, seem to have left but little morainic material. The upper limit of this valley system of glaciers is between 2,500 and 3,500 feet.

On the north side of the Rocky Mountains, where the fall-off to the lowland is more abrupt (Pl. XXIX, *B*) and the climatic conditions were probably more favorable, the ice seems to have accumulated over a larger area, and probably had a fairly well-defined front 30 to 40 miles from the base of the mountains, while long tongues extended still farther north along the larger river valleys. Evidence of glaciation has been found up to an altitude of 3,000 to 4,000 feet, near the Arctic front of the mountains. The mountains to the east are almost unexplored, but there is no reason to believe that they are any less glaciated.

[a] Schrader, F. C., and Spencer, A. C., The geology and mineral resources of a portion of the Copper River district pp. 76-79.

[b] Spurr, J. E., A reconnaissance in southwestern Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 253-254.

[c] Brooks, A. H., Reconnaissance of Nome and Adjacent Gold Fields, pp. 43-47.

[d] Prof. Paper U. S. Geol. Survey No. 20, 1904, pp. 84-94.

Mendenhall found evidence of valley glaciation to the west of Schrader's route of travel, and ascribes a glacial[a] origin to several of the lakes which are tributary to the head of the Kobuk, and is inclined to the belief that in the mountains between the Kobuk and the Noatak was an accumulation of glacial ice which spread out into the valleys from both slopes.

On the glacial map these fragmentary data have been generalized, and considerable areas have been included in the glacial limits. The map should not be interpreted as indicating the presence of an ice cap comparable to that of southeastern Alaska, but rather as showing an area in which there was an extensive development of alpine and piedmont glaciers.

PLEISTOCENE SEDIMENTS.

The Alaska Pleistocene, as a rule, has not been differentiated into distinct horizons, and it is not possible to give detailed descriptions. The deposits near the limits of glaciation are characteristically heavy beds of gravels and sands, which are cross-bedded and present every indication of having been fluvial deposits in swift water. Away from the source of the material the deposits become gradually finer, eventually grading into fine silts, with horizontal bedding and every evidence of sluggish water deposition (Pl. XXV, *B*). A good example was observed at the northern base of the Alaska Range, in the valley of the Cantwell River, where a coarse gravel and sand deposit, aggregating probably 800 feet in thickness, mantles the base of the range. These terranes, which have a very perceptible dip away from the mountains, and probably represent an initial plain of deposition, rapidly decrease in thickness and merge gradually into finer deposits; and finally, 50 miles away, are replaced by fine silt deposits less than 100 feet thick. It appears as if Schrader's[b] Goobic sand, which mantles the upper Tertiary beds north of the limit of glaciation in the Arctic slope province, may have a similar history. These latter are of fine sands with some silts and an occasional layer of gravel, and appear to resemble closely the Pleistocene silts of the Yukon Valley.

Fine silt deposits occur throughout the length of the Yukon and on many of its tributaries and are typically buff colored, with a thickness of 50 to 200 feet, and often rest on a layer of gravel (Pl. XXV, *B*). On the upper Lewes these silts overlie glacial till, showing them to have been deposited after the retreat of the ice. The large bowlders occurring in the silt must have been ice borne, suggesting deposition during the floods which accompanied the retreat of the ice. Spurr,[c] who described the Recent deposits of the Yukon Valley in considerable detail, grouped all of the fine material together under the name Yukon silts. It appears that he has included in this formation not only the sediments which accumulated during the post-Glacial floods, but also the recent alluvium of the present rivers, and it seems desirable to limit the formation to include only the older silt deposits. He suggested that these silts were deposited in lake basins, but this hypothesis seems to be only locally applicable. He also discusses a number of other theories[d]

[a] Mendenhall, W. C., A Reconnaissance from Fort Hamlin to Kotzebue Sound: Prof. Paper U. S. Geol. Survey No. 10, 1902, pp. 45-48.

[b] Prof. Paper U. S. Geol. Survey No. 20, 1904, p. 93.

[c] Geology of the Yukon gold district: Eighteenth Ann. Rept., U. S. Geol. Survey, pt. 3, 1898, pp. 200-221.

[d] Ibid., p. 222.

advanced by various writers as to their origin. These will not be discussed here, as it appears desirable to obtain more facts in regard to the occurrence of the silts before speculating further on their genesis. At a number of localities these silts have yielded both vertebrate and invertebrate Pleistocene fossils.

In most of the Alaska geologic reports mention is made of widely distributed sands and gravels, but as it is yet impossible to establish any system of correlation between them they will here be passed over in a few words. A marine bench has been found by Spencer at about 200 feet above sea level near Juneau, in southeastern Alaska, and Russell found Pleistocene marine fossils in unconsolidated material 5,000 feet above sea level on the southern slope of St. Elias. Extensive gravel benches occur around the head of Cook Inlet, 100 to 300 feet above sea level, while high glacial benches are found on both sides of the Alaska Range, and similar features are present in the Aleutian Range. The great Copper River basin is filled to depths of several hundred feet by silts and sands, with some gravel, up to an altitude of about 3,000 feet (Pl. XXV, *A*). In the Yukon basin, ancient stream gravels are found to an altitude of several hundred feet above the present water courses. The Seward Peninsula has well-marked fluvial and marine benches up to an altitude of 800 or 1,000 feet, and some less well-marked features have been observed at still higher altitudes (Pl. XXX, *A*). All these facts have bearing on the recent orographic movements in the province and will be referred to again in the discussion of the geomorphology.

RECENT DEPOSITS.

The distribution and origin of the ground ice, which is found in all parts of the Territory north of the Pacific coastal belt, is an important but unsolved problem. While it has been supposed to form a practically continuous layer below the thick coating of moss, such has not been found to be the case. In the Seward Peninsula, where the mining operations have pierced the surface coating at many places, the ground ice has not by any means been universally met with, for though in places it extends to the extreme depth of excavation of 100 to 150 feet, in other localities near-by it is often entirely wanting.

IGNEOUS ROCKS.

INTRUSIVES.

References have been made in the foregoing pages to the igneous rocks which are associated with the various sedimentary horizons. It seems worth while to briefly summarize these facts, though it is beyond the scope of this paper either to enumerate the many rock types which have been reported or to discuss the petrography of this province.

The so-called Archean gneisses are partly made up of altered igneous rocks, and dikes and stocks of massive acidic and basic rocks are not uncommon in the gneissic areas. These could not be shown on the map (Pl. XXI) because it is impossible with the meager data at hand to draw boundaries between the massive igneous rocks and the gneisses.

In the metamorphic rocks, including the undifferentiated Paleozoic, stocks, dikes, and sills are almost equally common. These intrusives are of varied types, though chiefly acidic, and belong to different periods of injection, for some have been rendered quite schistose, while others are entirely massive. Intrusives occur in the Devonian and Carboniferous, though here they are less prominent than in the older terranes. Schrader's researches have brought out the important fact that intrusives are apparently entirely absent from the Paleozoic terranes of the northern axis of the Rocky Mountains.

The largest intrusions took place probably during Jurassic times, when the great granite and granodiorite batholith was injected, which is traceable as an almost unbroken mass from southern British Columbia into Alaska, a distance of over a thousand miles. Beyond the point where the granite ceases to occur in continuous outcrops the same period of injection seems to maintain itself to the west and southwest by a series of large granodiorite stocks which occur along the axis of the Alaska Range. In the same range are dikes of more basic rocks, which seem to belong to a later dynamic revolution. Another large granitic intrusion is exposed in a belt along the axis of the Alaska Peninsula. Granite stocks and dikes are also not uncommon in the Cretaceous rocks of the Kuskokwim Valley. In the Seward Peninsula are many stocks of granitic rocks which are entirely massive. Basic dikes of later age have been found in the Eocene beds of the Yukon.

VOLCANICS.

Though petrographic work may reveal effusives among the metamorphic rocks of the older terranes, up to the present they have not been definitely recognized below the Devonian.

The Rampart series (Devonian) of the Yukon-Tanana region includes a great thickness of volcanic rocks, chiefly of a basic character. The pre-Permian Nikolai greenstone of the Copper River region is entirely composed of a succession of basaltic flows. The greenstones of the Permian beds of southeastern Alaska are known to be in part of volcanic origin. The same horizon in the Copper basin, called the Mankomen group, contains a large amount of effusive material.

As Mesozoic extrusives can be counted the Kasaan greenstone (?) of the Prince of Wales Island and the extensive Triassic, Jurassic, and Cretaceous volcanics of the Alaska Peninsula. In all these extrusives andesitic rocks are the prevalent type.

Little has been learned of these older volcanic phenomena, but the history of more recent volcanic activity is somewhat better known. Since early Tertiary times volcanism has been active in the Copper River basin and probably in the Alaska Peninsula, and in both districts it still persists in the present volcanoes. Here, too, andesite is the most abundant type, but basalts are not uncommon.

In the Wrangell region an extensive mountain group has been built up entirely of extrusive material, chiefly andesitic, and the limit of distribution of the volcanics is well marked by lowlands surrounding the mountains on all sides except on the south, where they are coextensive with the unexplored part of the St. Elias Range.

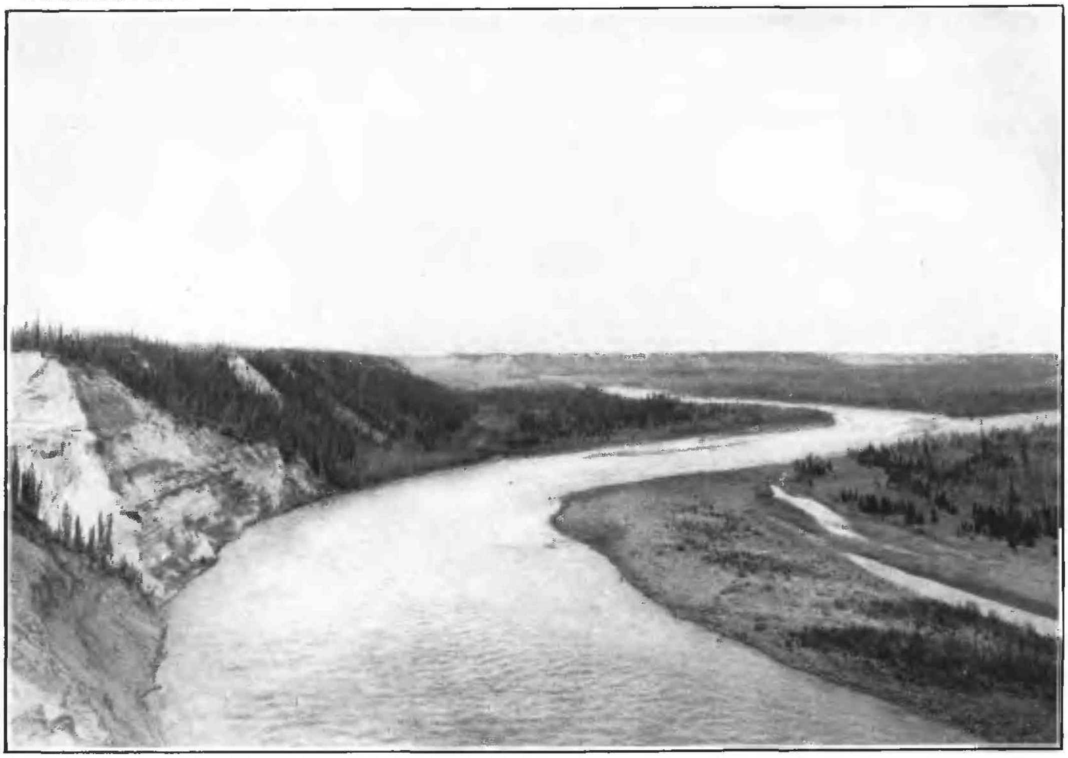
The Aleutian volcanics, in which, as far as known, andesites dominate, can probably be regarded as a southwestern extension of the same zone, though they are not geographically connected with the Wrangell Mountains. The Aleutian

A. GLACIATION IN UPPER JOHN RIVER VALLEY, ENDICOTT MOUNTAINS.

Looking S. 25° W.

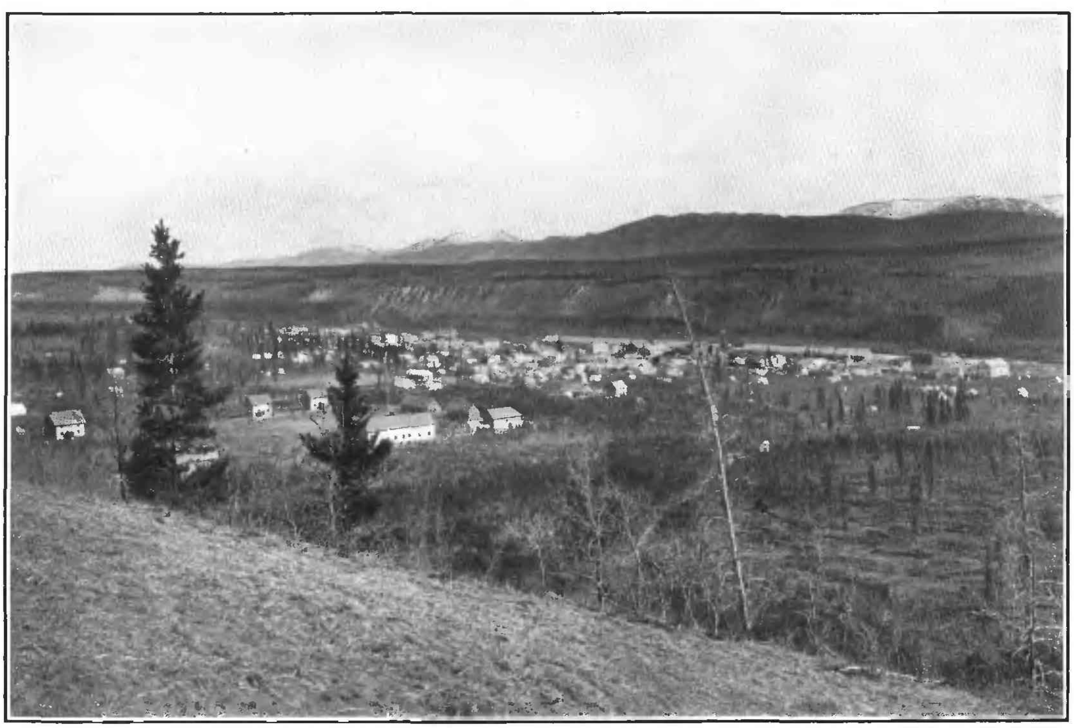
B. ICE REMNANT OF JOHN RIVER VALLEY GLACIER IN ENDICOTT MOUNTAINS.

Looking southwest.



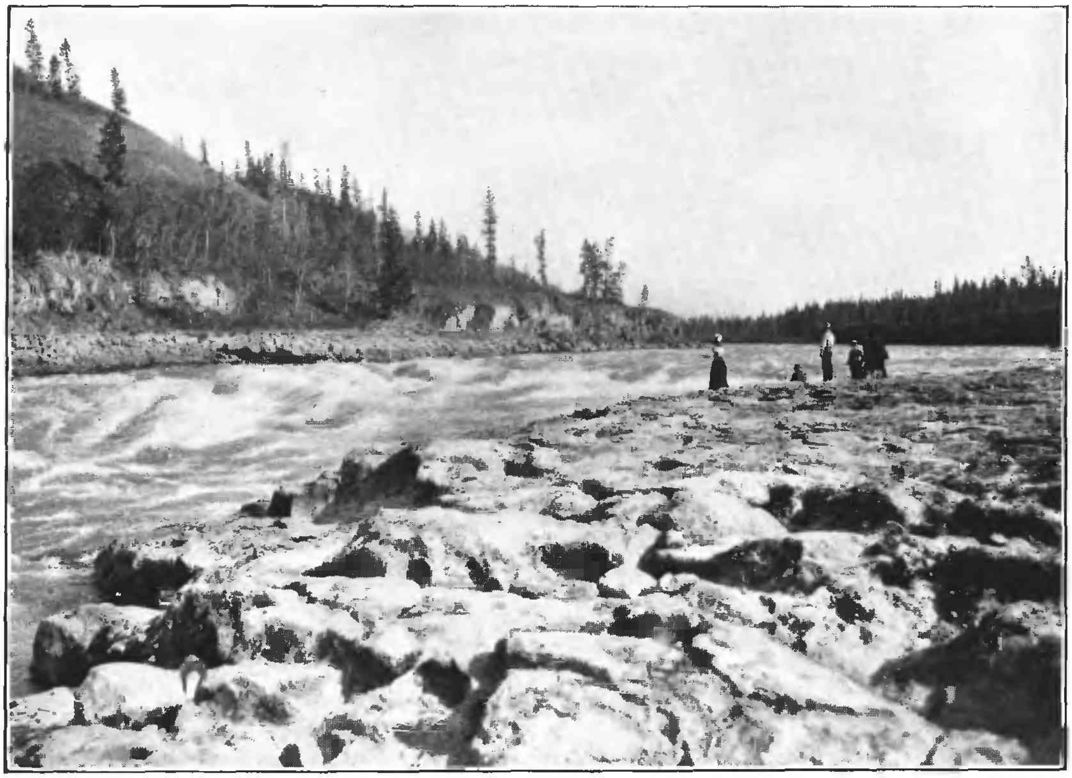
A. EASTERN MARGIN COPPER RIVER PLATEAU.

Showing silt deposits.



B. LEWES VALLEY AT WHITE HORSE.

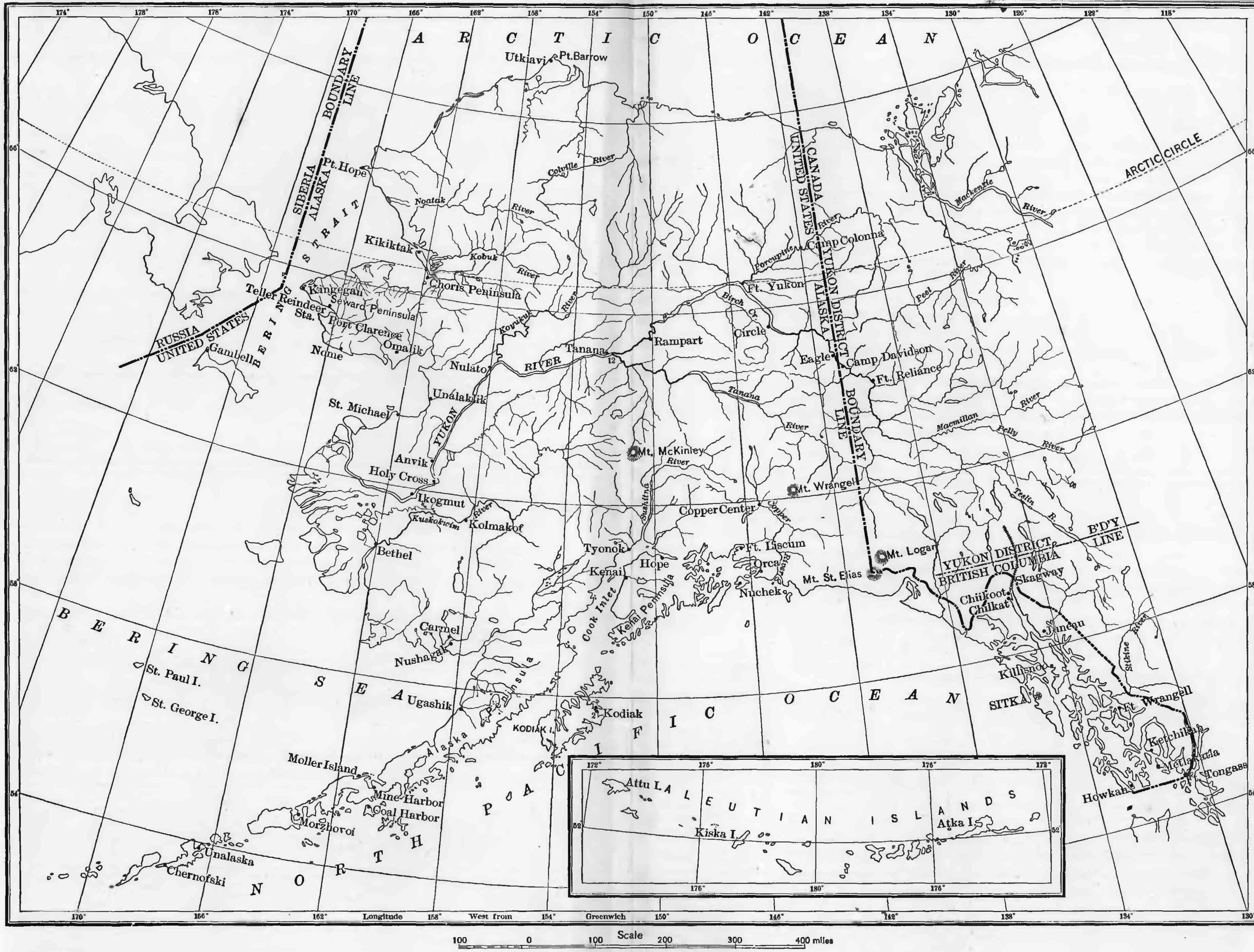
Showing silt terraces.



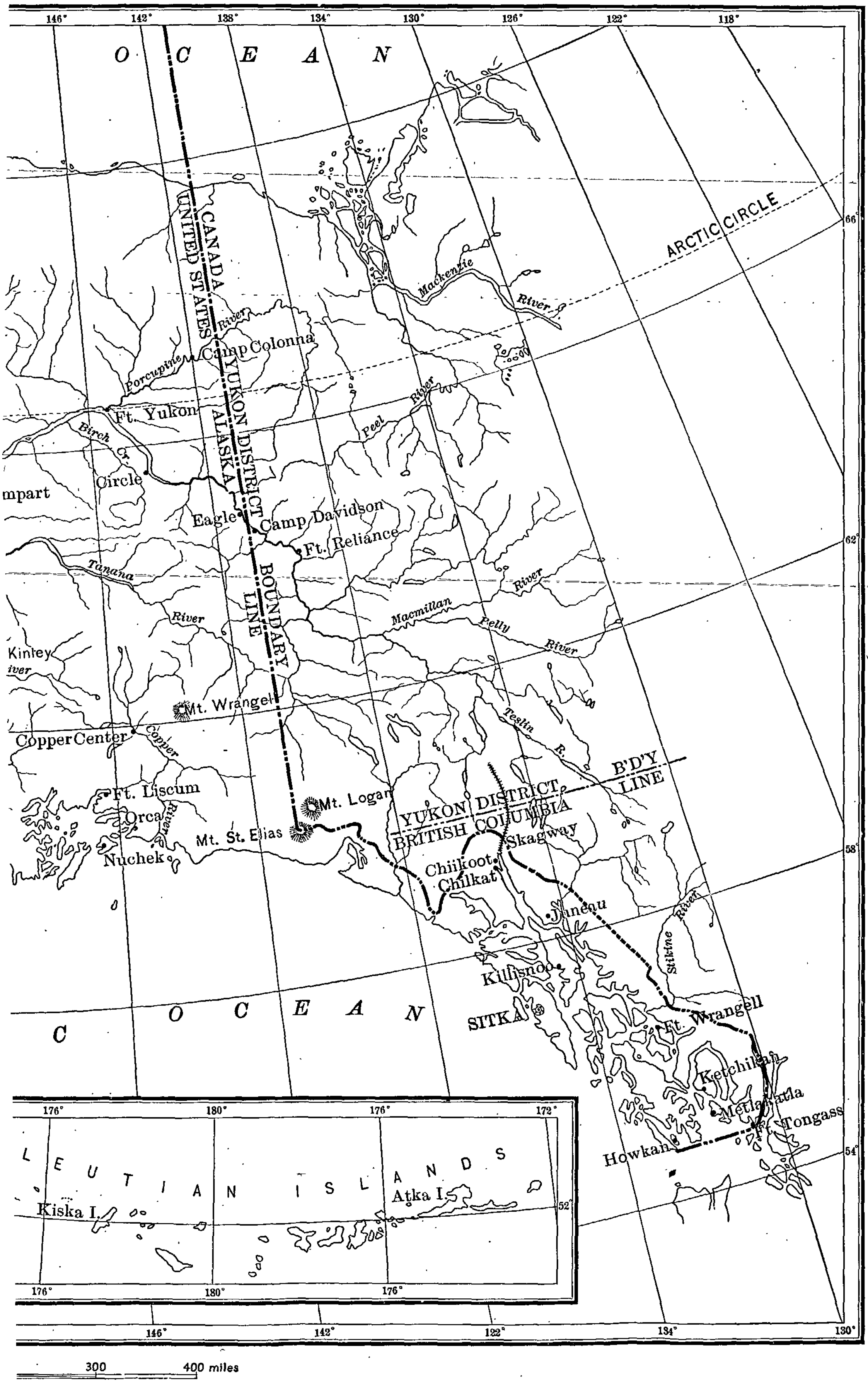
A. WHITE HORSE RAPIDS OF THE LEWES.

Caused by recent lava flow.

B. MILES CANYON, LEWES RIVER, CUT IN RECENT LAVA FLOW.



MAP SHOWING METEOROLOGIC STATIONS.


OCEAN
CANADA
UNITED STATES
YUKON DISTRICT
ALASKA
BOUNDARY
LINE
ARCTIC CIRCLE
Mackenzie River
Porcupine River
Camp Colonna
Ft. Yukon
Birch
Circle
mpart
Peel River
Eagle
Camp Davidson
Ft. Reliance
Tanana River
Macmillan
Pelly River
Kinley
iver
Mt. Wrangel
Copper Center
Copper
Teslin R.
B'D'Y LINE
YUKON DISTRICT
BRITISH COLUMBIA
Ft. Liscum
Orca
River
Mt. Logan
Mt. St. Elias
Nuchek
Chilkoot
Chilkat
Skagway
Juneau
Stikine River
Killisnoo
SITKA
O C E A N
C
Ft. Wrangell
Ketchikan
Metlakatla
Ft. Tongass
Howkan
A L E U T I A N I S L A N D S
Kiska I.
Atka I.
300
400 miles

'IC STATIONS.

Range, forming the backbone of the Alaska Peninsula, consists of a series of volcanic cones scattered on a northeast-southwest axis. Like the Wrangell volcanics, many of them are still more or less active, probably a survival of the more intense volcanism of Tertiary-Mesozoic times.

Mount Edgecumbe, which lies a few miles northwest of Sitka, is the only volcano known in southeastern Alaska. According to F. E. Wright, basic andesite is the prevalent rock type. This mountain seems to mark the southern termination of that broken zone of volcanoes which lies on a crescentic axis, on one arm of which are the Wrangell volcanoes, and on the other those of the Alaska Peninsula and the Aleutian Islands. Its western end lies near Kamchatka, and may have some connection with the volcanoes of that isthmus.

The inland and northern regions of Alaska are marked by an absence of volcanoes, but evidence of volcanism is not entirely lacking, for throughout the Yukon basin and in the Seward Peninsula small areas of Pleistocene or Recent volcanic flows are not uncommon. Some of these have been extruded so recently that they have affected the present drainage system (Pl. XXVI, *A* and *B*). The distribution of the larger of these areas is indicated on the accompanying map (Pl. XXI), and it will be noted that none of them has yet been found in the northern Rockies, where, as has already been indicated, intrusive rocks are also absent. These recent outpourings of lava are especially noticeable in the Bering Sea littoral, for nearly all the islands of the sea are made up largely of these volcanic rocks. Among these recent extrusions basaltic rocks appear to dominate.

One other phase of volcanic activity deserves mention; that is the extensive deposit of volcanic[a] tufa of the upper White River basin, in many places entirely bare or overlain by only a few inches of soil. This tufa is of andesitic character and seems to have been ejected from a vent lying in the St. Elias Range near the international boundary. It has been traced northward as far as Fortymile River, westward to about the one hundred and forty-second meridian, and northeastward to near latitude 62° 30′. It covers an area of about 90,000 square miles. Near its outward margin the layer of tufa is only a fraction of an inch in thickness, whereas near its source in the White River basin it is found in drifts upward of 100 feet deep. This volcanic deposit is the only one of the district which appears to have had an explosive origin.

SUMMARY OF STRATIGRAPHIC SUCCESSION.

The Pelly gneisses form the basal complex of the province. They are made of crystalline rocks, believed to be of Archean age, occur in but small areas, and their relations to sedimentary beds are not definitely determined. The oldest sediments include a great thickness of phyllites and related clastics, succeeded

[a] Schwatka, Frederick, Along Alaska's great river: New York, 1888, p. 196.

Dawson, G. M., An exploration in British Columbia and Northwest Territory: Ann. Rept. Geol. Nat. Hist. Survey Canada., new series, vol. 3, pt. 1, 1889, pp. 43B–46B.

Russell, I. C., Notes on the surface geology of Alaska: Bull. Geol. Soc. America, vol. 1, 1899, p. 145.

Hayes, C. W., An expedition through the Yukon district: Nat. Geol. Mag., vol. 4, 1892, p. 146.

Spurr, J. E., Geology of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, p. 223.

Brooks, A. H., A reconnaissance in the White and Tanana river basins: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, p. 475; Reconnaissance from Pyramid Harbor to Eagle City: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 365–366.

by calcareous deposits which in places carry Silurian fossils, the oldest organic remains, except a few Ordovician which have been found in Alaska. This extensive limestone horizon, usually highly altered, is provisionally referred to Silurian, but has yielded fossils at only a few localities. Though some of these limestones may prove to be of different age, it seems to be probable that there is in Alaska a Silurian horizon, represented by heavy limestones, which has a very wide distribution and which is underlain by a great series of argillaceous and arenaceous rocks, which are here assigned to the Paleozoic, though they may be in part pre-Cambrian.

The Devonian, which is probably everywhere separated from older terranes by an unconformity, includes a heavy conglomerate, also shales and limestones, and, in part of the territory, extensive masses of igneous rocks.

Of the Carboniferous divisions, the Permian is best represented, but some heavy limestones have been found which are referred to a lower horizon in the system. The Permian beds include limestones and slates, and, in the Copper River basin, where this series reaches a thickness of 6,000 to 7,000 feet, considerable volcanic material. There is evidence of local unconformities between the Carboniferous and Devonian, but a wide-reaching erosional interval has not been established.

Triassic fossils have been found in the Copper River basin and on the Alaska Peninsula in limestones and shales. In the same districts, as well as in northern Alaska, Jurassic beds of diverse composition, aggregating many thousand feet in thickness, have been found. The Jura-Cretaceous is represented nearly throughout the province, usually as a limestone and shale series, but often carrying sandstones and conglomerates. It rests unconformably on the older horizons.

Both Lower and Upper Cretaceous rocks, usually limestones and shales, occur on the lower Yukon basin and in northern Alaska. Upper Cretaceous beds have been found in the Alaska Peninsula and in southeastern Alaska. The Kenai, the oldest member of the Tertiary, typically a fresh-water deposit, including conglomerates, sandstones, and shales, with lignite seams, is very widely distributed. Some marine Eocene beds have been found on the Alaska Peninsula. Miocene, including sandstones, limestones, and shales, has been found along the southern base of the St. Elias Range in southwestern Alaska. Pliocene beds have been reported at some localities, but appear to have a very limited development. The Pleistocene is represented by deposits of glacial origin in the two mountain systems, and by more extensive terranes, including unconsolidated gravels, sands, and silts throughout the territory. The glaciation, except in southeastern Alaska, must be considered due to a former wider extension of the present alpine and piedmont glaciers rather than to a general ice sheet.

STRUCTURE.

INTRODUCTION.

References to structure have, as far as possible, been omitted from the preceding discussion for the sake of presenting a clearer conception of the stratigraphic sequence by disregarding the complexities introduced by deformation. This arrangement, however, involves a certain amount of repetition. As it seems desirable to avoid constant use of qualifying phrases, the geologic sequence, already fully discussed, will be regarded as definitely established. It will also not be deemed necessary to cite all authorities to which full references have already been made.

There will here be no attempt to indicate more than the barest outline of the larger structural features, and the following pages will be largely devoted to a discussion of nine geologic cross sections (see Pl. XXVII) of various parts of the province. The location of these sections has of necessity been determined by the districts which have been investigated rather than by those which might be expected to elucidate the dynamic history. For example, there are no data upon which a section through the St. Elias Range can be constructed, though this would form the key to the relation of the structural features of southeastern Alaska to those of the Copper River region.

A few of the dominant structural axes are indicated on the geologic map (Pl. XXI), but these must be regarded as largely hypothetical. They represent chiefly the results of the deformation during Mesozoic times, for the older structural axes are not well known, and the Tertiary and later crustal movements were rather of the character of broad uplifts and depressions than of plications. That some of these later disturbances were accompanied by important deformations is indicated by the close folding and faulting of some of the Eocene beds, but these seem to have been rather local in their effect.

The general trend of the structural lines parallel to the coast and to the mountain systems has been repeatedly dwelt upon. All of the dominant structures in southeastern Alaska strike northwest; following the coast they swing gradually to the west, and near the one hundred and fiftieth meridian turn southwest and continue in this same general direction to the Bering Sea. Most of the important lines of deformation throughout the province are parallel to these structures.

STRUCTURE OF PACIFIC MOUNTAIN SYSTEM.

Though the axes of the four great ranges of the Pacific Mountain system have a marked parallelism, their geologic history has been by no means uniform. The rocks of the Coast Range are igneous, intruded as a great batholitic mass, while the St. Elias Range proper seems to be built up of complexly folded sedimentaries, probably chiefly Paleozoic, together with many intrusives. The component strata of the Chugach and Nutzotin mountains, the two main forks of the St. Elias Range, are closely folded sediments (Mesozoic?), while the Wrangell Mountains consist of great series of Recent and Tertiary volcanics resting on the beveled edges of folded Mesozoic beds. In the Alaska Range, Mesozoic and Paleozoic terranes are found closely infolded as a great synclinorium, interspersed by large stocks of granodiorite. The Aleutian Range is formed of a series of volcanoes and their ejecta, resting on folded Mesozoic strata and Tertiary sediments.

In southeastern Alaska there is a complex of metamorphic sediments, ranging in age from Silurian or older to Permian and possibly Triassic, and bounded on the east by the intrusives of the Coast Range. In some places these metamorphics are mantled by less altered and less deformed sediments, in part Tertiary (Eocene) and in part assigned to the Mesozoic. The metamorphic sediments, usually intensely plicated, have a general northwest strike and steep westerly dips. The oldest of these terranes are believed to lie in a belt which extends southward from Glacier Bay through the western part of the Alexander Archipelago to Dixon Entrance. The general structural relations in this district are illustrated in the section AA (Pl. XXVII), which is drawn at right angles to the strike from Prince of Wales Island eastward, through the Ketchikan region, traversing the Coast Range, and extending into British Columbia. The closely folded limestones and phyllites of the Wales series, together with some intrusives, are shown at the western end of the section. Though the dips of these beds are concentric the structure is probably anticlinal and fan shaped. The Wales rocks are supposed to be Silurian and hence older than the Vallenar series (Devonian), which lie to the east and apparently dip underneath them. The Mesozoic (?) volcanics (Kasaan greenstone) rest horizontally on the beveled edge of the Vallenar beds.

The Ketchikan schists, made up of argillites and greenstones, with some limestones, separate the Devonian rocks from the Coast Range intrusives to the east, and are probably in part Carboniferous in age. The schists all dip westerly at high angles, and, as the oldest beds are on the west, indicate an anticline overturned toward the east. To the east the Ketchikan schists become more highly crystalline, are broken by granite masses, which are injected parallel to the bedding, and finally give way to a broad belt of the Coast Range intrusives 30 to 40 miles in width, which probably consists entirely of massive rocks, though it has not been explored throughout. Metamorphosed Paleozoics bound the igneous rocks on the east and are unconformably overlain by less highly folded Mesozoic beds.

Though prevalently the dips are westerly, suggesting a monocline, the age determinations indicate that the oldest horizons are on the west, and therefore there has been an overturn to the east. There is also a suggestion of an anticlinal axis along the medial line of Prince of Wales Island, though this is largely hypothetical. It also seems quite probable that there may be duplication in beds in the Ketchikan series, and that these are made up of a succession of closed folds overturned to the west. The metamorphic sediments which lie adjacent to the Coast Range intrusives on the east are of undetermined age, and furnish no clew to the structures.

As the post-Triassic Mesozoic beds of this section are comparatively little deformed, the extensive dynamic revolution must have taken place before their deposition. There can be little doubt that the major structures are the result of more than one period of deformation. The Coast Range batholith was probably injected in late Jurassic times.

The same general geologic features are shown in the section BB (Pl. XXVII), which is constructed on rather fragmentary [a] data, and extends from Sitka through Juneau and across the Coast Range into British Columbia. As in the southern section, the metamorphic sediments have the same westerly monoclinal dip, but the evidence here also points to an anticline overturned to the west. The closely folded limestones and phyllites of Admiralty Island, provisionally correlated with the Wales series to the south, are believed to be identical with those of Glacier

[a] Wright has recently made a detailed study of this section, but his results are not yet available.

Bay to the north, which carry Silurian fossils. Though a Devonian fossil has been found in this district, no well-defined group of rocks has been mapped which can be correlated with the Vallenar series. The equivalents of the Ketchikan schists are found in the metamorphic rocks exposed near Juneau, with which the Ketchikan schists have a close lithologic similarity, and which have yielded a few ill-defined organic remains which are probably Permian. The Coast Range intrusives have the same character in both sections, between which they have been continuously traced. In the Juneau section (BB) are some flat Eocene beds resting on the upturned edges of the older rocks, and on Admiralty Island another group of sediments rest unconformably on the older rocks and have yielded Jura-Cretaceous fossils.

The two sections AA and BB, nearly 400 miles apart along the strike, show enough similarity to make it probable that the general geologic features of the intervening belt are much the same. What appears to be a closely folded anticline overturned toward the mainland brings up Silurian rocks in the westernmost of the islands of the Alexander Archipelago, east of which is a belt of limestones (Devonian), which give way still farther east to phyllites and schists of Carboniferous and possibly Triassic age. All of these groups of strata probably include some duplication by folding or faulting, and all are overturned to the east. A broad belt of granodioritic rocks, which crosses diagonally the strike of the sediments to the east of the schists, separates them from another belt of Paleozoics. At several localities little-disturbed Mesozoic and Tertiary beds are found resting on the upturned edges of the metamorphic sediments.

The strike of the Silurian limestones and phyllites at Glacier Bay would carry them into the heart of the St. Elias Range, but little is known of the component strata of this great mountain mass. Mesozoic and Tertiary beds have been found along its southern flank, and metamorphic terranes are known to occur toward its center, while a fairly well-defined belt of Permian strata has been traced along its inland front. Mount St. Elias itself is known to consist of a great intrusive mass of dioritic rock, which may likely belong to the same period of injection as that of the Coast Range. These fragmentary data and the topographic continuity suggest that the general sequence and structures of southeastern Alaska and the St. Elias Range may be the same.

In the Copper River basin the succession and structure are so different from those to the south that it is hopeless to yet attempt correlations. It has been shown that west of the one hundred and forty-first meridian the mountains appear to break into three distinct ranges—the Chugach along the coast, the Wrangell, forming the central mass, and the Scolai or Nutzotin Mountains, constituting the inland limit of the system. The section CC, from Controller Bay to the Tanana Valley, is an expression of the general structural features of the three highland masses. A comparison of this with the Juneau section (BB) indicates the futility of correlating between the two districts until the intervening area has been examined.

Sandstones and shales, probably Mesozoic, closely folded and faulted, but with a general westerly dip, are represented at the western end of the section. These are underlain on the east by the closely folded graywacke, slates, and phyllites of the Valdez series, which go to make up the Chugach Mountains of unknown age, but here provisionally assigned to the Mesozoic. On the north the Valdez rests probably uncomformably on the crystalline limestones and schists, provisionally referred to the Paleozoic, under the name Klutina series. The Valdez rocks are thrown up into a series of folds, indicated diagrammatically on the section.

A strong contrast between the geology on the north and that on the south side of the Chitina Valley suggests faulting, for on both walls the strata dip away from the axis and appear to be of different ages. North of the Chitina the Nikolai greenstone, a succession of lava flows, forms the basal member, and is overlain by the Chitistone limestone (Permian?), on which rest conformably several thousand feet of Triassic shales, which are succeeded unconformably by the Kennicott series, of Jura-Cretaceous age. The higher parts of the Wrangell Mountains are made up entirely of a great complex of Recent and Tertiary lavas, which on the southwest lie unconformably on the Kennicott series and on the northeast are in contact with shales which can probably be referred to the Triassic or Jura-Cretaceous. These shales of the northeastern slope are in turn underlain by Permian limestones, which also dip to the southwest.

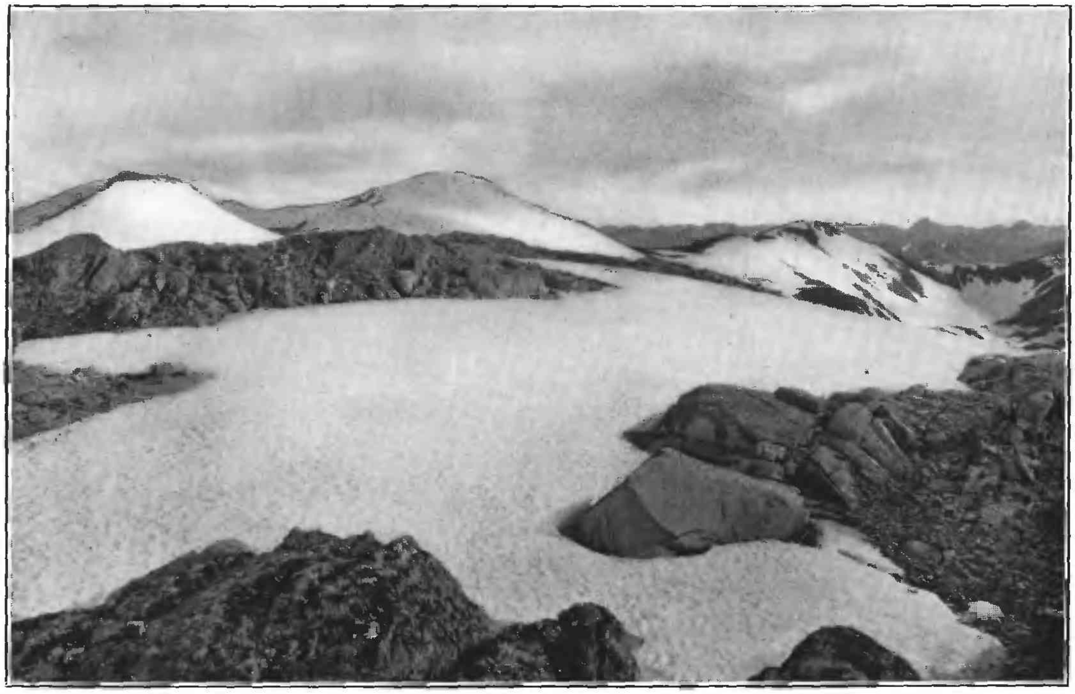
This Permian limestone seems to be separated by faulting from the closely folded graywackes, limestones, and slates (Mesozoic) which make up the component strata of the Nutzotin Mountains. This fault separates the southerly dipping Permian limestone at the base of the Wrangell Mountains from the northerly dipping Nutzotin rocks (Mesozoic?), which comprise a closely folded series, ending in the north at the alluvial-floored Tanana Valley, beyond which the section shows westerly dipping metamorphic sediments (Tanana schists) resting on a gneissic complex (Archean?).

The beds of the Wrangell Mountains seem to lie in a syncline bounded on both sides by faults which have broken the adjacent anticlines and beyond which are broad synclinoriums of Mesozoic beds. The central syncline of the Wrangell Mountains is then faulted on both margins and forms an uplifted block. On the west the Wrangell Mountains break off to the alluvium-filled Copper River basin and afford no further clew to the structure.

The succession of dynamic events in this district is perhaps as follows: The supposed lower Paleozoics were probably deformed and metamorphosed at some time previous to deposition of the Permian. After Triassic beds had been laid down another crustal movement took place, followed by erosion and the accumulation of the Jura-Cretaceous sediments. These latter were then thrown up into the broad syncline of the Wrangell Mountains, which was at the same time blocked out by faulting along both arms. The later crustal movements seem to have been not sufficiently localized to bring about any considerable deformations.

The structure of the Chugach Mountains is still more uncertain, for its extension lies in the unexplored western part of the range.

The Nutzotin Mountains merge to the northwest into the Alaska Range, but the Mesozoic beds seem to end near Mentasta Pass, beyond which, at the head of the Chistochina and along the valley of the Delta River, metamorphic schists (Paleozoic?) appear to be the component strata of the range. The supposed syncline of



A. SUMMITS OF COAST RANGE FROM POINT NEAR JUNEAU.

Showing dissected plateau feature.

B. SUMMITS OF CHUGACH MOUNTAINS.

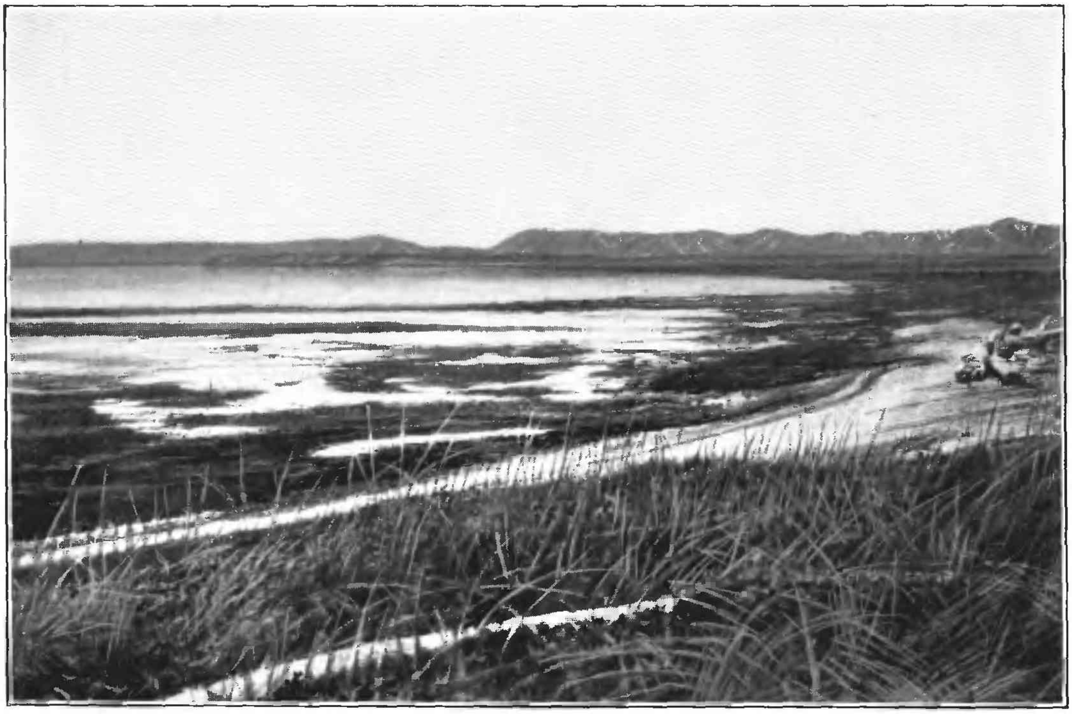
Showing dissected plateau feature.

A. SUMMITS OF ENDICOTT MOUNTAINS (ROCKY MOUNTAIN SYSTEM).

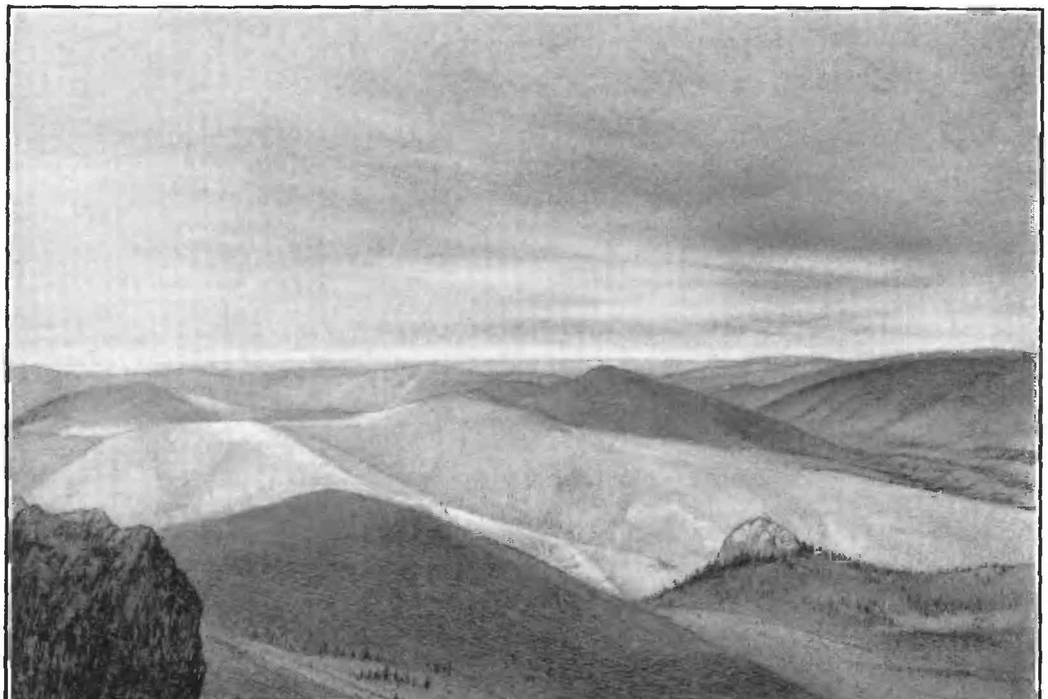
Showing dissected plateau featuie.

B. NORTH FRONT OF ENDICOTT MOUNTAINS.

Showing relations to Anaktuvuk Plateau and planated surface of plateau.



A. WAVE-CUT ROCK BENCH, NORTH SIDE OF PORT CLARENCE, SEWARD PENINSULA.



B. YUKON PLATEAU.

From altitude of about 5,000 feet at north base of Nutzotin Mountains.

Mesozoic rocks has therefore been indicated as ending near Mentasta Pass. (Map, Pl. XXI.)

Mendenhall has mapped a great fault[a] near the head of the Chistochina, which brings up the Permian rocks on the south against the metamorphic schist (Silurian?) on the north, with a throw estimated at between 8,000 and 10,000 feet. The eastward extension of this fault lies in the Nutzotin Mountains, where no detailed surveys have been made, while its projection to the west lies in an almost unexplored district.

The Nutzotin Mountain syncline probably continues into the eastern end of the Alaska Range, beyond which the structure is in doubt, but, following the same mountain mass westward for about 200 miles, evidence of synclinal structure is again found along the upper part of the Cantwell River Valley. (See section DD, Pl. XXVII). This suggests that the general structure may be synclinal throughout this belt.

The section DD, transverse to the Alaska Range, extends from the Sushitna River on the south to the Tanana Valley on the north. The presence of a broad synclinorium is inferred from the fact that metamorphic sediments, probably chiefly Paleozoic, dip toward the axis of the range from both its margins, but between are probably many subordinate folds. Near the center of the mass is a syncline of sandstones and conglomerates, probably of Tertiary age, which is faulted on the north arm. In this section[b] again there is at least a suggestion of the same synclinorium structure of the Nutzotin Mountains.

The section includes a part of the Tanana Valley, near which it intersects an area of gneisses (Archean?) overlain on the north by Pleistocene and on the south by metamorphic sediments (Paleozoic?). For about 10 miles to the south the Paleozoic are covered by nearly horizontal Tertiary sandstone, and these are in part buried in Pleistocene gravels.

From the Cantwell Valley the Alaska Range and the bed-rock structures swing gradually to the south. For nearly 200 miles the structure has been inferred only from what is known of the geology of the mountains along the northwestern front, where a highly deformed series of Paleozoic sediments have been found with some infolded Eocene beds. The higher peaks, such as Mount McKinley, are probably stocks of granodiorite. The remarkably straight front of the range for 200 miles suggests sharp flexures or faulting.

The fact that the cross section of the Alaska Range (EE, Pl. XXVII) at the Skwentna River, 200 miles southwest of the Cantwell, also shows a synclinorium suggests that this structure may be persistent throughout this belt. Here the closely folded Paleozoics, including Ordovician and Devonian strata on the west, are unconformably overlain by the sandstones, graywackes, slates, and limestones of the Tordrillo series (middle Jurassic), which are closely folded and faulted, and often cut by granodioritic igneous rocks similar to those of the higher peaks of the range. On the east the Jurassic beds rest unconformably on an intricate succession of igneous intrusives and lavas, with some sediments called the

[a] This fault has not been indicated on the accompanying map.

[b] That part of the section south of the Cantwell River is generalized from very incomplete data.

"Skwentna complex" and provisionally assigned to the Triassic. It will be noted that the Paleozoic beds which should underlie the Skwentna are not shown in this section on the east side of the range, but are probably present about 50 miles to the northeast. On the west side the absence of the Skwentna rocks is explained by the period of erosion which preceded the deposition of the Jurassic. The central syncline of Jurassic rocks is supposed to narrow down to the north and to end near Mount McKinley. To the southwest the extension of this structure lies in the unexplored region west of Cook Inlet.

If the evidence of these three widely separated sections is to be correlated it would suggest a synclinorium structure for the entire Alaska Range. At its southern end broad belts of Mesozoic strata are included in the synclinorium, which seems to die out to the north only to appear again in Nutzotin Mountains. The presence of infolded Eocene sediments indicates that the last extensive deformation dates from Tertiary times.

Intrusions of granodiorite occur in large stocks along the axis of the range, and these are identical in composition and probably in age with the batholiths of the Coast Range. As indicated on the geologic map (Pl. XXI), these intrusions lie along the same general axis, while there appears to be a second zone of intrusions to the east along the Sushitna Valley.

A broad anticline appears to be the dominant structure of the Alaska Peninsula broken by extensive faults on the eastern area. This arch occurs in Mesozoic beds, chiefly Jurassic, which on the west overlie a complex of granitic igneous rocks of undetermined age. Along the crest of the arch a series of volcanic vents forms the higher peaks of the Aleutian Range. Like the Wrangell Mountains, the Aleutian Range owes its relief to the constructive action of Tertiary and Recent volcanoes which lie along an axis of crustal deformation. This axis is probably in part determined by movements in the earth's crust as early as the middle Mesozoic, but there is reason to believe that the folding has continued up to very recent time. The western extension of this anticlinal fold probably forms the submarine ridge along which the Aleutian Islands are strung.

STRUCTURE OF CENTRAL PLATEAU REGION.

No detailed structural features have been worked out in the great intermontane region where the bed-rock succession includes Archean gneisses, probably terranes of every division of the Paleozoic, Lower and Upper Cretaceous, Eocene beds, and probably some Pliocene. Several unconformities have been noted in this succession, and the pre-Upper Cretaceous rocks are closely folded and faulted while the Eocene beds are locally often considerably deformed.

The zone of Archean gneisses which crosses the one hundred and forty-first meridian is flanked on either side by metamorphic sediment, indicating a broad anticline, and the same axis may find an extension along the gneissic area of the Cantwell Valley. To the north the metamorphic sediments are probably duplicated by an infinite number of closed folds overturned to the south. The structures of most of the younger beds along the upper Yukon remain to be determined, but the Eocene beds probably lie in synclinal basins.

The Cretaceous beds of the lower Yukon basin probably rest on Paleozoic terranes somewhere east of the Kuskokwim, and thence stretch to the northwest, to where they overlap on the Paleozoic or older sediments at the southern flank of the Rocky Mountains. It has been indicated that the central part of this area along the lower Yukon is occupied by Upper Cretaceous and Tertiary rocks. If such are the facts the Cretaceous beds occupy a broad syncline between two areas of older rocks.

The succession in the Seward Peninsula includes Silurian as well as older and younger metamorphosed Paleozoic sediments with some small basins of Tertiary or Mesozoic rocks, together with more extensive areas of recent lavas. The dominant structural feature of the central part of the peninsula is shown in the section FF (Pl. XXVII), which shows that the oldest terranes occur in the Kigluaik Mountains. The axis of this range, which makes a horseshoe bend from the northeast to the east, and finally almost due south, appears to be a line of anticlinal uplift. The Kigluaik series is the oldest, and is made up of a basal member consisting of heavy crystalline limestones, with mica-schists, succeeded by a great thickness of mica-schists and gneiss, and the entire succession is cut by large granite dikes. These rocks are overlain by the Kuzitrin formation, mostly graphitic slate and quartzite, with a thickness of probably 1,000 feet. The next horizon is the Nome series, whose basal member includes micaceous and calcareous schists, with some limestone, succeeded by several thousand feet of massive limestone called the Port Clarence limestone, containing Upper Silurian fossils. In a larger way the Nome series shows rather broad, open folding, but where opportunities are given for detailed studies there are known to be many minor plications and often extensive faulting. In the northern part of the peninsula there are some indications of east-west structural lines, but these have not yet been followed up. Extensive intrusives of granite have taken place since the last extensive deformation.

STRUCTURE OF ROCKY MOUNTAIN SYSTEM.

The one cross section made by Schrader along the one hundred and fifty-first meridian affords the only clew to the structure of the Rocky Mountain system. It appears that in its broader features the system can be regarded as anticlinal, for it is flanked on both the north and the south by Cretaceous beds (map, Pl. XXI), but the details are complex. The generalized section (GG, Pl. XXVII), after Schrader, shows two anticlinal axes, with sharp flexures and faulting, separated by a broad syncline. The southern anticline exposes the mica-schists of the Totsen series, succeeded by the Skagit formation, a heavy crystalline limestone. These rocks probably lie in the protaxis of the range. In the northern anticline, which is not nearly as well defined, only Devonian rocks are exposed, and Schrader's studies indicate a zone of block faulting rather than anticlinal structure. This faulting increases in complexity toward the northern escarpment, where it culminates in so intricate a system that Schrader's rapid journey of exploration can not be expected to yield final results regarding the structure. Between these two zones of maximum uplift a broad belt of rocks of diverse lithologic composition, called by Schrader the Fickett series, and provisionally assigned to the Carboniferous, appear to lie in a broad synclinorium.

The range, then, is bounded by Mesozoic beds on both sides, which on the south are sharply flexed, but on the north seem to be less plicated. The three axes recognized within the range strike east and west, and along the two outer there has been anticlinal folding, separated by a broad syncline. Schrader characterizes the general structure as consisting of broad folds, with faulting. The folds are sometimes accompanied by overthrusts.

There is some indication that the same anticlinal structure of the northern axis of the range extends westward to the Arctic coast to Cape Lisburne. No geologic work has been done to the east of this section, except by S. J. Marsh, whose journey from Camden Bay to Chandlar River has already been referred to. Through the courtesy of Mr. Marsh, it is possible as this report goes to press to insert a part of his geologic and geographic notes relating to northeastern Alaska. Though this material does not all properly belong to this part of the report, it seems worth while to publish all the notes on bed rock, both because they include the only scientific observations made in this part of the territory and because it gives opportunity to make record of a journey almost unique in the annals of Alaskan exploration. The notes have previously been published only in some of the Nome newspapers.

"The section of country of which this report treats lies between the meridians of 141° and 150° of west longitude and the parallel of 68° north latitude and the Arctic Ocean, and also includes the headwaters of the Chandlar River lying between 146° and 148° west longitude south to its confluence with the west fork at about 67° north latitude.

"The region actually explored lies between 144° 30′ and 149° west longitude, and embraces a strip of country 114 miles in width and about 241 miles in length, stretching southward from the Arctic coast. This is the first exploration made of this district.

"The trip was under somewhat peculiar circumstances and, owing to a lack of proper means of transportation of supplies into the interior, I could make only cursory examinations.

"I arrived at Collinson Point, Camden Bay, September 21, 1901, in company with Mr. F. G. Carter, having taken passage on the schooner *Helen* from Port Clarence. Here we built winter quarters of driftwood and remained until the following April. During the winter all the dogs in the vicinity died of an epidemic of hydrophobia.

"The 7th of April, 1902, I left the coast alone, hauling 1,250 pounds by relays, and reached Cache Creek on June 1, at which time the snow disappeared. Mr. Carter also started a few days later, taking a similar route, intending to make a short trip into the mountains and return to the coast in May, but I did not see him after leaving the coast.

"After building a cache of rock to protect my supplies I proceeded up the Kooguru [Canning] River and to the eastward along the northern slope of the main watershed, packing my supplies on my back. During the summer I sank many prospect holes and explored the mountain sides, studying the rocks as far as possible.

"The latter part of August I again descended the Kooguru to about 25 miles from its mouth, where I met Carter, Ned Carey, two Japanese, and a number of natives ascending the river with skin boats, the first human beings I had seen for a period of one hundred and twenty-eight days. I accompanied them back to about 15 miles above Cache Creek, where we all built winter quarters, using willows, the only available timber.

"After hauling my supplies from the cache and making a short trip to the westward I settled down for a much-needed rest, spending some of the milder weather in surveying for map data and spare time in teaching two native children.

"On February 21, 1903, Carter left me, intending to cross the mountains to the Koyukuk, taking with him a native and his wife.

"On the 8th of April I again started with about 375 pounds, went up Right Fork and crossed the main watershed by a very low pass, which I named for Carter, as I found he had taken the same route.

"On April 30 I overtook Carter and his natives about 30 miles down a river which I afterwards found to be the Chandlar. As the river was now beginning to break up, I laid over three weeks, helping Carter to build a cabin and doing some prospecting, and again started out, packing my supplies and tools, prospecting along the main range. By the 4th of July my supplies were practically exhausted and the country I was in was devoid of game. I was therefore forced to turn toward civilization, and taking what appeared to be the easiest route to the southeast, I finally came to a large river. Here I built a raft, on which I floated but a short distance when I encountered some bad rapids and came near losing my life. I was finally forced to abandon the raft and again take to packing, but soon becoming exhausted because of having been on practically a flour diet for some time, I built another raft, on which I floated for three days, when I came to an Indian village and found I was on the Chandlar. Here I obtained some dried moose meat, and a short time after Jack Carr, mail carrier from the Koyukuk to Fort Yukon, came along with a canoe bound for the latter place, to which I accompanied him, arriving there July 28.

"The watershed which divides the Yukon and Arctic drainage systems is formed by a continuous range of mountains, extending from Cape Lisburne slightly north of east to Mackenzie River. A subrange (designated on the maps as the Franklin Mountains) stretches eastward from the one hundred and forty-sixth meridian nearly along the sixty-ninth parallel, which is part of the main system and includes a number of large valleys. The elevation of the mountain at Carter Pass is about 4,000 feet, and of some of the higher peaks 5,000 to 8,000 feet above the sea.

"A slightly rolling plateau, rising from banks of 12 to 35 feet along the Arctic Ocean to an elevation of 250 to 490 feet at the base of the ranges, stretches from the coast line to the Franklin Mountains, a distance of 19 to 34 miles, and west of the Kooguru [Canning] to the main range 60 to 140 miles.

"Till is found along the bays of the coast line. The most prominent points consist of large bowlders, rough masses of rock, chiefly of granites and diorites, and heavy sands, all foreign to the vicinity.

"At Sunset Pass, a low gap through the Franklin Mountains, leading from the head of Ooselik [Kuselik] Creek to the head of the Barter River, alternate bands or layers of sandstones, conglomerates, and limestones are exposed. The limestones contain some fossils, mostly crinoids, and are but little changed by metamorphic action.

"South and southeast of Sunset Pass and between the Franklin Mountains and the main range is a large basin which appears to have been formerly occupied by a lake and is now drained by the Barter River, which traverses a subrange through a narrow valley.

"In this basin slates are exposed which are generally soft, colored dark brown to black, and lie in a series of folds with a general nearly east and west strike. In places they are siliceous, and in a few localities are filled with a network of small veins of quartz, generally much stained with oxide of iron. Near the center there occur several large bands of quartzite, also considerably stained by the decomposition of iron-bearing minerals.

"A series of these basins appears to occupy a similar position in relation to the two ranges to the east, and these are drained by the Hoola-Hoola, Bathhouse, and Turner rivers, all of which cut through the subrange.

"The same slates seem to continue to the west, except that the higher mountains are made up of limestones and soft slates, lying generally nearly horizontal. These latter are rich in fossils, those in the limestones being generally crinoids, while the slates contain numerous worm burrows and many species of shells, none of which were determined. The higher mountains in the whole region, as far as a line running easterly and westerly near latitude 68° 10′, are generally covered by the above-described fossiliferous limestones and slates; therefore, only a description of the rocks cut by the streams will follow.

"On lower Cache Creek and the Kooguru [Canning], from Carey Creek to a point some 12 miles above winter quarters of 1902–3, the streams have not cut down through the above-described rocks. From above point to the junction of the east and south forks the Kooguru has incised alternate bands of slates, quartzites, sandstones, and conglomerates, in places slightly stained by the decomposition of iron-bearing minerals.

"The south and east forks of the Kooguru [Canning] rise in small basins well up in the main range and which are partially filled with glaciers.

"From the mouth of Right Fork to Carter Pass the rocks are principally slates and sandstones, their structure indicating an immense anticlinal. At a point about 10 miles above Hyaks Creek and at what appears to be the axis of this anticlinal occurs a large band of siliceous slate, carrying seams of graphite and bunches of calc-spar much stained by oxide of iron. On the south side of this band there are chloritic slates. This band can be traced for a long distance. It is cut by the head of the Sawanukto and its principal branch, the Evasha. Westerly from the Kooguru [Canning] the rocks under the universal limestone capping are more sandstones and conglomerates. Near the mouth of the Evasha occurs a large cropping of lignite. Little work was done, however, in this direction, and limited time did not admit of much examination. Westward from the Chandlar, between the sixty-seventh and sixty-eighth parallels of latitude, the rocks are largely mica-schists, with some crystalline limestones."

It would appear from Mr. Marsh's notes that this section is very similar to the one described by Schrader along the Colville—on the south a belt of metamorphic schists and limestones, succeeded to the north by less altered fossiliferous limestones and slates. Approaching the Arctic coast are found sandstones, slates, and conglomerates, which would appear to be of Mesozoic age. The latter would seem to belong to the same general horizon as the Cretaceous beds described by McConnell along his portage route from the Mackenzie to the Porcupine.

The Rocky Mountains where crossed by McConnell,[a] along the Rat River portage, also seem to have a general anticlinal structure with numerous faults. The rocks, as far as known, all belong to the Cretaceous, and trend northwest and southeast parallel to the axis of the range. The relief is not as great as to the west, and for that reason erosion probably has not cut deep enough to expose the underlying Paleozoics found by Schrader.

GEOLOGIC HISTORY.

To complete this account of the geology it will be necessary to pass in brief review the succession of events from the earliest times up to the present, and in so doing to muster, as far as possible, all the facts of the stratigraphy and structure in one systematic scheme. The matter is so fragmentary that it will be possible to touch only the main facts of the history in outline, and the conclusions must remain in large measure speculative. Errors can not be avoided, and many false deductions will doubtless be made, yet a systematic treatment of the geologic evolution may not be without value. The pre-Tertiary history will here be treated at greater length than that of later date, which will receive more detailed consideration under geomorphology.

The gneisses (Archean ?) of the Yukon-Tanana district probably contain the oldest geologic records of the province, but these are very obscure, for the original character of the complex has been entirely destroyed during the repeated dynamic revolutions to which it has been subjected, and its genesis must for the present remain in doubt. There are probably clastics, as well as intrusives, included in the gneissic complex, which is largely made up of the rocks of undetermined origin which are usually classed as metamorphic, but all must for the present be placed in one group, which can be conveniently called Archean, though it may eventually, in whole or in part, find a much higher place in the stratigraphic column.

Whatever the origin of the gneissic series, it is certain that its typical members are much more highly crystalline than those of the known sediments. This fact is usually interpreted as indicating extensive deformation and metamorphism before the later sediments were laid down. It is not to be overlooked, however, that original lithologic character, localization of deformation, and the intrusion of large igneous bodies may also bring about differential metamorphism, and that the relative degree of crystallization between rock masses is in itself alone not a safe criterion for age determination.

That some of these so-called Archean rocks are older than the undoubted clastics is indicated by the presence at several localities of a basal conglomerate resting unconformably on the gneisses from which it has derived its detrital material. These occurrences go to show that the gneisses were metamorphosed and eroded before the conglomerate, probably the basal member of the stratigraphic column,

[a] McConnell, R. G., Report on an exploration of the Yukon and Mackenzie basins, Northwest Territory, Ann. Rept. Geol. Nat. Hist. Survey Canada, vol. 4, 1888–89, p. 120D.

was laid down. It seems then fair to assume that at sometime in the early geologic history there was a crustal movement which brought gneissic rocks above sea level. What little is known of the distribution of the conglomerate which resulted from this erosion suggests that the land mass or land masses were insular rather than continental, but beyond this and its probable pre-Silurian age, nothing is known of its form or size, or at what period it was elevated above the sea. It may have been a northwestern extension of the insular group, supposed to have existed in western North America at the close of the Archean, or it may have emerged from the sea at a much later date. Since this earliest denudation the gneissic areas have been deeply buried in accumulated sediments, and have been revealed only as a result of crustal movements which again brought them above the sea where they were uncovered by erosion. These later movements seem to have taken place along the same protaxis, and the present outline of the gneissic rocks may in a measure correspond with that of the first land mass exposed.

The cycle of sedimentation inaugurated with the deposition of the conglomerate which rests on the gneisses seems to have continued without any considerable interruption by dynamic revolutions to about the end of Silurian time. The deposits of this period which were laid down upon the conglomerate throughout the Yukon basin seem to have been of an arenaceous and argillaceous character and accumulated to a thickness measured by thousands of feet. If the stratigraphic correlations made of the pre-Silurian sediments are correct, there was a decrease of clastic material toward the northwest, which would indicate that it had been derived from a land mass to the southeast. The age of these early sediments being unknown, there are little data for speculations in regard to this land mass. As sedimentation went on the proportion of clastic material gradually decreased, and the deposits became more calcareous, indicating a subsidence of the sea floor and an accompanying retrogression of the shore line. These conditions seem to have persisted until late Silurian times, when the sea probably covered the greater part of Alaska, and the deposition of thousands of feet of comparatively pure limestone took place.

In short, the earlier sedimentary record indicates the deposition of thousands of feet of argillaceous and arenaceous matter followed by the accumulation of calcareous material also to a thickness of thousands of feet. Though the earlier sediments have yielded no organic forms, the latter on fossil evidence are assigned to the upper Silurian, and the entire conformable succession has been assigned to the Paleozoic. It is quite probable that volcanism was at times active during this long period of sedimentation, but of this there is no definite proof. It seems more certain that while the later sedimentary rocks of this epoch were being deposited, the earlier were so deeply buried as to have become indurated and were intruded by eruptive rocks.

Throughout the province, except possibly in the panhandle, an extensive dynamic revolution seems to have put an end to deposition in late Silurian or early Devonian time and brought about deformation and metamorphism to such an extent as to render the thin-bedded sediments as well as some of the eruptive rocks schistose, and to cause a recrystallization of calcareous and other material. This disturbance was accompanied by the injection of a large amount of igneous rock which also played a part in the metamorphism.

As a result of these movements, a land area emerged from the sea, of whose extent little is known. In the middle Yukon basin an erosional interval gives a sharp line of demarcation between this and later crustal movements, and the same is probably true in northern Alaska, but in the panhandle no physical break has yet been found between the Silurian and Devonian, though the relative degree of metamorphism suggests that such a one did exist. As a matter of fact, however, this post-Silurian dynamic revolution, though regional in its effect, locally differed very much in intensity, a fact strikingly illustrated in the Seward Peninsula, where in some places the Silurian rocks are semicrystalline, while in other near-by localities they are almost entirely unaltered.

The length of the period of denudation is entirely unknown, but in the Yukon basin it was of sufficient extent to bevel the upturned edges of the older terranes.

Sometime before the middle of the Devonian a gradual subsidence took place, which continued until the sea covered the entire province. In the Yukon-Tanana district, and possibly in the Copper River region, at about the time of this invasion, volcanic vents opened and poured out great masses of lava, together with extensive beds of tufa. This lava was deposited in part on land and in part in the sea. In the near-by waters extensive coral reefs furnished the calcareous matter for limestone deposits. In other parts of the province the aggregations of this period were entirely of a calcareous nature, and there was a marked absence of all eruptive material. The limestones thus deposited are of the most widely distributed Alaskan formations, having been identified nearly throughout the province by their corals of middle Devonian age.

The records of the succeeding epoch are obscure, but indicate that limestone deposition continued in some places during early Carboniferous times, while in others a considerable land area was exposed to erosion. Deposition was probably almost entirely checked by a crustal movement which took place about the beginning of the Permian and this was followed by subsidence. On the Yukon there is evidence of an extensive period of erosion which immediately antedated the deposition of the Permian sediments, but this has not been recognized elsewhere.

The Permian sea seems to have covered much the larger part of the province, for its sediments have been found along the Yukon, in the panhandle, and in the Copper basin, where they aggregate 7,000 to 8,000 feet. In the two latter districts the deposition was accompanied by the extrusion of volcanic rocks. In part of the province deposition apparently continued unbroken into the Triassic and was characterized by a gradual change from limestones to shales. It was ended by a crustal movement which deformed the beds, exposed a considerable land mass, and thus began another period of erosion. This uplift seems to have begun in Permian times in northern Alaska and progressed gradually southward during Triassic times, for the latter period does not seem to have left any sedimentary record north of the Pacific Mountains. In southeastern Alaska the indications are that the Permian-Triassic cycle of deposition was closed by an extensive dynamic revolution which metamorphosed and deformed the Paleozoic sediments and probably left them very much as they are now.

Volcanism seems to have been active in the southern part of the Alaska Range and in the peninsula to the southwest during the Triassic, for this epoch is represented in those regions by an igneous complex, in part made up of volcanic rocks which were deformed and eroded before the deposition of the Jurassic beds.

During Jurassic times deposition continued in the region of the Alaska Range and Alaska Peninsula and in northern Alaska until many thousand feet of sandstones, slates, and some limestone were laid down. As these are the only Jurassic sediments of Alaska, except the Jura-Cretaceous and possibly a narrow belt of clastics, which fringe the St. Elias Range on the south, it is probable that much the larger part of the province was dry land during this epoch.

A crustal movement in late Jurassic times interrupted all sedimentation and was followed by large injections of igneous rocks. These intrusions, which embrace the great batholiths of the Coast Range, are the most extensive of any in Alaskan history.

At the close of this dynamic revolution a considerable area was above water and there began what was probably a short cycle of erosion followed by a far-reaching depression in Jura-Cretaceous times, when the entire land mass seems to have been submerged. The sediments which followed were coarsest in the panhandle and Copper River region, where they included considerable conglomerate, but to the west and northwest were largely impure limestones. This may indicate the existence of a land mass in northern British Columbia during this epoch.

The close of the Jura-Cretaceous deposition may be conveniently regarded as the end of the older geologic history of the province, for the later epoch had for the most part a more or less direct influence on the development of the present topography, and, as this subject will be treated in some detail below, only its salient features will here be recounted.

The various crustal movements of the late Paleozoic and Mesozoic were mostly of far-reaching character, but appear to have been intensified along the zones now marked by the mountain ranges, and the post-Jura-Cretaceous later deformations, though they have affected all parts of the province, seem also to have been most intense along the same zones where previous folding had taken place.

The Jura-Cretaceous deformation again revealed a considerable land mass and active degradation began. Much of Alaska has probably not been below sea level since the close of this epoch. A transgression of the sea, however, took place along the present Yukon Valley during Upper Cretaceous times, and this may have extended up to the Porcupine and northward to the present base of the Rockies. A part of the Arctic Slope region and possibly some of the Pacific littoral were submerged during this period. Deposition continued in the lower Yukon basin up into the Eocene, but in the upper Yukon basin the Eocene is represented only by fresh-water beds which seem to have been laid down in isolated basins.

In late Eocene or early Miocene times folding took place, which to some degree affected the entire province and is the last which has caused any considerable deformation, for all the subsequent movements were of an orographic character and had little or no local effect on the rock strata. This was accompanied by intrusions of igneous rocks. Uplift followed and during a long period of stability extensive erosion took place, during which the exposed land surface nearly throughout the province was reduced to a peneplain which was subsequently uplifted and dissected.

GEOMORPHOLOGY.[a]

INTRODUCTION.

As the consideration of the origin of physiographic features demands a comprehensive knowledge of the lithology, structure, and distribution of the rock masses, as well as of the successions of recent earth movements, it is evident that the groundwork is yet very incomplete. There are almost endless varieties of land forms in the province, every part of which offers a host of physiographic problems, but only a few of them have been investigated. This writing must, perforce, be limited to the general features of geomorphology, and these will be treated only in brief outline. It is hoped that the tentative conclusions which will be advanced may at least serve as working hypotheses until the surveys now in progress may yield more definite results.

Though a full account of physiographic features has been given under the heading "Descriptive geography," it will be well to review this matter briefly before taking up the consideration of the origin of the topography. This will be followed by a genetic classification of the more important topographic types, while the last subdivision of this section will be devoted to a systematic discussion of the geomorphology.

TOPOGRAPHY

The broad cordillera which stretches northwestward through the western United States traverses western Canada, and extends into Alaska, where it swings west and southwest parallel to the great bend in the shore line of the northern Pacific (see Pls. I and VII). This crescentic sweep has a wide import, for in Alaska the trend of the cordillera maintained from Mexico for 3,000 miles to the northwest changes its direction and turns to meet the northeastern extension of the Asiatic continent, and, as this feature is repeated in the bed-rock terranes, it can be said to mark the change from American to Asiatic structure. The extension of the structural and physiographic provinces of Alaska are to be sought in Siberia to the west of Bering Sea and Strait.

This cordillera is outlined by two mountainous zones separated by a broad upland of relatively low relief, called the Central Plateau region. The southern highland belt—the Pacific Mountain system—is a rugged mass 100 to 200 miles wide, which in many places rises almost sheer from the waters of the Pacific, while inland it often descends with almost equal abruptness to the upland region. The northern highlands, a northwestern extension of the Rocky Mountain system, are of lesser relief, though they also form a rugged mass 100 to 200 miles in width. Their inland slopes appear to merge with the highlands of the central upland region, but on the north they fall off abruptly to the fourth province—the Arctic Slope region.

The coasts of northern and southern Alaska are in striking contrast. Innumerable waterways and islands break the shores of the Pacific, and the land

[a] An abstract of a part of this section has been published by the writer in a paper entitled "The Geography of Alaska with an Outline of the Geomorphology." Eighth International Geographic Congress. Washington, 1905. pp. 204-230.

ascent is usually steep from tide water, while seaward the descent to deep water is equally abrupt. On the other hand, the shores of Bering Sea and the Arctic Ocean are even, the land slopes up gently inland, and the sea is shoal for a long distance from the coast.

The Pacific Mountain system of Alaska trends northwesterly to about the one hundred and forty-ninth meridian, where it makes an almost right-angled bend, continues southwest, but with decreased relief, to Bering Sea. The system comprises four dominant ranges—the Coast, St. Elias, Alaska, and Aleutian—together with some lesser highland masses and two areas of low relief, the Copper River Plateau and the Sushitna Valley.

The Central Plateau region is very different from the bordering mountains, for here bold ranges and sharp peaks give way to a much dissected rolling upland with flat-topped, interstream areas having a general accord of summit level. These mark the surface of a dissected plateau, which has given to this province its name (Pl. VII).

In its narrowest part, near the one hundred and fifty-second meridian, the plateau province has a width of but 200 miles, but broadens out both to the southwest, where it presents a frontage to Bering Sea of nearly 500 miles, and to the southeast in Canada, where it widens to 300 or 400 miles. The altitude of the plateau remnants, varying from 1,500 to 6,000 feet, is greatest along the margin, and its surface also shows a general incline to the north and west. Several broad lowlands lie within the plateau region, and near Bering Sea it gives way to a wide coastal plain.

The Rocky Mountain system of Alaska, called the Endicott Mountains by Schrader, is formed of several high ranges which stretch from the international boundary westward to the Arctic Ocean, and constitute the divide between the polar and Bering Sea waters. These ranges are little explored, but near the boundary probably reach altitudes of 5,000 to 8,000 feet, while to the west they decrease in height and near the Arctic appear to be separated into a number of minor ranges by broad valleys.

On the north the Rocky Mountains fall off abruptly to the Arctic Slope region, which is of relatively low relief and divisible into two subprovinces, the Anaktuvuk Plateau and the Coastal Plain. The Anaktuvuk Plateau has an altitude of 2,500 feet at the base of the mountains and slopes gently for 60 miles to the north to a scarp which marks the beginning of the Coastal Plain.

The drainage of Alaska flows southerly to the Pacific Ocean, westerly to Bering Sea, and northerly and westerly into the Arctic Ocean. Several trunk streams, such as the Stikine, Taku, Chilkat, and Alsek rivers, which rise in broad, open valleys within the Central Plateau region and then traverse the coastal ranges by steep-walled canyons, drain the southern part of the Pacific Mountain system. A broad depression lying within the Pacific Mountains is drained by another group of rivers, including the Copper, Matanuska, and Sushitna.

The Central Plateau region sends nearly all its waters to Bering Sea through the Yukon, the master stream, but the Kuskokwim also drains a part of this province. These and their many large tributaries usually occupy broad valleys, with gently sloping walls, sometimes opening out into large lowland basins.

The waters of the southern slope of the Rocky Mountain system go to tributaries of the Yukon, while those of the northern slope flow into the Arctic Ocean through north-south valleys which traverse the Arctic Slope region. The western drainage of these mountains goes to the Arctic through the Noatak and Kobuk valleys.

GENETIC CLASSIFICATION OF TOPOGRAPHIC TYPES.

GENERAL STATEMENT.

The descriptive geography took account only of form and grouping of the topographic features, entirely disregarding their genesis and evolution. Such a classification is essential for the purposes of geographic description, for it emphasizes the orographic continuity of some of the forms and shows the interrelations of others, but a discussion of their origin calls for a genetic grouping, and this will here be attempted.

Some of the land forms, such as the volcanic mountains, are of comparatively simple origin, and lend themselves well to such a genetic classification, while the evolution of others, such as the Yukon Valley, is so complex that it can only in part be determined from the facts in hand. The size of the province and the variety of its land forms will make it impossible to here describe all of the topographic types, and therefore only those will be considered which seem to have a close connection with the general geomorphologic problems.

MOUNTAINS.

GENERAL TYPES.

Mountains and ranges, or areas of greatest relief, are the most striking of the topographic forms and often among the most complex. In general terms they are areas in which erosion has not kept pace with elevation, and usually mark zones of rapid recent uplift. Of equal or greater height, though in this province of far less extent, are the mountains which owe their relief to the accumulation of volcanic material faster than it is removed by erosion. Some of these volcanic ranges lie in zones of recent crustal movement, and their altitudes may in part be due to uplift. A third type of mountains of subordinate importance, though it probably includes the highest individual peaks of the province, are the residuary masses left by differential erosion, whose preservation is determined either by the lithologic composition of component rocks, or by accidents of erosion and remoteness from the main drainage channels.

MOUNTAINS OF RECENT UPLIFT.

To this class belong most of the highland areas, the greater part of which lie in zones of recent crustal movement and are the resultants of the interaction of uplift and erosion. As these mountains are carved by erosion from an uplifted area, their contour is determined in a measure by the older topography, but to a still greater degree by the character and structure of the exposed bed rock. Unfortunately, often all vestiges of the older topography have been removed, and in many cases the bed-rock geology of the highland areas is almost unknown. Glaciation, too, has played an important part in the sculpturing of the high ranges, for they are, or have been within recent times, the loci of the accumulation of glacial ice.

The character of the uplift, whether rapid or slow, uniform or differentiated, will determine the topography. To properly trace the evolution of the mountains, all of these factors should receive consideration, though here but a few are imperfectly understood, while many are entirely unknown.

The Coast Range is an irregular aggregate of peaks and crest lines with little symmetry of arrangement, except a rough alignment along a northwest-southeast axis. The whole aspect of this range is precipitous and rugged, with needle peaks, knife-edged crests, and sharply incised drainage channels, but this young topography was carved out of older highlands whose surface was base-leveled (Pl. XXVIII, *A*).

Evidence of this old base-level is preserved in the summits of the present mountains, which rise to a strikingly uniform altitude ranging from about 7,500 feet in British Columbia to about 5,000 feet in Alaska. Viewed from a point at least as high as the general level, the summits fall into the same plane with an even sky line, broken here and there by pyramidal peaks rising above the general crest line, the fast disappearing remnants of unreduced areas.

On the inland side at its northern end the Coast Range merges with the Yukon Plateau, while seaward it is not sharply differentiated from the highlands of the Alexander Archipelago. The uplift was greatest in the southern part of the range, where the summits are 8,000 to 9,000 feet above the sea, and several thousand feet higher than the surface of the interior plateau. It decreased to the north, for at Lynn Canal the summit level is only about 5,000 feet, while at Cape Spencer 50 miles to the northwest, Gilbert[a] recognized the same degradational surface in an upland only 2,500 to 3,000 feet high, which here abuts abruptly against the southern slope of the Fairweather Mountains. Passing inland of the St. Elias Mountains to the north, the Coast Range decreases in altitude, and its upland surface seems to merge with that of the interior plateau near the northern boundary of British Columbia. The relations of the Coast Range to the interior plateau will be considered in a later paragraph.

The irregularity of the Coast Range topography is what might be expected in a dissected plateau, but the lack of symmetrical arrangement of crest lines is also largely due to the character of the bed rock. Here there are no hard and soft layers to be emphasized by degradation, nor are there any dominant structural lines to determine lines of erosion, for nearly the whole mountain mass is made up of massive granodiorite of considerable lithologic uniformity. As all parts of this highland mass offer about the same resistance to erosion, no dominant crest lines were established and the drainage channels must have been determined by antecedent conditions. Though this holds true of the larger features of the land sculpturing the detailed dissection has been in a measure influenced by lines of weakness caused by fracturing of the homogeneous rocks. Glacial erosion, too, has played an important part, for all of the larger drainage

[a] Harriman Alaska Expedition, vol. 3, p. 125.

channels have been ice scoured, while the many cirques are characteristic features of the topography.

The Stikine and Taku rivers traverse the range in steep-walled valleys, which are in strong contrast to their open headwater basins. They have the characteristics of antecedent water courses, and as such bear evidence of the slowness of the uplift of the land mass from which the Coast Range was carved.

The elevation was markedly differential, for in British Columbia the altitude of the old degradational surface is 8,000 or 9,000 feet, while at Lynn Canal it is 5,000 feet, and at Cape Spencer, near at hand, it is less than 3,000 feet above the sea. The elevated plateau from which the present Coast Range was carved had then a warped surface with a general northerly tilt. There is reason to believe that a profile transverse to the present mountains would everywhere show a slope of the old peneplain to the east and west from what is now about the axis of the highland mass.

The Pacific coastal zone has been the scene of many recurrent dynamic revolutions from early Paleozoic to Mesozoic times, but though these are recorded in the bed-rock structure, whatever expression they found in the topography has been nullified by subsequent degradation, for the present relief is due entirely to comparatively recent uplift. The granodiorite batholith was intruded in Jurassic times underneath a heavy blanket of strata, which were displaced and possibly in part absorbed,[a] and the resulting relief on the earth's surface was removed by erosion, the igneous core exposed, and finally during a long period of stability the present mountain belt, together with the adjacent regions, was reduced to a peneplain, across which the rivers flowed to the Pacific. Differential uplift raised this lowland area, and it became an undulating plateau from which the rejuvenated drainage system carved out the present Coast Range. So slow was the uplift that the larger water courses maintained their valleys across it.

The axis of the Coast Range, which had been a locus of previous disturbances, was uplifted higher than the interior region, so that while the latter preserved to a large extent its plateau character, the Coast Range, by reason of the greater relief, was extensively dissected and thus became the present rugged, irregular mountain mass, which has preserved its plateau features only in the even crest lines.

The rugged highlands, 80 to 100 miles in width, stretching from Cross Sound to the Copper River, and forming the main mass of the St. Elias Range, are almost unsurveyed and geologically unexplored. With a mean altitude of probably over 10,000 feet, embracing many peaks over 12,000 feet, and culminating in Mount St. Elias (18,100) and Mount Logan (19,500), it is the greatest névé field of the North American continent. On the south it descends through a series of foothills to a steep-shelving coastal plain, often buried in huge piedmont glaciers, while inland it ends in a great scarp at the margin of the Yukon Plateau (Pl. X, *B*).

It has been shown that on the southeast, at Cape Spencer, the summit level of the Coast Range abuts abruptly against the flank of the Fairweather Mountains (a part of the St. Elias Range), and, as Gilbert has indicated, the two provinces are sharply differentiated.

[a] Lawson, A. C., The Cordilleran Mesozoic revolution: Jour. Geol., vol. 1, 1893, pp. 579-586.

To the west of Mount St. Elias the range splits, and the Skolai and Nutzotin on the north and the Chugach Mountains on the south diverge to inclose the Mount Wrangell volcanoes and the Copper River basin. The Chugach Mountains are a broad, rugged, highland belt, whose summits reach a uniform altitude of about 6,000 feet, with occasional peaks of 7,000 and 8,000 feet (Pl. XXVIII, *B*). This upland surface, like that of the Coast Range, is interpreted as evidence of a former surface of degradation. The topography of the northern wing of the St. Elias Range also bears evidence of base-leveling at about the same altitude.

Tracing the southern coastal mountains westward and around the bend into the Kenai Peninsula there is here also an upland surface, which, according to Gilbert,[a] is probably the remnant of an ancient peneplain. He recognized a similar feature in the upland of Kodiak Island, 100 miles to the south. The altitudes of the planated surfaces at the two latter localities have not been determined, but are probably only a few thousand feet.

The St. Elias Range is broken by one broad water gap through which the Alsek River finds its way to the sea. The walls of this valley, which is unsurveyed, are reported to be interrupted by a broad bench above which the slopes rise gradually and below which the river has incised a narrow channel. Similarly, the Chugach Mountains are bisected by the Copper River which traverses them in a narrow valley.

The St. Elias Range can then be defined as a block of rugged topography, with a mean altitude of probably 8,000 to 10,000 feet, bounded on the south, north, and west by scarps which fall off to uplands of lower altitude, whose summits mark dissected plateaus. It is bifurcated by the Alsek Valley, which will be shown to be probably in part of an antecedent character.

It seems certain that the axis of the range has been a zone of crustal movement since early Paleozoic times or older. Mount St. Elias itself appears to be a great intrusive stock of a dioritic[b] rock. Its great altitude is due probably in part to the greater resistance offered to erosion by this hard rock than by the adjacent schists, and in part to the fact that it and the adjacent high peaks appear to be in the locus of maximum uplift. Along the southern flank much folded and faulted beds have been found, which Russell[c] reports may be of early Tertiary age, but of more physiographic interest is the proof of very recent uplift which he found in the occurrence of Pleistocene or Recent marine organisms at an altitude of 5,000 feet.

These facts, together with the high relief and jagged character of the range, all point toward an extensive upward movement. The Pleistocene and Recent glaciation has been very active in the St. Elias Range, but the resulting topography is still in a large measure buried under the present glaciers and névé fields.

The Alaska Range, the third of this type, attains its maximum altitude in Mount McKinley (20,300) and Mount Foraker (17,000), which tower above the well-defined crest line of 8,000 to 10,000 feet (Pl. VIII, *B*). These majestic

[a] Harriman Alaska expedition, vol. 3, p. 177.
[b] Filippi de Filippo, The ascent of Mount St. Elias, New York, 1900, pp. 234-236.
[c] Russell, I. C., Expedition to Mount St. Elias. Nat. Geog. Soc. Mag., vol. 3, 1891, pp. 170-175.

peaks lie near the center of the axis of the range, near where it swings from northeast to east. From this central mass its mean altitude decreases in both directions along the axis. This rugged mass, which defines the northern boundary of the Pacific Mountain system, is extended to the east by the Nutzotin Mountains. The crest line lies close to the western margin, where the mountains fall off abruptly to a gravel-floored piedmont plateau, with the sharp line of demarcation which is such a striking topographic feature for upward of 200 miles along its northern front. (Pls. XI and XXXII.) The main mass of the range, which stretches for about 40 miles east of the crest line, has been but little explored, but probably includes many high transverse ridges separated by glacial-scoured valleys, some of which are still filled with ice.

In the geologic discussion it has been noted that the component strata of the Alaska Range date back at least to the Ordovician and include Jurassic, but the plication of these older horizons has had no direct effect on the present topography. Of more import is the presence of infolded Eocene beds in the heart of the mountains, indicating extensive dynamic revolution since early Tertiary times. It was probably after this Eocene deformation that an area was uplifted from which the present mountains were carved. Though this movement may have begun in Middle Tertiary times, the present altitude of the range must be due to more recent elevation, for the youthful character of the topography as well as its great relief indicate that erosion has not been active for a long period.

Mount McKinley and Mount Foraker both lie in the zone of maximum uplift, but, like Mount St. Elias, their extreme heights may be in part accounted for by the fact that they, too, are formed of stocks of granodiorite, which offer greater resistance to erosion than do the adjacent sediments.

The facts presented suggest that the mountains have been carved from an uplifted area whose culminating crest corresponded in a general way with the present crest line of the range, and that the maximum upward movement was near Mount McKinley. This highland mass sloped off gently to the east and south, but fell off abruptly to the west, like the present range, which would indicate a sharp flexure or fault along the western margin. What is known of the bed-rock geology bears out these suggestions, for the oldest strata along the axis of the range are found near Mount McKinley, and along the western front there is every evidence of intense deformation.

The rugged highland belt stretching across northern Alaska is an extension of the Canadian Rockies. Westward from the international boundary the axis of the ranges has a direction a little south of west, and the relief gradually decreases from 7,000 to 8,000 feet on the east to 5,000 and 6,000 feet at the one hundred and fifty-first meridian, and to probably 1,000 or 2,000 feet in the highlands north of Kotzebue Sound. On the north the mountains probably fall off abruptly to the Anaktuvuk[a] Plateau (Pl. XXIX, *B*) throughout their extent, but on the south the descent to the interior plateau seems more gradual.

This highland belt, which probably includes several distinct ranges, is but little explored. The western end of the system is known to be broken into distinct

[a]Schrader, F. C., A reconnaissance in northern Alaska: Prof. Paper U. S. Geol. Survey No. 20, 1904, pp. 39-45.

ranges by the broad longitudinal valleys of the Kobuk and Noatak rivers, but except for these two rivers the drainage as far as known is carried north and south by large transverse streams, fed by smaller tributaries having longitudinal courses. The watershed lies close to the northern front, and from this the main drainage channels flow almost due north or due south. During recent times the higher parts of the range were the collecting ground of glaciers, which helped to scour out the valleys, and in some cases reached far out from the mountains into the adjacent lowlands.

In the central part of the range an even sky line and accordance of summit levels has been noted by Schrader and interpreted as indicating an uplifted and dissected base-level of erosion. (Pl. XXIX, *A*.) He first noted this feature in the Chandlar[a] and Koyukuk basins, at an altitude of 6,000 feet, and later was able to trace it northward along the John[b] River Valley and across the divide. The degradational surface seems to maintain a remarkable uniformity of altitude (6,000 feet) throughout the area in which it has been recognized. The base-leveling seems to have been very complete, for Schrader observed practically no unreduced areas standing above the peneplain.

As regards the structural geology, there is little to be said which would throw light on the genesis of the present topography. Of the two anticlinal axes[c] which have been described the southern is probably the older, and probably dates from early Paleozoic times. The Carboniferous is the youngest horizon which has been found within the mountainous belt, but the evidence of the absence of Mesozoic is purely negative. Only Cretaceous beds have been found along the Porcupine-Mackenzie divide of the Rockies, and in Alaska the Cretaceous beds lying both north and south of the mountains are deformed, and seem to have been involved in the last important dynamic revolution.

These facts indicate that the component strata of the Rocky Mountains have passed through many recurrent epochs of deformation, the last of which was probably in late Mesozoic or early Tertiary time. These movements have in no direct way affected the topography of the only part of the range which is known, for the relief induced by this deformation was abraded to base-level, and a succeeding uplift gave a highland mass out of which the present topography has been carved. The uplifted Eocene strata on the north side of the range are gently folded and somewhat faulted, while the succeeding Pliocene are entirely undisturbed, indicating that the last crustal disturbance followed the deposition of these lower or middle Eocene and antedated the deposition of the Pliocene. The whole aspect of this highland suggests a maximum uplift along the present northern axis of the range, from which the main watercourses took consequent courses to the north and south.

In the preceding discussion, incomplete as it is, certain facts regarding the probable genesis of the highland masses have been developed. First, erosion has probably removed any areas of high relief which may have resulted from the many recurrent crustal disturbances which antedate late Mesozoic or early Tertiary times;

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[a] Schrader, F. C., A reconnaissance in the Chandlar and Koyukuk basins: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 463.

[b] Prof. Paper U. S. Geol. Survey No. 20, p. 42.

[c] See Structure, p. 259.

second, in early or Middle Tertiary time several of the areas now in high relief were reduced to a peneplain; third, this cycle of erosion was followed by differential uplift and from the highlands which resulted the present topography was carved.

VOLCANIC MOUNTAIN RANGES.

Of volcanic ranges largely of constructive origin there are only two in Alaska—the Aleutian Range, which stretches through southwestern Alaska, and is continued in the highlands of the Aleutian Islands, and the Wrangell Mountains, which lie between the two forks of the St. Elias Range. Besides these there are some isolated volcanoes, such as Mount Edgecumbe, near Sitka, in southeastern Alaska.

The Aleutian Range is composed essentially of a series of typical volcanic cones distributed along a northeast-southwest anticlinal axis, which was a zone of deformation as early as the Triassic, and along which there may have been recent uplift. The extrusion of the volcanic material probably began in Tertiary time, and some of the volcanoes are still active. Many of these have the beautifully symmetrical forms typical of ash-built cones (Pl. X, *A*).

The Wrangell[a] Mountains, an irregular group of volcanoes, form a rugged highland mass, having an area of about 100 by 50 miles and a mean altitude of probably over 10,000 feet, with some individual peaks rising to 15,000 feet. The mountains are built up of volcanic extravasations, which appear to rest on the surface of the same elevated plateau, which is defined by the summit level of the Chugach Mountains. Volcanism has been active probably since late Mesozoic times, but the present relief is largely due to outflows of lava since middle or late Tertiary times. The individual peaks are of the unsymmetrical type of lava cones (Pl. IX), and are in contrast with the ash cones of the Aleutian Range (Pl. X, *A*).

RESIDUAL MOUNTAINS.

The residual mountains form a third group, which, though subordinate from the standpoint of dimensions, is of physiographic import. These embrace a few small highlands and innumerable individual peaks, whose relief is due either to position relative to main drainage channels or because the resistance to abrasion of their component rocks has left them unreduced during the erosion of adjacent areas. Many of these mountains are true monadnocks, as their surrounding areas have been base-leveled, but the group as a whole will hardly fall within the definition of a monadnock, and hence they are here termed residual mountains. In not a few instances the relief of these residuary mountains is in part due to the fact that they lie in loci of maximum uplift. Highlands of this type are very common in the Central Plateau region, but attain no great altitude. The Glacier Mountains of the Fortymile region, which stand considerably above the general altitude of the Yukon Plateau, are examples, and there are many more. It is probable also that the Kigluaik Mountains, of the Seward Peninsula, have a similar origin. Many of the highest peaks of Alaska are of the residual type, though this relief is usually emphasized by differential uplift (Pl. VIII, *A* and *B*).

[a] Schrader, F. C., and Spencer, A. C., The Geology and Mineral Resources of a Portion of the Copper River district: Special publication U. S. Geol. Survey, p. 67.

PLATEAUS.

GENERAL TYPES.

The plateaus of Alaska, like the mountains, fall into two general types—first, areas planated by erosion and subsequently elevated; and, second, constructional plateaus. Those of the first type do not differ genetically from the highland areas, whose summits mark degradational surfaces already grouped with the mountains. Though the distinction between these two land forms is to a certain extent arbitrary, it seems desirable to retain the name plateau only for such uplands as actually preserve something of the plateau features, besides the accordance of summit levels.

The plateaus of the degradational type are of far greater extent in Alaska than those of the constructional type. The first can be conveniently classed as "plateaus of the dissected peneplain type," and the second as "constructional plateaus."

PLATEAUS OF THE DISSECTED PENEPLAIN TYPE.

These can be further subdivided into those whose planated surface is due to subaerial erosion and those of marine abrasion. The first is well represented in the province, but of the second type there is only one example known and that is of small extent.

The Central Plateau region has been described as a great upland, diversified by numerous drainage channels, whose interstream areas mark the surface of a dissected plateau in Alaska called the "Yukon Plateau." It has a general slope to the northwest, and its surface is rolling and varies locally in altitude. The plateau is best seen from a summit which stands at about the level of its surface, where the observer will be impressed with the even sky line sweeping off to the horizon (Pl. XXX, *B*), and broken only here and there by isolated residuary masses, which stand above the general level. So even and flat-topped are the interstream summits that the plateau closely resembles a constructional surface. The plain, however, bears no constant relation to rock structures, and erosion has beveled the upturned edges of hard as well as soft strata. In fact its surface is entirely discordant to the highly contorted metamorphic rocks which make up much of the plateau.

Some of the flat-topped summits which mark this plain include smooth and unbroken areas several square miles in extent, but as a whole the plateau surface is by no means a horizontal plain, but rather, as has been shown, a gently rolling upland.

The plateau is deeply dissected by its drainage system, which has carved out broad valleys several thousand feet below the summit level. In most instances the valley slopes rise gently to the plateau surface, and the exceptions can be explained by recent local elevations, which have caused an acceleration of stream cutting.

The surface of the plateau falls off gently to the north from about 6,000 feet in central British Columbia to 5,000 feet near the head of the Lewes River. Along the northern base of the Pacific Mountains it retains this altitude as far as the Tanana basin, whence it falls off northward to about 4,500 feet at the mouth of the White

River and to less than 4,000 feet in the Fortymile basin. Toward the west it continues to decrease in altitude, and the interstream areas which mark the plateau level have an altitude of about 3,500 feet in the Birch Creek region, and of probably less than 2,000 feet near the mouth of the Tanana.

The divide between the Yukon and the Koyukuk lies in an upland region whose summits have an altitude of between 2,500 and 3,500 feet. The summits are probably remnants of the plateau and indicate a general rise northwest of the Yukon.

Schrader[a] recognizes three base-levels of erosion in northern Alaska. The highest is the summit level of the Endicott Mountains (6,000 feet) already described, which falls off on the south to an upland area which has an altitude of about 3,000 feet and is correlated by him with the Yukon Plateau. The third is the so-called Koyukuk Plateau, which is traced in a general accordance of the summit levels (1,200 feet) of the lower hills and ridges of the Koyukuk Valley. There is here an excellent example of the difficulties of studying physiographic forms with the aid of the incomplete maps based on reconnaissance surveys. While Schrader's field observations lead him to note that the lower plateau is easily recognized, and the higher plateau is obscure, a diametrically opposite conclusion is obtained from a study of the contour maps. On these the flat-topped summits between 2,500 and 3,500 feet show a general accordance in altitude rising gradually toward the base of the mountains, but the lower 1,200-foot level is recognizable only in some gentle valley slopes whose lower relief might be due to more rapid erosion, as they lie near the main drainage channels and appear to be cut on softer rocks.

As the Koyukuk Plateau has been traced over only a small area it can be disregarded in this general discussion. It is worthy of note, however, that there is some evidence of degradational surfaces of a later date than the Yukon Plateau in other parts of the plateau region, and more detailed work may yet lead to a recognition elsewhere of this later planation.

According to Schrader the Yukon Plateau has an elevation of 2,500 to 3,000 feet in the upper Koyukuk and Chandlar basins, and a study of the map suggests that it may rise still higher as the mountains are approached. Its relation to the summit level of the Endicott Mountains will be a subject for further scrutiny, when facts will be presented which suggest the identity of the two peneplains.

There is little clew to physiographic features of the northeastern part of the Yukon, but the plateau probably rises toward the base of the Rocky Mountains. McConnell[b] has described a plateau of 5,000 feet altitude at the Porcupine-Mackenzie divide, which may represent the same level. There is also a hiatus in topographic mapping in the lower Yukon basin, but the ridges and hills are known to decrease as Bering Sea is approached, and it appears that the plateau level slopes gradually toward tide water, and possibly passes beneath the coastal plain.

In the Seward Peninsula several distinct base-levels of erosion are recorded in the topography. The most striking is found in the general accordance of summits (1,500 to 2,000 feet) (Pl. XIII) in the rolling upland region of the northern

[a] Schrader, F. C., A reconnaissance in northern Alaska: Prof. Paper U. S. Geol. Survey No. 20, pp. 44-45.

[b] McConnell, R. G., An exploration in the Yukon and Mackenzie basins: Ann. Rept. Geol. Nat. Hist. Survey Canada, new ser., vol. 4, 1889.

section of the peninsula, but there are at least one younger and probably one or more older planated surfaces. It will be shown elsewhere that in recent times the peninsula has been a locus of instability. Rock-cut terraces found up to an altitude of 1,700[a] feet are interpreted as evidence of recent elevation, while tidal estuaries afford equally strong evidence of recent depression. That these movements of the earth's crust have been differential is made evident by local warping,[b] which has had an important influence on the topographic development.

The surface of the Yukon Plateau, in a general way, has the form of a broad, shallow trough, pitching to the north, whose axis, coinciding with the valley of the Yukon, trends northwest to the Arctic Circle, and then bends to the southwest. In other words, the trough makes a nearly right-angled bend and pitches toward Bering Sea. Along the base of the Coast and St. Elias ranges the plateau stands at an altitude of 4,000 or 5,000 feet; it then falls off near the center to 3,000 feet, probably to rise again as it approaches the Rockies.

While these are the general altitudes the plateau surface rises and falls locally. In the ramparts of the Yukon, there is a doming which brings the plateau 300 to 500 feet above the general level, and this is but an example[c] of many irregularities. The plateau has in fact a warped surface, with many minor ridges, troughs, domes, and basins.

Along a part of its southwestern margin the plateau abuts almost directly against the slopes of high mountain ranges (Pl. X, *B*), and so abrupt is this change from the smooth flat summits of the upland to the rugged mountains that it is very suggestive of fault scarps. This sharp transition has been noted by Hayes and by the writer (in reports cited) along the northern slopes of the St. Elias Range, and similar relations probably prevail along the north base of that part of the Alaska Range which fronts on the Tanana Valley, but the west front of this range is so deeply buried in a mantle of gravel that the plateau feature is not recognizable.

In the discussion of the structural geology it has been shown that the oldest formations of Alaska occur in this province, and that in it probably lies the protaxis of the northwestern part of the continent. Paleozoic rocks of various horizons are closely infolded and with them occur beds of Upper and Lower Cretaceous age. In the Yukon Valley fresh-water sandstones, conglomerates, and shales of Eocene age occur in isolated basins to thicknesses of several thousand feet, and these are indurated and sometimes closely folded and faulted, the deformation representing the last extensive dynamic revolution of this district. Miocene[d] or Pliocene beds have not been definitely recognized, but are probably represented at several localities on the Yukon by some unconsolidated gravels and horizontal sands, while silt deposits of Pleistocene age are found along the entire length of the valley.

The Eocene beds (Kenai) were deposited and deformed before the erosion of the Yukon Plateau surface, and the later Tertiary beds seem to have been

[a] Brooks, A. H., A reconnaissance of the Cape Nome and adjacent gold fields: Special publication U. S. Geol. Survey, pp. 48–64.

[b] Ibid., pp. 62–64.

Collier, A. J., A reconnaissance in northwestern Alaska: Prof. Paper U. S. Geol. Survey No. 2, 1902, pp. 38–42.

[c] Brooks, A. H., Reconnaissance from Pyramid Harbor to Eagle City, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 347.

[d] Spurr, J. E., Geology of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 87–392.

deposited in channels incised in the plateau. This would place the period of erosion of the peneplain in the late Eocene or in the Miocene, which corresponds in general with the age determination made by Dawson and others.

These facts show that during late Eocene or early Miocene time a large area, whose limits will be further discussed, was elevated above sea level, and that during a long period of stability which followed it was reduced by erosion to a featureless plain which sloped gently toward sea level with some monadnocks which stood above the general level. The altitude of these remnants which now stand above the plateau surface affords a measure of the minimum amount of this erosion. About the middle of the Tertiary this cycle of erosion was terminated by a differential elevation which was greatest along the present margins of the plateau and was probably both gradual and intermittent. This elevation revived the activities of the streams, and the present drainage system was gradually developed.

The Anaktuvuk Plateau seems to be even a better example of peneplanation than the plateau above described, but its features are known only along Schrader's route of travel in northern Alaska. According to his descriptions[a] this plateau stretches from the seaward scarp of the Rocky Mountains, where it has an altitude of about 2,500 feet northward for about 100 miles to where it merges into the constructional Tertiary plateau at an altitude of 800 feet. For 50 to 60 miles from the base of the mountains the plateau is a gently rolling upland, diversified by broad, shallow drainage channels. Flat-topped ridges rise several hundred feet above the general level, but the aspect of the plateau as a whole, both from the descriptions and the photographs, indicates an erosional surface (Pl. XXIX, *B*). Collier has recognized what appears to be the same surface of erosion in the flat-topped upland, about 1,500 feet high, which stretches inland from Cape Lisburne.

The bed rock includes sediments of Upper and Lower Cretaceous[b] age, thrown up into broad open folds, and succeeded unconformably by slightly indurated shales and limestones of Eocene age, which have suffered some deformation, the beds being folded and faulted. These are overlain by unconsolidated Pliocene (?) silts, which are entirely undisturbed and probably rest unconformably on the Eocene beds. The broad open folds of the Cretaceous strata and the minor plications and faults of the lower Tertiary beds are all beveled by the plateau surface, which is undoubtedly a plain of erosion, and probably passes with gentle dip underneath the constructional plateau formed by the younger horizontal Tertiary silts. This seems the most probable explanation, though Schrader's hasty exploration could not establish the relation of the planation surface and the youngest Tertiary beds. The Anaktuvuk Plateau is then a peneplain which was formed in late Eocene or Miocene time and elevated to 2,500 feet at the base of the mountains. Its age seems to correspond closely with that of the Yukon Plateau.

The surfaces of the two plateaus described are believed to have been the result of denudation under subaerial conditions, but the York Plateau in the Seward Peninsula appears to be an elevated plain of marine erosion. The York Plateau[c]

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[a] Schrader, F. C., Reconnaissance in northern Alaska: Prof. Paper U. S. Geol. Survey No. 20, 1904, pp. 45–46.

[b] Ibid., pp. 50–97.

[c] Reconnaissance of the Cape Nome and Adjacent Gold Fields of the Seward Peninsula, p. 52.

(fig. 4) embraces about 40 or 50 square miles near the extreme western point of the Seward Peninsula (Pl. VI). Its surface, which is about 600 feet above sea level, is perfectly smooth, but is interrupted here and there by a few remnants of unreduced areas. A broad, rock-cut bench extends the plateau level to the east around the southern face of the York Mountains (Pl. XXX, *A*), and is undoubtedly an example of the result of marine abrasion. The material produced by the wave cutting of such a small area could easily have been removed by the current sweeping through the strait, which probably then as now separates the Seward Peninsula from the Asiatic Continent.

CONSTRUCTIONAL PLATEAUS.

Constructional plateaus are of two kinds—those of sedimentary and those of igneous origin, but the former are of far greater areal extent and physiographic importance.

The northern part of the Anaktuvuk is probably built up of horizontally bedded late Tertiary sediments, and hence is constructional. To the same type belong plateaus which are formed of horizontally bedded Pleistocene sands and gravels. Small table-lands of this character are very common as coastal features, but only those which lie inland are of sufficient extent to deserve special mention.

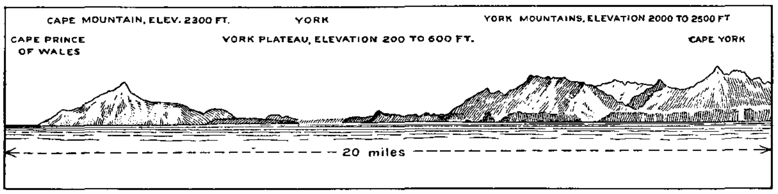


FIG. 4.—Sketch of the coast from Cape York to Cape Prince of Wales, showing York Plateau.

The northwestern front of the Alaska Range falls off abruptly to a gravel-floored plateau from 2,000 to 2,500 feet high, which slopes gently to the north and has been dissected by the larger streams (Pl. XXXII, *A*). Near the mountains it is often covered by glacial erratics and sometimes by moraines. This plain appears to have been built up of bedded sands and silts which have already been described as glacial overwash deposits.

Of similar character is the Copper River Plateau, which stretches westward from the Copper River Valley, meeting the headwaters of the Sushitna. This has been described by Mendenhall,[a] as a great flat upland region which is floored with gravel, and near its margin is covered with glacial débris (Pls. XIV, *A*, and XXV, *A*). So far as known, it is everywhere underlain by gravel, sands, and silts, but recent investigations have shown that these in some places mantle Tertiary sediments.

Small plateaus of lava type are not uncommon, but are usually of low relief and small extent. The plateau at the junction of the Lewes and Pelly rivers is formed by a Pleistocene extrusion of lava, and many similar features are found on

[a] Reconnaissance from Resurrection Bay to Tanana River: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 297, 316, and 331-335.

the lower Yukon. Some of these formed temporary obstructions to stream courses, such as at the Miles Canyon on the Lewes (Pl. XXVI, *B*). More extensive examples occur in the Mount Wrangell region, where Mendenhall and Schrader have discovered lava plateaus of considerable extent.

LOWLANDS.

The lowlands fall into two general groups. One embraces the coastal plains, and is essentially a constructional type; the other, which will be called the basin lowland, is primarily a degradational form.

COASTAL PLAINS.

The coastal plains are very simple land forms, being essentially featureless lowlands which stretch along the coast and extend inland for a greater or less distance. They are characterized by meandering drainage lines, abundance of lakes and monotonous relief, and are often only a few feet above sea level. Their inland margin is often bounded by an escarpment.

The coastal plains are, for the most part, the result of alluviation at the mouths of larger rivers, which has extended the deltas seaward and, in some instances, has been aided by a seaward tilting of the land. Of less extent are the coastal plains which were formed by marine benching and subsequent elevation.

Extensive coastal plains occur in northern Alaska, where they border the southern Arctic and the eastern coast of Bering Sea. These have been built of fluvial deposits, aided in some instances by seaward tilting, and are usually bounded inland by a more or less abrupt scarp.

The silted estuary, another type of coastal plain, is well exemplified by the lower part of the Sushitna Valley, where a broad lowland extends inland for 150 miles and stretches eastward so as to include the lower Matanuska drainage, and is represented on the west side of Cook Inlet by a slightly elevated plain which reaches to the base of the foothills.

BASIN LOWLANDS.

Broad, flat depressions, separated from the encircling highland areas by almost unbroken scarps, are a very common topographic type in Alaska, and to these the name "basin lowlands" has been given. A basin of this kind always forms a part of a drainage system, but is in fact distinct from any valley type. These land forms are well illustrated by a typical example in the Fish River Valley, of which a contoured map is reproduced in fig. 5. The basin shown has a flat floor, rather steep walls, and is drained by the Fish River through a constricted valley with steep grade. One of the characteristic features of this lowland type is that within it the water courses are sluggish and aggradation is going on, while the comparatively narrow channels of exit are being rapidly cut down. In the basin of Fish River the floor is only about 100 feet above sea level. But there are other examples, the floors of which are known to be much higher.

The Yukon Flats (pp. 74-78), with its area of probably 20,000 square miles, is the largest of these basin lowlands, but except in size it is in every way similar to the Fish

River basin. Similar types occur on Koyukuk and Kuskokwin rivers, and many smaller ones have been noted in the Seward Peninsula (Pl. XXXIII, *A*).

The basin lowlands are believed to be due to changes in the cutting power of streams brought about by barriers, and in the examples cited these barriers are

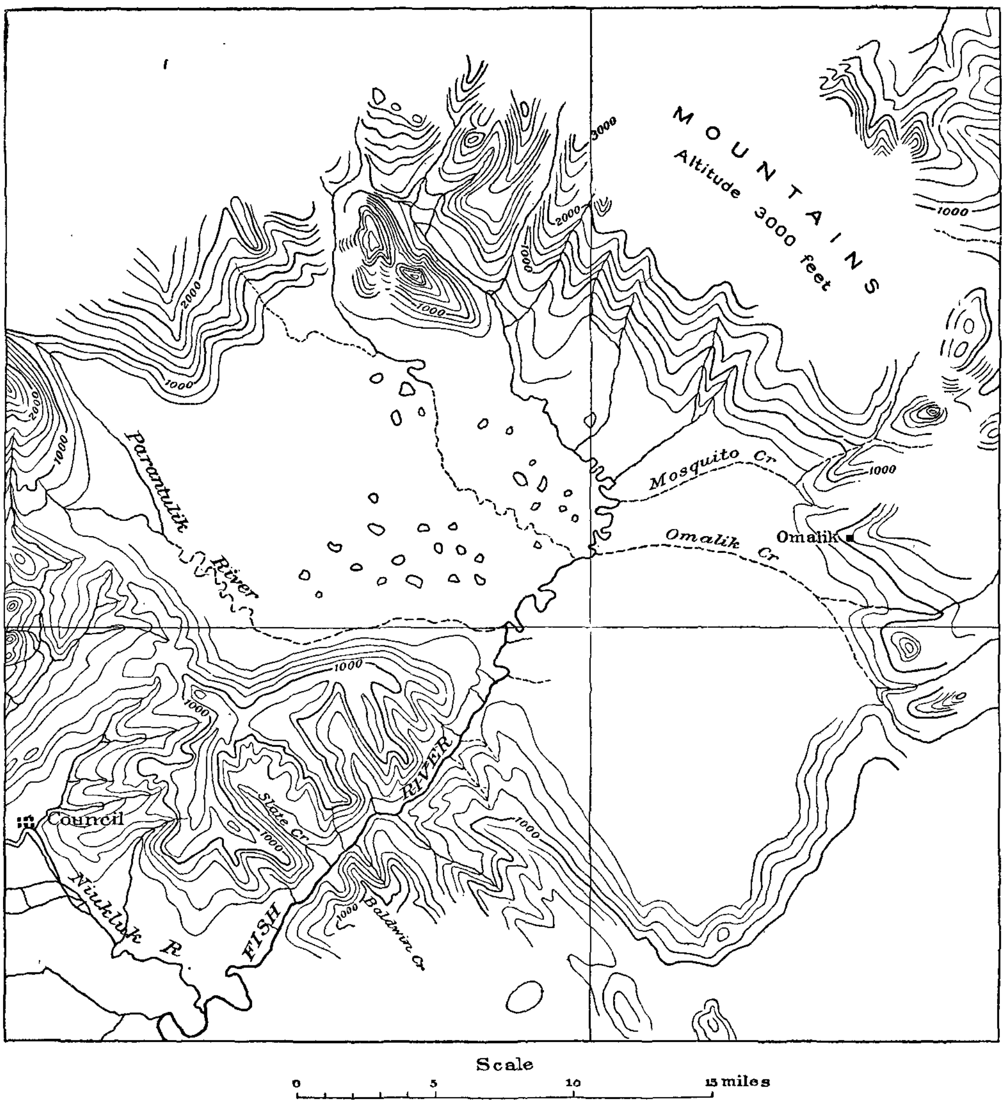


FIG. 5.—Upper basin of Fish River, Seward Peninsula, a typical basin lowland.

believed to be warpings of the crust of the earth. It has already been shown that there is evidence of a local doming of the Yukon Plateau at the Ramparts of the Yukon. This arch has brought about a local base-level, above which has been cut the broad basin called the Yukon Flats. The uplift kept pace with the cutting power of the Yukon, which flows across it, and the base-level conditions above the barrier resulted in an accumulation of alluvium.

LAKES.

The lakes of Alaska are probably chiefly of glacial origin, but some, similar to the basin lowlands, may have been formed by the damming of drainage channels by local warpings. The lakes of glacial origin have been scoured out by ice action or dammed by moraines. The many smaller lakes in regions of volcanic activity or of glaciation and in the flood plains of rivers will not be here considered.

The largest Alaska lakes, Clark and Iliamna, lie just west of Cook Inlet, and are separated from Pacific waters by the northern end of the Aleutian Range. They drain southwestward into Bristol Bay, but have not been accurately mapped. Spurr[a] has suggested that lakes Clark and Iliamna may be due to a rock barrier caused by a local crustal movement. Lake Iliamna seems, however, up to very recent times to have been an arm of the sea, and may owe its origin to the damming by river deltas.

Lake Minchumina, lying northwest of the Alaska Range, is probably of glacial origin, for though it is unsurveyed it is known to lie close to the northern limit of glaciation. Mendenhall[b] has described a number of large lakes in the upper Kobuk Valley and assigned a glacial origin to them. Chandler Lake, at the head of the Colville, in the absence of evidence to the contrary, may also be provisionally classed with the glacial lakes.

The origin of Lake Kluane and the lakes lying east and north in adjacent regions of Canada is probably closely connected with the extensive changes in drainage which have taken place in this region during and since the Glacial epoch. The larger lakes through which the Lewes River flows are probably caused by local warpings.

COASTAL FEATURES.

In regard to the coastal topography northern and southern Alaska are in strong contrast. The Pacific coast line is of great irregularity, being broken by innumerable inlets and diversified by many islands, while the mountains often rise steeply directly from the water. The coast of Bering Sea and the Arctic Ocean is characterized by a monotonous uniformity, with its long, straight beaches and gentle inland slopes, often broken by a series of steplike benches which mark old sea beaches.

These two types of shore line are usually believed to indicate, respectively, recent elevation and recent depression. The barrier beaches and coastal plains show that the land has been elevated relative to the sea, while the deep estuaries and broken coast line are interpreted as a depression which has led to invasion of the sea.

In northern Alaska there is abundant confirmatory evidence of recent elevation besides the contour of the actual shore line. Along the Bering and Arctic

[a] Spurr, J. E., A reconnaissance in southwestern Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, p. 258.
[b] Prof. Paper U. S. Geol. Survey No. 10, 1904, pp. 45-48.

coast terraces of unquestionable marine origin have been found at many localities up to an altitude of 600 feet, and on the Seward[a] Peninsula some rock-cut benches at altitudes of 1,000 to 1,700 are also believed to be wave-cut. The evidence of the depression of the Pacific littoral rests entirely in the contour of the coast. It is certain that the fiords of southeastern Alaska seem to have all the characteristics of a drowned topography, but Gilbert[b] has pointed out that much of the erosion of channels now below tide water was the result of glaciation.

DRAINAGE.

The physiographic history of the drainage is too varied and complex to permit any categorical classification, such as has been used for some of the land forms. It is proposed, therefore, to here give only a general account of the development of some of the larger rivers.

In a broad way, the Yukon, and probably the Kuskokwim, follow directions determined by structural lines, and the same may be true of the Noatak and Kobuk rivers, whose valleys are parallel to the general trend of the Rocky Mountains. Of the Pacific drainage the Sushitna River alone is of this type, for the lower courses of the Copper, Taku, and Stikine lie in valleys which are transverse to the main lines of height. The streams flowing northward to the Arctic are at right angles to the dominant structural lines, but it will be shown that their direction was consequent on a line of recent maximum uplift.

The great southwesterly bend of the Yukon is in harmony with the general structural features of this part of northwestern America, being parallel to bends of the southern coast line, and of the Pacific and Rocky Mountain systems. In a general way the Yukon follows the line of minimum uplift of the Yukon Plateau. The upper Yukon flows in a rather narrow valley, which makes broad, sweeping curves, very similar to the oxbows of a mature drainage system. These curves were probably a heritage from a previous cycle, when the region stood at or near base-level, and during subsequent gradual elevation were sunk in the old valley floor. Similar curves in the valley of the Yukon occur in the Rampart region. The great bend of the Yukon, near the mouth of the Koyukuk, parallel to the coast line, has not been explained, and it may be that at one time the Yukon found a more direct route to Norton Sound.

Reference has been made to a system of abandoned valleys which form a series of broad depressions stretching parallel to the mountains in the upper Yukon basin. These valleys lie in a northwest-southeast direction and belong to an older drainage system of which little is known (fig. 6, Pl. XXXII, *B*). The writer has suggested elsewhere[c] that these are part of a drainage system tributary to the Alsek, which traverses the St. Elias Range and empties into the Pacific. The intermontane portion of the Alsek Valley has not been mapped, but from the descriptions there seems to be an old valley floor, possibly 8 to 10 miles in width, below which the river has

[a] Brooks, A. H., Nome and adjacent gold fields, a special publication U. S. Geol. Survey, pp. 57-58. Compare Coast of Bering Sea and vicinity, by G. M. Dawson: Bull. Geol. Soc. America, vol. 4, 1894, pp. 117-146.

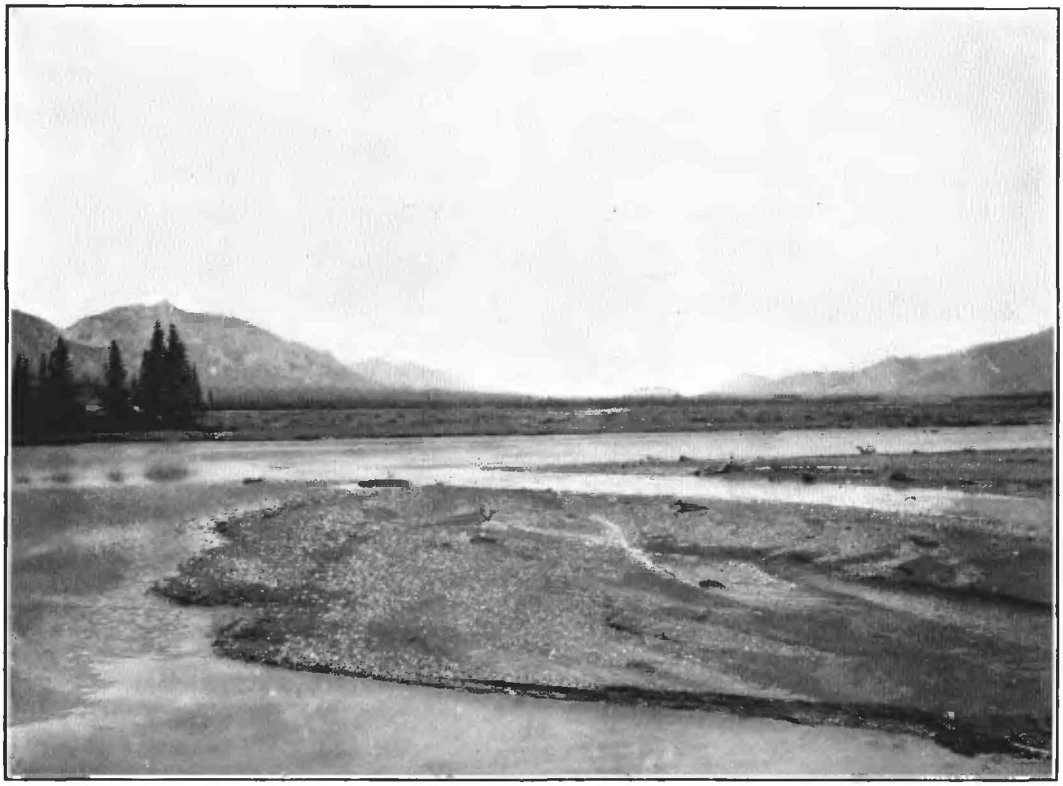
Dawson was the first to recognize the evidence of general elevation in the Bering Sea province.

[b] Gilbert, G. K., Glaciers and glaciation: Harriman Alaska Expedition, vol. 3, pp. 119-139. New York, 1904.

[c] Reconnaissance from Pyramid Harbor to Eagle City, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 354-355.

WAVE-CUT ROCK BENCH ON SOUTH SIDE OF KING RIVER VALLEY, SEWARD PENINSULA.

A. GRAVEL PLATEAU AT NORTHWEST BASE OF ALASKA RANGE.



B. VIEW ACROSS DONJEK RIVER.

Abandoned valley in middle distance.

A. UPPER NIUKLUK BASIN, SEWARD PENINSULA.

A typical basin lowland.

B. LOWER GORGE OF KOBUK RIVER.

Draining a basin lowland.

incised a channel several hundred if not thousands of feet deep. The older and higher valley is interpreted as marking the outlet of the older drainage system which has been referred to.

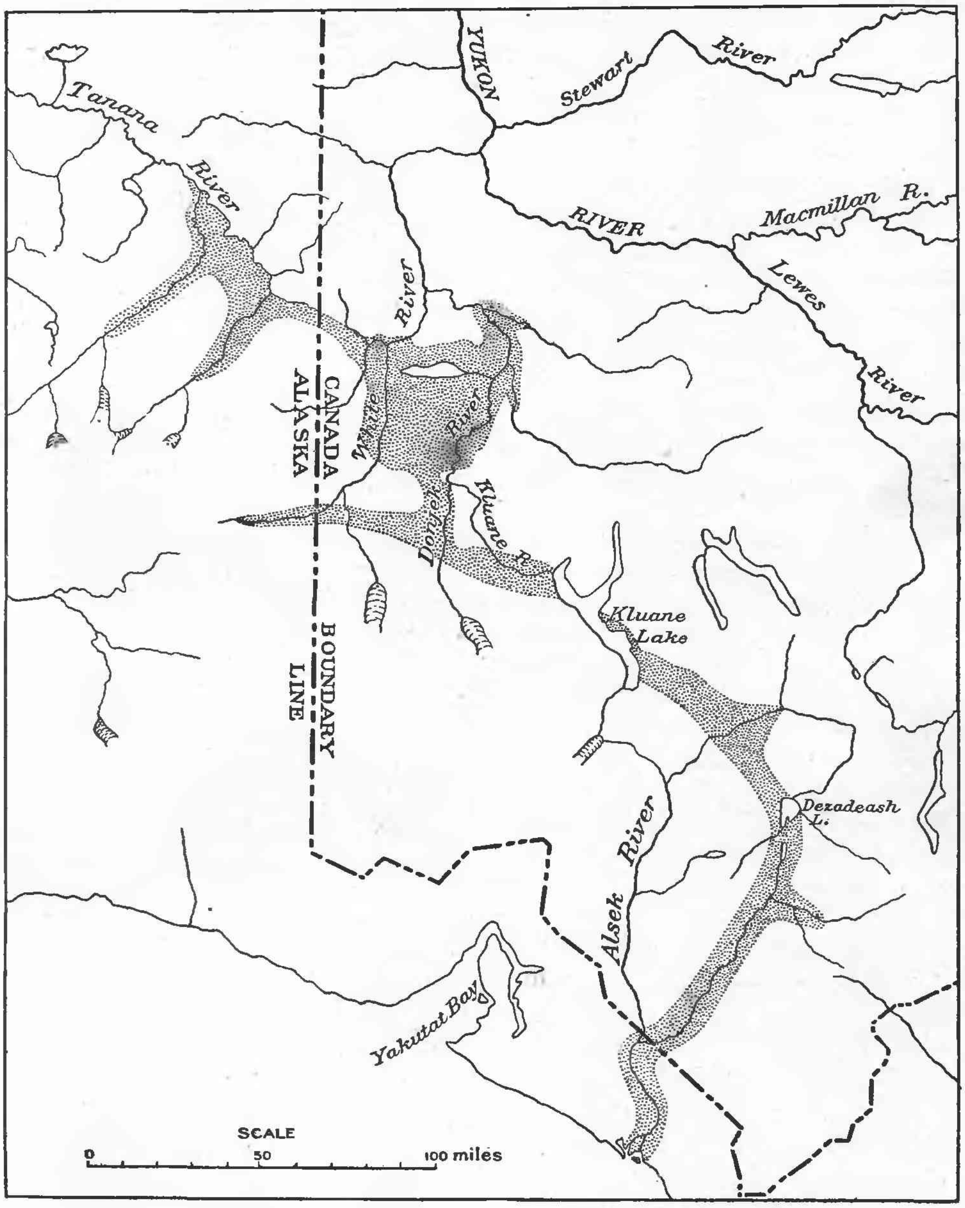


FIG. 6.—Sketch map, showing former drainage courses.

The Kuskokwim Valley indicates a maturely developed drainage system, but little is known of its history. Below the flats it takes a winding course, making a series of right-angled bends, one of which has a striking parallelism to the bend of the Yukon at the mouth of the Koyukuk. An examination of the map (Pl. XXXIV, in pocket) shows that there is also a striking parallelism of parts of the valleys of a number of the Yukon tributaries, suggesting a unity of cause, probably of a structural character.

The Sushitna Valley, broadly speaking, follows the strike of the bed rock. Changes of drainage have taken place, which will not here be discussed in detail, which have diverted some of its headwater tributaries to the Tanana (see map, Pl. XI).

Mendenhall[a] has stated that a recent uplift has accelerated the cutting power of the Matanuska River, which has incised a steep-walled valley in an older floor which remains as a series of benches 200 feet above the water (Pl. XV, *A*). He has also called attention to the influence of the recent warpings on the drainage of this region.

The history of the Copper, Alsek, Taku, and Stikine rivers is probably alike in its broader features, and the details will not here be recounted. These, together with the other large rivers of British Columbia, seem to traverse the coastal mountain barrier along valleys determined by antecedent conditions.[b] Their lower valleys at least have the same direction as before the present coastal mountains were elevated, and the streams maintained their courses across the barrier during the slow uplift.

Spencer conceives that the Copper River basin is due to headwater erosion of the present river, which maintained its course across the uplift of the Chugach Mountains. Mendenhall's[c] more recent studies of this field lead him to assign a structural origin to the Copper River basin—that is, that this great depression is a "graben."

CORRELATION OF PENEPLAINS.

INTRODUCTION.

The matter presented makes it clear that in the correlation of the several peneplains lies the key to the entire physiographic history of the province. The writer is well aware that in attempting correlations on such fragmentary data he is treading on dangerous ground, for the results of surveys now in progress may entirely overturn any conclusion arrived at before it can appear in print. He believes himself fortunate, therefore, to be able to share the burden of responsibility with Spencer, who has already broken the ground for speculations by his very suggestive paper entitled "The Pacific Mountain systems in British Columbia and Alaska,"[d] which contains the first attempt at any general conclusions regarding the origin of the physical features of Alaska. What here follows is largely an exposition of Spencer's theory, but with a somewhat broader application.

THE PENEPLAINS.

It will be well to pass in brief review the facts already recited in regard to the recognized planation surfaces. In British Columbia the summits of the Coast

[a] Reconnaissance from Resurrection Bay to Tanana River: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 331–335.

[b] Spencer, A. C., The Pacific Mountain system in Alaska: Bull. Geol. Soc. America, vol. 14, pp. 117–132.

[c] Geology of the central Copper River region: Prof. Paper U. S. Geol. Survey No. 41.

[d] Bull. Geol. Soc. America, vol. 14, pp. 117–132.

Range rise to a uniform altitude of 8,000 to 9,000 feet, but to the north gradually decrease in height, and in Alaska stand between 3,000 and 5,000 feet. Though the change in altitude is apparently great it is so gradual as not to break the general uniformity of summit level. This summit level bears no constant relation to structural features, and appears to admit of no other explanation than an elevated surface of erosion (Pl. XXVIII, *A*).

To the north, and along a part of its inland front, the summit level of the Coast Range merges with that of the Yukon Plateau in a way which seems to prove the identity of the two peneplains. On the other hand, it has been shown that the Coast Range peneplain abuts abruptly against the southern slope of the St. Elias Range. The valleys of the Stikine and Taku rivers, as well as those of other streams of British Columbia to the south, which lie transverse to the Coast Range, have probably inherited their courses from a former mature drainage system which was developed on the old peneplain.

The uniformity of summit levels (Pl. XXVIII, *B*) of the Chugach Mountains, which form the coastal barrier of the Copper basin, has been explained by assuming that these mountains form an elevated erosional surface which now stands at about 6,000 feet, with occasional residual peaks rising to 8,000 feet. The same base-level finds expression in conformity of altitude of a highland on the south side of the Wrangell Mountains, as well as in a general uniformity of summit levels of the Skolai Mountains to the north, and probably in the Nutzotin Mountains, where it seems less well marked.

This dissected plateau varies in altitude by gradual slopes from 6,000 to 8,000 feet, while its eastward projection abuts against the higher mountain mass of the main St. Elias Range. The same relation seems to exist between the westward extension of the summit level of the Skolai and Nutzotin mountains and the Alaska Range, for the latter rises as a rugged mass above the level of the dissected plateau. The relation at the north base of the Nutzotin Mountains is less well known, though a study of the topographic reconnaissance maps makes it appear at least that here, as along the inland slope of the Coast Range, there is a transition between the summit level of the Nutzotin Mountains and that of the Yukon Plateau. In any event there is no such sharp line of demarcation as between the Yukon Plateau and the northern base of the St. Elias Mountains.[a]

The Chugach Mountains are broken by the Copper River, which traverses them in a rather sharply cut valley. This drainage course, like the drainage courses transverse to the Coast Range, has been explained by Spencer as antecedent, being inherited from former base-leveled conditions which now find expression in the elevated peneplain.

The Yukon Plateau (Pl. XXX, *B*) is the third and by far the most extensive of the Alaskan peneplains, and is in fact of the same age as that recorded in the Coast Range summits. Its general altitude along the inland front of the Pacific Mountains is between 5,000 and 6,000 feet. It has been shown that it merges into the Coast Range summit level, abuts abruptly against the northern face of the St. Elias

[a] It should be noted that the sharp transition between the rugged mountains of the Pacific system and the upland of the interior, which has been so often emphasized in descriptions of Alaskan topography, is true only of the St. Elias and Alaska ranges, and along the southern part of the Coast Range.

Range, possibly merges into the summit level of the Nutzotin Mountains, and that there is a sharp line of demarcation between it and the northern front of the Alaska Range.

The Yukon Plateau level falls off toward the north and west to less than 2,000 feet near the Yukon, and probably rises again near the Rocky Mountains in the upper Porcupine basin. Schrader recognized it in the Koyukuk basin, and believes it to be sharply differentiated from the Rocky Mountains, though a study of the topographic reconnaissance maps hardly bears out this view, for the plateau seems to rise gradually toward the summit level of the mountains. A lower peneplain was recognized by Schrader and called the Koyukuk Plateau. The following statement by Schrader seems to find support in the contoured maps, and points toward a gradual transition between planated summits of the Endicott Mountains, the Yukon Plateau, and the Koyukuk Plateau, and does not accord with his conclusions:

"The higher level (Yukon Plateau),[a] which also suggests a former plateau, now dissected and largely removed by erosion, lies at about 3,000 feet, but is indefinite. Its best expression occurs along the base of the mountain, where portions of nearly flat-topped ridges, rising gently northward, soon merge into the foothills of the mountains, while to the south they become lost in irregular ridges and hills, descending to the lower or Koyukuk Plateau."

It thus seems possible that more detailed studies may here show a gradual transition between the plateau and mountain provinces.

The highest level is preserved in uniform summits of the mountains, which stand at an altitude of about 5,000 to 6,000 feet, and is believed to mark a peneplain. (Pl. XXIX, *A*.) On the north these summits fall off abruptly to a second peneplain, which finds expression in the Anaktuvuk Plateau. (Pl. XXIX, *B*.) The surface of the plateau is a gently rolling upland, which slopes from 2,500 feet at the base of the mountains, and 60 miles to the north appears to merge into a constructional plateau of Tertiary (Pliocene?) sediments.

A careful analysis of the rather fragmentary data of the stratigraphic and structural geology already presented goes to show that the Yukon, Coast Range, Endicott, and Anaktuvuk peneplains were formed during post-Kenai (Eocene) pre-Pliocene times; in other words, that they appear to be practically of the same age. Of the Chugach peneplain there is less definite evidence, but it is certainly post-Mesozoic and pre-Pleistocene.

CORRELATION.

The correlation of the southern peneplains—the Coast Range, the Chugach, and the Yukon—has already been suggested by Spencer in the paper cited. The writer must confess to having at first maintained considerable skepticism toward this correlation. The topographic surveys of recent date in the headwater region of the Copper and Tanana rivers, however, appear to indicate a transition between the Chugach-Nutzotin and Yukon Plateau peneplains, and seem to lend support to Spencer's theory, as do also the stratigraphic studies which point toward the conclusion of a synchronism of all of the peneplains recognized in Alaska.

[a] Reconnaissance in northern Alaska: Prof. Paper U. S. Geol. Survey No. 20, 1904, p. 44.

Spencer's argument,[a] which was based almost entirely on the topographic evidence, is summarized by him as follows:

"I. The interior and Yukon plateaus of British Columbia, Yukon, and Alaska have been previously recognized as uplifted peneplains, and in the Copper River region the summits of the high mountains have been described as upraised base-level surfaces. It now appears that the uniform summits which are found over the greater portion of the Pacific Mountain system in the north are also representative of elevated peneplains which have suffered deep dissection.

"II. The peneplains of the different portions of the coastal mountains and the inland plateaus can be correlated one with another. The antecedent nature of the rivers which cross the present coastwise barrier demonstrates the identity of the ancient erosion surfaces throughout the region outlined.

"III. The Pacific province was raised after the production of the peneplain by erosion extending through Eocene time, mainly through uplifts of a continental character. Regional elevation was accompanied by warping, flexure, or displacement, raising tectonic blocks which have been effaced by subsequent erosion, but there has been no mountain building due to tangential compression."

Spencer's contention then is that the Pacific Mountain system of Alaska, with the exception of the Alaska and parts of the St. Elias ranges, was planated at the same time with the Yukon Plateau, and the present relief is largely due to subsequent differential uplift.

It has been indicated by Schrader that the summits of the Endicott Mountains of northern Alaska also mark a planation surface which he believes to be of the same age as the Chugach peneplain but older than the Yukon peneplain. In other words, Spencer recognizes but one extensive peneplain in the portion of the Alaskan cordillera considered by him, while Schrader believes there must be two distinct surfaces. One objection to Schrader's interpretation of these features lies in the improbability that any remnants of an older peneplain should be preserved during the long period of erosion while the second was being cut, for it must be remembered that the second erosion level has been traced through an area 500 by 2,000 miles in extent. If there were two peneplains it would be expected that the younger would be cut only in the soft strata and the older recorded in the more durable rocks, but nothing of this kind has been noted. Moreover, this older period of planation must have been pre-Eocene in age, and would have been distorted if not entirely destroyed by the marked epoch of deformation which is known to have taken place throughout Alaska in post-Eocene times. It seems at least improbable that any pre-Eocene land surface should still be preserved.

A logical extension of Spencer's correlation of the peneplains noted in the Chugach Mountains, Coast Range, and Yukon Plateau would include the peneplain of the Endicott Mountains, and even that represented by the Anaktuvuk Plateau. The little that is known of the geology of the Arctic Slope region points toward such a correlation, though it is evident that it is impossible now

[a] Bull. Geol. Soc. America, vol. 14, p. 132.

to give it any more weight than that of a working hypothesis. If the Anaktuvuk and Endicott peneplains are identical in age, there must have been a sharp flexure or fault at the northern front of the mountains during or subsequent to the uplift which brought the plateaus in their present position.

RECENT GEOLOGIC HISTORY.

INTRODUCTION.

In the foregoing pages the chain of geologic events from the earliest stratigraphic records has been passed in brief review, the topography has been described, and the genesis of its dominant types has been discussed. It remains to present a summary of the recent geologic history, and thus outline the development of the existing land forms, as far as the evidence at hand will permit. Many of the details of the topographic evolution will necessarily be entirely neglected. Briefly stated, the topography is believed to be the result of the following succession of events, which, for the sake of brevity, will be presented categorically.

1. Some time in the late Jurassic or early Cretaceous there was a dynamic revolution which seems to have affected the entire province, and can be conveniently taken as the beginning of the recent geologic history. At the close of the disturbance much of Alaska was above the sea and a long cycle of degradation began. Volcanic vents opened in the Alaska Peninsula and in the Wrangell Mountains.

2. A partial submergence followed during Upper Cretaceous time, and the sea invaded the lower Yukon and Kuskokwim regions, the Arctic Slope province, and probably a part of the Pacific littoral. This submergence in certain districts continued well into the Eocene. The Eocene deposition was in part in open ocean, in part in embayments, and in part probably in lakes.

3. Sedimentation was terminated late in the Eocene or early in the Miocene by an uplift accompanied by widespread deformation. After this disturbance Alaska had about its present shore line, and its two mountain systems were probably marked by areas of considerable relief. A long period of relative stability followed, during which a large part of the province was reduced to a peneplain. At the close of this cycle some kind of a mountain barrier was probably left along the present St. Elias Range and this was bisected by the ancestor of the Alsek River. Volcanism continued in the Wrangell and Alaska Peninsula regions.

4. In late Pliocene or early Pleistocene time the region was again elevated by an uplift, differential and probably intermittent, to about its present altitude, and the previously developed peneplain was deeply dissected. The Yukon drainage system was developed in part along lines determined by the previous base-leveled conditions. The Alsek, Stikine, and other southerly flowing rivers maintained their courses across the coastal mountain barriers, which had been uplifted to a greater altitude than the interior province. At the same time the Noatak and Kobuk valleys were incised in a general way following bed-rock structures. Volcanism continued in the Wrangell and Aleutian mountains.

5. The elevated tracts throughout the province became the gathering grounds of glaciers, which moved down the slopes, filled up the valleys, and in many instances

stretched out into the lowlands far beyond the mountain slopes. In southeastern Alaska the great cordilleran glacier scoured out the preexisting valleys.

The ice subsequently retreated and the accompanying floods filled the valleys and lowlands with extensive alluvial deposits, in which were mingled Pleistocene organisms. Gradually, as the waters became less burdened with sediments, they began to erode and trenched the extensive mantle of overwash, a process which is still going on.

There is evidence that during Pleistocene times there were many local elevations and depressions and some of them have affected the drainage systems.

CONDITIONS ANTERIOR TO UPPER CRETACEOUS TIMES.

It is known that deformation and metamorphism took place in recurrent epochs during Paleozoic and early Mesozoic times, but these influenced the development of the present land forms only so far as they determined lines of weakness along which erosion was subsequently active. The last of these disturbances of sufficient intensity to produce any considerable metamorphism, deformed rocks of late Jurassic or early Cretaceous age.[a] This movement of the earth's crust seems to have been far-reaching, for its influence has been observed in the Lower Cretaceous terranes throughout Alaska. Its intensity varied greatly, for in one locality, as on the upper Yukon, the strata of this age were closely folded and more or less metamorphosed; while in another, in the Copper[b] River basin, they were only indurated, uplifted, and slightly deformed. This epoch of disturbance will be chosen as the starting point of the discussion of the recent history of the region, for it seems to have been the first to have directly influenced the development of the topography.

At the close of this disturbance much of the province was uplifted above the sea, and erosion began on the newly disclosed land surface. During this period of degradation volcanism first became active since Paleozoic time in the Copper[c] River region, and probably was also revived in the Aleutian Range.

There is no measure of the duration of this cycle of erosion, but in the Copper River basin at least it seems to have continued a sufficient length of time to reduce the land nearly to base-level. It seems probable that some parts of the province remained exposed to atmospheric agencies much longer than others, for in some places the Upper Cretaceous rests on the Lower Cretaceous; in others the former is absent and the latter are directly overlain by Eocene beds. The evidence of this deformation and subsequent erosion is found in the marked unconformity between the Lower Cretaceous and overlying Mesozoic or Eocene sediments which have been noted throughout the province.

LATE CRETACEOUS AND EARLY EOCENE DEPOSITION.

A gradual submergence of a part of the province terminated the period of erosion and inaugurated sedimentation. In southeastern Alaska, in lower Yukon and Kuskokwim valleys, and in the Arctic Slope province the deposition began during

[a] The tratigraphic position of the *Aucella*-bearing beds of Alaska is still in some doubt, but they are here classed as Lower Cretaceous.

[b] Geology and Mineral Resources of a Portion of the Copper River District, p. 51.

[c] Op. cit., p. 51.

Upper Cretaceous times and continued without interruption through a part of the Eocene. The fragmentary nature of the evidence[a] makes it impossible to determine what part of Alaska was submerged during this epoch, but it is probable that the transgression of the sea in Upper Cretaceous times was gradual from the southwest and extended as far inland as the mouth of the Porcupine. Dawson[b] has suggested that during the Laramie times (Upper Cretaceous) much of the lower Yukon basin was occupied by the sea, and the stratigraphic studies of Collier[c] would confirm this in part at least. He found marine Upper Cretaceous beds on the lower Yukon, succeeded by Eocene beds with conformable relations. As these latter are chiefly fresh-water deposits and of a coarse character, such as conglomerate and sandstone, it is fair to presume that they were laid down in embayments or estuaries. These beds of Eocene age are found on the Yukon near the international boundary, which makes it probable that deposition was going on throughout the Yukon Valley below. It is possible, however, that the fresh-water beds are in part of lacustrine origin, and there is no definite evidence that the invasion of the Tertiary sea extended above the mouth of the Tanana. Indurated sandstones of Upper Cretaceous or Eocene age were observed by the writer as far east as the head of the Cantwell, a southern tributary of the Tanana. The surveys in the Copper River region have failed to reveal any Upper Cretaceous sediments, but some Eocene beds have been found and the Wrangell volcanoes had at this time long been active.

Schrader[d] has described marine Upper Cretaceous fossils in a sandstone shale series overlain by Eocene beds north of the Rocky Mountains, and presented less definite evidence of the occurrence of this horizon on the south slope of the mountains. His results suggest at least that these deposits may have been laid down in seas separated by a barrier. Some Upper Cretaceous sediments have been found in the Pacific littoral, which indicate that a part of this district was submerged early in this cycle.

The facts indicate that during late Cretaceous and early Eocene times deposition was going on in western Alaska, probably in part in what was open ocean, in part in an embayment, and in part in lakes. During this long period there were probably recurrent vacillations of the land mass, which brought about repeated changes of shore line. It seems probable that there was then a land area in the present region of the Rocky Mountains and another east of the one hundred and forty-first meridian, but with the gradual elevation begun in Eocene times the sea retreated toward the present coast line of Bering Sea.

UPLIFT AND PLANATION (LATE EOCENE OR MIOCENE).

About the close of the Eocene there was a gradual uplift throughout the province, which, though of an orographic character, was accompanied by considerable local disturbance of the Eocene beds.

The date of this uplift, though in doubt, is probably late Eocene or early Miocene times. Dawson[e] refers this orogenic movement to the Eocene, but if the

[a] The Upper Cretaceous and Tertiary succession in Alaska is as yet imperfectly known.

[b] Late physiographical geology of the Rocky Mountain region: Trans. Royal Soc. Canada, 1890.

[c] Collier, Arthur J., The coal resources of the Yukon: Bull. U. S. Geol. Survey No. 218.

[d] Schrader, F. C., A reconnaissance in northern Alaska: Prof. Paper U. S. Geol. Survey No. 20, pp. 79–83.

[e] Geological record in the Rocky Mountain region of Canada: Bull. Geol. Soc. America, vol. 12, p. 79.

identification of the upper Eocene beds in the lower Yukon basin, deformed at this period, is trustworthy it would show that the dynamic revolution took place somewhat later. Further evidence on this point is afforded by some unconsolidated beds which have been found on the Yukon below the mouth of the Tanana, which are practically undisturbed, and must have been laid down since this period of deformation. As these are Miocene or Pliocene, they go to prove that the movements were pre-Pliocene and possibly of pre-Miocene, and as this is in general accord with the other evidence they can be regarded as marking the close of the Eocene.

It seems probable that this elevation affected all of Alaska and exposed a land mass of considerable relief, with a shore line not essentially different from that which now exists.

Degradation began on the exposed land mass, and during a long period of stability which followed an area including hundreds of thousands of square miles was reduced to a peneplain. The limits of this planation surface have been discussed in full, but it must be understood that whatever may be the correlations of the higher plains there can be no doubt that the Yukon Plateau, the British Columbia Plateau, and the Coast Range were base-leveled during this epoch. The evidence which suggests the synchronous origin of the Chugach, Endicott, and Anaktuvuk peneplains has been presented, and for the purposes of this exposition this will be accepted as proof.

Whatever then may have been the history of the bordering mountain systems, a large part of the central region at least was reduced to a peneplain during the epoch of erosion which followed the late or post-Eocene deformation. The resulting plain sloped generally gently toward the sea, and occupied the larger part of what is now the Yukon basin. Here and there the featureless lowland was broken by a mountain or peak which rose above the general level.

The ancestor of the present Yukon was among the rivers which meandered across this lowland, with the tortuous courses characteristic of base-leveled conditions, and it probably occupied very much its present course from the junction of the Pelly and Lewes to the sea. Only a part of the present drainage of the Yukon flowed to Bering Sea, for some found outlet to the Pacific by a river which followed the course of the present Alsek. This stream appears to have bisected a low mountain barrier which occupied the present position of the St. Elias Range. According to Spencer, another river reached the sea along the valley of the present Copper. As the planated surface extended across the present Coast Range, there was there no coastal barrier. The drainage was carried to the Pacific by the Taku, Stikine, and other rivers, which during the subsequent uplift, like the Alsek, maintained their valley to the Pacific across a gradually rising barrier. In northern Alaska the peneplain swept across the present Rocky Mountains and stretched northward to the Arctic, where the base-level was extended seaward by the constructional surface formed of late Tertiary sediments.

At the close of this extensive period of denudation central Alaska had probably the contour of a broad shallow trough, whose sides sloped gently from the borders to an axial line. A broad flat watershed probably separated the western trough from the northerly flowing Arctic drainage, and another similar divide may have intervened between the Bering and Pacific drainage somewhere in what is now northern British Columbia. This divide appears, however, to have been broken by drainage courses.

DIFFERENTIAL ELEVATION AND EROSION.

A gradual elevation of the entire land mass closed the long period of stability when this extensive planation took place. The trough-like form of central Alaska was emphasized by the uplift, which was greater at the margins than at the axis of the trough, forming a broad, shallow depression between two lines of height which corresponded in a general way with the position of the present Yukon Valley.

The fact that the several rivers which flowed into the Pacific across that part of the peneplain which is now marked by the Coast Range maintained their courses shows the uplift to have been very gradual. The tortuous character of the Yukon Valley in the Ramparts and above the Flats is interpreted as being the incised meanders of the previous base-leveled conditions, and also points toward slow elevation.

Coordinate with the increased relief river and stream valleys were incised and a drainage system developed, much of which was probably along the lines determined by the preceding lowland condition. It has been indicated that the course of the Yukon was not very different from what it is now. Its great southwest bend appears to have been consequent upon the contour of the uplifted area, a feature partly inherited from the configuration of the lowland areas and in part induced by differential uplift.

It seems well established that a part of the southern drainage of the upper Yukon then found an outlet to the Alsek, whose basin included a valley now represented by a series of broad northwest-southeast depressions lying southeast of the one hundred and forty-first meridian and south of Yukon River (fig. 6). These indicate a well-developed drainage system tributary to the Alsek, which at that time must have included the upper part of White and Tanana valleys, as well as several of the southern tributaries of the Lewes and upper Yukon rivers. It seems probable that the broad northeast-southwest depressions extending southward into British Columbia have had a similar history, and mark the position of a drainage system tributary to rivers emptying into the Pacific through transverse valleys.

The differential uplift was greatest along the margins of the province, and these differences in places brought about sharp flexures or possibly faults. In British Columbia, for example, there is a difference of several thousand feet in the summit level of the Coast Range and of the Yukon Plateau. This flexure or fault finds topographic expression in the steep front which the Coast Range presents toward the plateau.

If the correlations of peneplains be accepted, there are many similar examples in Alaska, of which the most striking is the escarpment marking the Rocky Mountain front toward the Arctic. Here the mountains descend abruptly from an altitude of about 5,000 feet to the Anaktuvuk Plateau (2,500 feet). Later movements may have taken place along the same lines, but it seems probable that the escarpments are in a large measure due to the differential character of the initial uplift.

Attention has been directed to irregularities of the surface of the Yukon Plateau. This also may in part be due to the irregularities of the initial elevation, though they are also accounted for by subsequent deformation of the peneplain. Stratigraphic evidence of recent deformations is found in the Pleistocene deposits, which in some places show broad plications. Of greater import is the evidence of extensive uplift and probable fracture along the western front of the St. Elias Range, where Russell[a] found Pleistocene fossils in unconsolidated beds 5,000 feet above sea level.

There is also physiographic evidence of recent minor deformation in the plateau region, as well as in the Seward Peninsula. Near Rampart, on the Yukon, the plateau surface shows a marked doming, and this is believed to have caused the erosion of the broad basin above, known as the "Yukon Flats." It appears that there has been here a local base-level during the period while the Yukon was channeling out its valley through the uplift athwart its course. Such local domings may account for some of the other lowlands and even lakes of Alaska and adjacent portions of Canada. Evidence of recent deformations in the Seward Peninsula is found in the general character of the coast line and in the warped marine benches, which have been fully discussed[b] elsewhere.

The Aleutian Range and Wrangell Mountains have been ascribed to extravasations of volcanic material which took place after the last stage of deformation, and probably during and subsequent to the abrasion of the peneplain. The date of the beginning of the volcanic activity has not been determined, but it is safe to say that it was post-Eocene and it has continued up to the present time. In these mountains erosion has lagged far behind the upbuilding, hence their present high relief.

The uplift was probably not a single movement, but the total effect is the result of a number of recurrent elevations, interrupted by periods of stability. Nor was the movement necessarily all upward, for the land may have oscillated, but the algebraic sum of these disturbances was elevation. These orographic movements have left records in the topography, but are not yet sufficiently well known to be correlated, and will not here be discussed.

INFLUENCE OF GLACIAL EPOCH ON TOPOGRAPHY.

Glaciation in the larger part of Alaska was of limited extent, and except in the panhandle had no very marked effect upon the topography, but it contributed a large amount of material, which formed extensive overwash deposits beyond the limits of the ice.

The cordilleran glacier, uniting with the ice from the Coast and St. Elias ranges, effectually blocked the channels of the southward flowing streams, such as the Alsek, and their drainage was for a time diverted to the Yukon. It has been shown elsewhere[c] that probably one of the effects of this ice blockade was thus to divert some of the former drainage of the Alsek to the Tanana and White rivers. This same cordilleran glacier traversed the valleys transverse to the Coast Range, and uniting with the local glaciers covered the greater part of southeastern Alaska and the adjacent islands. It has been indicated that probably much of the erosion of the fiords and channels of this coast may have been brought about by

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[a] Russell, I. C., Expedition to Mount St. Elias: Nat. Geog. Mag., vol. 3, 1891, pp. 170-175.

[b] Brooks, A. H., A reconnaissance of the Cape Nome and adjacent gold fields of Seward Peninsula, Alaska, in 1900: U. S. Geol. Survey, 1901, pp. 56-62.

Collier, A. J., A reconnaissance of the northwestern portion of the Seward Peninsula, Alaska: Prof. Paper U. S. Geol. Survey No. 2, 1902, pp. 34-42.

[c] Brooks, A. H., Reconnaissance from Pyramid Harbor to Eagle City: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 354.

ice erosion when the land stood at about its present level. According to Gilbert,[a] the flooded shore line is due rather to this glacial erosion than to an extensive depression, and the glacial scouring followed the channels of an older drainage system.

Other districts afford nothing to compare with southeastern Alaska for extent of glacial erosion, except possibly the irregularities of shore line of Prince William Sound. In all the higher ranges, where there has been ice accumulation, cirques and U-shaped valleys are typical topographic forms, but these are regarded as comparatively slight modifications of a preexistent topography.

The overwash deposits of the glacial epoch embrace the silts which are found in the entire length of the Yukon Valley, the gravel plateaus in the upper Kuskokwim basin, as well as on Cook Inlet, together with many deposits of lesser extent. After the ice disappeared the streams gradually lost their burden of glacial débris, soon began actively cutting the aggradational surfaces, and the remnants remain as silt and gravel bluffs along the walls of the present valleys.

In previous reports the author had advocated the view of a marked post-Glacial uplift, but he is now inclined to interpret the terraces as the result of changes in the erosive powers of the streams. It is impossible, however, to deny that some uplift has taken place since the retreat of the ice, for even in southeastern Alaska, where the topography suggests a depression, marine benches have been found 200 feet above the present sea level, and in other districts the evidence all points toward elevation. It seems then probable that there has been and now is a general upward movement relative to sea level throughout the interior and in northern Alaska. Of this there is undeniable evidence in the terraces and marine benches along the shores of both the Arctic Ocean and northern Bering Sea. The retreat of the several ice sheets and the deposition and incision of their overwash material left the topography essentially in its present form.

DESCRIPTION OF TOPOGRAPHIC MAP OF ALASKA.

By R. U. Goode.

Prior to 1898 knowledge of the geography of the interior of Alaska useful for map-making purposes was fragmentary, being practically confined to information derived from a few reconnaissance expeditions sent from time to time, for various purposes, by different branches of the United States Government. In the year above mentioned systematic geographic and topographic work was commenced by the United States Geological Survey, and has been uninterruptedly prosecuted during the field seasons from 1898 to 1902, inclusive. As a result of the above work the following maps have been published or are in course of publication:

E. C. Barnard. Fortymile quadrangle; scale 1:250,000.

E. C. Barnard. Cape Nome and adjacent gold fields; scale 1:250,000.

Robert Muldrow. Sushitna River and adjacent territory; scale 1:625,000.

W. S. Post. Region from head of Cook Inlet to Kuskokwim River and down the Kuskokwim to Bering Sea, Bristol Bay, and a part of Alaska Peninsula; scale 1:625,000.

[a] Gilbert, G. K., Glaciers and glaciation: Harriman Alaska Expedition, vol. 3, 1904, pp. 134-139.

WALTER C. MENDENHALL. Head of Cook Inlet to the Tanana via Matanuska and Delta rivers, also part of Kenai Peninsula; scale 1:625,000.

Lieut. P. G. LOWE, EMIL MAHLO, and F. C. SCHRADER. Copper River region; scale 1:376,000.

EMIL MAHLO. Prince William Sound and vicinity; scale about 1:376,000.

W. J. PETERS. Portion of Tanana and White rivers; scale 1:625,000.

W. J. PETERS. Routes from Lynn Canal via headwaters of White and Tanana rivers to Eagle City; scale 1:625,000.

W. J. PETERS. Norton Bay region; scale 1:625,000.

W. J. PETERS. From Koyukuk River to mouth of Colville River, including John River; scale 1:625,000.

W. J. PETERS. The Juneau special district; scale 1:62,500.

T. G. GERDINE. Portions of Koyukuk and Chandlar rivers; scale 1:625,000.

T. G. GERDINE. Northwestern part of Seward Peninsula; scale 1:250,000.

T. G. GERDINE. Upper Copper and Chistochina rivers; scale 1:250,000.

T. G. GERDINE. Fairbanks and Birch Creek districts; scale 1:250,000.

T. G. GERDINE. Yukon-Tanana region; scale 1:625,000.

T. G. GERDINE. Nome special; scale 1:62,500.

T. G. GERDINE. Grand Central special; scale 1:62,500.

T. G. GERDINE and D. C. WITHERSPOON. Chitina and lower Copper River regions; scale 1:250,000.

ALFRED H. BROOKS. Sketch maps of York and Kugruk regions.

D. L. REABURN. From Fort Yukon to Kotzebue Sound, including Dall, Alatna, Kanuti, and Koyuk rivers; scale 1:625,000.

D. L. REABURN. Mount McKinley region; scale 1:625,000.

D. C. WITHERSPOON. Headwaters of Copper, Nabesna, and Chisana rivers; scale 1:250,000.

D. C. WITHERSPOON. Northeastern part of Seward Peninsula; scale 1:250,000.

D. C. WITHERSPOON. The Seventymile and Circle region; scale 1:250,000.

ARTHUR J. COLLIER. The Cape Lisburne region; scale 1:625,000.

L. M. PRINDLE and F. L. HESS. Sketch map of Rampart region; scale 1:625,000.

The map of Alaska is principally based upon the above maps, but other available maps have been consulted and drawn upon for information, especially those published by the Coast and Geodetic Survey, from which the entire coast line has been taken, as well as those by the Army, the Navy, the Revenue-Marine Service, and the Russian, British, and Canadian governments. When exact cartographic data were lacking, the compiler has been forced to rely on such information as has been collected by the Geological Survey parties from prospectors, traders, and natives. The different sections of the map therefore have very unequal value, for it is in part based on accurate surveys, in part generalized from verbal descriptions and sketch maps. In every case the most reliable source of information has been used, and though the map will be subject to many corrections in the future, the demand for a general map of Alaska has been so great as to justify the publication of one based only in part on accurate mensuration.

There are many general maps of Alaska, but none of them show anything except the horizontal relationships. The map published herewith embodies the first attempt to represent the vertical element, or in other words to show the inequalities of the surface. For this purpose contour lines are used, which appear on the map in brown. Each contour line passes through points which are supposed to have the same altitude, that is, if one would follow a contour on the ground he would go neither uphill or downhill, but on a level, the line of the sea coast at mean tide being the zero contour. The first contour line indicated on the map is that which would be the coast if the sea were to rise 1,000 feet. When the contours are far apart or close together gentle or steep grades are respectively indicated, and thus the slopes of the plains and the shapes of the mountain masses are shown within the limits of the contour interval employed, which is 1,000 feet. For convenience in reading the maps every fifth contour is accentuated, those corresponding to 5,000, 10,000, 15,000, and 20,000 being drawn with a heavier line than that employed for the intermediate contours.

The map was compiled for the most part by Mr. E. C. Barnard, but material assistance was rendered by Messrs. W. J. Peters, T. G. Gerdine, D. L. Reaburn, D. C. Witherspoon, F. C. Schrader, W. C. Mendenhall, Arthur J. Collier, and Alfred H. Brooks, who have been engaged in the Alaskan geologic and topographic work. Mr. A. F. Hassin assisted in the drafting.

It was originally planned to include in this publication an exhaustive catalogue of Alaskan maps and such a task was begun, but it was found that owing to the great number of recent accessions the preparation of the catalogue—involving as it will some 1,500 or more entries of maps in various languages—required so much time that it was concluded that a corresponding delay in the issuance of the map of Alaska would not be justified. Moreover, the catalogue is considered to be of sufficient importance to warrant its presentation as a separate publication. Work is progressing on the catalogue as rapidly as circumstances will allow.

PUBLICATIONS ON ALASKA AND ADJACENT REGIONS.

There has been no bibliography of Alaska compiled since the exhaustive one by Dall and Baker[a], which was published in 1879. The following list of works on Alaska makes no pretense at being complete, but it includes all the reports consulted in the preparation of this report, and, it is believed, will form a convenient catalogue of the more important publications relating to the geology, geography, and development of Alaska. Publications relating to the fisheries, botany, zoology, or ethnology, and many short papers relating to mineral resources, have, as a rule, been omitted. With a few exceptions all of the works listed are in the English language. It has been the intention to make this a fairly complete list of the United States Government publications relating to Alaskan surveys. Purely administrative reports on surveys and investigations have, however, for the most part been omitted.

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G.

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[Professional Paper No. 45.]

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MARCH, 1906.

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MAP OF
ALASKA
Compiled under the direction of R.U. Goode, Geographer,
by E.C. Barnard and others.
1903
Scale 1/2,500,000
Approximately 40 miles to 1 inch.
Contour interval 1000 feet.
Datum is mean sea level.
1904
ARCTIC OCEAN
SIBERIA
BERING SEA
BERING STRAIT
NORTON SOUND
KOTZEBUE SOUND
SEWARD PENINSULA
BRISTOL BAY
GULF OF ALASKA
NORTH PACIFIC OCEAN
ALEUTIAN ISLANDS
FOX ISLANDS
SHUMAGIN IS.
PRIBILOF ISLANDS
ENDICOTT MOUNTAINS
ALASKA RANGE
CHUGACH MOUNTAINS
YUKON RIVER
KUSKOKWIM RIVER
MACKENZIE RIVER
BOUNDARY LINE
NEAR ISLANDS
RAT ISLANDS
ANDREANOF ISLANDS
ISLANDS OF THE FOUR MOUNTAINS
DIXON ENTRANCE