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

A RECONNAISSANCE IN NORTHERN ALASKA

ACROSS THE ROCKY MOUNTAINS, ALONG KOYUKUK, JOHN, ANAKTUVUK, AND COLVILLE RIVERS, AND THE ARCTIC COAST TO CAPE LISBURNE, IN 1901

BY

FRANK CHARLES SCHRADER

WITH NOTES BY

W. J. PETERS

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DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., August 3, 1903.

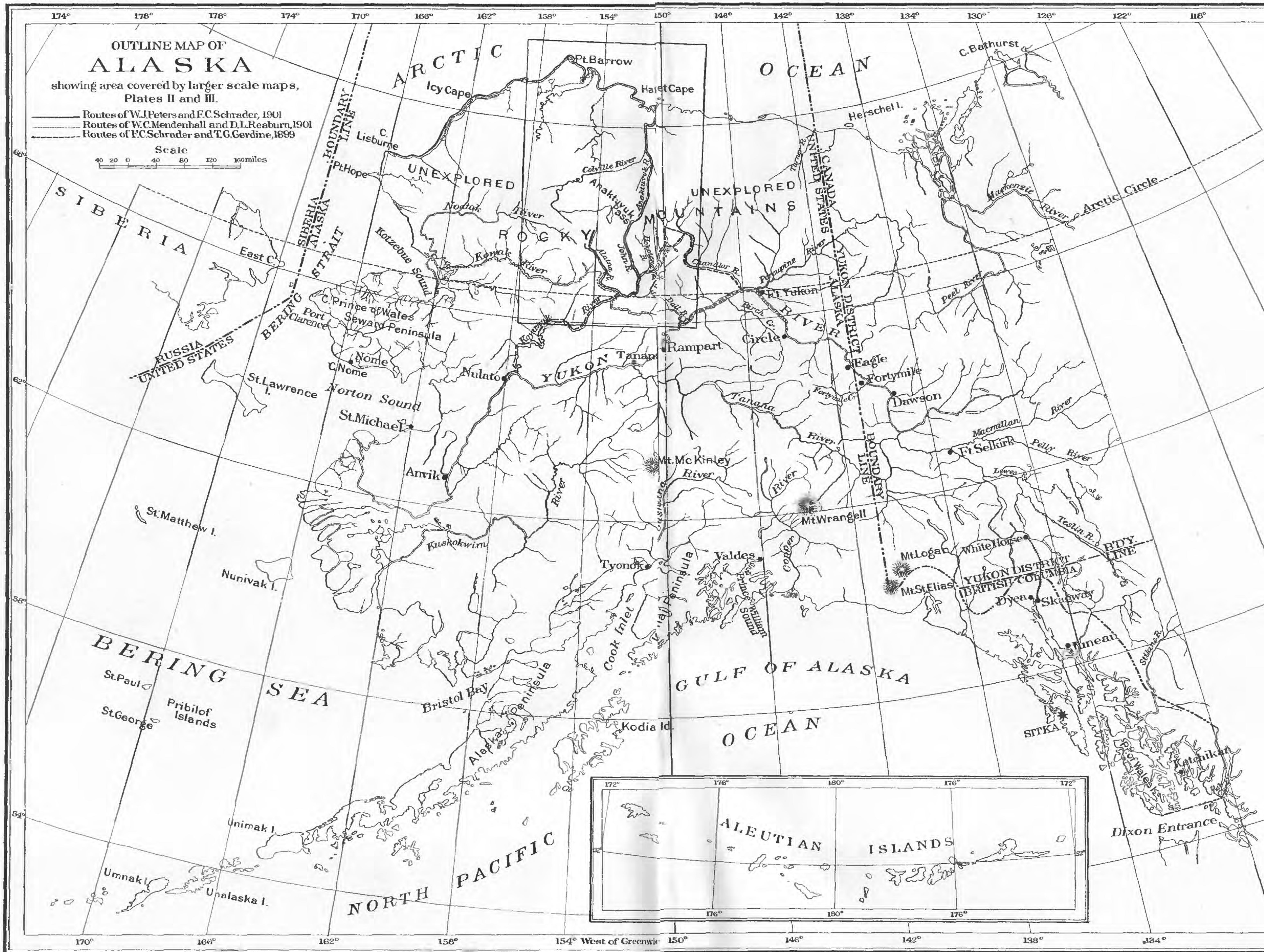
SIR: I have the honor to transmit herewith a manuscript by Mr. F. C. Schrader, entitled "A Reconnaissance in Northern Alaska in 1901," and to recommend its publication as a professional paper.

This report is based on an exploration made by Messrs. W. J. Peters and F. C. Schrader from Yukon River to the Arctic Ocean during the winter and summer of 1901. Besides important geographic results, the investigation is the first to throw light on the complex geology of the Rocky Mountain system of northern Alaska. Mr. Peters, leader and topographer of the expedition, has contributed notes on itinerary, topographic methods, and climate.

Very respectfully,

ALFRED H. BROOKS,
Geologist in Charge Division Alaskan Mineral Resources.

Hon. CHARLES D. WALCOTT,
Director of United States Geological Survey.



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A RECONNAISSANCE IN NORTHERN ALASKA IN 1901.

By F. C. SCHRADER.

INTRODUCTION.

Since 1898 the United States Geological Survey has been carrying on systematic topographic and geologic surveys in Alaska under an appropriation made for the investigation of the mineral resources of the Territory. This work has included not only areal surveys of regions already being developed by the miner and prospector, but also explorations and investigations of regions that are little known or entirely unexplored. As a result of these explorations a network of reconnaissance traverses has been extended over a large part of Alaska, where route surveys of this character must necessarily precede more detailed topographic and geologic mapping. They serve to outline the main geographic features of the country and afford the pioneer or prospector a guide for his journeys as well as help him to select his field of operations. The present report and maps are the results of such an investigation.

Previous to 1901 but two journeys[a] which yielded any geographic results had been made across northern Alaska by white men. The first of these was made by Lieutenant Howard, U. S. Navy, in 1886, and extended from Kowak River to Point Barrow, while the second, made by J. H. Turner, in 1890, followed the one hundred and forty-first meridian from the Porcupine. The conditions under which these journeys were carried on precluded instrumental work. The present survey must therefore be considered the first made with precise instruments from the Yukon to the north coast of Alaska. In connection with the traverses made of Chandlar and Koyukuk rivers by Mr. T. G. Gerdine, and of Dall, Alatna, and Kowak rivers by Mr. D. L. Reaburn, both of the Geological Survey, it outlines some of the most important of the physical features and drainage channels of northern Alaska.

The exploration on which the following report is based was made by the writer during the season of 1901, while attached as geologist to a party in charge of W. J. Peters, topographer. The other members of the party were Gaston Philip, topographic assistant; Thomas M. Hunt, George H. Hartman, Charles H. Stuver, Ben

[a] For references and details see pp. 29 and 33 of this report.

Bennett, and Joe Edge, camp hands, all of whom rendered untiring and efficient service and manifested genuine interest in the expedition. Sections prepared by Mr. Peters are credited to him in the proper places.

As early as 1896 the Survey considered projects for reaching this unexplored field in northern Alaska, but owing to the remoteness of the region and the difficulties of transportation, no plans could be devised which did not involve the wintering of a party in this arctic country at great cost and much loss of valuable time. The first plans submitted were by Mr. J. E. Spurr, who proposed a traverse from the lower Koyukuk to Point Barrow, essentially along the route followed by Howard. The probable existence of a passable route 200 miles east of the above, between the upper Koyukuk and the Arctic slope, was not learned until 1899. The transportation difficulty, however, became less formidable when the discovery of gold on the Koyukuk, in the widespread search which attended the Klondike excitement of 1897 and 1898, led to the location of a trading post at Bergman, on Koyukuk River, near the Arctic Circle, nearly 500 miles above its mouth, and subsequently to annual visits to this post by the steamboats of a reliable company.

In the light of this later information, gained by a visit to the upper Koyukuk in 1899, the plans of the present expedition were formulated by the writer and submitted to the Director of the Survey, who approved them, and preparations were accordingly begun in the spring of 1900. The writer being otherwise engaged, the task of purchasing and assembling at San Francisco the necessary outfit, including four months' provisions for eight men, fell to Mr. Alfred H. Brooks, who was aided by Mr. R. B. Marshall.

The outfit, including canoes and supplies, was shipped from San Francisco through the Alaska Commercial Company early in the spring of 1900 and stored at the Bergman post until called for by the Survey party in 1901. From this base it was planned to carry the work northward across the Rocky Mountains of northern Alaska to the Arctic coast, and to conduct a parallel return traverse, from some other point on the coast than that at which it was reached, southward into the Koyukuk Basin, if conditions should permit. In case the return trip to the Koyukuk should be found impracticable the party was to proceed northwestward along the coast and seek relief at Point Barrow, where it was hoped it might be picked up by a returning revenue cutter or arctic whaler. In the event, however, that no such vessel appeared (as proved to be the case), it was proposed to at once continue southwestward along the coast in native skin boats or by dog sleds, as conditions might permit, until some chance vessel along the coast or some mining camp in the Nome region should be reached.

As this northern region was practically unsurveyed and much of it was entirely unexplored, it was planned to make an instrumental survey along the route of travel, which was to traverse the Rocky Mountains stretching across northern

Alaska, as already noted. It was believed that by this means, even though the actual survey was of a reconnaissance character and embraced only a narrow strip, the general physiographic features of the region would be determined and important contributions would be made to geographic and geologic knowledge. It was planned to carry on the work in as much detail as the adverse conditions would permit. It was believed by the writer that the metamorphic rocks of Paleozoic age or older, which are the source of the placer gold in the Koyukuk Basin, extended to the west, and probably formed important members of the formations which make up the Rocky Mountains, and hence valuable economic results of the investigations were to be expected. In short, the expedition was planned to collect information of all kinds relating to the geography, geology, and resources of the region; and data bearing on the preparation of the proposed general map[a] of Alaska for public use were particularly desired.

Owing to the shortness of the Arctic summer it was important that progress should be as rapid as possible, regardless of the character of the weather, and as much of the energy of the party was expended in contending against the swift currents of John and Anaktuvuk rivers, the accompanying report is necessarily incomplete. For want of opportunity to make more extended observations many important problems had to be left unsolved. This is especially true with reference to the structural relations of the Paleozoic rocks in the northern part of the range, and to the relation of these Paleozoics to the Mesozoic rocks forming the Anaktuvuk Plateau or "Great Plains" on the north. The time devoted to actual field work in carrying the line from Bergman, on the Arctic Circle, to Pitt Point, on the Arctic coast, a distance of 513 miles, was sixty-five days.

For courtesies, information, and material assistance rendered on our long winter trip necessary to reach the field of work, thanks are due the Canadian Development Company and other leading trading and transportation companies, as well as numerous individuals at various points along the route of travel down the Yukon, and to the United States army officers at Eagle. In the Koyukuk region the ever hospitable hand of the prospector and miner was generously extended. Special thanks are due, also, to the Alaska Commercial Company for the excellent condition in which our supplies were delivered and wintered at Bergman, and to Mr. Gordon C. Bettles, Pickarts Brothers, and other pioneers, for valuable information concerning the people, geography, routes, trails, resources, and conditions of the country.

On the Arctic coast, where the larder and foot gear of the party had become reduced to inadequacy, the generosity of the Eskimos, manifested in their gifts of fresh fish, the loan of their mukluks, the use of their skin boats for transportation, and their aid as guides to Point Barrow, was of material value and too greatly

[a] Topographic map of Alaska, compiled by the U. S. Geol. Survey, 1902.

appreciated to pass without notice. Thanks are also due to Mr. Charles Brauer and others for hospitality and courtesies received at Cape Smyth, and to Captain Ericson for transportation on the steamship *Arctic* from the Corwin coal mines, near Cape Lisburne, to Nome.

The determinations of the fossils collected on the trip and referred to in this report were made by Drs. Lester F. Ward, W. H. Dall, T. W. Stanton, George H. Girty, Mr. Charles Schuchert, and Prof. William M. Fontaine, each dealing with the fossils from the horizons of which he has special knowledge. The coal analyses and mineral tests were made by Messrs. George Steiger and H. N. Stokes in the chemical laboratory of the Survey, and the assays for gold and silver by E. E. Burlingame & Co., of Denver, Colo. Fig. 1 (p. 40) and other information bearing on the Cape Lisburne region have been generously contributed by Mr. A. G. Maddren.

METHODS OF WORK.

Dog sledding.—As the success of the work required the surveyors to reach the field before the break-up of winter, and Point Barrow by September 1, the party set out from Skagway early in February, and, after proceeding over the Coast Range by the White Pass Railway, traveled by dog sled from White Horse 1,200 miles down the Yukon to Bergman, which was reached April 10. Traveling by this means is known, in the language of the country, as "mushing," and the traveler is called a "musher." The "musher" does not ride on the sled, which is used only for carrying the absolutely necessary supplies and luggage, but follows the sled afoot and urges the dogs forward, or runs ahead on snowshoes to break a trail where none exists, or where, as frequently happens, it has been drifted over. To keep trail breaking and friction in travel at a minimum the dogs are all hitched tandem, from five to nine in a team. The Survey party used four teams, or about forty dogs in all. Their feed, which is given once a day, usually at night, consists of some cereal, rice, meal, or flour, cooked with meat, fish, or grease. Rice and bacon, flavored with a little dried salmon, is best. It is affirmed by experienced and reliable prospectors throughout Alaska that on arduous prospecting trips, where a man is dependent for sustenance on the food supply packed on his own back, he, too, can go farther and accomplish a greater amount of hard work on rice and bacon than on any other ration.

At the present day two classes of dogs are used for sledding in Alaska—the "inside" or native, consisting of Siwash and Malemut, and the "outside," consisting of various breeds of imported dogs, principally from the United States. The outside dog excels in intelligence and is usually desirable for a leader, but the native dog is best for all-round service and for long, hard trips, as he requires less food and care, and having a dense pelt, much like that of the wolf, is less affected by the severity of the climate, hardship, and exposure. He is also less liable to become footsore on a trail of rough ice and freezing slush.

In "mushing," the best progress is made in relatively cool weather, at a temperature 10° or 12° below zero. As the atmosphere warms under the midday sun, the dogs, especially the natives, pant and become tired or lazy, and can not be urged. On a long trip, under reasonable conditions, 25 miles is a good average day's drive. In one instance, where the trail was good, 46 miles were covered by the Survey party in a single day. The mail carriers on the lower Yukon are known in exceptional instances to have made as high as 60 miles, the record for the Yukon country.

Camping.—During the last two years, sled journeys on the upper Yukon have been rendered less arduous by the so-called road houses, which are located at points a fair day's drive apart, and which consist usually of a log cabin and a dog kennel. Though the accommodations are of the crudest order, these places facilitate progress by affording the weary traveler much-needed shelter and rest, and by lessening the amount of outfit and supplies he is compelled to transport on a long journey. The rates charged by these road houses average about $1.50 a meal.

Where there are no road houses, as was the case beyond Fort Yukon, the traveler at the end of the day's drive selects his camp spot for the night, and, unless provided with tent and stove, digs a hole through three or four feet of snow to the ground for a fireplace. As a shovel is rarely carried, the snow is scooped out with an axe and snowshoes. In sleeping on the snow and ice, spruce boughs, where available, form a desirable mattress. A light-weight tent, provided with broad bottom flaps and a closable entrance, besides affording protection from storm and cold, is useful in keeping the dogs from lying on one's bedding or person, as they are wont to do on a cold night. A light-weight sheet-iron stove, suited for cooking inside the tent, is very desirable, but not indispensable, as an outdoor fire is usually required to cook the dog feed.

Chronologic summary of operations.—After doing some triangulation and topographic work in the Koyukuk Valley, principally between the Arctic Circle and the sixty-seventh parallel, the party waited at Bergman for the disappearance of the snow and ice—the "break-up," as it is called; for the sheet of soft snow or slush, several feet in thickness, which everywhere overspreads the country during the thaw period of spring renders travel of every kind at that time impossible. Owing to the heavy snowfall of the previous winter and the lateness of the spring, the break-up period of 1901 was of unusual length, extending from the middle of May to June 6, about twenty-five days. During this time some astronomic observations and other investigations of a local nature were made.

Except its arching feature, the breaking up of the ice on the Koyukuk, as observed by the writer at Bergman, differed but little from that seen on most of the large rivers in northern United States. As the stream beneath the ice became swollen and distended its ever-increasing hydrostatic pressure gradually bulged or raised the formerly level ice floor along the middle part of the river into a low arch, whose crown, by May 26, stood about 5 feet above its edges or pedal extremities, which were still frozen fast to the shores. In the meantime the excess water, increased by surface drainage due to thaw, unable to find passage beneath the ice, formed broad overflow streams, several feet in depth, coursing on the surface of the ice that formed the limbs of the arch on either side between the crown and the shore. These conditions increased until the 29th, when, at 2.30 p. m., the ice, now visible in the middle of the river only along the crown of the arch, broke or parted transversely and almost bodily moved one-eighth of a mile downstream, when it was stopped by a jam; but at 6.30 it again started and moved about a mile. Soon after this, with increased rise of the river, a general breaking up of the ice took place, and it continued to run more or less steadily until June 6, when the river cleared of it and became navigable. So far as observed, the ice rarely exceeded 2½ feet in thickness, this comparative thinness being probably due to the protecting heavy mantle of snow. Permanent ice usually forms on the river by October 10.

Stoney[a] has described a break-up witnessed by him at Fort Cosmos, on Kowak River, which was probably in most respects similar to that on the Koyukuk just described. In Stoney's description occurs the statement that "the ice suddenly became covered with water, increasing in depth on both sides of the river and decreasing toward the middle." As no reason appears to be assigned for the otherwise peculiar increase of water at the sides and its decrease toward the middle, the writer infers that this phenomenon was due to the ice-arch feature, which seems not to have been recognized by the observer at the time.

The arching feature of the ice, which seems to be characteristic in the breaking up of Arctic rivers and does not attend those in temperate zones—granting a rise in the water at the head of the rivers in both zones—is ascribed by the writer primarily to the presence of permanent subterranean frost, in whose icy grasp the edges and lateral portions of the ice become so firmly welded and held to the frozen earth along shore and the shallow riparian portions of the river bed that it is not released until thawed from the surface downward by almost midsummer suns. In temperate climates, on the contrary, where perennial underground frost does not exist, the longshore ice is the first to give way, and is often replaced by open-water leeways due to the warming and thawing influence of the underground temperature soon after the climax of winter is past.

After the break-up the party proceeded by river steamboat 80 miles up the Koyukuk to Bettles, a new supply post near the sixty-seventh parallel. From this point, commencing June 13, after doing a day's work on Lookout Mountain, the work was continued northward 125 miles, with Peterborough canoes, up a large tributary

[a] Stoney, Lieut. George M., Naval Explorations in Alaska, U. S. Naval Institute, Annapolis, Md., 1900, p. 52.

of the Koyukuk, John River,[a] to its headwaters, thence by a 5-mile portage via Anaktuvuk Pass through the mountains to the upper waters of Anaktuvuk River, the large east fork of the Colville, which flows northward to the Arctic coast. These rivers were descended by canoe and the coast was reached August 15. The ice on the Colville is reported to have broken up July 16.

After mapping a considerable portion of the Colville delta, the work was continued by canoe 100 miles northwestward along the coast to Smith Bay. Here, owing to the lateness of the season, the stormy weather, and heavy surf incident thereto, the plane-table work was dropped and the journey was continued with Eskimos, who, traveling in walrus-skin boats of native make, were encountered on the journey to Point Barrow. These skin boats were found to be more seaworthy and to sail better than our Peterborough canoes.

September 3 Point Barrow was reached, where it was hoped that passage to the States might be procured on a vessel of the United States Revenue-Marine Service or some whaler; but when it was learned that all such vessels had gone, and that the ice on the ocean was expected to close within a week (September 10 being the usual date), supplies and an open whaleboat were hastily procured and the party proceeded southwestward along the coast, hoping to make connection with a whaler several hundred miles farther south, at Point Hope, where one was expected to touch to leave her native crew. By exceptional good fortune, however, on September 18, at the Corwin coal fields, 80 miles above Point Hope, the steamer *Arctic* was met, which carried the party to Nome, where it landed on September 26. From here passage to Seattle was readily obtained on one of the numerous Alaskan steamers.

Methods of scientific work.—As the Koyukuk did not break up until June, and the expedition, to be successful, was obliged to reach Point Barrow early in September, the season of work was necessarily limited to a period of less than three months, during which 500 miles had to be traveled. Since it was impossible to make more than from 3 to 7 miles a day up the swift waters of John River—and to accomplish even this required the united efforts of the entire party—it became necessary to make almost daily advances, and therefore many mountains could not be climbed that might have afforded more extensive opportunity for observation.

The topographic work was carried on by a combination of the plane table, triangulation, and tachometry, of which an account is given by Mr. Peters on pages 24–25. An independent traverse was carried on by the geologist by means of compass and aneroid to serve as an immediate base for locations in the geologic notes. In this traverse the distances were paced or estimated, and the work was daily connected with the more accurate surveys of the topographer, while from the topographic stations and other established points panoramic photographs with recorded bearings

[a] Named for John Bremner, pioneer prospector and explorer, who was killed and robbed by a native in the Koyukuk region in 1888. Its native name is Alchichna, meaning *wind river*, so named on account of the fierce wintry blasts that sweep down it from the Arctic side of the divide, through Anaktuvuk Pass. See also note on p. 58.

were usually taken to show the character and relations of surrounding rock masses and to supplement topographic sketches.

So far as possible the geologic section was continuously examined, and, where conditions permitted, detailed sketches and diagrammatic notes were made of contacts, structures, mineral zones, and other important features.

ITINERARY AND TOPOGRAPHIC METHODS.

By W. J. Peters.

Following is an extract from the letter of instructions from the Director of the Survey:

PLAN OF OPERATIONS.

"The object of the expedition under your charge is to execute a reconnaissance survey from Bergman to the Arctic Ocean. The advance will be made by ascending some tributary of the Koyukuk to the divide against which head streams flowing northward to the Arctic Ocean, and thence down such a stream to the Arctic. The return trip will be preferably overland over a route east of that traversed in reaching the Arctic, so as to obtain as much information relating to the interior as possible. If the main branch of the Colville is not descended, however, in going northward, it will probably be advantageous to return along its course. If time or other circumstances do not permit of the overland return, the most practicable alternative route will probably be along the shore via Point Barrow, until the party may be picked up by a vessel of the Revenue-Cutter Service or a steam whaler cruising in the Arctic. If relief should not be obtained from the above sources, the journey should be continued southward until a vessel becomes available or the mining camps are reached.

"As the territory to be traversed is so entirely unknown, you are especially instructed to secure all topographic and geographic information that can possibly be obtained. Sights to all mountain peaks should be taken, distances estimated if intersections are not practicable, and sketches made. In short, no opportunity should be neglected for locating, however approximately, all features that can be seen, especially in view of the fact that it is proposed to prepare a general map of Alaska on the scale of about 40 miles to the inch, and that your party will probably be the only one that will penetrate this region on a geographic mission for many years.

"You are further instructed to afford every facility to the geologist accompanying the party for the prosecution of his special work, and to consult with him in regard to all important emergencies."

In accordance with the above instructions I left Seattle February 9 on the steamer *Victorian*, accompanied by three men—Gaston Philip, assistant, Tom Hunt, and Charles Stuver. It had been arranged that the rest of the party, under Mr. Schrader, should join us at Bergman before the thawing of the ice and snow. We arrived at Skagway[a] February 15, where we were obliged to wait three days on account of the snow blockade on the White Pass and Yukon Railway.

[a] I wish here to make acknowledgment of the courteous treatment shown us by Mr. E. S. Busby, supervising officer Canadian customs, on presentation of the letter of Mr. John McDougald, commissioner of customs (Canadian), furnished me through the Director of the Geological Survey.

WHITE HORSE TO BERGMAN.

We left Skagway on February 18 and arrived the following day at White Horse, the terminus of the railway. We found the thermometer at 55° below zero, but it rose 30° before we started on our march. On February 21 we left White Horse with 335 pounds, principally instruments and personal baggage, on each of two sleds. The first marches were made very short to avoid the lameness which results from the vigorous exercise of untrained muscles.

Fifty-three road houses are distributed along the 369 miles of trail extending from White Horse to Dawson. This stretch of trail was broad and hard packed by pedestrian, dog, and horse. Considerable heavy freighting was being carried on by horse sled. Below Dawson the trail was narrow, in deep snow, and no wider than a dog sled. From Dawson to Eagle, a distance of 106 miles, there are but four stopping places, while farther down the Yukon they are even less frequent and usually not so well supplied, owing to their remoteness and to the scarcity of patrons. It is 240 miles by winter trail from Eagle to Fort Yukon, and along this stretch are scattered 12 road houses. During the last portion of the journey, from Fort Yukon to Bettles, a distance of 330 miles, there are no cabins, and we were dependent on our own resources. The trail followed there had been made by some parties that preceded us a few weeks, but owing to subsequent snowfalls it was frequently obliterated. This trail followed Chandlar River to Granite Creek and extended up that stream about 20 miles. It then led directly over the summit, crossed the South Fork of the Koyukuk, again ascended a divide, and finally descended into Slate Creek, another tributary of Koyukuk River. From Slate Creek to Bergman there had been much travel by prospectors sledding their summer's supplies up from Bergman.

The whole party stood the low temperature and arduous travel without bad effects. Only woolen garments were worn, which were found to give ample protection while on the march. Wolf robes, one to each man, afforded a warm sleep. Our principal discomfort was due to wet feet. Probably the best footwear for wet snow and overflowing streams are mukluks, or the native boots made on the coast.

Spruce timber was found on all the river bottoms and extending up the tributaries and gulches. Two short stretches, one on the divide between the Chandlar and South Fork of the Koyukuk and the other on the divide between the South Fork and the main Koyukuk, are above timber, but both of these were crossed in less than one day, so that every night we had firewood and some sheltering spruce, though it was small and scattered near the two divides.

Moose tracks were plentiful in the Chandlar Flats, and ptarmigan were occasionally found along the trail, but no other game was seen.

We arrived at Bettles April 14, and were hospitably cared for by Mr. Turner, the agent at this post. The following day we proceeded to Bergman to examine our supplies, which had been sent in the previous season, and found them intact.

RECONNAISSANCE UP ALATNA RIVER.

The party was now divided into two parts for the purpose of reconnoitering a route through the mountains to the Colville waters. Mr. Philip was placed in charge of one of these, and, employing a native guide, ascended Alatna River[a] about 90 miles, to its eastern branch—the Kutuark. On May 5, his provisions becoming exhausted and the increased flow of water betokening a break-up, he turned back, after climbing a mountain near the mouth of the Kutuark, from which the head of this stream appeared to be completely surrounded by high mountains. The northern limit of timber appeared a few miles above the confluence of the streams. Up the western branch the timber extended as far as the valley floor could be seen.

Returning, Mr. Philip reached Bergman May 10. On this trip a few natives on their winter hunt for caribou were encountered.

RECONNAISSANCE UP JOHN RIVER.

On April 23, with the remainder of the party and a native, I started up John River. The first day's march was over the lowlands and directly toward a gap in the mountains. This direct course avoided many large bends in the river, and by night we camped close to the foot of the mountains, having made 16 miles. April 24 we entered the mountains, which rose from 3,000 to 4,000 feet above the valley, and traveled over the frozen stream, with but few cut-offs. On this trip we overtook a native woman, whose four previous camps we had passed. She was subsisting on rabbits that she caught with primitive traps. Camp was made after a march of 10 miles. On April 25 overflows were frequently encountered in the morning, but in the afternoon we were again in deep snow, which was soft, and necessitated the breaking of a trail. This was very tedious work, as the trail had to be traveled several times by all of the party and tramped down with snow shoes before it would support the sled. Sixteen miles were made in this day's march. Natives were seen in the afternoon. On April 26 we were traveling in soft, deep snow, and after going 10 miles were glad to end the weary tramp. On April 27 more natives were seen, who gave us the welcome information that little snow was ahead of us, and but little further on was the bare ice of the frozen stream. In the afternoon another camp of natives was found, and shortly after we ran onto bare ice, which was a great relief to man and dog. The day's march was 17 miles. On April 28 the traveling was on bare ice. Early in the morning we reached timber line and took on a supply of fire-

[a] Called Allen River by Mendenhall in Prof. Paper U. S. Geol. Survey No. 10, 1902.

wood. Grass could be seen protruding through the snow. Wind drifts and marks in the snow indicated very strong wind storms; indeed, we had been warned by the natives last met to go into camp if a blow from the north came on. The pass was visible at the end of a march of 20 miles. I left camp standing and proceeded to explore the pass, which appeared to be short and easily passable. It was impossible to estimate correctly the length of portage for the canoes on account of the frozen conditions. On April 30, being satisfied that the mountains could be crossed through this pass, which I called Anaktuvuk, from the northward-flowing river that it leads to, we started on the return to Bergman, which, with our now lightened sled, we reached on the morning of May 3. During our absence Mr. Schrader had arrived with the rest of the party, according to the original plan. He had found the trail again covered with snow, and to make better progress had thrown away tent, stove, and other articles.

On the reconnaissance up John River, about thirty natives—men, women, and children—were counted. It is their custom to ascend the tributaries of the Koyukuk in winter to hunt. Caribou is their principal source of food. They never go beyond timber line, and it is very seldom that natives of the north coast come as far south. When the waters run they build rafts and float down, bringing skins to Bergman for trade.

It was now too late to move the cache of provisions with sleds, for the snow was fast becoming soft and the streams were beginning to run. We therefore proceeded to Bergman to await the breaking up of Koyukuk River, and spent the remaining time in starting plane-table work in that vicinity. A base was measured on the river, and four points had been occupied with plane table, when travel became impossible.

At Bergman there were three white men, and but one of these, Mr. Powers, the agent, was there permanently. Not more than half a dozen natives live near the trading post. Mr. Powers succeeded in keeping a horse all winter, feeding him oatmeal and hay, made from a coarse native grass. Several horses were also wintered at Bettles.

The cost of travel from Seattle to Bergman, via Skagway, during the winter, is about $800 per man. The cost of freight from San Francisco to Bergman, by ocean and river steamers, was $150 per ton.

CANOE TRIP FROM BETTLES TO POINT BARROW.

On May 29 the river ice broke, but jammed again in a few minutes. It alternately moved and jammed until June 6, when the river became practically clear of ice. On June 8 the river steamer *Luella* came down from winter quarters and carried the party and outfit up again to Bettles. Preparations were immediately begun for ascending John River, and Lookout Mountain was occupied with the plane table.

A horse was hired, to be used later in packing across the divide, and T. M. Hunt was instructed to provide himself with ten days' provisions and proceed up the valley of John River to good grazing, there to await the arrival of the party, which would work up the river in canoes. The canoes started June 13, when the water was high and very swift. Progress was best made by reaching out from the bow of the canoe, clinging and hauling on projecting bough branches and snags (which is known as "milking the brush"), and aiding the advance by the judicious use of a pole from the stern. High water gradually decreased until June 27, from which time on poling and tracking were more advantageous. Working canoes up this stream necessitated constant wading in the water at a temperature of about 50°. No ill effects, however, were observed in any of the party. Snow had by this time disappeared, except on some of the highest mountains. Occasional stops of one day each were made to ascend prominent points to carry on the mapping. The northern limit of spruce was passed July 8. Beyond this was a thin growth of willows along the stream and its tributaries. On July 9 we passed through a narrow gorge in which the stream was very swift and many bowlders occurred. This was one of the most dangerous parts of the river, and from this point to the camp of July 15 the river was a constant succession of rapids and dangerous rocks, and should not be descended in boats by any one unfamiliar with it. Between camp July 15 and camp July 16 the stream is sluggish. Above the latter point it spreads out, becoming shallow and swift. From camp July 17 the outfit was packed over by the men and horse to a small lake which empties into the Anaktuvuk, and which I have called Cache Lake. Numerous small lakes occur in the pass and along the sluggish parts of the stream.

Grayling abound in the lakes and in the pools that occur in the streams. Several caribou were shot, and signs of goats were frequent on the mountain tops. Everything having been packed over to Cache Lake, on July 22 mail and reports were intrusted to a native, together with the horse, to take back to Bettles.

On July 24 the party started down the Anaktuvuk. About 4 or 5 miles above camp July 28 the mountains end and the stream runs through rolling tundra in a fairly straight course. The channel frequently spreads out and becomes so shallow that wading had to be resorted to in order to lighten the canoes. Many caribou were seen, and one was shot. A small grove of balm of gilead, consisting of about a dozen trees, was passed August 3. Mosquitoes, which had been extremely annoying since June 14, had practically disappeared. Redtop grass was seen growing in many places, particularly at camp August 5. Between camp August 6 and the mouth of the Anaktuvuk willows became thicker, and some were several inches in diameter. Among these were scattered a dozen or two balm of gilead, which, growing to a height of about 30 feet, look gigantic in the absence of other timber. The stream flows through a country that is almost flat, covered with moss, and dotted with small lakes.

From the camp of August 8 the bluffs of the Colville were seen, and on August 9 we ran into that river, which, at the confluence of the Anaktuvuk, is 12 feet deep and about 800 feet wide, with a current running 4 miles an hour. High-water marks were 10 feet above the stage of August 9. The water was fairly clear, but increased in turbidity as we floated down. I believe this turbidity is due to the wash from the bluffs, from which muddy little rivulets continually drip with the thawing of ice. Five miles below the mouth of the Anaktuvuk a short stretch of rapid water (6 miles an hour) occurs, in which bottom was touched at 2½ feet in midstream. Though it is possible that deeper water might have been found, I doubt if it would have been more than 4 feet at that stage. Between the rapids, shown on the map accompanying this report, the current was not over 2 miles an hour, and in them it was not greater than 6 miles. The rapids shown are all very gentle, and average not more than 100 yards in length. Four feet of water was the minimum found over all of these swift places, except the one opposite Sentinel Hill,[a] where the depth was not over 3 feet. At high water, which probably occurs in June, all of these small rapids would disappear. Good grass was found on "Coal" Bluffs.

At Sentinel Hill the Colville divides and thence flows in two or more channels. The one nearest the bluffs on the western side of the valley is the deepest. Twenty-four miles below Sentinel Hill the end of the bluffs is reached, and the river, containing four islands, runs in one channel through a flat whose surface is 10 to 15 feet above sea level. The river gradually widens from 1,100 feet at the end of the bluff to 5,000 feet at the head of the delta. The head of the delta, where a very small tide is perceptible, was reached August 13. The main channel has a course N. 30° E. magnetic, and is the one farthest to the right, or the most easterly one. There was not sufficient time to follow this to the sea. It is over 12 feet deep at the head of the delta and apparently continues unbroken to the ocean. This is the only one that would be navigable for river steamers. In the endeavor to find the native village of Nigaluk, several channels were explored and the delta was roughly mapped, but it being evident that we had passed the westernmost or left-hand channel, on which Nigaluk is probably located, and not having time to return, we put out to sea. I estimated the delta to be about 20 miles wide.

Tracks of caribou were numerous on the delta, and later I learned that caribou frequent the coast to avoid the clouds of mosquitoes in the interior. On August 18 we left the delta and its mud flats and followed the coast, which varies from a low beach to ice bluffs 10 to 20 feet high. A camp of natives was seen on the delta, but little information could be obtained from them. They appeared friendly, but were not communicative. On August 20 these natives overtook us, followed by about a dozen umiaks, each containing from three to six persons—men, women, and children—on their way to Point Barrow. As they appeared to weather seas that we dared not

[a] An isolated hill, so named on account of being a prominent landmark.

attempt in our canoes, and as our time was getting short and storms were brewing, I decided to induce these natives to take us in their boats.

Along the coast we were dependent for firewood on the ocean drift. This is abundant in places, but at several camps there was barely sufficient for our need. It does not compare in quantity with that found on the southern coast of Seward Peninsula. Among the logs, which were principally spruce, were noticed a redwood and one or two pines. Drinking water is to be had almost everywhere along the coast, even on the small islands, provided they are covered with moss. It is, however, often brackish.

After losing several days by storms, we arrived at Point Barrow on the evening of September 3, and at Cape Smyth about midnight. Mr. Brauer, agent of the whaling station here, gave us a warm welcome. A steam whaler had left a day or two before, and as no more vessels were expected to pass the point, he supplied us with a whaleboat with which to sail to Cape Hope, where he thought we would likely catch a vessel bound home. We started on September 5, as there was danger of the ice pack being driven in if the wind shifted to the northwest or north.

The coast from Cape Smyth to Cape Beaufort is very low, with a sandy beach, back of which bluffs rise rarely to a height of 75 feet. No high land could be discerned in the interior. Except when prevented by the storms of September 6, 9, 11, 12, and 13, we were constantly working toward Cape Hope, sailing, rowing, or towing.

In the afternoon of September 18 we sighted the funnel and masts of a steamer lying off the coal veins east of Cape Lisburne, and about dark, there being a perfect calm, this steamer, which proved to be the *Arctic*, was boarded. She was taking on a load of coal for Nome, and on the night of September 21 she steamed away, arriving at Nome September 26. Here one of the regular steamers was taken for Seattle, where the party was disbanded.

METHODS OF TOPOGRAPHIC WORK.

At intervals of about 10 miles prominent points adjacent to the river were ascended for topographic sketching on the plane table. Two signals, usually stone cairns about 6 or 7 feet high, were left on each of these points to mark the ends of the base which was to be used in determining the distance to the next station. This next station was usually selected first, so that the base might be laid off at right angles to a line joining the two stations, or as nearly so as the shape of the summit would permit. The direction of the base was always projected on the plane-table sheet to permit of the measurement of the angle between it and a line to any other station that might be occupied. The length of the base was from 300 to 600 feet, and was chosen with regard to the estimated distance and direction of the next station so as to subtend an angle of about 22 minutes, which was measured with the micrometer screw of the alidade.

Between stations a traverse of the river was made with prismatic compass and stenometer. The plat of the traverse was transferred to the plane-table sheet and fitted to the located points. The orientation of the plane table was controlled by the azimuths, determined with the theodolite when necessary.

The method of plane-table locations was followed from Bergman to a point 20 miles beyond the summit, and, judging from intersections on points on either side of the route, it was satisfactory and sufficiently accurate for the publication scale of the accompanying exploration map. The compass and stenometer were used from a point 20 miles beyond the summit to the end of the traverse, on the Arctic coast.

PREVIOUS EXPLORATIONS.

HISTORICAL SKETCH.

Soon after the discovery of America interest was awakened in, and attempts began to be made to find, a northwest passage from the Atlantic to the Pacific Ocean, and these led directly or indirectly to explorations of Alaska and adjacent regions. The discovery of the northwestern side of America, and especially of the Arctic coast of Alaska, was preeminently the work of the English and the Russians.

For the benefit of the reader who may desire to extend his knowledge on this subject, a list of works from which much of the information here compiled has been drawn is given at the end of this chapter. Though the following sketch aims to note the more important of these discoveries and explorations, it does not attempt to be exhaustive.

Samuel Hearne,[a] of the Hudson Bay Company, reached the Arctic Ocean as early as 1770 by way of Coppermine River, in longitude approximately 110°. His journey was considered as demonstrating the practicability of reaching the coast by this route and means of travel, and, what was of much greater importance, the absence of any waterway connecting Hudson Bay with the Pacific Ocean.

In 1778 Captain Cook's expedition,[b] composed of the vessels *Resolution* and *Discovery*, in search of the northeast passage, explored the northwest coast from Norton Sound to latitude 70° 41′, a little north of Icy Cape, where they were obliged by the ice pack to turn back. The conclusion reached at this time (and the correct one it afterwards proved to be) was that no passage existed south of latitude 65°, and that it must be sought north of Icy Cape.

In 1789 Sir Alexander Mackenzie, a member of the Northwest Trading Company, descended to the mouth of the great river which bears his name. In its delta he

[a] Hearne, Samuel, A Journey from Hudson's Bay to the Northern Ocean, Dublin, 1796, p. 162. See also Barrow's Arctic Regions, p. 300.

[b] Cook's Voyage to the Pacific Ocean, 3 vols., London, 1785, vol. 2, pp. 446-465.

located Whale Island, so named by him from the large number of white whales observed at this point. He also made observations on the tide of the Arctic Ocean. His descriptions and locations of channels were later found by Sir John Franklin to be very complete and accurate.

In the year 1815 Lieutenant von Kotzebue,[a] of the Russian Navy, penetrated Bering Strait and explored the sound which bears his name, together with the northwest region as far north as Cape Lisburne. After this time we have no record of this part of the coast until the voyage of Captain Beechey, who explored the larger part of the entire Arctic coast in the years 1825–1828.

In 1826, under the auspices of the Earl of Bathurst, Sir John Franklin descended the Mackenzie to its mouth and surveyed the coast line to the west as far as Return Reef, near longitude 149° W. Acting in conjunction with Franklin, Captain Beechey, of the *Blossom*, had entered Bering Strait and sent a boat expedition in charge of Master Thomas Elson, which in the same year explored the coast as far north as Point Barrow, the northwesternmost point of the American continent.[b] The exploration of the intervening distance, consisting of 160 miles of coast line, between the points reached by Beechey and Franklin on the west and east, respectively, was subsequently completed, and the north coast of the continent was outlined about ten years later, in 1837, by Dease and Simpson, by whom many of the natural features along this section of the coast were named.

In his westward advance beyond the mouth of the Mackenzie, Franklin was the first to round the great chain of the northern Rocky Mountains, consisting here, as he perceived from the coast, of several parallel ranges. These are the Richardson, Buckland, British, Romanzoff, and Franklin mountains. According to Dease and Simpson the portion of the Rocky Mountains visible from the coast does not terminate, as conjectured by Franklin, in the Romanzoff chain, but after a brief interval the Romanzoff Mountains are succeeded on the west by another chain, less lofty but equally picturesque, which was named by Dease and Simpson the Franklin Mountains. These mountains present a precipitous front to the coast.

In the days of these earlier discoverers the above-named parallel ranges, rising from 2,000 to 3,000 feet, were apparently supposed to be the final termination of the Rocky Mountains extending northward from the United States and British Columbia. The great extension of the main axis to the west along the sixty-eighth parallel and its development into a range nearly 100 miles in breadth and 6,000 feet high were unknown. Not until the performance of the work forming the basis of this report was a correct idea of this obtained.

At the same time that Franklin was conducting his discoveries westward along the coast, a detachment of his party proceeded from the mouth of the Mackenzie

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[a] Dall, W. H., Alaska and its Resources, London and Boston, 1870, pp. 329–330.
[b] Voyage of Captain Beechey to the Pacific and Behring's Straits, London, 1836.

eastward, connecting their explorations with those previously made by him near the mouth of Coppermine River.

In the meantime, the Russians, having obtained a foothold in Bering Sea and on the coast to the south, pushed up the Kwikpak, or lower Yukon, which Malakoff,[a] a creole, explored in 1838 as far north as Nulato, below the mouth of the Koyukuk, where he built a small post for the purpose of trading with the natives. In 1842 Lieut. A. Zagoskin, of the Russian Imperial Navy, explored the Koyukuk for 50 miles or more above its mouth, but explorations on the upper Koyukuk were not made until some time after much of Yukon River had been ascended and explored.

While the above explorations were being conducted along the coast during the first half of the century, in the interior the pioneers of the Hudson Bay Company, representing the English, pushed still farther northwestward from their remote outposts on the Mackenzie into regions then unknown, in quest of new fields in which to ply their fur trade. Liard and Dease rivers were explored, and in 1842 Robert Campbell descended the Pelly to its confluence with the Lewes, where Fort Selkirk was subsequently established in 1849. Also in 1842 J. Bell[b] crossed the divide from the Peel River drainage into that of the Porcupine, and in 1847 McMurray descended the Porcupine to its mouth and founded Fort Yukon, on the banks of the river of this name, under the Arctic Circle, whence trade was opened with the natives. Not until two years later, however, when Campbell descended the Yukon from Fort Selkirk, was it learned that the two posts were on the same stream. The river was not ascended to this point from the western coast, however, until 1863, when the trip was made by Ivan Simonson Lukeen, an employee of the Russian American Company, and the Yukon of the English and the Kwikpak of the Russians were found to be identical. Not until then was it fully realized that the Yukon flowed into Bering Sea instead of northward into the Arctic Ocean by way of the Colville, as had been supposed, and as was represented on the maps of our school geographies until and even subsequent to that time.

In 1849 Lieutenant Pullen, of H. M. S. *Herald*, made a boat voyage from Bering Strait to the Mackenzie, and in 1850 the boats of the *Plover*, starting from Cape Lisburne, reached Bailey Island, in longitude 127°. In 1850–1854 Commander Captain McClure, of H. M. S. *Investigator*, proceeded from Bering Strait to Banks Island and Lancaster Strait, where the crew finally abandoned the ship in the ice, and by walking over the ice to Beechey Island discovered and made the northwest passage. Also, in 1850 and 1855, Capt. R. Collinson, of the *Enterprise*, sailed from Bering Strait to near King William Island, in Victoria Strait, whence, being short of coal, he retraced his course to Bering Strait. In 1852–53 the *Plover*, in command of Cap-

[a] Dall, W. H., Alaska and its Resources, London and Boston, 1870, p. 48.

[b] Spurr, J. E., Geology of the Yukon gold district, Alaska: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, p. 104.

tain Maguire, wintered at Point Barrow, in Moores Harbor, whence members of the expedition made journeys southwestward to Tasiak River and eastward along the coast to Return Reef, in longitude 150°, Maguire himself going as far as Smith Bay.

In the autumn of 1860 Robert Kennicott,[a] crossing from the Mackenzie, arrived at Fort Yukon, and in the spring of 1861 descended the Yukon as far as Small Houses.

In 1865 J. T. Dyer and R. D. Cotter,[b] in connection with the Western Union Telegraph expedition, are reported to have made a very creditable exploration of the country between Norton Bay and the mouth of Koyukuk River, on the Yukon.

In 1866 Ketchum and Laberge, explorers for the Western Union Telegraph expedition, ascended the Yukon to Fort Yukon with Lukeen, and later, in 1867, continued their investigations up the river as far as Fort Selkirk.

In 1867 Dr. W. H. Dall, at first in connection with the Western Union Telegraph expedition and later at his own expense, in descending the Yukon, visited the Koyukuk. Though Dall's work was necessarily of a pioneer character, his contributions to our knowledge of the interior of Alaska were very important, as they gave the first clue to the geology of the Yukon Basin.

Astronomic observations made at Nulato by Capt. C. W. Raymond, who ascended the Yukon in 1869, materially aided in more accurately locating the mouth of the Koyukuk, also the position of the upper Koyukuk, which until recently rested largely upon the astronomic determinations subsequently made by him in the same year at Fort Yukon.

The first whaler is reported to have entered the Arctic Ocean in 1848, and since then whaling has there been an important industry.

From 1881 to 1883 a signal service station, in charge of Lieut. P. H. Ray, of the United States Army, was maintained at Point Barrow, which was one of the polar magnetic stations located by international agreement. The report of this expedition and station gives statistics and valuable tables containing results of meteorologic, astronomic, magnetic, zoologic, ethnologic, geographic, and some marine observations. In making inland explorations, a part of the upper course of Meade River was mapped and the Meade River Mountains were discovered.

In 1884 additional valuable information on northwest Alaska, including the Kowak River region, was gathered on the cruise of the *Corwin*, by Capt. M. A. Healey and officers of the United States Revenue Service. Their work was subsequently continued by various other revenue cutters, some of which have visited the northwest coast of Alaska almost every year. Of these visits the most notable is probably that of the U. S. revenue cutter *Bear*, which sent out the winter overland expedition of

[a] Smithsonian Reports, 1861, pp. 39–40; 1864, p. 417.
[b] Dall, W. H., Alaska and its Resources. London and Boston, 1870, p. 277.

Lieutenant Jarvis and Drs. Call and Lopp to Point Barrow, for the relief of the whalers in the Arctic Ocean. These investigations, including the explorations of Kowak River, by Lieut. J. C. Cantwell, and of the Noatak, by Asst. Engineer S. B. McLanigan, of the *Corwin*, were continued in 1885.

In 1885 Lieut. H. T. Allen, of the United States Army, leaving the Yukon by way of the Tozikakat route, reached the Koyukuk near the Arctic Circle and ascended it to near the sixty-seventh parallel. In the same year a detachment of Lieutenant Stoney's expedition crossed from his camp on the Kowak to the lower Koyukuk by way of the Dakli.

During the winter and spring of 1886 further explorations were made on the Arctic slope by Lieut. W. C. Howard,[a] who, on a trip that was productive of important results, crossed from Stoney's camp on the Kowak to the head of the Colville, Chipp (Ikpikpuk) River, and thence by way of the head of Dease Inlet to Point Barrow. Howard's trip showed that a low pass leads through the mountains from the Kowak to the Noatak; that another leads from the Noatak to the upper waters of the Colville, and that on the upper Colville in the region of longitude 156° W. the mountains are succeeded on the north by an undulating country, in which the river has a winding course, with steep banks. Farther northward, down Chipp (Ikpikpuk) River toward the coast, the undulating country is reported to give way to a "dead level waste of tundra."

To the east, Mr. R. G. McConnell, of the Canadian geological survey, descended the Mackenzie in 1888 on geologic reconnaissance work as far as the mouth of Peel River, near the sixty-eighth parallel, whence he crossed by way of the Porcupine to the Yukon.

In 1889 Mr. I. C. Russell, who as geologist accompanied the Alaskan-Northwest Territory boundary survey parties sent out by the United States Coast and Geodetic Survey, ascended the Yukon from its mouth to its source, and soon after published valuable geologic and geographic notes on his observations made along the route.

In 1890 the Arctic coast opposite Herschel Island was visited by Mr. J. H. Turner, of the United States Coast and Geodetic Survey, in connection with the international boundary survey between the Canadian Northwest Territory and Alaska. On this trip Mr. Turner made a geographic reconnaissance from the Porcupine across the Davidson Range, following the one hundred and forty-first meridian, which resulted in a material contribution to our knowledge of the mountains and country in this region.

In 1892–1894 Mr. Frank Russell, under the auspices of the Iowa State University, descended the Mackenzie, principally to make ornithologic and ethnologic investigations.[b]

[a] Stoney, Lieut. George M., Naval Explorations in Alaska, U. S. Naval Institute, Annapolis, Md., 1900.
[b] Russell, Frank, Explorations in the Far North, published by the University of Iowa, 1898.

In 1896 extensive geographic and especially geologic contributions were made to our knowledge of the Yukon Basin by a United States Geological Survey party in charge of Mr. J. E. Spurr,[a] who descended the river and mapped the gold- and coal-producing districts.

Owing to the extended interest taken in Alaska by reason of the Klondike discoveries, during the years 1897 and 1898 the Koyukuk[b] was visited by 1,200 or more prospectors, miners, and adventurers, many of whom ascended the river by steamboat nearly to the Arctic Circle. Some of these subsequently explored and prospected various tributaries as far up as latitude 67° 30′. Many spent the winter of 1898–99 here. During approximately the same period, 1897–98, some of the prospectors who had ascended the Kowak crossed the divide to the northeast and reached the Koyukuk by way of the Alatna.

In 1899 a United States Geological Survey party,[c] conducting a reconnaissance traverse from Fort Yukon to Nulato, ascended Chandlar River, and, crossing from its headwaters, mapped the Koyukuk from near the head of its middle fork, near the sixty-eighth parallel, to the mouth of the river at the Yukon.

During the summer of 1900 a party of prospectors crossed the divide between the head of the Koyukuk and the Arctic drainage by way of Dietrich River and descended the Arctic slope along the one hundred and fiftieth meridian to a point probably a little north of the sixty-ninth parallel. From a personal interview with members of this party the writer infers that the country is passable by pack train. It is, however, mountainous and is reported to contain some glaciers of considerable size, but these are probably valley glaciers only. To the east of this the country has been traversed by deserters from whaling vessels at Herschel Island, who made their way in a destitute condition from the coast to the Yukon by way of Chandlar River. From accounts given by some of these men in a personal interview, the writer obtained the impression that this part of the region is largely a waste of rugged mountains, containing some glaciers, which are probably confined to the heads of the valleys.

During the season of 1901 a geologic reconnaissance survey was also made from Fort Hamlin, on the Yukon, by way of Dall, Koyukuk, Alatna, and Kowak rivers, to Kotzebue Sound by a party in charge of Mr. W. C. Mendenhall.[d]

During the years 1901 to 1903 the region lying between the Colville Basin and the international boundary was visited, it is reported, by S. J. Marsh and T. G. Carter, two prospectors who landed at Camden Bay in the fall of 1901, and,

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[a] Spurr, J. E., Geology of the Yukon gold district, Alaska: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898.

[b] Schrader, F. C., Preliminary report on a reconnaissance along the Chandlar and Koyukuk rivers, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 458.

[c] Op. cit.

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

proceeding inland during the following winter, prospected without success on Kugrua River, about 90 miles from the coast, during the summer of 1902, where they remained in camp during the next winter, in latitude approximately 69°, longitude 146°.

Mr. Marsh reports that this section of the country is barren or timberless, and consists largely of tundra swamps and niggerheads, underlain by rocks which he regards as a geologically young and nonmineral-bearing limestone formation. The country is reported to be plentiful in game, of which caribou, bear, wolves, foxes, and ptarmigan are the most important, the latter being very abundant. Kugrua River, which flows northward into the Arctic Ocean, is estimated to be about 280 miles long. Besides the Kugrua, four other rivers of considerable size are reported to enter the ocean between the Turner and the Colville.

In the spring of 1903 Mr. Marsh crossed the divide to the south of the Kugrua, where he reports that he found a mineralized zone on the headwaters of Chandlar River, which stream he descended to the Yukon.

During the summer of 1903, it is reported, a prospecting party, of which James L. Reed and Walter Lucas were members, crossed from the Kowak by way of the headwaters of the Noatak and of the Alatna, a tributary of the Koyukuk, to the Killik, a tributary of the upper Colville, which they descended to its mouth. The Killik is said to transport much floating ice, to be about 100 miles long, and to have many rapids in the lower 50 miles of its course. They then explored the Colville for a distance of 175 miles below the mouth of the Killik and for 50 miles above it, and found this section of the Colville to be 400 to 500 yards wide and navigable, with a current of about 6 miles an hour. The topography of this part of the basin is reported to be undulating, with low hills, as described by Howard, and the rocks to consist of a sandstone formation in which thick veins of bituminous coal crop out along most of the creeks. This coal was burned by the prospectors in their camp fires. As no trace of gold was found, the formation is inferred to be probably nonauriferous.

Excepting willows, which occur along the streams, and are often of large size, the country is timberless; there is no spruce. Game is present and caribou are plentiful.

CHRONOLOGIC LIST OF WORKS EXAMINED.

1784. COOK, JAMES. A voyage to the Pacific Ocean * * * for making discoveries in the northern hemisphere. 3 vols. Vol. 2. London. 4°. 421, 548, and 556 pp.

1796. HEARNE, SAMUEL. A journey from Prince of Wales's fort, in Hudson's Bay, to the Northern Ocean * * * in the years 1769, 1770, 1771, and 1772. Dublin. 8°. 459 pp., 5 maps, 4 pls.

1801. MACKENZIE, Sir ALEXANDER. Voyages from Montreal on the River St. Laurence through the continent of North America to the Frozen and Pacific oceans, in the years 1789 and 1793. 4°. viii, cxxxii, 412 pp., 3 maps, 1 pl. London.

1821. KOTZEBUE, Lieutenant OTTO VON. A voyage of discovery into the South Sea and Bering Straits, * * * 1815–1818. 3 vols. Vol. I, pp. 187–240. London. 8°. xvi, 358, 442, 433 pp., 7 maps, 7 pl.

1828. FRANKLIN, Sir JOHN. Narrative of a second expedition to the shores of the polar sea in the years 1825, 1826, and 1827. Philadelphia. 8°. 318 pp., 1 map.

1831. BEECHEY, F. W. Narrative of the voyage of the *Blossom* to the Pacific Ocean and Bering Straits. London.

1836. BEECHEY, F. W. Voyage of Captain Beechey to the Pacific and Behring's Straits, 1825–1828. London.

1843. SIMPSON, THOMAS. Narrative of the discoveries of the north coast of America effected by the officers of the Hudson's Bay Company during the years 1836–1839. London. 8°. xix, 419 pp., 2 maps.

1848. MOORE, Commander T. E. L. General proceedings of Commander T. E. L. Moore, of H. M. S. *Plover*, through Bering Straits and toward Mackenzie River, 1848–49. British Blue Books. London.

1850. SHILLINGLAW, JOHN J. Narrative of Arctic discovery from the earliest period up to the present time. London.

1854. McCLURE, ROBERT. Cruise of the *Investigator*, by Captain McClure. Blue Books, Accounts, and papers. Navy. Vol. 42.

1854. British Blue Books. Arctic expeditions, 1854–55. Vol. 35.

1857. ARMSTRONG, ALEXANDER, M. D., R. N. A personal narrative of the discovery of the northwest passage. * * * London. 8°. xxxii, 616 pp., 1 pl., 1 map.

1861. KENNICOTT, ROBERT. Exploration of the Hudson's Bay territory. In Smithsonian report, 1861, pp. 59–60. 8°.

1861. RICHARDSON, Sir JOHN. The polar regions. Edinburgh. 8°. ix, 400 pp., 1 map, 1 pl.

1864. KIRBY, W. W. A journey to the Youcan, Russian America. In Smithsonian report, 1861. pp. 416–420. 8°.

1868. DALL, W. H. Explorations in Russian America. American Journal of Science, 2d ser., vol. 45, pp. 96–99. 8°.

1869. WHYMPER, FREDERICK. Travel and adventure in the Territory of Alaska. * * * New York. 8°. xvix, 353 pp., 1 map, 16 pl. German edition: Alaska. Reisen und Erlebnisse in hohen Norden. Translated by Dr. Friedrich Steger. Braunschweig, 1869. 8°. 1 map, 16 pl.

1870. DALL, WILLIAM H. Alaska and its resources. London and Boston. 8°. xii, 628 pp., 13 pl.

1871. RAYMOND, Capt. CHARLES W. Report of a reconnaissance of the Yukon River, Alaska Territory, July to September, 1869. By Capt. Charles W. Raymond, Corps of Engineers, U. S. Army. Senate, Executive documents, No. 12. 42d Congress, 1st session. 8°. 112 pp.

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POPULATION AND CONDITIONS.

ON THE KOYUKUK.

Natives.—So far as can be judged, there are about 100 native inhabitants on the upper Koyukuk. The United States census for 1900 places the population of Peavey village, near the South Fork of the Koyukuk, at 35. The settlements of the Koyukuk natives, each consisting usually of a few cabins and tents, are sparsely scattered along the river from below the Arctic Circle to the sixty-seventh parallel of latitude. They are generally located at the mouth of some tributary stream, as in the case of Alatna River, Pickarts Creek, and Kanuti River. Their village at Bettles, which is larger than most others, forms an exception to the above rule, and exemplifies the disposition of the natives to remain near a trading post and the abode of white men.

At the post the natives are frequently employed by the whites for boating, sledding, and other work, for which service they receive provisions and clothing, which, added to what they get of game and fish, make up their living. They take but little interest in prospecting or mining. Apart from the partial sustenance they procure at the post, their chief source of food and clothing is the wild Alaskan reindeer or caribou, bear, salmon, whitefish, rabbits, grouse, and ptarmigan.

The Koyukuk country is also visited by the Kowak natives from the northwest, a more hardy and industrious race than the Koyukuks.

Whites.—After the exodus of the thousand or more inexperienced adventurers who in the Klondike rush reached the upper Koyukuk in the fall of 1898, wintered there, and disappeared from the country almost with the ice when navigation opened in the following spring, about a hundred sturdy men, mostly prospectors and miners who had arived with the influx the preceding fall, remained. Stimulated by the discovery of placer gold, they continued to prospect and began to mine some during the summer and engaged to some extent in development work during the following winter. In the meantime, especially in the months of February and March, 1900, as the reports of the presence of gold became authenticated, many people from various camps along the Yukon were attracted thither. This materially increased the mining activity of the district, which in a general way has continued to the present time; so that in 1901–2 about 200 white people, mostly miners and prospectors, wintered there, and at present[a] (1903–4) they number about 350, the most of whom are prospecting or doing development work about the mines. Besides the people who winter there, many others reside there during the summer only, while working their claims. Since the discovery of gold the wage for the district has been $12 a day. Ground that will not yield this amount or more is not worked. Board is $6 a day.

Transportation and means of travel.—Since 1900 there have been two supply posts[b] in the country, Bergman and Bettles, both operated by the Northern Commercial Company, successor to the well-known Alaska Commercial Company. Of these posts, the lower and usually the best stocked is Bergman, at the head of steamboat navigation, near the Arctic Circle, and about 450 miles above the mouth of Koyukuk River. At high water, however, in both spring and fall, steamboats ascend with freight to Bettles, near the sixty-seventh parallel, about 80 miles above Bergman. From Bettles, which has become the leading distributing point for the country, the supplies are conveyed to the various mining camps, about 75 miles farther up the river, by rowboat during the open season, or, preferably, by dog sled in the winter. The country is also reached by pack train from the Yukon in summer, by way of Chandlar River from Fort Yukon and by way of Dall River from near Fort Hamlin, the distance in each case being about 150 miles. Pack horses have been used to some extent during the last few summers, both for packing and for working at the mines, but the heavy snowfall renders the horse unfit for winter use. A shorter route than either of the above, leaving the Yukon at a point about midway between the Dall and the Chandlar and about 100 miles from Coldfoot direct, is now being investigated.

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[a] Information on present (1903) conditions in the district has been contributed by Mr. L. M. Prindle, a member of the Survey, to whom it was recently furnished by miners en route from there to the States.

[b] Besides these, the company keeps a branch post at Coldfoot.

The principal post-office is at Bettles, but mail is also distributed from Bergman and from Coldfoot, at the mouth of Slate Creek. The judiciary of the district, consisting of United States commissioner, probate judge, coroner, and recorder, is located at Slate Creek, near the center of the mining region. Since early in 1901 these offices have been held by Judge D. A. Mackenzie, a former citizen of Seattle, and one of the pioneers of the Koyukuk country.

The placers.—The gold placers are shallow deposits, well suited for development by men of moderate means, who are able and willing to work. No one, however, should go to this country intending to mine without taking with him a year's supplies, commonly known as a "grub stake," or its money equivalent, about $1,000. The mining period is confined to about 2½ months in summer.

The placers now being worked extend over a large area, but occur chiefly on the middle drainages of the Middle and North forks of Koyukuk River, where they embrace a score or more creeks with their tributary gulches, some of which have been discovered recently. The gold is coarse. The yield of the district to date, as shown on page 102, is about $717,000.

ON THE ARCTIC COAST.

Natives.—With the exception of about a dozen white persons at Cape Smyth, near Point Barrow, and some at Point Hope, the bleak Arctic coast of northern Alaska is inhabited only by the Eskimo. From the international boundary to Point Hope, through a distance of 800 miles, the native population aggregates about 1,500 persons. Their settlements are far apart. The principal ones are those of Point Hope, Cape Smyth, Nuwuk at Point Barrow, Nigaluk at the mouth of the Colville, and Barter Island about 150 miles farther east. There is also a settlement at Herschel Island, east of the international boundary, and one in the Mackenzie River delta. There is yearly communication between all these points. The census of 1900 credits Point Hope village with a native population of 314, and the settlement of Cape Smyth, probably including Nuwuk,[a] with a population of 623. That of Nigaluk, at the mouth of the Colville, also probably amounts to about 200. There are also smaller settlements or single huts at points along the coast, as at Wainwright Inlet and Icy Cape, which are occupied in winter but generally vacated in summer.

The principal food supply contributed by the sea is derived from the whale, walrus, seal, polar bear, and some small fish. Salmon, herring, smelt, and other small fish are found in the inlets and rivers. During the summer season there are large numbers of geese and ducks. The principal land quadrupeds are Alaskan wild reindeer or caribou, brown and black bear, wolverine, marten, wolf, hare, lynx,

[a] Nuwuk, meaning in Eskimo "the point," is the name of the native village on Point Barrow proper, while the main settlement of the white people, where are the trading post, mission, and post-office Barrow, is 9 miles southwest of Point Barrow, at Cape Smyth, to which the name Point Barrow is generally though somewhat incorrectly applied.

fox, beaver, muskrat, and lemming. Of these, the most important for food and clothing, and fortunately the most abundant, is the caribou, whose migrations the natives follow. Berries and roots are also used for food by the natives.

As the coast region is destitute of timber, affording only a few dwarfed willows at distant points along the rivers and inlets, the principal fuel of the natives is driftwood, most of which has been discharged into the ocean by the larger arctic rivers, whose headwaters lie in forested regions. This is fairly well distributed along the coast, but is not so abundant as often supposed.

The Alaskan Eskimos, so far as seen by the writer, are not the dwarfed race of people they are often depicted. The men will probably average nearly 5½ feet in height and 150 pounds in weight. They are generally robust, muscular, and active, inclining rather to angularity than to corpulence. The face may be described as flat, broad, and rounded, with high cheek bones. The eyes are brown or dark and the hair is black. As a people they are relatively intelligent and industrious and appear to be reasonably honest and moral. They are hospitable, good-humored, and cheerful, apparently free from care, and generally patient and tactful in manner. Their feelings have been described as lively but not lasting, and their temper is frequently quick but placable. The conjugal and parental affection is strong. Though thankful for favors, their gratitude is of short duration.

Owing to its mixture with that of representatives of other races who reach the arctic regions, principally on whaling vessels, the blood of the Alaskan Eskimo is rapidly losing its purity. Children of pure Eskimo blood are reported to be very few.

Whites.—There are at present about a dozen white persons living at Point Barrow. There is a mission school here at present, in charge of Doctor and Mrs. Call. A trading post, maintained here by the Cape Smyth Whaling and Trading Company for purposes of trade with the natives and whalers, is now in charge of Charles Brauer. The keepers of the post engage to some degree in whaling, in which they employ the natives. Early in April the whaling parties proceed by dog sled 10 or more miles out over the ice to the open sea, where they pursue their calling in open skin boats.

Point Barrow is almost annually visited by vessels of the United States Revenue Service and by various whaling vessels. Ten of the latter are reported to have called there during the summer of 1901. Whaling in this part of the Arctic Ocean has been carried on with varying success by several companies during the last half century, but is now reported to be on the decline. The pursuit is hazardous, as the vessels are often caught in the ice pack.

In 1901 effort was being made by a Japanese to establish a small trading post at the mouth of Staines River, near the one hundred and forty-sixth meridian.

Transportation and means of travel.—Transportation and travel in this barren region is principally by native skin boats along the coast and streams during the short open summer, and by dog sled over the snow and ice in winter; though the north coast Eskimos sometimes make trips into the interior from the mouth of Chipp (Ikpikpuk) River southward to the head of Colville, Noatak, and Kowak rivers. Their knowledge of the country in general is not definite beyond a distance of 40 or 50 miles from the coast.

The native skin boats, or umiaks, are usually made of walrus skin. Being light, flat-bottomed, and responsive to sail, they are admirably adapted for use in the shallow waters of the deltas and tidal mud flats so characteristic of the Arctic coast, and for small craft are very seaworthy.

TABLE OF DISTANCES.

The following table, prepared by Mr. Peters, is here inserted to afford an idea of approximate distances along the route of travel.

Distances up John River.

Mouth of John River	0
Fool Creek	51
Hunt Fork	92
Rocky Gorge	106
Anaktuvuk Pass	120
Cache Lake	125

Distances down Anaktuvuk and Colville rivers.

Cache Lake	0
Canyon	43
Small grove Balm of Gilead	54
Ice field	63
Two native huts	101.5
Mouth of Anaktuvuk River	114
Rapid [a]	117
Rapid [a]	119.5
Rapid [a]	121
Sentinel Hill	140
Rapid [a]	143
Rapid [a]	147
Rapid [a]	157
Ocean Point	164
Head of delta	192.5
Arctic Ocean	212

[a] These rapids are short stretches of the river, running about 6 or 7 miles an hour, with no rough water.

Distances along coast from Colville River to Cape Smyth.

Middle channel of Colville River	0
West channel	17
Cape Halket	67
Pitt Point	90
Simpson Cape	137
Tangent Peak	189
Point Barrow	198
Cape Smyth	207

GEOGRAPHY.

LOCATION AND GENERAL FEATURES.

The region here considered, as shown on the outline map, Pl. I, lies in northern Alaska, mainly in its middle part. The area covered by the detailed maps (Pls. II and III) trends in a nearly northward direction from the sixty-sixth parallel of latitude approximately along the one hundred and fifty-second meridian to about the seventy-first parallel at the Arctic coast, a distance of about 400 miles. The maps are based entirely on observations made during the present exploration along Koyukuk, John, Anaktuvuk, and Colville rivers, except that to these have been added some notes of observations made by Mr. T. G. Gerdine and the writer in the Koyukuk district in 1899.

Geographically the region consists of three well-marked provinces—the mountain or middle, the Koyukuk or southern, and the Arctic slope or northern.

Orographically the mountain range, forming the middle province, is regarded as a northwestern continuation of the Rocky Mountain system of the United States, which, extending northwestward through Canada nearly to the Arctic Ocean, bends abruptly to the west beyond the Arctic Circle and trends nearly westward across northern Alaska, forming the great trans-Alaskan watershed between the Yukon Basin on the south and the Arctic Ocean on the north. In its northward and finally westward course the range forms a prominent feature of the "concentric" orography of Alaska, and embraces in its southward-facing curve the great basin of the Yukon and the well-known, but not always well-defined, Yukon Plateau.

From its character and relation to the range, it seems probable that the gently rolling plain bordering the mountains on the north and sloping gently to the Arctic Ocean may be physiographically correlated with the Great Plains in western United States, while the basin of the Yukon corresponds to the great Interior Basin of the West, lying between the Rocky Mountains and the Coast Range.

In their trend across Alaska the mountains agree with those in the Canadian territory adjacent to the east, which extend nearly to Mackenzie River. In the region north of the mountains, both in Canadian territory and in Alaska, the valleys trend northward toward the Arctic coast, while those on the south trend southwestward toward the Yukon.

Considering the country more in detail, we may note that the line of profile extending through the region as a whole, in a north-south direction (see Pl. II), beginning on the south, at the sixty-sixth parallel, traverses for the first 120 miles of its course an undulating country whose low, rounded hills attain elevations of from 1,000 to 3,000 feet. It then crosses a rugged range of mountains 100 miles wide and about 6,000 feet high, whence it descends steeply to the elevation of 2,500 feet at the inland edge of a gently northward-sloping plateau or rolling plains country (Pl. IV). It then traverses this rolling plain for 80 miles, and thence passes for about 80 miles through a nearly flat, tundra country or coastal plain to the Arctic coast.

To facilitate description each province will be treated separately.

MOUNTAIN PROVINCE.

The most striking is the middle or mountain province, which, as noted, consists of an inland range of rugged mountains trending east and west across the field between latitudes 67° 10′ and 68° 25′, as shown on the topographic map, Pl. II. These mountains here have a width of about 100 miles and an average elevation of about 6,000 feet.

It is unfortunate that the term Alaskan has already been applied to a local range lying south of the Yukon, as that name would seem to be the most fitting term by which to designate this portion of the great Rocky Mountain system, which here extends east and west entirely across the northern part of the Territory. That these mountains are regarded as a northwestward continuation of the Rocky Mountain system has been noted. and the term Rocky Mountains has been broadly applied to them on the map.

That portion of the main range lying between the international boundary and Mackenzie River has been called the Davidson Mountains, while to the several small groups on the north, between the main range and the coast, and extending from the one hundred and thirty-eighth to the one hundred and forty-eighth meridians, the names Richardson, Buckland, British, Romanzoff, and Franklin have been applied. They are all probably more or less closely connected with the main range, from the northern side of whose great bend to the southwest between Mackenzie River and Colville River they seem to branch. So far as known they trend in a general northwestward direction, but have a somewhat imbricated relationship, each group tending to overlap the inland part of the one next to the west. They seem to represent the northward dying out of the range near the Arctic coast. If they are considered a part of the range in the region of the one hundred and forty-seventh meridian, they give to it a breadth of about 210 miles. In elevation these groups lie generally between 2,000 and 4,000 feet, while the height of the main range near the international boundary is from 5,000 to 7,000 feet. From this point, with but slight if any decrease in elevation, the range continues westward to the one hundred and fifty-third meridian, beyond which, in the region at the head of Colville and Noatak rivers, it diminishes in height, and seems to divide into two parts or ranges. Of these, the northern range, continuing westward, terminates in the low mountains and abrupt sea cliffs of Paleozoic rocks at Cape Lisburne (see Pl. V and fig. 1), while the southern forms the divide between Noatak and Kowak rivers.

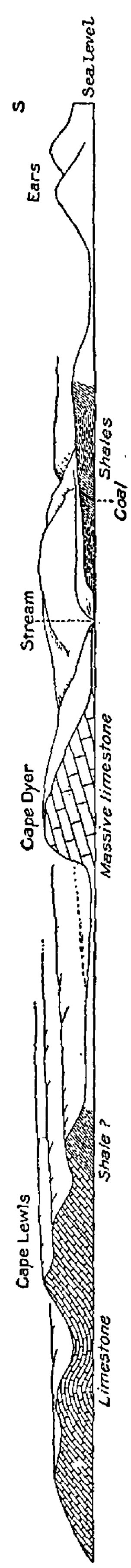

FIG. 1.—Sketch section of supposed Paleozoic rocks on the coast south of Cape Lisburne.

ENDICOTT MOUNTAINS.

GENERAL FEATURES.

It is probably to the range between Noatak and Kowak rivers, as seen from Lookout Mountain, on the Koyukuk, that Allen in 1885 gave the name Endicott Mountains. Though the name appears on Allen's map,[a] and is referred to in the text of his report, it is not known to have come into use or to have appeared on any of the numerous succeeding Alaskan maps. Allen refers to the mountains of this region as comparatively low, and says the highest are the Endicott Mountains, between Koyukuk and Kowak rivers, which, extending northward, were supposed to contain the headwaters of Colville River. The highest peaks were estimated at 4,000 feet. As printed on Allen's map, however, the term is given a broader significance, applying to practically the entire portion of the range embracing the headwaters of the Koyukuk and the sources of the drainage ways which flow in an opposite direction into the Arctic Ocean, between the one hundred and forty-fifth and one hundred and fifty-fourth meridians. As the term embraces and seems fittingly to apply to all that part of the range considered in this report, it will here be retained, and the mountains will be referred to in this report as the Endicott Mountains.

Where crossed by the Geological Survey party the range lies between the rolling, hilly country of the Koyukuk Basin on the south and a very gently undulating plateau country on the north. On the south the rise from the rolling country to the mountains is by foothills, but rapid. On the north the mountains break off abruptly, much as they do along the edge of the Great Plains in western United States.

[a] Allen, Lieut. H. T., Reconnaissance in Alaska, 1885, Washington, Government Printing Office, 1887.

Pronounced faulting and uplift are evidenced by marked deformation of the strata and in some places by fault scarps miles in extent.

The comparatively regular southern edge of the range trends approximately east and west, in latitude 67° 10′, while the northern edge, where it was crossed, in the region of Anaktuvuk River, latitude about 68° 25′, presents a concave front to the north, as shown on the maps (Pls. II and III). This crescentic feature is repeated by several low concentric ridges in the Anaktuvuk Plateau to the north. These seem to have been formed by a part of the same orographic uplift as the main range, for they lie parallel with its front and grow weaker and finally die out northward with increase of distance from the seat of maximum uplift.

West of the Anaktuvuk the crescentic front of the range soon gives way to a more nearly westward trend, bearing in the direction of Cape Lisburne. To the east of the Anaktuvuk, however, the curved front continues in a northeasterly and finally north-northeasterly direction, so that in about latitude 70° and longitude 147° it reaches a point within 35 miles of the coast, where it merges with the Franklin Mountains, one of the northern groups previously noted. From this point eastward to Mackenzie River the northern edge of the mountains continues near the coast.

Along the one hundred and fifty-second meridian the range is somewhat higher in the northern than in the southern part, and contains two distinct orographic axes, the surface of the northern having an elevation of a little more than 6,000 feet, and that of the southern somewhat more than 5,000 feet. Between these axes there is a slight depression, where the surface has apparently been somewhat more rapidly reduced by erosion in soft rocks. This is notably true on the west side of John River, somewhat north of the middle of the range, where in the region of the sixty-eighth parallel and the one hundred and fifty-third meridian the country between the head of Hunt Fork, which flows southeastward into John River, and the head of the Colville on the northwest, probably does not exceed 5,000 feet in elevation.

The topography of the range varies, depending on the character and structure of the rock formations. That of the Fickett series, composed of phyllites, slates, quartzites, and conglomerates, is characterized by sharper crests and peaks than the limestone areas, whose ridges, being broader and more rounded, are often studded by knobs and bordered by steep cliffs, with extensive slopes of heavy talus at their foot.

Though marked cliffs and precipices occur, the side slopes of the valleys, as shown in Pl. VI, *A*, can generally be ascended without difficulty. They are moss covered to within about 2,000 feet of the top of the mountains, where steeper slopes of barren rock and talus begin. Exceptions occur in the faulted Paleozoics in the northern side of the range, at the head of the Anaktuvuk, where some scarps rise abruptly to a height of several thousand feet above the valley.

ANCIENT PLATEAU FEATURE OF ENDICOTT MOUNTAINS.

Where best observed on this reconnaissance, principally on John and Anaktuvuk rivers, a view across the top of the range presents the general appearance of an ancient plateau or peneplain from which, by deep dissection, the mountains have been carved. The former surface of the plateau is evidenced by numerous closely crowded peaks, rising generally to an elevation of 6,000 feet, where they present an even sky line, as shown in Pl. VII, *A* and *B*. For this plateau feature of the range the name Endicott Plateau is proposed. About 4,000 feet below this level lie the floors of the main valleys, at an elevation of about 2,000 feet; and the open Anaktuvuk Pass, near the northern edge of the range, between John and Anaktuvuk rivers, is at an altitude of scarcely 2,500 feet.

Since for geologic purposes the accompanying geologic section (see section on Pl. III) is confined to the line of traverse along the valleys, where the elevation has been much reduced by erosion, the profile of the section does not express the plateau character of the range. This feature is probably best shown in the illustrations forming Pl. VII, which are reproduced from photographs taken on the upper part of John River, near the top of the range, at an elevation of about 6,000 feet.

It seems to the writer not improbable that, as our knowledge of the physical geography of Alaska becomes more complete, it will be found that the Endicott Plateau, including its extension to the east, possibly beyond the Davidson Mountains, may be correlated with the Chugach Plateau, a similarly dissected plateau surface, which is observed in the westward continuation of the St. Elias Range, at an elevation of about 6,000 feet.[a]

The interstream areas, which in general rise to the surface of the Endicott Plateau, are rarely flat topped, but consist of a network of peaks connected by irregular and often sharp-crested ridges. Only occasionally does an isolated peak rise a little above the general level of the plateau. None that could be observed are monadnocks.

The relation of the Endicott Plateau to the supposed Yukon and Koyukuk plateau features, to be considered later, is diagrammatically illustrated in fig. 2 (p. 44). So far as known, no rocks younger than Lower Carboniferous have been found in the Endicott Plateau. But as it seems not improbable that Upper Carboniferous and possibly even Lower Mesozoic rocks may be present in the Fickett series, it does not seem safe to suggest for the plateau an age earlier than Mesozoic. It seems undoubtedly older than the supposed Yukon Plateau, which in turn is considerably older than the Koyukuk Plateau, as the latter lies at a much lower level and is composed of rocks which are in part Cretaceous, and some possibly younger.

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[a] Schrader, F. C., and Spencer, A. C., Geology and Mineral Resources of a Portion of the Copper River District, Alaska; a special publication of the U. S. Geol. Survey, 1901.

See also Schrader, F. C., A reconnaissance of a part of Prince William Sound and the Copper River district, Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, p. 375.

A. INLAND EDGE OF ANAKTUVUK PLATEAU AND NORTH BASE OF ENDICOTT MOUNTAINS.
From surface of the plateau at 2,200 feet; looking southwest.

B. LISBURNE LIMESTONE AND FICKETT SERIES IN ENDICOTT MOUNTAINS AT HEAD OF JOHN RIVER.
From an altitude of 6,000 feet; looking west. Fickett series is in left background.

Since the Yukon Plateau, as to whose age there is slight difference of opinion, has been shown by Dawson,[a] Spurr,[b] and other writers to be due to Eocene or early Neocene erosion, if the present writer is correct in his supposition concerning the representation of this plateau feature in this northern field, the interrelations of the several features here make it obvious that the Endicott Plateau, which is certainly post-Lower Carboniferous, must be at least pre-Neocene and is probably considerably older, and that the Koyukuk Plateau is at least post-Eocene and possibly considerably younger.

DRAINAGE.

In the portion of the range crossed by the Survey party the drainage is principally southward into the Koyukuk. The master stream is John River, which rises near the northern edge of the range. The main drainage ways are therefore transverse, extending across the strike and trend of the rocks, as well as across the trend of the range. The small tributaries, being nearly always controlled by rock structure, flow in general along the strike and enter the master stream at right angles, producing a rectangular drainage system.

Though John River Valley is intramontane and contains some canyons, it is broad and in general open. A portion of it, near the middle part of the range, seems to lie in a syncline in the Fickett series, trending a little east of south. The valley probably averages about 1½ miles in width, from base to base of the mountains. Portions, however, are much wider and contain flats, through which the river freely describes great bends from side to side. The present stream channel has apparently been sunk into several older valley floors, as is shown by the bed-rock benches along the sides of the valley. Of these benches the most pronounced occur at heights of 1,700 feet, 600 feet, and about 100 feet above the present stream, and seem to mark stages of comparative rest in the progress of orographic uplift. It is probable that the 600-foot bench may be correlated with the benching noted on the Koyukuk, in the region of Red Mountain.[c]

At the head of John River, benches sloping northward against the present drainage seem to denote that a considerable area lying at the head of this stream formerly drained northward, through the Anaktuvuk and the Colville, into the Arctic Ocean, instead of southward, through the Koyukuk and the Yukon, to Bering Sea, as at present.

The bed-rock benching and the topography of the lower side slopes of the valley are frequently found to have been materially modified by ice action, which has

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[a] Dawson, G. M., The physiographical geology of the Rocky Mountain region in Canada: Trans. Royal Soc. Canada, vol. 3, 1890, sec. 4, pp. 1-74.

[b] Spurr, J. E., Geology of the Yukon gold district, Alaska: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 257-265.

[c] Schrader, F. C., Preliminary report on a reconnaissance along the Chandlar and Koyukuk rivers, Alaska, in 1899: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 468.

eroded the rocks and brought down deposits of gravel and drift, as shown in Pl. VI, *B*. Such deposits, however, rarely attain a thickness of more than 100 feet.

The John River system, just described, is believed to be a fair type of the other adjacent drainage systems of the mountains, such as Hokotena River or Wild Creek and North Fork, which trend parallel to it and also flow south into the Koyukuk.

KOYUKUK PROVINCE.

GENERAL FEATURES.

This province, extending from the southern base of the mountains 120 miles southwestward to the limit of the map at the sixty-sixth parallel, lies mainly in the northwestern part of the large basin of the Koyukuk, which forms the northwestern part of the Yukon Basin.[a] It consists mainly of a rolling or hilly country of known and supposed Mesozoic rocks, whose hills rise to elevations of from 1,000 to 3,000 feet, while the main valley floors lie at approximately 600 feet.

The general accordance in height of the hills and ridges of this province at two different levels strongly suggests that the present topography has been carved from two

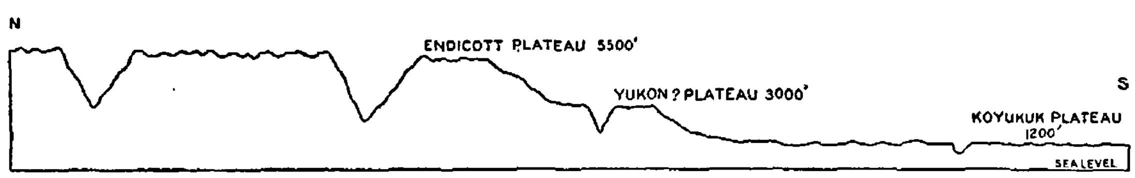


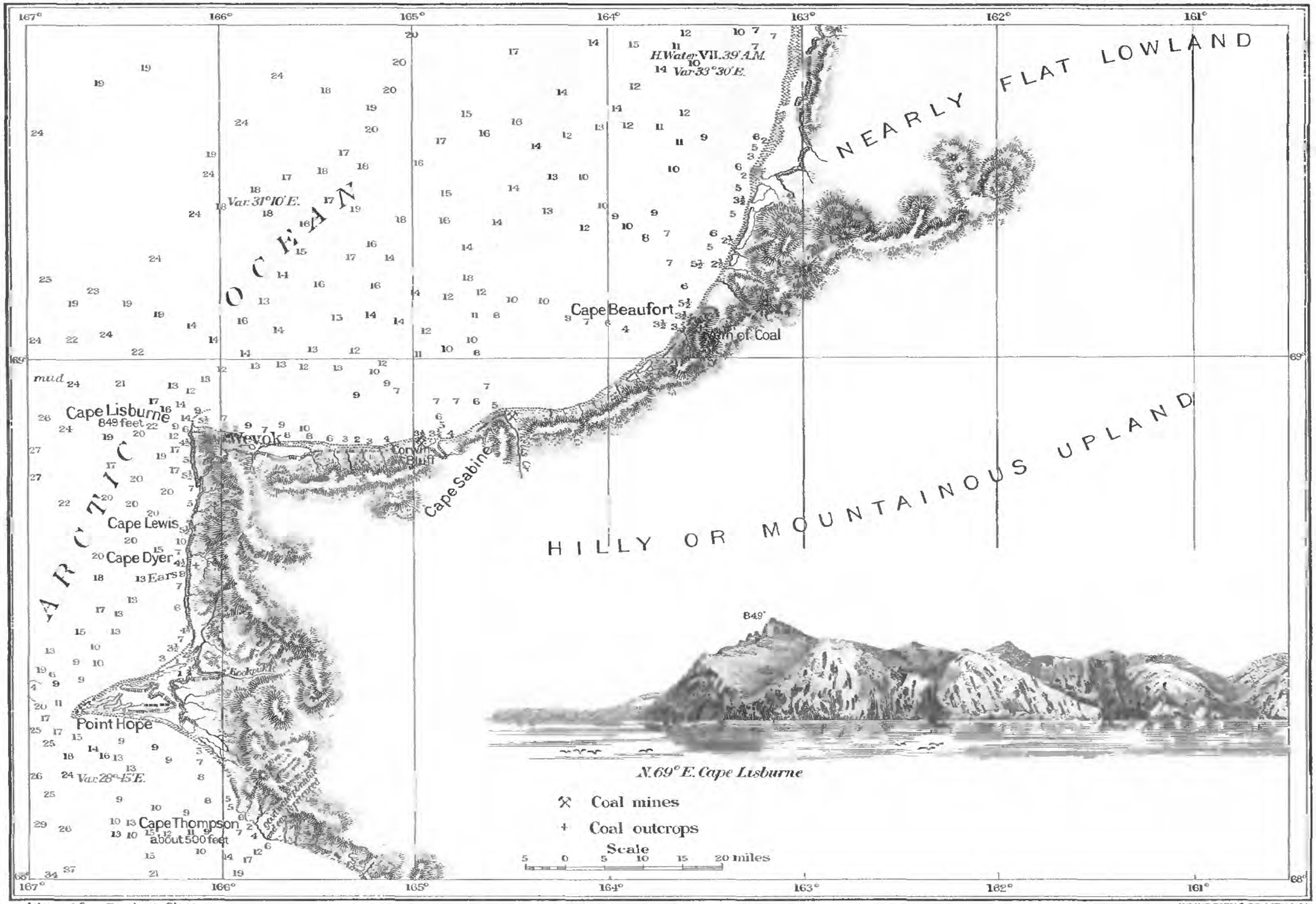
FIG. 2.—Diagrammatic profile showing relations of Endicott, Yukon, and Koyukuk plateaus.

former plateau features (see fig. 2). Though, for need of further investigation, this question can not be discussed in detail in this place, it may be noted that of these two features the lower level, at about 1,200 feet, is relatively distinct and well marked, and represents the general elevation of the land mass over the larger part of this portion of the Koyukuk Basin, as may be seen on the map (Pl. II). For it the name Koyukuk Plateau is suggested.

The higher level, which also suggests a former plateau now dissected and largely removed by erosion, lies at about 3,000 feet, but it is indefinite. Its best expression occurs along the base of the mountains, 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. This higher level, where formerly observed, at an elevation of from 2,500 to 3,000 feet, to the east, on Chandlar and upper Koyukuk rivers, near the sixty-seventh parallel, was supposed to represent the Yukon Plateau,[b] but

[a] For a more complete description of the Koyukuk Basin the reader is referred to Preliminary report on a reconnaissance along the Chandlar and Koyukuk rivers, Alaska, in 1899: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 467. See, also, Recent work of the United States Geological Survey: Bull. Am. Geog. Soc., vol. 34, No. 1, Feb., 1902.

[b] Schrader, F. C., Preliminary report on a reconnaissance along the Chandlar and Koyukuk rivers, Alaska, in 1899: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 99.



Adapted from Beechey's Chart

JULIUS BIEN & CO. LITH. N.Y.

SKETCH MAP OF CAPE LISBURNE REGION

SHOWING COAST LINE AND LOCALITIES OF COAL DEPOSITS

owing to its feeble development to the northwest and to its remoteness from the known Yukon Plateau feature, the present work, though it yields supporting evidence, has not gone far toward confirming this supposition.

DRAINAGE.

The drainage of this province, which is separated from that of the Arctic slope by the above-described mountain range, is southwestward. The master stream is the Koyukuk, which flows into the Yukon. It is navigable for some distance above Bettles, to near the sixty-seventh parallel. Next in size are John and Alatna rivers, tributaries to the Koyukuk from the north, and South Fork from the south, all of which at high water may be ascended by steamboat for 20 to 30 miles above their mouths. Other prominent tributaries are Hokotena River or Wild Creek and Alashuk River from the north and Kanuti River from the south.

All the above streams, as shown on the map, meander over their broad, flat valley floors, which vary from 1 to 10 or more miles in width. On the lower and middle portion of the Koyukuk the flats attain a very much greater width, being, in a measure, comparable with the Yukon Flats. To this portion the name Koyukuk Flats[a] has been applied.

ARCTIC SLOPE PROVINCE.

This province, beginning at the north base of the Endicott Mountains, in latitude 68° 25′, extends 160 miles northward to the Arctic coast. From the Anaktuvuk and Colville it appears to extend eastward to the foot of the mountains, 70 to 80 miles distant, while on the west it is inferred to probably extend to the Arctic coast, between Point Barrow and Cape Lisburne, a distance of about 400 miles. It is mainly with the eastern portion of the province that we shall here have to deal. This portion embraces almost the whole of the Colville Basin, and consists primarily of two distinct features, plateau and coastal plain. For the former feature the name Anaktuvuk Plateau is proposed.

ANAKTUVUK PLATEAU.

Beginning at the north base of the Endicott Range, at an elevation of 2,500 feet, as shown on the left in Pl. IV, *A*, this gently rolling plateau or plains country, composed of Mesozoic rocks, extends with gentle slope northward for a distance of 80 miles, to latitude 69° 25′, where, at an elevation of 800 feet, begins the nearly flat coastal plain next to be described. In the Anaktuvuk Valley a still more gentle aspect is given to the topography of the Mesozoic rocks by the glacial drift.

The most prominent features of this plateau are a few low, broad ridges, which lie parallel to or concentric with the curved front of the mountain range, and the shallow drainage valleys (see Pl. IV, *A*), trending north and south. These ridges

[a] Schrader, F. C., Preliminary report on a reconnaissance along the Chandlar and Koyukuk rivers, Alaska, in 1899: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 468.

present the concavity of their curve to the north, and, as suggested, appear to owe their origin to a part of the same uplift that formed the more abrupt front of the main range. They seem to be persistent features between the Colville and the head of Chipp (Ikpikpuk) River, where they trend a little north of west. Farther west they presumably merge into the Meade River Mountains, at the head of Meade River, in latitude 69° 20′, and probably continue still farther westward to the Arctic Ocean, where much the same type of topography, also cut in Mesozoic rocks, appears in the region north of Cape Beaufort.

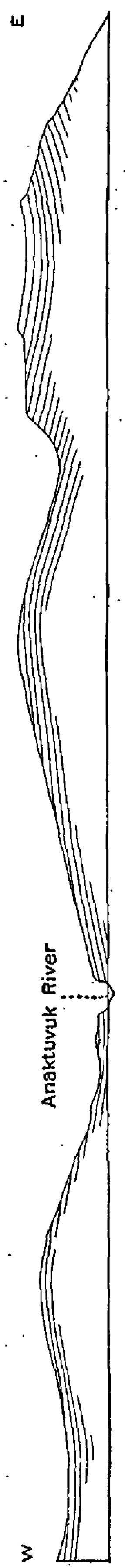


FIG. 3.—Sketch profile showing structure in Anaktuvuk series on Anaktuvuk River 10 miles above Willow Creek.

Where traversed by the Survey party, the most pronounced of these ridges occurs about 20 miles north of the mountains. It is low, broad, and somewhat rounded. Its highest points rise only 500 to 600 feet above the general plateau level, or about 1,200 feet above the bed of Anaktuvuk River. A sectional profile of this ridge, sketched from a point a few miles above it, on the Anaktuvuk, is presented in fig. 3.

ARCTIC COASTAL PLAIN.

In latitude approximately 69° 25′, at a distance of 80 miles from the mountains, and at an elevation of about 800 feet, the northern edge of the above-described Anaktuvuk Plateau gives way to a nearly flat tundra country or coastal plain, which from this point extends about 80 miles northward to the Arctic coast, and descends in this distance practically to sea level, with slope so gentle as to be inappreciable to the naked eye. For this feature, by reason of its geographic position, the name Arctic Coastal Plain is here proposed. This plain is practically constructional. The flat surface of its large interstream areas is dotted here and there by extremely shallow ponds and lakelets, which in most instances are without outlet and present no suggestion of the development of any system of drainage. Along the west side of the Colville the eroded edge of this part of the plain forms continuous steep bluffs, which gradually decrease in height northward, from 200 feet at the mouth of the Anaktuvuk to about 80 feet at Ocean Point, 40 miles distant. The few rivers that traverse the plain flow with considerable velocity in its inland portion, but toward the coast they become sluggish.

DRAINAGE.

COLVILLE RIVER.

The drainage of this Arctic slope province is essentially northward, into the Arctic Ocean. The master stream is Colville River. The Colville has a drainage basin of about 30,000 square miles. It rises in the

A. TOPOGRAPHY OF JOHN RIVER VALLEY IN ENDICOTT MOUNTAINS.

From near south edge of Fickett series; looking S. 60° E., into Skagit formation.

B. GLACIATED SIDE SLOPES OF JOHN RIVER VALLEY IN ENDICOTT MOUNTAINS.

Looking N. 15° E.

NE.

A.

SW.

B

BISECTED VIEW OF ENDICOTT PLATEAU AND ENDICOTT MOUNTAINS CARVED FROM IT, PRINCIPALLY IN FICKETT SERIES.

From Fork Peak, at 6,000 feet, near head of John River. *A*, Looking east; *B*, looking south.

northern part of the Endicott Mountains, near the sixty-eighth parallel and the one hundred and fifty-third meridian, whence it soon makes a large detour to the west and back, and then, in flowing northward to the ocean, traverses both the Anaktuvuk Plateau and the coastal plain. Practically all its tributaries of any importance are received from the right, or southeast. The chief of these—the Ninuluk, Anaktuvuk, and Itvelik—head in the mountains.

In the inland part of the coastal plain, at the mouth of the Anaktuvuk, as shown by continuous bluffs, the Colville has sunk its bed to a depth of 200 feet (see Pl. VIII), and at Ocean Point, 40 miles farther north, where it permanently leaves the bluffs, to a depth of 80 feet below the surface of the plain. In this downcutting, from a point above the mouth of the Anaktuvuk to the coast, the Colville has migrated laterally westward, into the terranes composing the plain, to such an extent that, while its left or western shore is for the most part lined by steep-faced bluffs, rising from 80 to 200 feet above the stream to the level of the plain, into which it is still cutting, on the right or east it is bordered by an expansive waste of low abandoned flats, laid waste by the river, for which the name Colville Flats is proposed.

These flats occupy a triangular area of probably 2,000 square miles, extending from the mouth of the Anaktuvuk as the apex northeastward to the coast, where, including the Colville delta, they attain a maximum width of probably 50 or 60 miles. They are dotted by numerous shallow ponds and lakelets. The monotony of their almost dead level is occasionally relieved by low mounds of gravel, rising 10 to 40 feet above the surface. In fact, from near the mouth of the Anaktuvuk the Colville seems formerly to have flowed more directly northeastward through the area now occupied by the flats and entered the ocean through Gwydyr Bay, from 30 to 40 miles east of its present delta, if not Prudhoe Bay, still farther eastward, at the base of Return Reef, as shown by the broken lines on the map forming Pl. III.

At the head of the Colville delta, where the edges of these flats form the stream banks, their surface lies about 10 feet above the river. Here they are composed chiefly of dark mud, muck, and ground ice, while at certain localities farther inland the banks give way to stretches of gravel beach sloping gently to the water's edge.

The Colville delta at present has a radius of about 15 miles and a width across the front of about 20 miles. It is composed of low islands, which coastward gradually pass into marshes, mud flats, bars, and expansive shallows, which are continuous with the very gradually deepening sea floor. Near the head of the delta sand dunes have been formed on some of the islands to a height of 60 or more feet. As the "Pelly Mountains" of Dease and Simpson, represented on their map to the west of the Colville delta, do not exist, it seems probable that the features which these men mistook for mountains were merely low sand dunes, similar to those above referred to. This view is strengthened by the fact that under certain conditions of light along the coast low objects become, by refraction, enormously exaggerated in vertical scale.

Colville River has formerly been described as having four mouths, but it probably has five or six. The westernmost is said to be shallow, but the second from the west is navigable and is used by the natives in ascending and descending the river on the west. Whether any of these channels will admit river steamboats was not learned. If so, it must be the right or most easterly channel, which seems to be the main one. Once across the delta, judging from its gradient and volume, the river can probably be ascended by steamboat for a distance of 150 or more miles above its mouth. McClure, in crossing Harrison Bay in 1850, found the freshening influence of the Colville to extend 12 to 14 miles seaward, the surface of the water being of a dirty mud color and scarcely salt.

ANAKTUVUK RIVER.

Next to the Colville, the principal stream of this province is Anaktuvuk River, the large southeast tributary of the Colville, which, rising in the northern part of the mountains, flows almost directly northward across the Anaktuvuk Plateau and joins the Colville at the inland edge of the coastal plain. At about 30 miles from the mountains the Anaktuvuk is joined on the east by Willow Creek, a stream equal to itself in size.

Above Willow Creek, owing to the swiftness of the current and frequent riffles formed by large bowlders that beset the bed of the stream, the Anaktuvuk can hardly be regarded as navigable at ordinary water for canoe or rowboat. In the upper section of the river, the valley, as shown in Pl. IV, *A*, is shallow and open, with no bluffs or banks to speak of. The tundra extends almost to the water's edge.

Below Willow Creek the floor of the valley consists of a gravel- or bowlder-covered flat, a mile or more in width, along the edges of which the gentle, moss-covered side slopes are occasionally interrupted by low bluffs rising from 20 to 100 feet above the river. Willow Creek and Nanushuk River both seem to head in the mountains to the southeast of the edge of the plateau, while Tuluga River, on the west, apparently takes its rise on the plateau, near its middle part.

COAST LINE.

From Colville River to Point Barrow.—The northern Arctic coast of Alaska, from the mouth of the Mackenzie to Point Barrow, trends a little north of west. It is low and flat, the actual shore line being formed by a low shelving beach (Pl. IX, *A*), whose seaward extension forms the shallow sea floor. From east of the Colville westward to Point Barrow the surface of the tundra often descends to or within a few feet of tide level, so that the same gentle slope seems to be continued in the very

B

D.

ERTIARY COASTAL PLAIN OF COLVILLE SERIES.

and *D*, looking northwest.

gradually deepening sea floor. The greatest height of the bluffs is about 30 feet. The drainage ways are consequently broad and very shallow.

The coast line is comparatively regular, though not nearly so uniform as represented by the early explorers Dease and Simpson. It is more or less broadly sinuous or wavy, its first striking uniformity being broken by occasional lagoons, shallow embayments, and inlets; but in comparison with the coast of southern Alaska, for example, in can not be called indented. Some of the embayments mark the mouths of rivers, but most of the larger ones seem to occur independent of inland drainage. The deepest, and perhaps the only one to which the term indentation will strictly apply, is Dease Inlet, at the head of which is situated Admiralty Bay, which receives the Chipp (Ikpikpuk) River. The principal streams entering the sea between the Colville and Point Barrow are Garry, Smith, Sinclair, Chipp (Ikpikpuk), and Meade rivers. These rivers, however, could not all be visited by the party in its rapid progress along the coast. So far as known, they in general have wide mud-flat deltas, much the same as the Colville, which pass seaward into shallows, merging with the shallow coastal shelf of the sea.

It is judged that the coastal shelf extends far offshore, with a slope probably even less than that of the nearly level subaerial coastal plain. Captain McClure found the soundings so exceedingly regular that during the foggiest weather the vessel could stand inshore with the most perfect confidence in 3½ fathoms of water, and the *Investigator* is reported to have passed the mouth of the Colville 40 miles out to sea in 3½ fathoms. The range of tides on this portion of the Arctic coast is very small, being only 2 or 3 feet.

Point Barrow, the northern extremity of this low coast and of the American continent, is a low spit of gravel and sand, projecting to the northeast, in latitude 71° 23′, longitude 156° 40′. It is 4 miles in length and about one-fourth mile in width, but expands at the end, where it rises to a height of 16 feet and sends out a long, narrow ridge, which extends east-southeastward for a distance of more than 2 miles. This ridge finally gives way to a line of sandy islets, inclosing a shallow body of water of considerable extent, named Elson Bay, after the discoverer of Point Barrow.

From Point Barrow to Cape Lisburne and beyond.—The trend of the coast line changes from northwest to southwest at Point Barrow and thence extends about 300 miles southwestward to Cape Lisburne. It continues comparatively straight and regular, but it is not so low as on the north. It soon loses the almost featureless edge which is characteristic of the flat coastal plain on the north, and gradually comes to exhibit low, but seldom rock-faced, bluffs, rising 30 or 40, rarely 70, feet above tide. Back from the shore a very gently rolling surface rises very gradually toward the interior, but no highlands or mountains can be seen. Seaward the bluffs overlook immense stretches of brackish lagoons, from one to several miles in width, which rather persistently line the coast. These lagoons are screened from the force of the open sea by broad wave-built barrier reefs and beaches of sand and gravel, through which occasional narrow channels, cut by the ebb and flow of the tide, connect with the outer water. On portions of the coast not thus protected, during a northwest gale the mouths of the smaller valleys become entirely clogged and the streams themselves are then dammed back by the broad beach barriers thrown up by the violent surf. In the rear of these barriers the lower reaches of the valleys then become temporarily converted into broad lakelets, whose surface may rise 5 or 6 feet above normal tide level; but with the abatement of the storm a new drainage channel is opened through the beach and the lake disappears.

Near Cape Beaufort, latitude 69° 15′, the above-described low topographic relief gives way to a range of hills or low, rolling mountains, which, sweeping a little south of west, appear at the coast with an elevation of 800 to 1,000 feet. They are supposed by the writer to represent the westward continuation of the Meade River Mountains, already referred to. Farther southwest they seem to merge into the somewhat more pronounced and rugged mountains of Cape Lisburne, which, as noted, are supposed to represent the westward continuation of the northern axis of the Endicott Range, noted at the head of the *Anaktuvuk*, in longitude 152°.

Here these mountains, as noted, terminate at the coast in abrupt sea cliffs, forming the bold promontory of Cape Lisburne, which rises to a height of 850 feet above tide. From Cape Lisburne the mountains, with decreased altitudes, continue southwestward in several successive parallel ridges, trending at about right angles to the coast. The shore line, however, is here less abrupt, as shown in fig. 1 (p. 40).

About 30 miles south of Cape Lisburne the shore extends out nearly 15 miles to the west in an immense tongue of low, sandy land, known as Point Hope, which is backed by bluffs at its inland end.

From Point Hope southeastward to Cape Krusenstern, at the entrance to Kotzebue Sound, the coast is reported to be low and somewhat rocky, with intervals of lagoons and wave-built barrier reefs, somewhat resembling those already described; but in latitude 67° 35′, opposite the great bend of the Noatak, low mountains, known as the Mulgrave Hills, again approach the coast.

The streams entering the coast on the northwest are nearly all short. The principal, beginning at the north, are Kee, Kukpowruk, Pitmegea, and Kukpuk rivers.

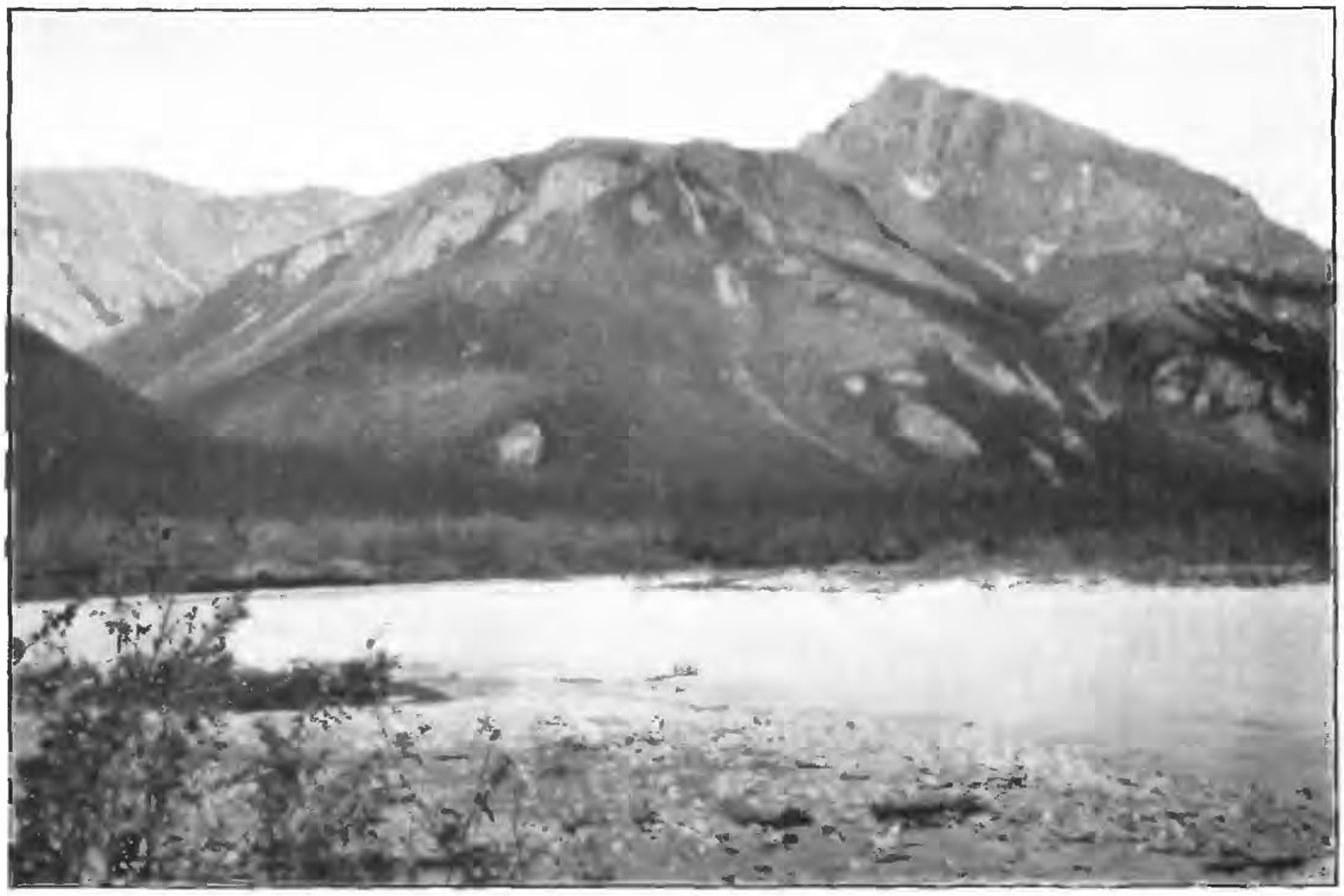
GEOLOGY.

GEOLOGIC MAP AND SECTIONS.

The results of the very incomplete observations concerning the distribution of the geologic formations here treated of are represented on the accompanying geologic map (Pl. III), the colored portion of which, comprising an area of about 27,000 square miles, lies mainly between the one hundred and fiftieth and one

A. ARCTIC COAST AND EDGE OF MOSS-COVERED ARCTIC COASTAL PLAIN.

From west of Colville River; looking S. 45° E.



B. SKAGIT LIMESTONE ON JOHN RIVER IN ENDICOTT MOUNTAINS.

Looking S. 65° E.

hundred and fifty-fifth degrees of longitude. As the line of traverse extends in a north-south direction across the trend of the terranes, which has been found to be relatively constant, especially in the mountains, the boundaries delimiting the various formations on the north and on the south, along the line of the section, are approximately correct and in some instances are well defined. In an east-west direction some liberties have been taken in making such broad generalizations as seemed permissible from the regularity of the terranes in the mountains and their relations and lithologic resemblance to those previously mapped to the east.

The boundaries of the post-Paleozoic formations of the Arctic slope, approximately determined on paleontologic and lithologic evidence along the route of traverse, have been extended eastward and westward on topographic evidence and on observations and collections made by the writer in returning southward along the coast from Point Barrow to Cape Lisburne.

At the north base of the mountains, where the profile, descending from the mountains, passes from the upturned Devonian onto Pleistocene till, which farther north is found resting on Lower Cretaceous, a belt several miles wide has been left blank, in view of the possible occurrence of Carboniferous and Lower Mesozoic rocks between the Devonian and the Cretaceous; and similar contact gaps have been left in other parts of the section. On topographic grounds, however, it seems probable that the Mesozoic and Carboniferous formations are absent at the above point on the Anaktuvuk, having been removed by erosion, and that the inland edge of the Lower Cretaceous or Jura-Cretaceous may rest directly on the Devonian, as indicated in fig. 4. Areas away from the route traversed, where the geology is unknown, are also left blank; while, on the other hand, general geologic information and the probable occurrence of certain formations are represented by notes printed in red. East of the geologically colored portion of the map the notes applying to the region lying north of the Arctic Circle are based on the work of the writer in a previous year,[a] while those to the south of the Circle, on the west, and along Alatna and Kowak rivers in the region of the sixty-seventh parallel are by Mr. W. C. Mendenhall, geologist in charge of the Kowak expedition, whose work[b] has just been published.

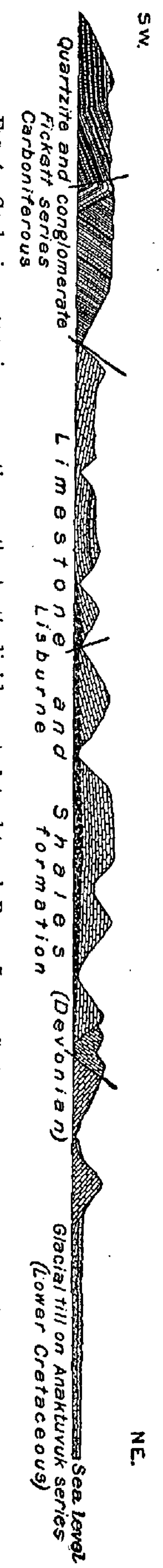


FIG. 4.—Geologic reconnaissance section on the Arctic divide west of Anaktuvuk Pass. Lower Cretaceous-Devonian contact is hypothetic.

[a] Schrader, F. C., Reconnaissance along the Chandlar and Koyukuk rivers, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 448.

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

A profile and geologic section appearing on Pl. III, drawn on the same scale as the map, illustrate the structural features and relations of the various rock formations. It extends from the southern edge of the map at A (Pl. III) to the foot of the Colville delta and the Arctic coast at J. In order to show the structure in the Tertiary coastal plain and to represent the flats and delta near sea level at the north, the scale of the section has been vertically exaggerated 5:1 as compared with the horizontal scale, and in order to represent more accurately the relations of the rocks as actually observed the section follows the somewhat zigzag line of traverse. Where it traverses the rocks diagonally, as in the northern edge of the Fickett series, compensation has been made therefor by reducing the dips of the rocks in the section. As the line of traverse follows the valleys, where the topography has been reduced by erosion, the profile rarely rises to the normal height of the adjacent land mass. Consequently the peneplain feature of the Endicott Mountain summits is not expressed by the profile. From studies thus far made of the section it promises to be of far-reaching importance, not only in deciphering the geology of Alaska, but also in making correlations with Asiatic stratigraphy.

Near the northern edge of the range, as shown on the map, the section traverses the mountains to the east of the Anaktuvuk Valley, but as the rocks have here been disturbed by folding and faulting, a supplementary short profile section (fig. 4), showing the rocks as they appear on the west side of the valley, has been introduced. It extends from the Lower Carboniferous at Contact Creek on John River a distance of about 25 miles northeastward across the Devonian, along the north side of Anaktuvuk Pass, to the Cretaceous of the Anaktuvuk Plateau on the west of Anaktuvuk River. The base of this section represents approximately the elevation of the floor of the Anaktuvuk Valley and that of the pass, which is about 2,500 feet. The mountains rise to about 5,500 feet. Besides the faulting shown between the Devonian and the Lower Carboniferous on the south, and in the Devonian itself toward the north, the section supposes the Lower Cretaceous to be resting unconformably on the upturned and eroded Devonian.

OUTLINE OF GEOLOGIC HISTORY.

The rocks composing the section here considered, extending geographically from the sixty-sixth parallel to the Arctic coast, a distance of nearly 400 miles, comprise representatives of most of the geologic ages ranging from Silurian to Recent, as shown in the accompanying table.

TABLE OF GEOLOGIC FORMATIONS.

Sedimentary rocks.

Pleistocene		Recent stream gravels, dune sands, mud flats, silts, beach gravels, Gubik sand, ground ice, and glacial drift.
Tertiary (Colville series)	Pliocene	Nearly horizontally stratified, fine-grained calcareous silts.
	Oligocene	Sand, clay, shale, soft sandstone and limestone with lignites, hard ferruginous sandstone, and conglomerate.
Mesozoic	Upper Cretaceous (Nanushuk series).	Soft sandstone, limestone, shale, and coal.
	Cretaceous (?) (Bergman series).	Sandstone, slate, grit, conglomerate, and coal.
	Lower Cretaceous (Koyukuk series).	Impure limestone, sandstone, slate, and associated igneous rocks.
	Lower Cretaceous (Anaktuvuk series).	Principally impure sandstone or arkose, with some conglomerate or grit.
	Jura-Cretaceous (Corwin series).	Sandstone, impure limestone, shale, and bituminous coal.
Paleozoic	Lower Carboniferous (Fickett series).	Phyllites, slate, limestone, sandstone, quartzite, grit, and conglomerate.
	Devonian (Lisburne formation).	Limestone and shale.
	Silurian (probably) (Totsen series).	Mica-schists and quartz-mica-schists.
	Upper Silurian (Skajit formation).	Schistose and micaceous limestone.
	Pre-Devonian (probably) (Stuver series).	Conglomerate, quartzite, slate, and shale.

Igneous rocks.

Post-Silurian dike (?) rocks, associated with the Skajit formation.

Cretaceous and post-Cretaceous dike rocks, associated with the Koyukuk series.

The oldest rocks encountered in the field consist of several metamorphic series. They are principally of sedimentary origin, and have acquired their present character largely by processes of mountain building, which, broadly speaking, seem to have been in progress intermittently since Middle Paleozoic time, and are probably still going on.

These metamorphic rocks are exposed only in the mountainous portion of the field. The different series are here designated by the names Skajit, Totsen, Stuver, Lisburne, and Fickett. Though the Totsen series is mainly sedimentary, it includes also some greenstone-schists of igneous origin, which appear to be old basaltic flows, but may be intrusives.

With probably a single exception, igneous rocks were not observed with any of the other metamorphic series. This exception was on John River, near the middle of the Skajit formation, at a point about midway between camps of June 23 and June 24. Here, in the face of the upper part of a cliff which rises steeply to a height of 2,000 feet above the edge of the stream, as seen from the opposite side of the river, looking northeast, but which, owing to difficulty of access and lack of time was not visited, the limestone is cut by what appears to be two classes of dikes (but which may possibly be veins), one dark and the other light. These supposed dikes are thin, and they are younger than the schistosity of the country rock. The dark ones are the older, and cut the rock for the most part obliquely to the schistosity or bedding, which they slightly exceed in dip, the dip being to the north, at an angle of about 45°. The light dikes cut the rocks at nearly right angles to the dark dikes and dip south at an angle of about 80°, and seem to follow fault planes or fissures that were manifestly produced subsequent to the intrusion of the dark dikes.

The above division of the rocks is based largely on paleontologic evidence. But the Totsen series, in which no fossils were found, is assigned to a low place in the geologic scale by reason of its crystalline character or high degree of metamorphism and the known relatively low stratigraphic position in which similar rocks occur in adjacent regions. The Stuver series, in which likewise no fossils were found, is regarded as among the older rocks by reason of its field relations to the overlying Devonian.

After the deposition of the oldest Paleozoic sediments occurring in the present southern axis of the main range, this part of the region seems to have been uplifted and subjected to dynamic action and metamorphism, following which a portion of the field probably remained above sea during the whole or a part of the period in which the Devonian sediments were being laid down in the region now occupied by the northern axis. During this period of deposition, which possibly extended into early Mesozoic, the later Paleozoic sediments, including apparently the Carboniferous, seem to have been deposited unconformably against the older rocks of the southern axis. This period was followed by stress, uplift, and the exertion of mountain-building forces, resulting in folding, metamorphism, and deformation of the strata.

Then followed a long pause, during which the reduction of the land area by subaerial erosion nearly to sea level gave rise to the peneplain or formerly nearly level surface of the Endicott Plateau. This base-leveling was, in turn, followed by elevation of the region, whence upward movement seems to have continued more or less intermittently down to the present time. Uplift was accompanied by vigorous dissection of the plateau, from which the Endicott Mountains, as we find them to-day, seem manifestly to have been carved.

Contemporaneous with this uplift and dissection the sediments eroded from the range were borne to the sea and deposited as new terranes on both the north and the south side of the mountains. These later deposits range in age from Middle Mesozoic to recent. Though throughout this period the Endicott Plateau seems to have stood above the sea, the region was subjected to somewhat pronounced changes of level and disturbance, as is evidenced by deformation and unconformities extending from Middle Mesozoic to Pleistocene.

The later of these disturbances is that suggested by the vigorous cutting of the left or west bank of Colville River into high bluffs (Pl. VIII), while the east bank consists only of the edge of an expansive waste of low flats abandoned by the river in its lateral migration during its down cutting. This shifting or lateral migration of the river was evidently brought about by a tilt, which is apparently more than a local disturbance, for other examples indicate that there has been a general tilt throughout northern Alaska, which has caused and is still causing the larger rivers, notably the Yukon, the Porcupine, the Koyukuk, the Kowak, the Colville, and the Anaktuvuk, to cut their western banks.[a] This differential upward movement of the region probably extends eastward to the international boundary or farther, and, judging from the lateral migration of the Colville into the Pleistocene as well as the Tertiary and Mesozoic terranes, it took place, in part at least, in the Pleistocene, and is probably still in progress.

During Lower Cretaceous time, deposition on the south of the range, in what is now the Koyukuk Basin, was apparently accompanied by igneous extrusions and followed by intrusions, which latter continued into post-Cretaceous time,[b] while the range itself and the Arctic slope, so far as observed along the route of traverse, are relatively free from igneous rocks. It was supposed by the writer that the northeast-southwest trend of the Koyukuk Valley, from the Yukon to the sixty-eighth parallel, probably represented in a general way a line of weakness in the earth's crust, along which igneous phenomena are especially manifest. More recent work, however, along Kanuti and Kowak[c] rivers and on Kotzebue Sound, shows that the igneous rocks are distributed over a much wider area in this northern country than in that occupied by the Koyukuk Valley.

SEDIMENTARY ROCK FORMATIONS.

PALEOZOIC ROCKS.

STRUCTURE.

Beginning with apparently the oldest, the several formations or rock series will be briefly described. As the field is new and the investigations have not been detailed, the formation names introduced are proposed provisionally.

To afford a more comprehensive view of the relations of the several series and to avoid repetition in referring to them individually, it will be well to note at the outset some features of structure which are common to nearly all the Paleozoic rocks, and which apply to the range as a whole, namely, that the series all strike approximately

[a] The fact that the Yukon in the lower part of its course is cutting its right or western bank has been noted by Dall, Russell, Spurr, and others.

[b] Schrader, F. C., Reconnaissance along the Chandlar and Koyukuk rivers, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 481.

[c] Mendenhall, W. C., Reconnaissance from Fort Hamlin to Kotzebue Sound, Alaska: Prof. Paper, U. S. Geol. Survey, No. 10, 1902, map, p. 30.

east and west, parallel with the trend of the range. They are nearly all traversed by the dominant jointing of the range, which cuts the rocks in a direction about northeast-southwest, with dip nearly vertical or inclined steeply to the northwest, at angles of 75° to 80°. There are also usually one or more sets of secondary jointing or minor structure, trending in general northwest-southeast, sometimes approximately at right angles to the major jointing.

The above statement of the structures affecting the Paleozoics in the range applies also in a limited way to the upland Mesozoics on either side.

With the exception of the greenstone-schists occurring in the Totsen series, the Paleozoics of the range, as well as the younger formations of the Arctic slope, are all sedimentary, and, so far as observed, are relatively if not wholly free from association with igneous rocks of any kind.

SKAJIT[a] FORMATION (UPPER SILURIAN).

Character and occurrence.—The Endicott Range, as noted, has two distinct axes, of which the southern seems to be composed of the older rocks (see Pl. III), those of the Skajit formation and the Totsen series, the former playing the principal part.

The rocks of the Skajit formation (Pl. IX, *B*) consist of heavy-bedded crystalline limestone and mica-schist. Weathered surfaces, parallel with the bedding and planes of movement and crushing, present a silvery sheen, due to the presence of mica, while some layers grade wholly into mica-schist. On a fresh fracture surface the limestone is found to be highly crystalline, generally fine or medium grained, and of impure white or bluish-gray color, the latter apparently denoting the more dolomitic phases of the rock. It weathers to a dirty gray or light brown, sometimes tinged with red.

The formation occurs in the southern part of the Endicott Mountains, where, in latitude approximately 67° 30′, it occupies a belt that is from 15 to 20 miles wide, in which the mountains rise to an elevation of more than 5,500 feet above sea level, the rocks forming some of the highest peaks and most rugged topography of the southern axis of the range. Judging from the attitude or prevailing dip of the rocks and their extent measured across the strike, the formation probably has a thickness of at least 4,000 feet.

Structure.—The Skajit formation has a nearly east-west strike, parallel with the general direction of the mountains; but about 20 miles west of John River this trend changes to north of west. The structure in general indicates a broad anticlinorium whose middle part is occupied by a broad, shallow syncline. In general the dips are gentle, as shown in Pl. IX, *B* and Pl. X, *A*. The latter shows the

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[a] The term Skajit is of native origin, and is taken from a group of rugged mountains occurring within the area of the formation to the east of John River.

A. NORTH EDGE OF SKAGIT LIMESTONE, DIPPING NORTH, ON JOHN RIVER, IN ENDICOTT MOUNTAINS. LOOKING EAST.

B. LISBURNE LIMESTONE AND GROUND MORAINE, FROM CACHE LAKE NEAR ANAKTUVUK PASS, IN ENDICOTT MOUNTAINS. LOOKING NORTHWEST.

C. CAPE SABINE AND UNDULATING PLATEAU. LOOKING SOUTH.

D. CAPE HALKETT, SHOWING GROUND ICE TERRANE RISING 30 FEET ABOVE TIDE.

formation as it disappears to the north unconformably under the Fickett series. In some localities, however, the faulting and folding have been intense.

Like the other Paleozoic rocks of the range, the Skajit formation is cut diagonally by the dominant northeast-southwest jointing, which divides the rocks into nearly vertical sheets varying from less than 1 to more than 10 feet in thickness, and by the secondary jointing sometimes at nearly right angles to this direction.

The joint planes are usually nearly vertical or have a steep westerly dip, and are sometimes locally followed by veins or veinlets of calcite and some quartz, carrying occasionally a little galena or iron pyrites and copper. Prospectors report that galena, probably of economic value, occurs on Wild Creek, 25 miles east of our route, in a wide "ledge" in limestone probably belonging to the Skajit formation.

Cleavage was also noted in a few instances, but none so pronounced or so well developed as that observed in similar rocks in the area to the east, at the head of Chandlar River.

Age.—The Skajit formation, as seen in the geologic section, probably represents the oldest or next to the oldest rocks in the field. It is the principal formation forming the southern axis of the Endicott Range, of which it seems to be the lowest terrane exposed. It is unconformably below the Fickett series on the north, and apparently bears similar relation to the Totsen series on the south, where, as shown in the geologic section on Pl. III, the probable unconformity is indicated by the beds of the Totsen series lying at a steeper angle than those of the Skajit formation, as well as by an abrupt change in the character of the sediments along the zone of contact. Similarly, on the north, where the heavy-bedded limestone of the Skajit formation finally disappears with a northerly dip, it is met by the overlying slates and schists of the Fickett series dipping south (section on Pl. III and Pl. X, *A*).

Though the limestone, as noted, is much altered by metamorphism, it contains faunal remains, some of which were collected in place on John River. While most of these forms are too greatly altered for determination, a single specimen has been identified by Mr. Schuchert as "having the ventral valve of a brachipod of the order of *Meristina* and *Meristella*, and also resembling a transverse *Seminula*. This kind of shell indicates that the rock can not be older than Upper Silurian and not younger than Lower Carboniferous."

On this evidence, and because the rock is much more disturbed and metamorphosed than the limestone of the Lisburne formation, in which Devonian fossils have been found in the northern axis of the range, the Skajit formation is provisionally referred to the Upper Silurian. This, if the inference be correct, places it among the oldest known fossil-bearing formations of northern Alaska. Late Upper Silurian forms have been found in the Glacier Bay limestone in southeastern Alaska.[a] Ordo-

[a]Brooks, A. H., Preliminary report on the Ketchikan mining district, Alaska: Prof. Paper U. S. Geol. Survey No. 1, 1902, pp. 19–20.

vician fossils have been found by the Survey party on Seward Peninsula,[a] and Lower Silurian forms[b] were also found by Mr. A. J. Collier during the season of 1901 in the same region.

Silurian fossils are also reported to have been collected[c] by Buckland, Dall, and others at Cape Lisburne and the adjacent Cape Thompson, but, so far as known to the writer, no section or description of the rocks is given. In Dana's Manual of Geology it is stated that species of *Lithostrotion* have been found in the Arctic coast lands between Cape Lisburne and Kotzebue Sound. Lower Silurian fossils were collected by Mr. Schuchert on the northeast coast of the continent, in Baffin Land.

Correlation.—From the schistose, crystalline, and micaceous character of the Skajit formation and its resemblance to similar rocks of the Bettles series,[d] it is here provisionally correlated with the schistose phase of the Bettles series occurring at the head of Chandlar River, with which subsequent detailed work in the intervening region may connect it. It seems probable that the limestone reported by prospectors to occur in the gold placer district in the Koyukuk, between the Skajit formation on John River and that on the Chandlar, represents this connection. In an earlier report[e] the Bettles series was tentatively correlated with the Fortymile series of Spurr. If, however, the Skajit formation proves to be Upper Silurian and its correlation with the Bettles series is correct, the previous correlation of the Bettles limestone to the north of the Yukon with the pre-Silurian Fortymile series to the south, in the Fortymile district, may have to be abandoned.

TOTSEN SERIES[f] (SILURIAN).

Character and occurrence.—This series of rocks occupies a belt about 12 miles wide on John River. It lies south of the Skajit formation, upon which the Totsen rocks seem to rest unconformably, while they in turn are unconformably overlain by the Bergman series on the south. The rocks are mainly mica-schists and quartz-mica-schists, in both of which the essential minerals are biotite and quartz. There is also some much-altered greenstone or amphibole-schist. Locally the mica-schist becomes graphitic, graphite bodies one-eighth inch in diameter being noted, and in some cases

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[a] Brooks, A. H.; Richardson, G. B.; Collier, A. J., and Mendenhall, W. C., Reconnaissances in the Cape Nome and Norton Bay Regions, Alaska: Special publication U. S. Geol. Survey, 1901.

[b] Graptolites were found by Messrs. A. H. Brooks and L. M. Prindle along the northern base of the Alaskan Range in the summer of 1902.

[c] Correlation papers, Neocene: Bull. U. S. Geol. Survey No. 84, pp. 248-249.

[d] Schrader, F. C., Reconnaissance along the Chandlar and Koyukuk rivers, Alaska: Twenty-first Ann. Rept. U. S Geol. Survey, pt. 2, 1900.

[e] Ibid.

[f] The name Totsen is derived from the term Totsenbetna—formerly applied by the natives to Wild Creek—by dropping the final syllables, which signify river. On the map accompanying the writer's report on the expedition of 1899, and on that in Mendenhall's report of 1902 (Prof. Paper U. S. Geol. Survey No. 10), this name was erroneously applied to the stream which is now called John River, but which Allen designated Fickett's River. The word was spelled Totzenbitna by Allen. It is said to mean *lune*, the waterfowl.

the rock carries much secondary quartz, both in small veins and in lenticular bodies. Some iron pyrite is also present, which on oxidation gives a reddish-brown color to the rock. The quartz veins tend to follow the schistosity and are often locally contorted and twisted. Some carry irregular veinlets or stringers of epidote.

The series is believed to be essentially of sedimentary origin, but the sedimentation seems to have been accompanied by basaltic flows, which were later sheared with the sedimentary beds, giving rise to amphibolite-schist, of which the most prominent strip, having an apparent width of several miles, occurs near the southern part of the belt occupied by the series. Here the rock, judging from the bent and crushed remnants of feldspar and augite shown under the microscope, is plainly of igneous origin. Though on account of faulting and folding there is doubtless some duplication of the rocks in the Totsen series, its total thickness, judging from the prevailing dip and distance across the strike, is 6,000 to 7,000 feet.

Structure.—The Totsen series, like the older rocks composing the range, trends approximately east and west, and though the series as a whole has been intensely folded, the dip in general is monoclinal, being, so far as observed, southward, at angles of 60 to 80°; but in the northern part of the belt, John River Valley, for a distance of several miles, seems to follow a north-south syncline in the series. The series is traversed by the major northeast jointing of the range, and by a secondary structure at nearly right angles to the major jointing. Cleavage was noted at a few localities, but apparently much of this has been obliterated by disturbance.

Age.—The Totsen series is represented in the geologic section as it appears to occur in the field, namely, above the Skajit series. It thus seems to be younger than the Skajit, but the actual contact between the formations was not seen, as is shown by the gap in the section, and the age relations here indicated can not be demonstrated. Furthermore, while the Totsen series, so far as observed, consists essentially of rocks that seem undoubtedly to belong to the class of older crystalline schists found in Alaska, and can not be correlated with the Fickett series, it should be noted that the observations made were confined to the line of traverse along John River, and the mountains in this part of the field not having been ascended, it is possible that the series may be overlain by or otherwise associated with rocks younger than those described above. The great thickness and probable extent of the Fickett series (to be noted later) to the north of the Skajit formation, makes it not unreasonable to suppose that members of this series may occur on the south side of the Skajit anticlinorium, but this point must be determined by future investigation.

Correlation.—The Totsen series can be correlated in a tentative way, on lithologic grounds, with the Lake quartz-schist[a] of Chandlar River. It is less evidently of

[a] Schrader, F. C., Reconnaissance along the Chandlar and Koyukuk rivers, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 474.

sedimentary origin, is more micaceous, and contains much less quartz and more greenstone-schist, of igneous origin. In some localities, however, it very much resembles the more altered phases of the schists to the east of the Koyukuk, in the Slate Creek diggings, which also have been correlated with the Lake quartz-schist of Chandlar River. That the Totsen series extending beneath the younger formations in the Koyukuk Valley may connect with the Slate Creek schists is not improbable, especially since the Bergman series, which occupies a large part of the intervening Koyukuk Valley, seems to rest unconformably upon both.

STUVER SERIES[a] (PRE-DEVONIAN).

Character and occurrence.—The next of the older groups of rocks to be considered is the Stuver series, comprising the oldest rocks exposed in the northern portion of the Endicott Range, and apparently forming the core of the north axis. (See section on Pl. III.) The rocks of this series are principally conglomerates, with interbedded layers of quartzite, which toward the top pass into slate and shale. The pebbles composing the conglomerate are practically all siliceous and consist of black, slate-colored, red, green, and bluish flint and milky-white quartz. They range in size from less than an inch in diameter to cobbles, and in a few instances approach bowlderets. The cement is siliceous, usually dense, and often contains grains of cryptocrystalline or aphanitic silica, undoubtedly derived from the same parent rock as the pebbles. Great force is required to break the rock with the hammer, and, when broken, the fracture plane is almost invariably found to take a direct course, traversing any pebbles, though perfectly sound, that may lie in its path; in fact, the cementation is so firm as to form of the conglomerate, as a whole, a rock substantially as hard as the hardest flint pebbles that are included in it.

The various colors of the pebbles in the conglomerate make it a very conspicuous rock, so that it is easily recognized where its fragments occur in Pleistocene and intervening formations. These fragments are conspicuous in the Lower Carboniferous rocks succeeding the Lisburne series, and are also represented in the Lower and Upper Cretaceous and in the Tertiary formations. No one of the parent rocks from which the various types of flint pebbles of the Stuver series have been derived has yet been observed. The specimens found in the placer mining gulches to the northeast, on the west side of the Koyukuk, and referred to by the prospectors as "emerald" and "adamant," probably represent flint pebbles derived from the Stuver conglomerate.

The interbedded quartzites in the Stuver series are medium grained and exceptionally hard and siliceous, and are usually of a gray or sometimes a pinkish or reddish color, while the slate is dark.

[a]The name applied to this series is taken from Mount Stuver, situated east of the Anaktuvuk, and named for a member of the party.

Where best exposed between the two limestone areas of the Lisburne formation to the north of the Anaktuvuk, the Stuver series, forming the lower part of the longer limb of an anticline, dips southward at an angle of 30° and passes beneath the limestone of the Lisburne formation. The relation of the two formations immediately at the contact is concealed by talus, but near by begins an exposure which, extending for several miles along the front of the mountains, shows the Lisburne formation dipping southward at an angle of 20°, this dip being but 10° less than that of the Stuver series, which, as it nears the Lisburne formation, gradually decreases southward. From this it is inferred that the Lisburne, where not faulted, probably rests conformably on the Stuver series. If any unconformity exists, it must be very slight.

As shown on the geologic map (Pl. III), the exposure of the Stuver series is limited to a narrow belt, about 5 miles in width, that trends eastward for an unknown distance from the Anaktuvuk Valley, lying between the eroded edges of the Lisburne formation. The series is also supposed to form the bed-rock floor of the Anaktuvuk Valley, beneath the glacial drift, from the north edge of the mountains for a distance of 10 to 12 miles southward, to near the southern edge of the Lisburne formation. There are some small exposures of its upper member beneath the Lisburne along the base of the mountains on both the east and the west side of the valley, while on the south it has probably been brought into contact with the Lower Carboniferous of the Fickett series by faulting. Both here and at the north edge of the series the faulting seems to be normal.

Structure.—To convey a clearer conception of the controlling conditions here, it should be noted that the Stuver series lies in an east-west zone that exhibits the most marked geologic disturbance of the region. Pronounced faulting extends southward into the range for a distance of 15 to 20 miles from its seaward face. This zone extends along the crest of the divide between the Yukon and Arctic coast drainages, in the region at the head of John and Anaktuvuk rivers, and at the southern part of the great crescent formed by the north front of the Endicott Range. The beds in a general way retain the east-west trend noted in the older Skajit and Totsen series. Roughly considered, the uplift, which, judging from sediments in the post-Paleozoic rocks and the unconformable relations of these to the Paleozoic rocks, seems to have been going on since middle or late Paleozoic time, apparently took place in the form of a broad anticline, whose longer limb extends with gentle slope southward and whose shorter limb forms in part the north front of the range. Elevation was accompanied by faulting. The thrust or movement came from the south and apparently produced an overturned fold in the terranes forming the crest of the anticline. The faulting which accompanied this movement broke the beds into several great fault blocks. Erosion followed, which finally brought the Stuver series to view along the axis of the fold. These are apparently the lowest and oldest rocks exposed in the northern part of the range.

Toward its northern limits and the crest of the fold, as has been noted, the Stuver series dips southward at an angle of 30°. But still nearer its northern limits, practically at the crest of the fold, the beds have been strained, bent downward, and broken, and finally terminate in a well-defined fault scarp, as shown in the section on Pl. III. This scarp trends a little south of east and is visibly pronounced for at least 5 or 6 miles. Along this distance, in the higher part of the mountains, the edges of the broken, hard conglomerate beds forming the scarp are distinctly exposed, generally dipping about 30° S., while at a lower elevation along the face of the scarp the broken-off portions of the same strata have dragged behind along the lower face of the scarp and stand nearly on edge, dipping northward at an angle of 80°. These nearly vertical beds of the Stuver series are met at the contact on the north by the limestone of the Lisburne formation, which dips south at an angle of 75° to 80°. (See section on Pl. III.) The contact of the two formations thus forms a reentrant angle of 25°, opening upward.

The conglomerate of the Stuver series, toward its north edge and along the fault scarp, is intersected by two systems of jointing about equally pronounced. One system trends east and west, with dip vertical; the other nearly north and south, with dip to the east at an angle of 80°. On the top of a low mountain along the edge of the scarp the same hard conglomerate is finely laminated by a well-marked cleavage trending N. 60° E. and dipping northwestward at an angle of 45°.

No estimate can be formed of the thickness of the Stuver series, as its lower limits are unknown. The exposed portion shows a thickness of at least 2,000 feet.

Age.—The Stuver series, from its position underneath the Lisburne series, which on paleontologic evidence is considered to extend to below Middle Devonian, is certainly not younger than Lower Devonian, and it is regarded as probably pre-Devonian.

Correlation.—No other Alaskan rocks with which it may be correlated are known to the writer. Sediments, notably of fine conglomerate, containing materials similar to those forming the conglomerates of the Stuver series, have been noted in the Mission Creek series of the Yukon district; but probably these, like the sediments derived from the Stuver series and now found in the Tertiary and other formations on the Arctic slope, have been many times deposited and reworked since they were derived from their original source.

LISBURNE FORMATION (DEVONIAN).

Character and occurrence.—Lisburne formation is the name here employed to designate the limestone, with some shale, occurring next above the Stuver series at the head of Anaktuvuk River. The name is taken from Cape Lisburne, where apparently the same formation, consisting of limestone and shale, occurs. On the Anaktuvuk the formation occupies a belt 15 or more miles in width, extending north and south along the valley. Toward the west the belt narrows and appears to soon be delimited on the southwest by the fault scarp of Contact Creek, and, farther west, by the Carboniferous of the Fickett series; while to the east of the Anaktuvuk it seems to widen. The westward extension of the formation may, however, somewhat exceed that represented on the map before it disappears beneath the Carboniferous, for the mountains south of Contact Creek were not ascended.

Where examined along Contact Creek, the north side of the valley for several miles consists of a steep wall, or fault scarp, of the Lisburne limestone, similar to that forming the scarp along the Anaktuvuk Valley on the east; while the rocks directly opposite, on the south side of the valley, less than three-fourths mile distant, are Carboniferous quartzite and conglomerate of the Fickett series. Northwest of this locality, however (as shown in Pl. IV, *B*, a view looking westward from the south edge of a Lisburne fault block near Contact Creek), the Lisburne, still forming the crest of the axis, with an elevation of about 6,500 feet, is less disturbed. The beds on the right, which show a marked increase in shale at the expense of the limestone, dip northward toward the base of the range, while farther west the Lisburne seems gradually to disappear beneath the Fickett series as a broad anticline, with the longer limb sloping gently southward and the shorter dipping more steeply northward, and probably playing an important part in forming the steep north front of the range, as has been shown to be the case to the east of the Anaktuvuk Valley.

In the foreground of Pl. IV, *B*, the Lisburne extends all the way across the field from left to right, but the sculptured cirque topography forming the top of the mountains in the left background lies in the slate and quartzite of the Fickett series, which, to the northwest, seems to overlie the Lisburne and form the crest of the range, and probably also descends the north slope and underlies the Mesozoics of the Anaktuvuk Plateau at the north base of the mountains.

The rocks of the Lisburne formation may be characterized for the most part as medium-bedded semicrystalline limestone of impure white or gray color. They weather gray, light rusty brown, or chocolate. They form the mountains that rise to a height of 2,500 to 3,000 feet above the floor of the Anaktuvuk Valley. Near the summit (see Pl. X, *B*, and fig. 4) occur two beds of intercalated shale, each apparently several hundred feet thick, and containing some thin layers of dark-gray limestone.

On the east the extent of the formation is unknown. On the south it is apparently in contact with the Carboniferous, while in descending the slope of the mountains on the north it disappears beneath a mantle of glacial till, where, judging from the topography, it is probably soon met and overlain by Mesozoic strata, which probably rest unconformably upon it at this point. (See. fig. 4, p. 51.)

Judging from exposures observed in the region of the Anaktuvuk, the thickness of this limestone formation is probably a little over 3,000 feet.

Structure.—The entire area of the Lisburne formation here considered is deeply involved in the system of faulting and disturbed blocks referred to under the heading "Stuver series." As viewed from the Anaktuvuk Valley, looking either east or west (see section on Pl. III; also fig. 4 and Pl. X, *B*), the Lisburne series reveals but little of the disturbance it has undergone. On the southwest, however, toward Contact Creek, the rocks have been folded and broken into blocks, which in some instances are highly tilted. The fault on the west side of the Anaktuvuk, shown on the right of fig. 4, probably represents the westward extension of the same fault that gave rise to the scarp along the northern edge of the Stuver series, which series however, has not here been brought to view. At the north base of the mountains, west of the Anaktuvuk, the Lisburne formation disappears beneath the covering of glacial drift with a dip of 60° to the north. East of the Anaktuvuk it similarly disappears beneath the drift, but with an opposing dip at an angle of 75° S., against the fault scarp of the Stuver series, as shown in the section on Pl. III. Between these two localities the Stuver series probably attains a steep westerly dip, of which there is some suggestion along the north edge of the valley, or a portion of the valley may be traversed by a north-south fault extending from the north edge of the mountains to the southern limits of the Stuver series.

In certain localities, notably on the south side of the Anaktuvuk, the Lisburne is cut by a close jointing, trending N. 27° E., with dip southeast-east at an angle of 85°, dividing the rocks into thin slices from 2 to 8 inches in thickness.

There can be but little doubt that the faulting between the Lisburne and the Fickett series continues eastward and connects with that along the southern edge of the Bettles series, on Koyukuk and Chandlar rivers. Its alignment with the boundary of the Bettles series, as located in a previous year's work,[a] is shown on the geologic map, Pl. III.

Age.—The most convenient disposition to make of the Lisburne formation would be to include it with the Fickett series and call the group Carboniferous and Devonian, since both Carboniferous and Devonian fossils occur freely in the stream gravels of the upper John and Anaktuvuk rivers, and none of the fossils found in place were sufficiently well preserved for identification. On lithologic grounds, however, the Lisburne formation can be set apart as quite distinct from the Fickett series, which it also seems to underlie. Therefore, on the basis of the Devonian fossils found in detached fragments of rock on the surface of the formation near the top of the mountains, and on the lithologic similarity of the rock attached to these fossils to that of the Lisburne formation, the formation is provisionally referred to the Devonian.

[a] Schrader, F. C., Reconnaissance along the Chandlar and Koyukuk rivers, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pl. lx.

The fossils from the Lisburne formation collected by the writer have been identified by Mr. Charles Schuchert as follows:

Fossils of the Lisburne formation.

Locality 455.
- Productella (2 species).
- Platystoma.
- Zaphrentis.
- Fenestella.
- Unitrypa.
- Eridotrypa, nearly identical with E. barrandei (Nicholson) of the Middle Devonian.

Localities 460 and 462.
- Spirifer disjunctus.

Localities 496, 498, 499, 501, 523, and 524.
- Diphyphyllum (1 species).

Locality 500.
- Zaphrentis.

Locality 528.
- Aulocophyllum.

Locality 533.
- Zaphrentis.
- Rhombopora.
- Fenestella.
- Hemitrypa.

Localities 455 and 528 appear to be of one formation of the Middle Devonian. The species present suggest very much the Athabasca-Mackenzie Middle Devonian, collected many years ago by Kennicott and described by Meek in the Transactions of the Chicago Academy of Sciences.

Localities 460 and 462.
- Spirifer disjunctus, one of the fossils characterizing the Upper Devonian. The same species is also found in the Peace, Hay, and Liard River regions of Arctic Canada.

Localities 496, 498, 499, 501, 523, and 524.
- Diphyphyllum (1 species). This genus extends in America from the Upper Silurian to the close of the Middle Devonian, and will probably also be found in the Upper Devonian, so that, unsupported by other evidence, it does not indicate an exact horizon. This or a very similar species has been found at or near the mouth of Mackenzie River in Devonian rocks.

Localities 500 and 533 are probably also of Devonian age.

Correlation.—On lithologic grounds it appears that the Lisburne formation can safely be correlated with the medium-bedded, unsheared limestone portion of the Bettles series, which is best exposed near the mouth of Bettles River, on the Koyukuk,[a] and it probably continues to the head of Chandlar River. Thus this limestone formation extends from the region west of the Anaktuvuk eastward 100 or more miles, and the presence of Devonian still farther eastward, to the north of the Chandlar, is rendered highly probable by a few fossils collected from the Chandlar River gravels in 1899 by the writer.[b] These fossils, a list of which follows, were identified by Dr. George H. Girty, whose statements thereon are here inserted.

[a] Schrader, F. C., Reconnaissance along the Chandlar and Koyukuk rivers, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 475.

[b] Ibid.

Paleozoic fossils from the Chandlar River gravels.

Locality 211. Indeterminable.
Locality 22. Syringopora sp. 1.
Locality 2. Syringopora sp. 2.
Locality 47. Spirifer, disjunctus type.
Locality 5. Cyathophylloid coral.
Locality 203. Crinoid stems.

Syringopora, so far as known, is not found above the Carboniferous; therefore 22 and 2 can be referred, with little doubt, to the Paleozoic.

The spirifer of locality 47 represents a type which is not found below the Devonian, and is, in a measure, restricted to rocks of that age. This spirifer can pretty safely be referred to the Devonian, and if, as I suspect, the form is *Sp. disjunctus* itself or one of its close allies, probably to the Upper Devonian.

The coral found at locality 5 probably belongs to the genus *Acervularia*. The age indicated is certainly Paleozoic, and probably Devonian.

The crinoid fragments found at locality 203 indicate nothing positive as to age. From their character and abundance I should be inclined to determine the horizon as Paleozoic.

It should also be noted that the trend of the series continued still farther eastward, beyond the Chandlar River Basin, strikes the Porcupine near the Lower Ramparts, where Devonian forms were collected by Kennicott,[a] and where Mr. McConnell, of the Canadian geological survey, reports the limestone to yield such fossils as *Atrypa reticularis*, with fragmentary specimens of corals referable, in part at least, to the Devonian.[b] It seems highly probable that the Lisburne formation may also be correlated with the similar limestone and shale formation occurring at Cape Lisburne, which, though nearly 400 miles distant, undoubtedly represents the westward continuation of the same mountain axis. (See Pl. V and fig. 1, p. 40.) This suggestion is based, in a measure, on the statements of different persons who have found Paleozoic fossils in the Cape Lisburne region, and more especially on the recent reports of Mr. H. D. Dumars and Mr. A. G. Maddren. The fossils collected by Mr. Dumars in the region, with notes by the collector, have been presented by Mr. Maddren to the United States National Museum, where they have been examined by Mr. Schuchert, whose communication on them to the writer is as follows:

Paleozoic fossils from the Cape Lisburne region.

There is an interesting coral fauna of Middle Devonian age from "limestone cliffs 4 miles south of Cape Lisburne, just south of the mouth of a considerable stream, where the rocks strike east and west, and dip south at 45°" (Dumars). This limestone contains—

Endophyllum, 2 species.
Syringopora, near S. tabulata.
Syringopora, near S. perelegans.
Diphyphyllum, near D. simcoense.
Diphyphyllum, near D. stramineum.
Zaphrentis, probably 2 species.

This limestone appears to be the same formation as that discovered by you last summer [at head of Anaktuvuk River] at localities 496, 498, 499, 501, 523, and 524, but more particularly at 455 and 528.

[a] Trans. Chicago Academy Sci., vol. 1, 1867. [b] Ann. Rept. Geol. Survey Canada, new series, vol. 4, 1890, p. 133 D.

In his field notes referring to this locality Mr. Maddren states that the limestones forming the cliffs referred to contain corals and other fossils and also veins of calcite. Fig. 1 (p. 40) is a profile section of the limestone and shale as sketched by Mr. Maddren at a locality a short distance south of the point where the fossils were found in place. The section includes Cape Lewis and Cape Dyer. So far as known, however, no fossils were found in the limestone represented in it. Cape Dyer is described as the sea terminus of a limestone range, about 1,000 feet in height, which trends inland in an easterly direction, the rocks striking east and west and dipping 35° N. In the valley between Cape Dyer and The Ears there is said to be a syncline of shale containing an exposure of coal along a sea cliff that rises from 50 to 100 feet above tide. The occurrence of coal here would seem to indicate the presence of some other horizon, probably Carboniferous or Mesozoic. According to Mr. Maddren the limestone beds at Cape Lewis also dip north and expose a thickness of 800 to 1,000 feet.

We may also note that the Middle Devonian discovered by Mr. Spurr in southwestern Alaska,[a] in the Kuskokwim country, is considered by Mr. Schuchert as about the same as that on the Anaktuvuk. The same is true of the forms collected by Mr. Brooks in southeastern Alaska.[b]

Distribution.—The thickness of the Lisburne formation in the mountains on the Anaktuvuk and at Cape Lisburne on the coast, and the important part it plays in the constitution of the Endicott Range and the continuation of these mountains westward to at least the one hundred and fifty-second meridian, as discovered by Howard,[c] as well as the general regularity in the disposition of the rocks, seem to render it highly probable that that formation is continuous between the Anaktuvuk and Cape Lisburne. Its lithologic resemblance to the limestones of the Bettles series on the Koyukuk[d] and the Devonian fossils found by the writer in the Chandlar River district, and by Kennicott and McConnell farther east on the Porcupine, would lead to the inference that the Lisburne formation, or at least the Devonian, forms a pretty constant component of this northern Rocky Mountain range from Cape Lisburne eastward throughout northern Alaska, for a distance of 600 or more miles, nearly to the international boundary and probably beyond it.

FICKETT SERIES (CARBONIFEROUS).

Character and occurrence.—The Fickett series, so named from the Fickett River of Allen (now called John River), comprises rocks of very diverse character, ranging from

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[a] Spurr, J. E., A reconnaissance in southwestern Alaska in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, p. 179.

[b] Brooks, A. H., Preliminary report on the Ketchikan mining district, Alaska: Prof. Paper U. S. Geol. Survey No. 1, 1902, p. 21.

[c] Stoney, Lieut. George M., Naval Explorations in Alaska, U. S. Naval Institute, Annapolis, Md., 1900, p. 70.

[d] Schrader, F. C., Reconnaissance along the Chandlar and Koyukuk rivers, Alaska; Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 475.

chloritic schists and phyllites on the south, through impure limestone, slate, sandstone, quartzite, and grit, to hard conglomerate on the north. As shown in the discussion of the Skajit, Totsen, Lisburne, and Stuver series, the Endicott Mountains contain two geologic axes, a northern and a southern, both composed of the older Paleozoic rocks, and, as represented on the geologic map and section (Pl. III), the Fickett series lies essentially in what appears to be a broad trough between these two axes. This trough or syncline, judging from the unconformity of the Fickett series to the Skajit and Lisburne formations, and the difference in character of the sediments, was probably occupied by an arm of the sea in late Paleozoic time, when the axes on the north and the south seem to have stood above sea level; and the sediments of the Fickett series, judging from their calcareous content, were probably in part derived from these Paleozoic land areas.

Here the Fickett series has a width, or north-south extent, of about 50 miles. On the south its edges appear to rest unconformably on the eroded Skajit formation of the southern axis, as shown in the geologic section, while owing to the faulting at the head of John and Anaktuvuk rivers its relations to the older rocks of the northern axis are not definitely revealed. It seems, however, to meet the Stuver series and the Lisburne formation by fault contact, as has been indicated. To the north of this contact, so far as observed in the region of the Anaktuvuk, all trace of the series in place seems to have been removed by erosion. To the west, however, beyond the limits of the fault-block system of the Devonian, about 20 miles from the Anaktuvuk, it seems to overlie the Lisburne formation, and probably extends beneath the Mesozoics at the north base of the range. From the occurrence of Carboniferous fossils in the stream gravels it is inferred that the same conditions probably prevail to the east of the Anaktuvuk, but they have not thus far been actually observed.

Beginning on the south slope of the north axis of the range, the lower part of the Fickett series, as it seems to be, consists of dark shale, schistose slate, and apparently some dark limestone, which is succeeded by quartzite, grit, and conglomerate. The sediments in the quartzite, and more especially those in the grit and conglomerate, though they are often fine, bear a marked resemblance to the vari-colored conglomerate of the Stuver series, from which they seem undoubtedly to have been derived. The quartzite, grit, and conglomerate are hard and flinty, the grains and pebbles being thoroughly united by a siliceous cement. The best exposure of these rocks that was seen is that at Fork Peak, on John River, east of camp July 12, from which point for about 15 miles northeastward, to beyond the Anaktuvuk portage, they present a steep face to the northwest, overlooking the upper part of John River Valley. Here the dip is gently south or southeast. Apparently these same conglomerates and grits were also encountered in the lower reaches of a deeply cut gulch about 20 miles south of Fork Peak, west of the mouth of Hunt Fork. Toward the top of Fork Peak the grit and quartzite give way to dark schistose slate and dark-gray micaceous sandstone.

Southward, at a geologically higher horizon, gray sandstone, limestone, gray schist, some quartzitic schist, slate, and conglomerate are encountered. These rocks are medium layered, variously interbedded, and more or less sheared. In the region of Hunt Fork a dark-gray or bluish schistose sandstone and soft slate become predominant. Apparently ascending in the column, still farther southward, the rocks become for the most part very fine-grained gray or bluish quartz-schist, with finally greenish chloritic schist and slate, which continues to the southern edge of the series, where it rests unconformably on the Skajit limestone formation. The quartzitic schist and the green chloritic schist often carry considerable quartz in small veins and stringers, trending more or less parallel with the schistosity and the bedding. But exceptions occur, as shown in Pl. XI, *A*, where a species of gash veining breaks across the bedding. This quartz frequently is most abundant in the bights of sharp folds and along lines of strain and breaking. So far as observed, the veins carry no valuable metals.

Besides the above-noted rocks, light-gray and dark or black limestones, apparently belonging to the series, but not met in place along the route traversed, were sighted and studied with the field glass both southeast and southwest of Fork Peak. These limestones, judging from the resemblance to the specimens found in the stream gravels, are the mother rocks of the fossils occurring so abundantly in the streams. Their position in the geologic section seems to be above the conglomerate, grit, and quartzite portion of the section and near the dark schistose slate and dark-gray micaceous sandstone, as shown to some extent in Pl. VII.

Structure.—The Fickett series, like the other Paleozoics of the range, has been subjected to faulting and folding, incident to mountain building. The general structure, however, seems to be monoclinal, with strike and trend east and west and dip south at angles of 20° to 45°. The dip may vary, however, from southeast in some localities to southwest in others, while in certain cases the rocks lie nearly horizontal or dip very gently north. The prevailing southerly dip of the series as a whole seems to point to a greater and probably later elevation in the northern than in the southern part of the range since the Fickett was laid down.

The series is finely cut in some localities by the major nearly northeast-southwest jointing, whose planes are frequently slickensided and usually dip 70° to 80° NW. Slight movement, or normal faulting, has frequently taken place along them. The rocks are also traversed by a secondary set of joints, trending nearly northwest and southeast, with dip nearly vertical, or in some instances 60° to 80° SW.

The schists, and notably the slates, often exhibit excellent cleavages, a good instance of which is shown at Crag Peak, 10 miles south of Hunt Fork and 4½ miles west of John River. Here the cleavage trends N. 35° E. and dips northwest at an angle of 85°. Four miles north of this point, on the west side of John River, occurs another good instance, in which the cleavage trends N. 70° E., with dip to the north at an angle of 45°. Also where the river crosses the sixty-eighth parallel a cleavage is found trending east and west, with dip south at an angle of 30°.

Age.—No fossils have been found in place in this series, but on the basis of abundant Lower Carboniferous forms obtained in the stream pebbles of the region, and the lithologic resemblance of these pebbles to the rocks of the series, and also from the relation of the series to the Lisburne formation (which is considered Devonian and seems to underlie it), the Fickett series is provisionally assigned to the Lower Carboniferous. Following is a list of the fossil forms collected by the writer within the area occupied by the series, largely on the headwaters of John and Anaktuvuk rivers. They have been identified by Mr. Schuchert, who reports as follows:

Fossils from the Fickett series.

Locality 493. Lithostrotion (of the group in which the corallites are not in close embrace).

Locality 495. Spirifer striatus Martin, Productus scabriculus Martin, and Spirifer near S. neglectus Hall.

Locality 513. Productus scabriculus Martin.

Locality 520. Productus semireticulatus Martin.

Locality 521. Spirifer striatus Martin; Productus, a very small undetermined species, and Cystodictya nearest to C. lineata.

Locality 522. Spirifer striatus Martin and Fenestella.

Locality 525. Spirifer striatus Martin and Spiriferina cristata Schlotheim?

Locality 534. Streblotrypa near nicklesi Vine; Fenestella, several species, one of which is near F. cestriensis Ulrich; Cystodictya, Pinnatopora, and Rhombopora.

The above eight localities represent one formation, in the upper portion of the Lower Carboniferous. This fauna, however, is unlike that of the Mississippi Valley in that it does not have its characterizing fossils, as the screw-like bryozoan *Archimedes* and the blastoid genus *Pentremites*.
parisons must be deferred until larger collections are at hand.

Localities 497 and 529 have a *Syringopora* much like *S. multattenuata* of the Upper Carboniferous. This genus, however, has little stratigraphic value, but the development of the species present is indicative of Carboniferous.

Localities 511, 518, and 454 are represented by a crinoidal limestone, apparently the same as at localities 525 and 521 and probably from the horizon of the latter.

Localities 463 and 464 represent another horizon, since the lithology is quite different from any of the other localities. The only fossils present are large crinoidal columns like those of the Lower Carboniferous.

Locality 461 also has large crinoid columns and may represent the Lower Carboniferous.

The above localities probably all represent the same Lower Carboniferous formation as that of the specimens from localities 493, 495, 513, 520, 521, 522, 525, and 534.

Locality 519 has *Fenestella*, *Cystodictya?* and crinoid columns. The material is unsatisfactory and all I can do is to state that it indicates either Devonian or Carboniferous.

A. QUARTZ GASH STRINGER VEINING IN FICKETT SERIES ON JOHN RIVER, IN ENDICOTT MOUNTAINS.

Looking southeast.

B. STRUCTURE IN ANAKTUVUK SERIES ON ANAKTUVUK RIVER

Looking N. 10° W.

In referring the series to the Lower Carboniferous, however, it should be borne in mind that the fossils were nearly all found in the northern part of the field, where they have apparently come from near the lower part of the section, and since the series is possibly 8,000 to 10,000 feet in thickness, it may extend not only into Upper Carboniferous but possibly into Lower Mesozoic.

Correlation.—Carboniferous fossils have been collected by Spurr[a] and Collier on the Yukon above Circle, by Mendenhall and the writer in the northern part of the Copper Basin, and by Dall in southeastern Alaska, on Kuiu Island, but these all seem to be Upper or Permo-Carboniferous, and therefore afford no ground for close correlation of the rock occurring there with those of the section here considered.

Independent of paleontologic evidence, on purely lithologic grounds, some of the gray schist, sandstone, and limestone beds of the series toward the northern part were associated by the writer in the field with the West Fork series of Chandlar River,[b] which is regarded as possibly the source of some of the Paleozoic fossils found in the river gravels below that point, and which has been relegated by Doctor Girty to Carboniferous or Devonian.

Carboniferous forms are reported to have been collected on Captain Beechey's voyage,[c] 1825–1828, on the northwest coast between Cape Beaufort and Cape Thompson (see Pl. V). More recently, in the Cape Lisburne region, plant remains have been collected by Mr. Dumars which have been identified by Mr. David White as a small species of *Lepidodendron*, related to *L. chemungense*, and a small form of *Stigmaria ficoides*, indicative of Carboniferous age. This denotes at least the presence of Carboniferous rocks in the Cape Lisburne region, which, on future investigation, may be correlated with the Fickett series, and suggests that the rocks of the two regions may be continuous in the mountains lying between them, as the Devonian is supposed to be. (See p. 66.)

In fact, if topographic criteria be taken into account—namely, the continuation of the mountains eastward beyond the international boundary—with what has been said of the occurrence of the Lisburne formation, it may here be briefly stated, in concluding the subject of Paleozoic rocks, that the present exploration, together with the evidence previously collected in the region to the east and that to the west, toward Cape Lisburne, seems to indicate beyond question the extension of a well-developed belt of Paleozoic rocks across northern Alaska, coinciding with the trend of the Rocky Mountains from the one hundred and thirty-fifth meridian, near the Mackenzie, to the one hundred and sixty-sixth, at Cape Lisburne, a distance of nearly 1,000 miles.

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[a] Spurr, J. E., Geology of the Yukon gold district, Alaska: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898.

[b] Schrader, F. C., Reconnaissance along the Chandlar and Koyukuk rivers, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900.

[c] Voyage of Captain Beechey to the Pacific and Behring's Straits, London, 1836, pp. 378–405.

In the Cape Lisburne region, as noted, the belt has a known width of nearly 75 miles and the rocks terminate in abrupt sea cliffs. The thickness of the section here is not known, but from what has been learned of the attitude of the rocks, it is judged to be considerable, since nowhere do older rocks appear to be exposed beneath these Paleozoics; from which it seems safe to infer that the latter probably extend far seaward as a submarine feature; and as this part of the ocean is known in the main to be shallow, it seems not unlikely that the same formations may extend across its floor and appear on the Siberian coast. It may be noted, however, that Doctor Dall, who visited this coast, reports that the rocks on portions of it are essentially crystalline or igneous. Some lignite occurs on Wrangell Island, but we do not know that Paleozoic or other formations occur there.

MESOZOIC ROCKS.

CORWIN SERIES (JURA-CRETACEOUS).

Character and occurrence.—The name Corwin is proposed for a series of sedimentary rocks which are younger than the Fickett series and older than the Anaktuvuk series (next to be described). The name is taken from Corwin Bluff, in the Cape Lisburne region (see Pl. V), where the well-known coal mines of this name are located, and where rocks typical of the series are well exposed.

The rocks in the main have a strong lithologic resemblance to the Anaktuvuk series, and seem to be closely related to it in geographic and stratigraphic position, but as they are not known to occur in the interior along the route followed by this traverse, they will not be found represented on the geologic map nor in the geologic section. However, sufficient has been seen of the rocks along the coast from Wainwright Inlet to near Cape Lisburne to lead to the inference that they probably form a part of the trans-Alaskan Rocky Mountain system; and on topographic, geographic, and lithologic grounds, as shown in what follows, it has been concluded that they are intermediate between the Fickett and Anaktuvuk series, a view which is also supported by paleontologic evidence. The series contains the Wainwright, Cape Beaufort, Thetis, and Corwin coals, most of which are of good grade. The inland extension of the series is also further suggested by the occurrence of coal on the Colville, reported by Howard and by Reed (see p. 31).

As observed along the coast, the Corwin series seems to extend from near Wainwright Inlet, latitude 70° 37′, longitude 159° 45′, southwestward a distance of 180 miles or more, nearly to Cape Lisburne (see Pl. V). Beyond this point, farther inland, it seems to give way with marked unconformity to the Paleozoic rocks forming the core of the mountains terminating in the sea cliffs at Cape Lisburne and the coast south of that point (fig 1, p. 40).

The series was first examined by the writer in the low coastal bluffs near Wainwright Inlet, where the rocks consist of layers of dense, earthy-colored or dark-gray, soft, impure limestone or calcareous shale, and hard, bluish gray sandstone of medium grain, all interbedded with dull-bluish, softer shale. Here the land mass, composed in the main of these rocks, rises about 90 feet above sea level, and presents a nearly flat or very gently undulatory surface extending as far as can be seen.

Cape Beaufort (see Pl. V) marks the southern termination of this very gently undulatory or nearly flat lowland, which extends southwestward from Point Barrow, and which is underlain by rocks belonging, in part at least, to the Corwin series. As we near Cape Beaufort, in proceeding southward, the surface soon rises by a succession of low, minor ridges, of which the cape itself is the chief. This ridge is about 800 feet high, and is a portion of a warped and dissected plateau extending inland to the southwest (see Pl. X, *C*). The rocks of this plateau, though resembling the Corwin series, seem distinctly more indurated and bear the stamp of greater age. For this reason it is thought that they may, on further research, prove to be as old as Triassic or possibly Carboniferous, especially since Carboniferous fossils are reported to have been found somewhere in the region. For the present, however, the Cape Beaufort rocks are regarded as part of the Corwin series.

At Cape Beaufort the rocks consist essentially of thin-bedded, impure, gray and brown sandstone and arkose, with sometimes a little conglomeratic material containing lignitic plant remains. The sandstone is occasionally hardened, almost to quartzite. There is also some very impure limestone, and some coal.

Farther west, in the region of Cape Sabine (see Pl. V and Pl. X, *C*), considerable shale is also known to occur; and still farther west, in the region of the Corwin coal mines, the rocks, as exposed in the beach bluff, are mainly soft, impure, dull-greenish, gray, or brownish sandstone, shale, slate, and coal. Some more typical hard, gray sandstone, however, is also present. In general, the rocks occur in thin beds, from 1 to 2 feet in thickness, but occasionally there are layers 4 to 8 feet thick. These heavier members are usually sandstone.

Structure.—Excepting the tilt which the beds have received by uplift, giving them a general southerly dip varying from a very low angle to 40° or more, they have been but little disturbed. Some folding, however, and apparently slight faulting have taken place.

In the lowland near Wainwright Inlet the rocks are nearly horizontal or dip very gently southeastward. At Cape Beaufort the strike is N. 25° W., with dip southwestward at an angle of approximately 20°. In the region of the Corwin mines the strike is N. 45° W., and the dip 36° or more southwestward. Here the rocks are also cut by two systems of jointing, trending nearly at right angles. The one trends nearly northeast and dips northwest at an angle of 60° to 70°, while the other trends nearly northwest, approximately parallel with the strike of the rocks, and dips northeastward at an angle of 60° to 70°. These jointings, however, do not cut up the rock greatly, not nearly so much as do those in the Lower Cretaceous rocks of the Anaktuvuk series in the interior.

Age.—Remains of fossil plants found in the Cape Beaufort region, and more particularly in the shale near the Thetis mine at Cape Sabine, by Mr. Dumars, Mr. Woolfe, and others, have been identified[a] by Professor Fontaine and Doctor Ward as not older than the Oolitic of the Jurassic, nor younger than the Lower Cretaceous, and as probably transitional between the two. Similar evidence is afforded by fossil plants collected by the writer on the coast about 7 miles southwest of Wainwright Inlet, which have been identified by the same authorities as—

Nageiopsis longifolia Font.
  Older Potomac of Virginia (Lower Cretaceous).
Podozamites distantinervis Font.
  Older Potomac of Virginia (Lower Cretaceous).
Baiera gracilis (Bean) Bunbury.
  Oolite of Yorkshire, England (Jurassic).

On the above evidence, therefore, the Corwin series is provisionally assigned to the Jura-Cretaceous.

Correlation.—Except the Kennicott[b] formation in the Copper River district, no Jura-Cretaceous rocks with which the Corwin series can be correlated have thus far been found in Alaska.

ANAKTUVUK SERIES (LOWER CRETACEOUS).

Character and occurrence.—The Anaktuvuk series takes its name from the native name of the river along which it was observed by the writer. It underlies the southern or principal part of the very gently rolling Anaktuvuk Plateau, along the north side of the Endicott Range, whence, with surface sloping gently northward, it continues to form the country rock for a distance of about 50 miles, where it is succeeded by younger rocks.

Along the base of the mountains the series, judging from the topography (see Pl. IV), is believed to rest unconformably on the Devonian, or Lisburne formation. Of this, however, we have no conclusive evidence, as the actual relation between the two rocks was not seen, because of the covering of glacial drift. The first exposure of the series visited by the writer is about 8 miles from the mountains.

To the east the Anaktuvuk series is probably soon limited by the Paleozoic front of the range, while to the west and northwest it probably constitutes in part the

[a] A full description of these collections, including the forms collected by the writer, will appear in Doctor Ward's second paper on the Older Mesozoic floras, to be published by the U. S. Geological Survey.

[b] Schrader, F. C., and Spencer, A. C., Geology and Mineral Resources of a Portion of the Copper River District, Alaska (a special publication of the U. S. Geol. Survey), 1901, p. 48.

so-called Meade River Mountains, and, continuing northwestward, may extend to the Arctic coast.

The series consists essentially of impure sandstone or arkose, with a little fine conglomerate. The sandstone is usually heavy bedded, beds 6 to 8 feet in thickness being common, and it is generally fine to medium grained, but in some localities becomes so coarse as to be almost a grit. In color it ranges from dark or bluish gray to dirty greenish, while the coarser grained rock often presents a speckled or salt-and-pepper appearance, and is seen to be composed of grains of the variously colored flints represented in the Stuver conglomerate. In fact, the color of the rock throughout seems to be determined largely by the relative abundance of the different colored sediments from the Stuver series.

Northward from the mountains the rocks, though distinctly sedimentary, contain also some detritus of igneous rocks, as fragments of feldspar and some dark mineral, apparently augite or hornblende. The igneous rocks from which such sediments have been derived probably occur in the mountains lying far east or southeast of the plateau, as none were observed in the mountains in the region of the Anaktuvuk.

Conglomerate is apparently rare in the series, having been observed at but a single place—on the right bank of the Anaktuvuk about 2 miles below the mouth of Willow Creek, where it is exposed in a low point, interbedded with a few lens-like layers of sandstone. The conglomerate is typically rather fine, with scarcely a pebble exceeding three-fourths of an inch in diameter. The pebbles and cement are composed largely of sediments of the Stuver series, white quartz and dark or slate-colored flint being the most conspicuous. The pebbles are noticeable for their angularity, suggesting glaciation about the time the series was deposited. The cementation is relatively firm for a young rock, but is not comparable with that in the Stuver or Fickett series. The cement is mainly siliceous, but contains also calcareous material, probably derived from the Lisburne formation.

Owing to the low relief and the covering of drift and moss, no accurate idea can be formed of the thickness of the Anaktuvuk series, but it is estimated to be at least 2,000 feet.

Structure.—The strike of the Anaktuvuk series is approximately east and west, agreeing in this respect with the several series of rocks that compose the range to the south. Broadly considered the structure seems monoclinal. The rocks in general dip gently northward at varying angles, but subordinate gentle anticlinal and synclinal folds are present, the latter being occasionally open. These were probably caused by the same mountain-building forces that were exerted in the range to the south. This is suggested by the fact that the trend of the more pronounced folds in the plateau is parallel with the main folding of the range, as if all belonged to the same system. Besides the east-west major flexures, the plateau is also traversed by a subordinate or minor system of cross folds or warpings, with axes trending north and south, giving rise to occasional low domes, as shown in fig. 3 (p. 46), which also shows that the region has been subjected to considerable denudation.

The series is freely traversed by two systems of jointing, as shown in Pl. XI, *B*. Of these, what seems to be the dominant or major system trends nearly northwest and dips southwest at an angle of 80°, while the minor system traverses the rocks at nearly right angles to the major, trending northeast, with dip 80° SE. Both systems seem to roughly correspond in trend with the similar structures in the Paleozoic rocks in the mountains to the south.

Age.—It has been determined, on paleontologic evidence, that the Anaktuvuk series is Lower Cretaceous. It contains typical *Aucella* beds of Alaska. The first fossils collected by the writer were found 8 miles north of the foot of the mountains. Subsequently others were found at several points farther north, principally at the first cross ridge on the Anaktuvuk, and in the bluff at the mouth of Willow Creek. Of these fossils the most characteristic, as determined by Doctor Stanton, are "*Aucella crassicollis* Keyserling, or closely related forms, and are of Lower Cretaceous age.

It should be borne in mind, however, that while its Jurassic forms prevent the Corwin series from being included with the Anaktuvuk series as Lower Cretaceous, it is not improbable that the discovery of such forms in the future may place the lower portion of the Anaktuvuk series, now assigned to the Lower Cretaceous, in the Jura-Cretaceous, since no fossils have yet been found in the extreme basal portion of the Anaktuvuk rocks.

Correlation.—On paleontologic grounds the Anaktuvuk series may be directly correlated with the Koyukuk series, next to be described. The rocks of the former, however, are free from all trace of igneous intrusions, while the Koyukuk series is associated with igneous rocks,[a] as dikes, and probably also as flows.[b]

Lithologically the Anaktuvuk rocks bear little or no resemblance to the Mission Creek series, assigned to the Cretaceous by Spurr,[c] nor to the Kennicott formation or the Orca series of the Copper River district. As shown in the table of provisional correlation, several other series of rocks found elsewhere in Alaska have also been referred to the Cretaceous—the Matanuska series by Mendenhall, between Resurrection Bay and Tanana River; the Tordrillo, Holiknuk, Kolmakof, and Oklune by Spurr, in southwestern Alaska; and the Cantwell conglomerate by Eldridge,[d] in the Sushitna River region.

[a] Schrader, F. C., Reconnaissance along the Chandlar and Koyukuk rivers, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 477.

[b] P. 78, this paper.

[c] Spurr, J. E., Geology of the Yukon gold district, Alaska: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898.

[d] Eldridge, G. H., A reconnaissance in the Sushitna Basin, Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1898.

KOYUKUK SERIES (LOWER CRETACEOUS).

Character and occurrence.—The rocks of the Koyukuk series consist of pink and reddish impure limestone, dark shale, slates, and some sandstones or arkose, with occasional associated igneous rocks. The latter include dioritic dikes, amygdaloids, and andesitic tuffs, which denote volcanic activity during and subsequent to Lower Cretaceous time.

The series is represented as occupying a small, roughly quadrangular area near the southern edge of the geologic map, lying principally between the sixty-sixth parallel and the Arctic Circle on Koyukuk River. It, however, is known to extend southwestward considerably beyond the limits of the map, and may with further investigation be found to occupy a large part of the Koyukuk Basin. It is represented as limited on the northeast by the Bergman series, which in a general way it seems to underlie, and with which further study may show it to be closely connected in point of age.

Owing to wide breaks in the sequence of outcrops and the changing attitude of the rocks, no attempt will be made at present to form an estimate of the thickness of the series. It may be noted, however, that at one point where fossils were collected, near the southern edge of the map, on the right (or west) bank of Koyukuk River, the limestone exhibits a thickness of about 800 feet.

Structure.—The Koyukuk series has been variously disturbed by folding and by some faulting, but the prevailing dip, so far as observed, is northward, roughly speaking, at an angle of 40° to 45°. A profuse jointing trends N. 25° W., and dips steeply northeast, and a well-marked cleavage strikes northeast and dips 75° SE.

Age.—The age of the Koyukuk series is supposed by Doctor Stanton to be the same as that of the Anaktuvuk series. This determination is based on fossils collected by the writer in the impure limestone near the southern edge of the area mapped, on the right bank of the river, and at another locality a few miles farther down the stream, to the southwest. In each instance Doctor Stanton states that Lower Cretaceous age is indicated by the presence of *Aucella crassicollis* Keyserling.

Correlation.—See "Correlation" under Anaktuvuk series, page 76.

BERGMAN SERIES (CRETACEOUS?).[a]

Character and occurrence.—The term Bergman is here employed to designate a group of comparatively uniform rocks covering a large area in the Koyukuk Basin and forming in large part the Koyukuk Plateau (see p. 44). This series lies north of the Koyukuk series and has a north-south extent of 60 to 70 miles. On the north it rests unconformably on the schists of the Totsen series, while on the south it is apparently infolded with the Koyukuk series, to which it is supposed to be closely related and which it is supposed to succeed in geologic age.

[a] The name Bergman is that of a trading post on Koyukuk River situated within the area occupied by the series, at a point where its rocks have become exposed by the incision of the valley into the plateau.

The Bergman series consists essentially of thin- or medium-bedded, impure, gray or brownish sandstone and dark slate, with some dark shale and occasionally conglomerate, but along the north it is bordered by a belt of conglomerate about 10 miles wide which is apparently the basal member. The sediments of the series have been derived very largely from igneous rocks, as is shown by the generally feldspathic constituents of the sandstones and the presence of basaltic, diabasic, and granitic pebbles or finer detritus in the conglomerate on the lower part of Alatna River and at Lookout Mountain. The supposed basal belt of conglomerate along the northern border, however, so far as it was observed in the John River region, is composed essentially of the débris of limestone and mica-schist derived from the Skajit formation and the Totsen series, on which latter it unconformably lies. This conglomerate is normally coarse, and in some instances contains bowlders.

Owing to the wide separation of the outcrops visited, data for forming an adequate estimate of the thickness of the Bergman series have not been obtained. From a general impression, however, it seems safe to suggest that it is probably at least 2,000 feet.

Structure.—The Bergman series, like the Koyukuk series to the south, has been considerably folded and somewhat faulted, but apparently to a less degree than the latter. Faulting has been observed on Koyukuk River just below Bergman and farther downstream, below Kanuti River. Though local folding has been pronounced, and the rocks are sometimes highly tilted and stand on edge, the prevailing dip of the series seems to be gently southward. On the whole the series does not seem to have received from the geologically late crustal movement the widespread tilt exhibited by both the Anaktuvuk series on the north of the range and the Koyukuk series on the south. Lookout Mountain apparently represents part of an anticlinal fold occurring in the series. Here the beds strike a little north of west and dip south at an angle of about 80°. A pronounced jointing trends northwest and dips 80° NE. A minor jointing trends north and dips east at an angle of 80°. On the north, where the beds apparently rest against the Totsen series, the dip is south at an angle of about 40°.

Age.—In 1899, owing to the presence of coal, lignite, and fragmentary plant remains in the beds, notably above Tramway Bar, and the resemblance of the beds in many instances to the Kenai formation occurring elsewhere in Alaska, it was conjectured that the rocks might be Tertiary and in part Kenai. The more extended observations made during the last season, though a large area of the series was traversed, have thrown no more definite light on the subject, for determining fossils were not found. It has been shown, however, that between Bergman and John River the series bears a marked resemblance lithologically to the Anaktuvuk series, or Lower Cretaceous, and that its rocks, on the whole, are more indurated than the coal-bearing Upper Cretaceous or Nanushuk series, both occurring in the Arctic slope region. Judging from this, and from the seemingly close relationship of the Bergman series to the Lower Cretaceous or Koyukuk series, and the bituminous character of its coal content (No. 187 in table of analyses, p. 114), it seems probable that on further investigation the Bergman series is more likely to prove to be Cretaceous than Tertiary.

NANUSHUK SERIES (UPPER CRETACEOUS).

Character and occurrence.—This series is named from Nanushuk River, the native name of the stream on which it occurs, and which flows into the Anaktuvuk north of the middle of the belt. The series lies north of the Anaktuvuk series, which it seems to overlie unconformably, and is itself in turn overlain by the Tertiary Arctic coast strata, with which its relations are apparently also unconformable. The unconformity between the Anaktuvuk and the Nanushuk is inferred from the difference in the topography and the marked change in the character and attitude of their rocks. In the most northern observed exposure of the Anaktuvuk the dip is north, while in the most southern of the Nanushuk it is steeply south. The north-south width of the series, in the region of the Anaktuvuk, is about 30 miles, while its east-west extent is not known. It is probable that to the east it is soon delimited by the Anaktuvuk series, lying between it and the Paleozoics at the foot of the range. Westward, or rather northwestward, it may possibly extend to the Arctic coast, in the region between Point Barrow and Wainwright Inlet, but of this we have no paleontologic evidence.

Along Anaktuvuk River the topography of the Nanushuk series is of a character intermediate between that of the gently undulatory region of the Lower Cretaceous or Anaktuvuk series and that of the flat Tertiary coastal plain, whose terranes will be next described.

The rocks of the Nanushuk series are best exposed in the north bank of the Anaktuvuk about 5 miles above the mouth of Tuluga River. The exposure occurs in a bluff about three-eighths of a mile long that rises steeply 120 feet above the river (Pl. XII, *A*). The rocks, which here have a steep dip, are mainly thin bedded (Pl. XII, *B*). The beds range from 3 to 6 inches in thickness and exhibit rapid alternation. They consist of gray and brown sandstone, generally fine grained and sometimes friable, with some gray and impure fossiliferous limestone, dark shale, fine-grained gray quartzite, drab-colored and green chert, and black slate, stained reddish along the joints. Coal of good quality is also present (see analysis 107, p. 114). The beds strike N. 82° E., and dip south at an angle of 80°.

The above exposure seems to represent part of the south or upstream limb of an anticlinal fold which has been beveled off by erosion, for farther downstream the dip is north. Similar beds, probably belonging to the same series, were encountered, but not examined, about 10 or 12 miles above this point on the opposite side of the valley. Northward toward the Colville, where they are finally succeeded by the younger formation of the Tertiary coastal plain, the beds seem to lie more nearly horizontal. They possibly floor the valley and form the bed of Colville River down to about 5 miles below the mouth of the Anaktuvuk. Here are rapids which probably mark the termination of the series in the river bed, though the rocks are no longer exposed in the banks. Below this point the bed of the Colville appears to lie in the younger and softer formations of the coastal plain, and the current continues slack nearly all the way to the coast.

Structure.—So far as observed, the strike of the Nanushuk series is about east and west, and though, from comparison with some of the older rock series, we might expect the prevailing dip to be northward, observation has hardly been sufficient to affirm that it is so. The apparent existence of at least one pronounced anticline has been shown in the previous paragraph. The series is traversed by a system of approximately horizontal jointing (Pl. XII, *B*).

Age.—On paleontologic evidence the Nanushuk series is assigned to the Upper Cretaceous. The fossils were nearly all collected in the locality above described—on the north bank of the Anaktuvuk 5 miles above the mouth of the Tuluga. They have been identified by Dr. T. W. Stanton, who reports the lot to be certainly of Upper Cretaceous age. The forms identified are as follows:

Fossils of the Nanushuk series from bank of Anaktuvuk River 5 miles above mouth of Tuluga River.

Inoceramus, a rather large species, fragmentary specimens.
A small Astarte, numerous specimens.
Nucula, numerous specimens.
Avicula.
Pectunculus, several specimens.
Thracia.
Tellina, 2 species.
Siliqua.
Modiola.
Scaphites.
Haminea.

Besides the above, there are casts and impressions of numerous bivalves not yet determined.

Concerning the above list, Doctor Stanton remarks that the species are all apparently different from those with which he is familiar, but that several of them are of types known only in the Upper Cretaceous.

Correlation.—Upper Cretaceous rocks occur also to the south of the Endicott Mountains in the Koyukuk and Yukon Basin, between the southern edge of the

A. BASE-LEVEL FEATURE IN NANUSHUK SERIES ON ANAKTUVUK RIVER.

Looking N. 30° E.

B. STRUCTURE AND RAPID ALTERNATION IN BEDDING IN NANUSHUK SERIES ON ANAKTUVUK RIVER.

Looking N. 70° E.

area here discussed and Nulato, and include, in part at least, the so-called Nulato sandstone. A description of this series was given in a previous report.[a] The fossils on which the assignment is made were collected by the writer in 1899 in the Nulato sandstone between Pickart's coal mine and Nulato, and are of interest as being the first Upper Cretaceous fossils found in Alaska. Of this collection, Doctor Stanton has reported the following forms, and refers the beds to about the same horizon as the early Chico of the Pacific region in the United States:

Upper Cretaceous fossils from the Yukon Basin.

Ostrea.
Anomia.
Mytilus.
Cardium.
Opis?
Lucina.
Trigonia cf. T. leana Gabb.
Corbula.
Actaeonella cf. A. oviformis Gabb.

East of the international boundary both Upper and Lower Cretaceous fossils have been found on the Porcupine by Mr. R. G. McConnell, of the Canadian geological survey.[b]

TERTIARY ROCKS.

COLVILLE SERIES (OLIGOCENE AND PLIOCENE).

Character and occurrence.—The Colville series is named from the large river along which it occurs and is excellently exposed. It is a series of Tertiary terranes which underlies the flat tundra country, or Arctic Coastal Plain, that succeeds the more southerly rolling plain formed by the Upper Cretaceous or Nanushuk series, which it apparently unconformably overlies, being itself in turn unconformably overlain by the Gubik sands. The strata which have been thus grouped extend along the Colville from some distance above the mouth of the Anaktuvuk nearly to the Arctic coast, occupying a belt 80 to 100 miles wide. Judging from the topography, the series probably has a very considerable extent in an east-west direction, possibly reaching the northwestern coast in the region of Point Barrow and farther southward. It also appears along the northern coast in places between Point Barrow and the mouth of the Colville, but has not been recognized.

The inland edge of the coastal plain, formed essentially by this series, has an elevation of about 800 feet, from which, with very gradual slope, the surface descends approximately to sea level at the coast. Beyond this, the very gradually deepening

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

[b] Ann. Rept. Geol. and Nat. History Survey of Canada, vol. 4, 1888–1889, Montreal, 1890, pp. 122–125 D.

sea floor seems to be its continuation. Thus the subaerial tundra country and the submarine coastal shelf almost appear to be parts of the same plain. Beneath the sea, deposition is still active, while on most of the surface of the subaerial portion of the plain the work of erosion has hardly yet begun.

The series consists principally of heavy-bedded silts, soft sandstone, limestone, shale, and lignite. It is best exposed along the Colville in the region of the mouth of the Anaktuvuk, where it forms steep-faced bluffs about 200 feet in height, extending for a number of miles both up and down the river (Pl. VIII).

Structure.—The Colville series has been but little disturbed. The beds lie nearly horizontal. On the left bank of the Anaktuvuk, 10 or 12 miles above its mouth, they dip southward at an angle of 4° or 5°, but from near the mouth of the Anaktuvuk, along down the Colville nearly to the coast, they dip northward or northeastward (see Pl. VIII), so gently that great care is required to detect the introduction of successively newer and younger beds, as one ascends the geologic section in proceeding northward downstream. In the vicinity of the mouth of the Anaktuvuk some very broad, shallow depressions or folds are revealed. Above the mouth the dip is northward, at an angle of 8° to 10°, but a few miles below it is southward at about the same angle, so that the lower part of Anaktuvuk River seems to lie in a very shallow syncline.

Besides this gentle folding, the beds have also suffered slight faulting (see Pl. VIII, *B*). The maximum vertical throw in the faults observed is about 2 feet. Lateral crowding has also taken place, producing local crumpling or folds and small overthrusts, as shown in Pl. VIII, *B*, *C*, and Pl. XIII, *A*. In nearly all cases the crowding or thrust seems to have come from the south, indicating that crustal movements have apparently taken place in the mountain region in geologically recent time. The inland or upstream side of any particular stratum which has been broken or disturbed has been crowded or overthrust onto the coastal or downstream side of the same, often producing a short overlap. Disturbance, however, is hardly noticeable in the younger Pliocene portion of the beds toward the coast.

Observations made along Colville River indicate that the series has a thickness of 500 or 600 feet.

On account of difference in degree of consolidation of the beds, together with their fossil and lignite contents, the series has been separated by the writer into two parts, upper Colville and lower Colville. It is possible that an unconformity may exist between the lower and upper parts of the series, but if present it must be very slight.

Lower Colville (Oligocene).—This constitutes the main portion or lower three-fourths of the section exposed at the mouth of the Anaktuvuk. It is about 150 feet thick, while the upper Colville at this same locality is about 40 to 50 feet thick.

A

B.

STRUCTURE IN COVILLE SERIES (TERTIARY).

A, Looking S. 50° W.; *B*, looking S. 65° W.

C. COAL BED AND ROCKS OF CORWIN SERIES AT CORWIN MINES.

Looking S. 45° E.

The lower Colville contains the more indurated class of rocks and consists mainly of partially consolidated silts in beds 6 to 8 feet in thickness. They are usually light slate-colored or ash-colored, and constitute about one-half of the lower Colville section, and are generally much less consolidated toward the top than near the base. The harder rocks, which increase in volume toward the base of the section, include impure, dull gray, medium to fine grained sandstone with detrital lignitic plant remains; slate-colored and brownish calcareous shale, with disseminated undeterminable vegetable detritus; lignitic coal in layers 1 to 5 feet in thickness; dark slate-colored or brownish chert, containing cavities incrusted with chalcedonic silica; rusty brown, very ferruginous sandstone or impure iron stone, and some iron-stained siliceous conglomerate, which also contains lignitic vegetable remains. There are also a few layers of hardened silts, forming a rock of very fine texture, resembling soft, smooth hone stone.

The lower Colville is tentatively classed as Oligocene, on account of the presence in it of lignite beds and vegetable remains, and from its resemblance to the Kenai beds occurring elsewhere in Alaska, and also on the ground of its relation to the supposed Pliocene silts which it immediately underlies. Several specimens of the shale collected from it, bearing lignitic plant remains, were examined by Doctor Dall, who reports that "the vegetable fragments are probably the needles of *Sequoia langsdorffii* Heer. These beds containing vegetable remains in northern Alaska are usually Upper Oligocene."

Upper Colville (*Pliocene*).—This portion of the section is practically free from indurated rock. It consists of nearly horizontally stratified beds of fine gray, slate-colored, or ash-colored calcareous silts, containing faunal remains. It is tentatively assigned to the Pliocene on the basis of fossils collected in place by the writer in the bluff (near its top) on the west side of the Colville about a mile north of the seventieth parallel (Pl. XIV, *A*). These have been reported on by Doctor Dall as follows:

Fossils from upper Colville series in bluff on west side of Colville River 1 mile north of seventieth parallel.

Chrysodomus, 2 species, both undescribed and very interesting; the first Tertiary arctic shells (not Quaternary) I have ever seen. Perhaps they are Pliocene.

Amauropsis sp., fragments.

Tachyrhynchus polaris Beck.

Macoma frigida Hanley.

Macoma incongrua von Martens.

Astarte semisulcata Leach (possibly Quaternary intrusion).

Saxicava arctica L.

PLEISTOCENE DEPOSITS.

GLACIAL DEPOSITS AND GLACIATION.

Glaciation in geologically recent time in northern Alaska has not been of a continental character comparable to that of the northern United States and of the Cordilleran glacier, which overspread the vast field of the Pacific coast mountains in southern Alaska between the Yukon and the coast. It has been far more extensive, however, than has generally been supposed. In the valleys nearly everywhere within the Endicott Range evidence of ice action is shown by bed-rock scorings, local roches moutonnées, terminal moraines, and deposits of till on the lower valley slopes and benches. It has modified preexisting topographic forms, both by erosion of the rocks and by deposition of drift. In some cases, as revealed in places by erosion of the glacial deposits, steep-faced bed-rock benches in the sides of the valleys were covered and concealed by the drift, whose surface slopes gently down from the steep mountain side a distance of one-half mile or more, nearly to the present stream (Pl. XIV, *B*).

In the lower part of the intramontane section of John River, where the valley occasionally widens, it is sometimes floored by a till sheet, from 50 to 100 feet thick, containing ponds and lakelets, some of which seem distinctly to be of glacial origin. Till is prominent also in the mouths of some of the side valleys, as Till Creek Valley, which opens into that of John River on the east at about the sixty-eighth parallel. Here good exposures show the deposit to be typical till. It has a thickness of at least 100 feet, and forms a broad terrace or sort of small, triangular plateau a mile or more in extent, occupying the mouth of the side valley. It slopes westward, to where John River has been crowded to the bluffs on that side of the valley. On the east it overspreads and conceals the lower benching and bed-rock topography. Till Creek, a torrential stream, flows in a small canyon whose steep banks are formed of the bowlder clay or ground moraine.

In the region of Fork Peak, near the head of John River, at the confluence of several of its tributaries, the valley is wide and open and is floored by a till sheet at least 150 feet in thickness. The surface declines to the southwest, denoting that the deposit has largely come from the northeast, a view which is supported by bed-rock striæ farther down the valley. The till ascends the northwest slope of Fork Peak to an elevation of 2,500 feet, and may continue much higher, but becomes obscured by younger talus and coarse débris of doubtful character, which, however, also exhibits an ill-defined terminal moraine topography. At the elevation of about 3,500 feet is a bench overlain by talus and drift, which, judging from topography, was probably largely deposited by a local hanging glacier.

A. PLIOCENE FOSSIL LOCALITY IN COLVILLE RIVER BLUFFS (COLVILLE SERIES), TERTIARY COASTAL PLAIN.

Latitude 70° 1′; looking N. 25° W. Native Eskimo family in foreground.

B. GLACIATION IN UPPER JOHN RIVER VALLEY, IN ENDICOTT MOUNTAINS.

Looking S. 25° W.

The John Valley till sheet extends across the divide by way of Anaktuvuk Pass and is continuous with that of the Anaktuvuk Valley and the Arctic slope. At the pass the valley is 3 miles wide and open, and its surface is so flattened with infilled drift that the small streams descending from the mountains in this locality are deflected by the merest obstacle to either side of the divide, flowing sometimes northward by way of the Anaktuvuk to the Arctic, and at others southward to John River and the Yukon.

At the pass occur lakelets of glacial origin. One of these, Cache Lake (Pl. X, *B*), just northeast of the divide, is 30 feet or more deep. Its surface lies about 100 feet below that of the adjacent ground moraine, giving for the till sheet here a thickness of at least 130 feet. Just south of the pass the till sheet formerly extended entirely across the valley, as is shown by the flat-topped outlying remnants of ground moraine in its middle. These rise to the height of more than 100 feet above the stream, and accord in level with the ground-moraine terraces on either side.

On the whole, the till sheet in this northern part of the range seems rarely to extend up the side slopes to more than 500 or 600 feet above the floor of the valley. Judging, however, from the rounded and sometimes relatively flat-topped aspect of the mountains near the middle of the range (Pls. XIV, *B*, and XV, *A*), certain areas were not only occupied by an ice cap, but the tops of some of the lower mountains were planed off by ice movement.

Naturally, the side valleys in this region were among the last to become free from glaciers, some of which probably remained long after the disappearance of the ice from the adjacent parts of main valleys. This is shown by the presence of relatively fresh terminal moraines in the side valleys. Four miles northwest of the middle of John River Valley the small valley of Contact Creek is crossed by such a moraine. It is typical, being about 60 feet high and one-fourth of a mile in length, measured parallel with the valley. A similar but older feature occurs in John River Valley, near the middle of the range, about 12 miles in direct line south of the sixty-eighth parallel. Here the valley flat is crossed by a terminal moraine about 60 feet high, a portion of which is shown in Pl. XV, *B*. It still forms a continuous ridge or dam across the valley, except where the river has cut a notch-like passage, 200 yards wide, at the left. At the right the moraine seems to be continuous with the till sheet, which is 10 to 20 feet thick, and rests on the bed-rock benching at a height of about 100 feet above the river. As seen in looking parallel with the valley, the ridge presents an undulating profile and is sharp-crested, owing to its upstream side being cut away by the river. Though it exhibits but little of the typical hummock-and-kettle topography of a terminal moraine, it is composed mainly of typical bowlder clay carrying striated pebbles and bowlders, some a foot or more in diameter. The materials noted are of the same constitution as those of the river gravels, there being no erratics. The principal surface or front of the moraine, which slopes southward, supports a growth of spruce, some of the trees having a basal thickness of 1½ feet.

A few miles above this moraine occurs the last lingering remnant of the John Valley Glacier. It consists of a lone, roughly circular mass of ice about 300 feet in diameter, rising from the middle of the gravel-covered valley flats to a height of 60 feet, as shown in Pl. XV, *A*. At the top the ice terminates in several distinct knob-like prominences, projecting 10 to 20 feet above the main mass. One of these is cylindrical or pipe shaped. The others are crudely pyramidal. The ice is partially capped and flanked by a deposit of genuine till from one to several feet thick, to whose protection it doubtless in large measure owes its preservation. From three sides small streamlets of light-colored muddy water, arising from the melting of the ice and thickened with glacial rock flour from the till, flow down and deposit their load of fine, argillaceous sediment over the flats around the foot of the mass. This glacial mud is of very light color. It is sticky, and differs decidedly from the present stream deposits of the valley. This ice mass is undoubtedly a remnant of the John Valley Glacier. Its presence at this late date, after apparently all the other glacial ice has disappeared from the surrounding region, together with the rounded topography of the adjacent mountains, already noted (Pl. XV, *A*), suggests that this locality is probably near what was the belt of maximum precipitation, and consequently of maximum ice accumulation, that traversed the mountains during Glacial time, and is therefore among the last to become free from ice.

In the north slope of Anaktuvuk Pass, between John and Anaktuvuk rivers, the till topography is locally rough and in part terminal morainic. North of Cache Lake it contains occasional stretches of distinctly termino-lateral moraine, trending toward Anaktuvuk River, and for the last 10 or 12 miles of its course, before leaving the mountains, the Anaktuvuk meanders sluggishly through a belt of flats one-half mile or more in width, which lie about 100 feet below the surface of the till sheet or ground moraine on either side. This till sheet, with a slope that rises gently in the main, but which is sometimes terraced, extends from the edge of the flats to the base of the mountains, 1½ miles distant. Near the flats the topography is often of a morainic type, being composed of characteristic hummocks and kettles, and undoubtedly represents a lateral moraine, deposited along the edges of the valley glacier that occupied the flats toward the close of Glacial time.

The height to which the drift, as a sheet, rises along the northern edge of the mountains away from the Anaktuvuk Valley was not determined. Judging from distant observations, however, it in some cases probably ascends the valleys to 800 to 1,000 feet above the general level of the Anaktuvuk Plateau.

As Anaktuvuk River leaves the mountains its current becomes less sluggish and its channel is soon beset with glacial bowlders. At about 4½ miles from the edge

A. ICE REMNANT OF JOHN VALLEY GLACIER IN ENDICOTT MOUNTAINS.

Looking southwest.

B. TIMBERED TERMINAL MORAINE RESTING ON FICKETT SERIES ON JOHN RIVER.

Looking southwest.

of the mountains the river bluff on the left exposes a thickness of a little over 100 feet of typical till. From this point the deposit continues laterally up the side slopes of the valley, and apparently overspreads the plateau indefinitely, while the lower portions of the deposit, extending downstream, form terraces along the river. At about 10 miles from the mountains and 2½ miles east of the river, at an elevation of 2,400 feet, or nearly 700 feet above the valley floor, the top of a rounded sandstone hill, which rises to the general level of the plateau, bears patches of till a foot or more in thickness. Here, too, some of the less firm portions of the bed rock have been disturbed, while others bear markings that have been interpreted as imperfect glacial striæ. These trend approximately parallel with the valley. A view of the surface of the plateau from this point, as shown in Pl. IV, seems to indicate the presence of drift almost everywhere, though the deposit is probably thin on the tops of the higher ridges.

Till occurs farther down the Anaktuvuk, forming terraces and moraines similar to those noted in the intramontane section of the valley. About 15 miles north of the mountains, just below camp July 1, on the side of the valley, there is a lateral moraine that rises to a height of about 150 feet above the valley flat, which is here about three-fourths mile wide. The steep angle, 45° to 60°, at which the drift materials lie, as exhibited in the face presented to the valley, clearly denotes that they were deposited largely against an ice wall. Just in front of this moraine is a characteristic overwash plain from whose upper edge an unquestionable terminal moraine extends indefinitely, both to the east and to the west, away from the valley.

A little north of the above region, about 23 miles from the mountains, occurs the first pronounced cross ridge of Lower Cretaceous beds, through which the river has cut a short canyon. A few miles east of the river this ridge attains an elevation of about 2,500 to 2,600 feet. On ascending the ridge in this vicinity, from the plateau on the south, the till sheet was found to continue up to the elevation of about 2,250 feet, where, on the slope becoming a little steep, it suddenly ceases and the bed rock becomes exposed and continues so across the broad top of the ridge, while till is again encountered on its north slope, which descends into Willow Creek Valley.

On the top of the above ridge, however, are glacial erratic bowlders, which, though not abundant, are decisive in showing that an ice sheet passed over the ridge. As these erratics occur 400 to 500 feet above the ground moraine, it is inferred that they were probably transported as englacial or superglacial material. Here, also, large blocks of bed-rock sandstone have been moved from their original position to an extent that can not be accounted for by frost or weathering, so that their transportation seems to have been the work of moving ice.

About 10 miles northward, on Willow Creek Ridge, a similar feature, no glacial drift was found. At a few points the edges of the sandstone beds are disturbed, as if by ice action, but the evidence as to the agency is not conclusive. On descending the slope northwestward, however, toward the Anaktuvuk, erratics of the Stuver conglomerate were found at an elevation of about 1,650 feet. The surface in this locality, however, is so densely covered with moss that drift may extend above this elevation and yet not be exposed. But on the whole, from this point northward, the till seems rapidly to become restricted to the lower side slopes of the valley, where it forms low bluffs and terraces.

About 14 miles below Willow Creek, near camp August 5, bluffs of probable till, resting against the bed-rock sides of the valley, rise to a height of 125 feet above the valley flats, and there, apparently as a thin veneer, the deposit overspreads the adjacent bed-rock bench. This bench is half a mile or more in width, nearly flat topped, and densely covered with vegetation, so that away from its river edge no satisfactory examination of the deposit could be made. A few hundred feet above the upper or distal edge of the bench, however, are outcrops of sandstone, presenting no drift or indication of ice action.

Twelve miles north of the above locality, about five miles above the mouth of Tuluga River (see Pl. XII, *A*), a similar bench, lying at 100 feet above the river, is capped by a deposit of gravel and sand 20 feet in thickness. Some of the pebbles approach the size of bowlderets, and even bowlders. Though they are waterworn, no stratification is apparent in the deposit, which has much the aspect of a sandy till. Its position suggests that it may have been deposited here by waters from the glacier that possibly occupied the valley at this point. The deposit may, however, be fluviatile.

Sixteen miles farther down the Anaktuvuk, about 10 miles above its mouth, the bluff on the left is again capped by from 10 to 40 feet of sand and gravel, in which the gravel is more distinctly washed and rounded than in the deposit above noted, but the absence of stratification and the character of the material again suggest that glacial waters may possibly have been an agency in its deposition. If this inference is correct, the ice stream which occupied the Anaktuvuk valley must have extended down nearly to this point. There is, however, no reason to suppose that it extended below it. On the adjacent part of Colville River there seems to be no evidence of glaciation within a score or more miles above the mouth of the Anaktuvuk. The drainage of this section of the Colville does not seem to have been interrupted since the Tertiary.

From the conditions above described it is concluded that in the region of the Anaktuvuk Valley, in that portion of the Colville Basin embraced by the curving front of the Endicott Mountains, an ice sheet in the form of a small regional or piedmont glacier, gradually thinning out toward the north, extended from the front of the range northward across the inner part of the Anaktuvuk Plateau to the region of Willow Creek, a distance of 30 or more miles. Beyond this point ice flowage seems to have been confined substantially to the present drainage ways, in the form of valley glaciers, of which that of the Anaktuvuk is the chief.

There is evidence that the Anaktuvuk glacier extended northward to the sixty-ninth parallel, and there are some indications that it may possibly have extended 30 miles farther, to within 10 or 12 miles of the present mouth of Anaktuvuk River, but it is not to be supposed that it crossed Colville River, if indeed it ever reached it. This latter statement is probably also true of the ice streams to the west that must have occupied the valleys of Ninuluk, Killik, Kurupa, and Kucher creeks, which enter the Colville a little north of the sixty-ninth parallel.

It does not seem probable that the drift sheet on the Arctic slope much exceeds 150 feet in thickness at any point. It apparently attains its maximum development in the valleys, not far from the mountains, the source of supply. Elsewhere on the slopes its surface seems to conform very largely to the preexisting topography of the underlying terranes.

In the southern part of the Endicott Mountains, evidence of glaciation, as has been shown, may be found up to an elevation of nearly 2,000 feet. From the point where John River leaves the mountains, southward to the region of Kanuti River, the Koyukuk Valley region exhibits a generally rounded topography, which suggests former glaciation, up to a height of 1,600 or 1,800 feet. On John River, near the base of the mountains, the drift, so far as observed, is essentially till. In some localities the deposit is at least 100 feet thick, and is marked by several terraces that rise successively from the river to the southeast, above which the surface continues to have a rolling, apparently ground-moraine topography, that finally gives way to low, rounded mountains or hills, which also are supposed to be glaciated.

Observations in the above region away from the immediate route of travel were very limited. Along the route, however, glacial drift seems to be more or less continuous all the way down the open flats of John River Valley, as is shown by the topography and by occasional exposures of till rising to a height of 30 or 40 feet above the river or resting in thinner sheets on the bed-rock benches at elevations of from 30 to 100 feet above the stream.

Till is present near the mouth of John River and on the right or west bank of the Koyukuk between Bettles and the mouth of Jane Creek, where it forms bluffs about 100 feet high. Similar conditions seem to prevail to the eastward, in the region of Gold Bench[a] on South Fork, whence they apparently continue northeastward across the divide into the Chandlar River Basin, where till deposits similar to those on John River have been noted in a previous report, and have since been observed to extend up Granite Creek.[b]

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[a] When the only opportunity for making observations at Gold Bench was presented, 5 feet of snow lay on the ground.
[b] Reconnaissance along the Chandlar and Koyukuk rivers, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 478.

No glacial drift was noted on the top of Lookout Mountain, and, as the surface was deeply snow covered at the time it was visited, the elevation to which the drift ascends on its slope could not be learned. Southward, on the northeast side of the lower Alatna Valley, what seem to be till terraces occur along the south side of Double Mountain up to a height of 1,600 feet.

Just below the mouth of the Alatna the right bank of the Koyukuk presents a steep-faced exposure of clay and gravel, rising 80 to 100 feet above the river.[a] The lower 50 feet of this section seems to be till, and is distinctly separated by a well-defined contact from the upper portion, which consists mostly of gravels and silts, some of which are discordantly stratified.

From the character of the topography glacial drift is supposed also to occur on the opposite side of the Koyukuk and to extend southward toward the mouth of Kanuti River. Mr. Mendenhall reports that in the country lying north of this region, on the upper waters of the Alatna and the Kowak, above the sixty-seventh parallel there is evidence of glaciation similar to that in the same latitude on John River. Furthermore, in the recent gravels along the Koyukuk near Bergman, notably on the south side of the river, there are large granitoid bowlders, totally foreign to the country rock of the region. These may have been brought here through the agency of river ice from far up the valley of South Fork, but it seems equally probable that they may have been brought by glaciers from the mountains to the north where similar rocks in place are known to occur.

The hill just west of Bergman consists of Bergman sandstone, but on its slope, at a height of nearly 200 feet above the river, there is a gravel deposit composed of heterogeneous materials. An examination, as thorough as could be made under unfavorable conditions, indicates that ice action was concerned in its origin. It contains characteristically angular and subangular ice-worn pebbles, with polished surfaces, often profusely striated. The striæ are of distinctly glacial origin and can in no wise be ascribed to the action of river ice.

From the above-enumerated observations in this southern part of the field it is inferred that glaciation extended from the mountains southward into the Koyukuk Basin across the Arctic Circle and beyond Bergman, but observation has not been sufficient to determine whether this extension was in the form of a continuous ice sheet, or merely as valley glaciers. From topographic criteria, however, it seems probable that most of the hills below 2,000 feet were covered by ice or névé, while such peaks as Mount Lookout and its higher fellows appeared as nunataks above its surface, and that glacial activity, or ice work, was largely restricted to the valleys and lower reaches of the hill slopes.

In the John River and Anaktuvuk River portions of the Endicott Mountains the

[a] This bluff is the Unatlotly of the natives.

glacier ice (save the single instance cited on John River) has disappeared. To the east, however, as noted under "Previous explorations," prospectors and whalers who have crossed the range in the vicinity of the one hundred and forty-ninth meridian report the presence of valley glaciers of considerable size.

The glacial phenomena that have been described tend to show that, although the Endicott Mountains (Pl. VII) do not on the whole seem to have been overridden en masse by a moving ice sheet, they were doubtless, especially in their northern part, largely occupied by an ice cap or perennial névé, constituting a breeding ground for glaciers. The zone of maximum snowfall, and consequently of maximum ice accumulation, trending in an east-west direction, was apparently in the northern part of the range at least somewhat north of its median line. From this zone the ice moved off to the north and to the south, respectively, into the Colville and Koyukuk basins. Its flowage, especially during the latter part of the Ice age, was confined mainly to the valleys and drainageways in the form of alpine glaciers, of which there is ample evidence. But there is also good reason to believe, as shown by the till sheet north of the mountains, that during the zenith of the Ice age the northern edge of the range was occupied by a more or less extensive ice sheet, which, as a small regional or piedmont glacier, thinning out toward the north, extended northward over a considerable portion of the Anaktuvuk Plateau, its occurrence at that time being, perhaps, similar to that of the Bering or Malaspina glaciers of to-day.

GROUND-ICE FORMATION AND KOWAK CLAY.

At some localities along the Arctic coast there are stretches of low bluffs or banks of ground ice overlain by a deposit of dark muck and moss several feet in thickness. Deposits of light-colored clay also are occasionally seen. The occurrence and distribution of these deposits appear, in a measure, to be as represented by Doctor Dall on his map of the "Known distribution of the Neocene formations in Alaska."[a]

The ground-ice formation was hitherto supposed to be of very widespread occurrence in this Arctic region. To give an idea of the evidence on which this supposition rests I shall here freely quote from Doctor Dall's report.[b]

"From information gathered from several masters of vessels in the whaling fleet, and derived from experience gained in the effort to dig graves for seamen who had died aboard vessels on this shore from time to time during the last twenty years, it would appear that somewhat north of Cape Beaufort the land between the low hills and the sea is low and the soil chiefly a sort of gravel. 'At a depth of 2 feet is a stratum of pure ice (not frozen soil) of unknown depth. This formation extends, with occasional gaps, north to Point Barrow, and thence east to Return Reef, where

[a] Dall, W. H., Correlation papers, Neocene: Bull. U. S. Geol. Survey No. 84, 1892, opposite p. 268. Becker, G. F., Reconnaissance of the gold fields of southern Alaska: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pl. i.

[b] Op. cit., p. 264.

the ice layer is about 6 feet above the level of the sea. It goes south at least as far as Icy Cape without any decided break, and is found in different localities as far south as Kotzebue Sound.' At Point Barrow, near the international station, under the direction of Lieut. P. H. Ray, U. S. Army, a shaft was sunk to a depth of 37 feet 6 inches, which passed through successive layers of mud, sand, and fine gravel, with fragments of driftwood and marine shells, showing here and there large fragments of pure fresh-water ice, but no continuous stratum of ice. The formation here was clearly a beach alluvium, and relatively modern, a pair of Eskimo wooden snow goggles with sinew string still attached to them being found at a depth of 27½ feet. The temperature of the earth varied from $-5°$ to $+17.5°$ F.; below the influence of the external air the temperature of the earth was quite steady at 12° F. for nine months. The earth was frozen and was extremely hard and tough. Blasts put into the side of the shaft blew out without shattering the frozen earth around the drill hole. It is probable that excavations farther inland might have revealed the ice layer, which at the locality of the station did not exist."

The observations made by the writer, while boating along the coast, lead to the inference that the ground ice is not of so widespread occurrence as the above quotation indicates. Between the Colville and Point Barrow the ice is possibly more or less continuous along the coast, but of its inland extension we have little evidence. Even along the coast it is not extensively exposed. Here long stretches of the low tundra country are apparently underlain by rock or earthy deposit.

Of the localities at which the ice was observed, the most important are Cape Halkett and Cape Simpson, at each of which it seems to be practically continuous for a distance of several miles. Cape Halkett, one of the most prominent promontories along this part of the coast (Pl. X, *D*), terminates in an ice cliff rising 30 feet above tide level, and is overlain by a foot or two of muck, which in turn is carpeted by a nap of moss and grass at the surface. Judging from topography, the ice at this locality may extend inland several miles. Its thickness is not known, since its lower limit lies below tide level. As shown in the view (Pl. X, *D*), the cape is being rapidly cut back by wave action, which undermines the cliff at tide level until by its own weight the ice breaks off in large blocks and is ground up by the surf.

Coal occurs at Wainwright Inlet, between Point Barrow and Cape Beaufort. A little southwest of that place the Jura-Cretaceous comes to the coast, and, judging from topography, seems to continue nearly all the way to Cape Beaufort, omitting a probable breach at Icy Cape. From Cape Beaufort to Cape Lisburne rocks of the Corwin series (Mesozoic) are known to be almost continuous. It therefore seems, from the above facts, that the southern boundary of the ground-ice area represented on Doctor Dall's map should be shifted from the region of Icy Cape northward, probably to at least beyond Wainwright Inlet, a distance of 60 to 75 miles.

Of the Kowak clay containing Pleistocene vertebrate remains, referred to by Doctor Dall in connection with the ground ice, but little was seen by the writer. Observation, however, has been sufficient to suggest that, if present along the coast between the Colville and Chipp (Ikpikpuk) River, they are not only far from continuous, but are probably of very limited occurrence. Along the northwest part of the coast, the only locality at which what seems with certainty to be the Kowak clay was observed, is at Woody Inlet, about 50 miles southwest of Point Barrow. As this inlet is not far from the seventy-first degree of north latitude it is thought that the deposit may be near that in which Captain Beechey's party obtained elephant remains.

GUBIK SAND.

Besides the Tertiary Colville series, which underlies the coastal plain along Colville River, the section here also comprises deposits supposed to be Pleistocene. Of these, probably the most important and interesting is a surficial deposit of brownish sand or loam about 10 to 15 feet in thickness, which unconformably overlies the beds of the Colville series, apparently as a continuous mantle.

This deposit seems to be distinct from the Colville series and to extend over a large area of country. It not only forms the surficial terrane of the coastal plain along the Colville, but seems to occur at some localities along the coast from the mouth of the Colville westward, in some instances apparently overlying the ground ice and probably the Kowak clay formation, while its inland margin probably overlaps the coastal edge of the Upper Cretaceous of the Nanushuk series along the Anaktuvuk nearly to the mouth of the Tuluga, where, in certain localities, judging from topographic criteria, it also appears to overlie gravels which are very tentatively referred to as glacial, but to which its relation is not definitely known.

The deposit consists of fine sand, with apparently an admixture of considerable silt. In some localities it seems to be more sandy toward the base, and more earthy toward the top, where it terminates in from one to several feet of dark brown or black humus, clothed at the surface with moss and a little grass. It is ordinarily free from gravel, but in several instances subangular cherty pebbles ranging from mere sand grains to fragments as large as one-fourth inch in diameter were found. These occur very scatteringly and are sometimes roughened, as if wind worn. In some localities a fine gravel seems to intervene between the base of the deposit and the underlying Tertiary beds, as if representing the basal part of the deposit.

The deposit as a rule is structureless or without stratification planes. Owing to this fact, together with its surficial and widespread occurrence, and the homogeneity of its materials for want of a better term in field work it was called loess, but in the fear that this term may be undesirable, it is here named the Gubik sand, after the Eskimo name of Colville River.

Various hypotheses have suggested themselves to account for the origin of the deposit, of which no one alone seems to be satisfactory. To the writer, the fluviatile delta theory, in conjunction with shallow coastal conditions and intense arctic freezing, seems the most tenable.

RECENT MUD, MUCK, GROUND ICE, DUNE SAND, SILTS, AND GRAVELS.

INLAND REGION.

The deposits mentioned in this heading are all represented on the map by the same color.

Along John River and the Koyukuk the color represents recent stream gravels, together with alluvial sands, silt with ground ice, mud flats, and areas of till too small to be represented on the scale of the accompanying map.

Along Anaktuvuk River the color denotes recent stream gravels, while along Colville River it includes, besides the recent stream gravels, a large, triangular area of flats extending from the mouth of the Anaktuvuk to the coast and eastward along the coast a distance of thirty or more miles to beyond Gwydyr Bay. This large area, as noted, is regarded as ground abandoned by the Colville in its lateral migration westward since Tertiary time, as the river is supposed to have formerly flowed more directly northeastward from the mouth of the Anaktuvuk, and to have entered the sea through Gwydyr Bay, following the course indicated by the broken lines on the map. (Pl. III.)

Though to the eye this area of flats seems a dead level the surface probably rises very gently from the Colville eastward. It is dotted by numerous ponds and lakelets. The monotony of the waste is somewhat relieved by occasional low mounds, as shown in Pl. XVI, *B*. These are composed, in part at least, of gravel and sand. Some of them rise as much as 40 feet above the flats. In shape they are low and rounded. Some have a tapering train on the lee side toward the coast. Their surface is usually scantily clothed with grass and other vegetation.

The origin of the mounds is not known. Only one of them was visited. Perhaps the most plausible hypothesis is that they are remnants of beds belonging to the Tertiary Colville series, which, chancing to be capped with some hard stratum, were not worn down by the river to the level of the flats, and so formed nuclei favorable for accumulation of gravel, and subsequently became bars, and, later still, islands in the Colville, until the river abandoned its bed about their bases.

Along the Colville the edge of the flats often terminates in gravel bars, descending to the water's edge, or in low, steep-faced banks of frozen black muck and ground ice, showing that at least the surficial portion of the flats consists in the main of recent stream deposits and the decayed products of marsh vegetation. The banks decrease in height toward the coast, and finally vanish as the land surface passes into the bars, reefs, and tidal mud flats at sea level.

The geologic work now being done by the river in its lateral migration shows that the processes by which the flats were formed were essentially those of planation. In the inland region, as the shifting stream, in its very gradual down-cutting and relatively very rapid lateral cutting, sawed its way westward into the coastal plain, it planated farther and farther on the west the ground which by its destructional work it claimed as its bed; while simultaneously, as it abandoned or receded from this planated ground on the east, it built thereon, notably at high-water stages, flood-plain and riparian deposits, which now constitute the surficial terrane of the flats. Thus, while degradation or destructional work was in progress on the west, aggradation or constructional work of flood-plain building was progressing on the east. At the same time in the coastal region the large amount of sediments borne down by the river was built into an expansive delta plain, which landward merges into and is continuous with the inland subareal portion of the flats, and seaward merges into the already mentioned expansive tidal mud flats, bars, and reefs at the coast.

The Colville Flats therefore appear to consist essentially of a Pleistocene veneer of flood-plain, ground-ice, and deltoid deposits resting on Tertiary beds of the Colville series that have been planated by the river in its lateral migration toward the west.

Another type of recent deposits is seen in the sand dunes that occur for a distance of a few miles along the upper part of the Anaktuvuk, just before it leaves the Endicott Mountains, and also over the inland portion of the Colville delta and adjacent mainland. The material of the dunes in both places is obviously river sand and silts derived from the wind-swept bars and flats exposed during stages of low water. This dune work is probably accomplished mostly during the dry, frozen periods of winter, when the bare ice surface is favorable for wind transportation of the material.

COASTAL REGION.

From Colville River to Point Barrow.—Though the Tertiary beds of the Colville series may come to the Arctic coast in some localities, they have not been positively identified there. From Colville River to Point Barrow the shore line materials consist mainly of recent beach deposits of mud, muck, some sand and gravel, and deltoid mud flats, backed in places by low banks of older dark muck and ground ice (see Pl. IX, *A* and Pl. X, *D*). West of the Colville, in Harrison Bay, deposits of sand or loam are occasionally seen, which, from similarity in character of material, seem to belong to the Gubik sand.

The eastward swing, or retreat, of Colville River in relatively recent time from bluffs of its own cutting on the west, leaving a portion of the Colville Flats on its west or left side, along the section extending from Ocean Point to the coast, a distance of nearly 40 miles, suggests for this particular part of the region a local tilt to the eastward in Pleistocene time, or at least subsequent to the production of the bluffs and the Colville Flats, which must have been formed by the river. If this tilt or differential uplift to the west of the Colville has been far-reaching in its westward extent, it favors the existence of a coastal belt of late Pleistocene as far as it extends.

To local differentials in elevation along this costal line of uplift are to be ascribed the occasional ground-ice cliffs as at Cape Halkett and Cape Simpson, alternating with long stretches of low shelving beach. The ice cliffs appear merely to represent completely solidified bays, lagoons, lakelets, or perhaps other coastal bodies of ponded water now raised into low anticlines and cut back by wave action.

From Point Barrow to Cape Lisburne.—Southwest of Point Barrow the coast line grows more marked. It is not so low, flat, and shelving as on the north, and the water is consequently less shoal. Here the long stretches of mud flats found on the north are in the main wanting. The mainland bluffs at the edge of the tundra, though still low, are not only higher than on the north but are almost continuous, and are frequently composed of true bed rock (Mesozoic terranes); between the base of these bluffs and tide water there is a narrow fringe of recent beach gravels and sand, whose surface slopes steeply seaward. However, from Wainwright Inlet to near Cape Beaufort there are extensive wave-built barrier beaches or bars of recent marine gravels and sand (see Pl. XVI, *A*), sheltering immense stretches of brackish lagoons lying between the bars and the mainland. Toward Cape Lisburne, the most bold and important promontory in this part of the northwest, the coast becomes steep and rock bound (Pl. V) by the Mesozoics and Paleozoics that have been described.

RECENT FOSSILS FROM THE ARCTIC COAST.

The following invertebrate fossils were collected along the Arctic coast between Colville River and Cape Lisburne. The identifications are by Dr. W. H. Dall, of the United States Geological Survey.

Chrysodomus fornicatus Gray, 649,[a] 650, 654.
C. despectus L., 639.
Admete couthouyi Jay, 652.
Margarites striatus Sowerby, 647.
Tellina lutea Gray, 647.
Macoma frigida Hanley, 636, 639, 647, 650.
M. tenuis Leach, 639, 652.
M. baltica var. inconspicua B. & S., 636.
Astarte arctica Gray, 636, 639.
A. borealis Schumacher, 636, 639, 650, 652, 654.
Venericardia alaskana Dall, 652.
Saxicava arctica L., 650.
Serripes grönlandicus Beck, 636, 654.
Cyrtodaria kürriana (Mörch) Dunker, 639, 650.
Thracia beringi Dall, 654.
Mytilus edulis L., 650.
Modiolaria nigra Gray, 650.
Yoldia sp. fragm., 639.

[a] The numbers refer to localities.

A. BARRIER REEF AND ESKIMO GRAVE ON ARCTIC COAST NEAR ICY CAPE.

Looking S. 25° W.

B. ABANDONED PLEISTOCENE FLATS OF COLVILLE RIVER, SHOWING MOUNDS AND LAKELETS.

From 30 miles inland; looking N. 80° E.

TABLE OF PROVISIONAL CORRELATIONS.

Era	Period	Epoch	Schrader: Chandlar and Koyukuk rivers, 1899.[a]	Mendelhall: Dall, Kanuti, *Alatna*, and Kowak rivers and Kotzebue Sound, 1901.[b]	Schrader: Chandlar, Koyukuk, John, Anaktuvuk, and Colville rivers and Arctic coast from Colville River via Point Barrow to near Cape Lisburne, 1901.
	Pleistocene		Stream silts and gravels.	Silts, clays, sands, and gravels, including glacial deposits, Kowak clays and ground-ice formation.	Stream and beach gravels, mud (flats), sands, and silts.
			Till and glacial gravels.		
			Lacustrine silts of Yukon and Koyukuk flats.		Dune sands. Gubik sand. Till and glacial gravels.
			Ground ice and Kowak (?) clays.		Ground ice and Kowak clay.
	Tertiary	Pliocene	Basalts of Koyukuk Mountain and Chandlar River.	Basalts, andesites, and andesitic breccias.	Upper Colville.
		Miocene	Nulato sandstone ?.		
		Oligocene			Lower Colville.
		Eocene	Kenai series ?	Kenai series.	
Mesozoic	Cretaceous	Upper	In Koyukuk Basin and in Nulato sandstone ?.	Bergman series	Nanushuk series. Bergman series (?).
		Lower	In Koyukuk Basin, including igneous rocks.		Koyukuk series, including igneous rocks. Anaktuvuk series.
	Jura-Cretaceous				
	Jurassic				Corwin series.
	Triassic				
Paleozoic	Carboniferous	Upper. Middle. Lower	West Fork series (?)		Fickett series.
	Devonian	Upper		Kanuti series.	
		Middle	Bettles series		Lisburne formation.
		Lower		Metamorphic complex.	
	Silurian	Upper	Lake quartz-schist		Stuver series. Totsen series. Skajit formation.
		Lower	Amphibolite-schist.		
	Pre-Silurian		Chandlar Rapids schist.		
			Gneissoid granite, basalt (?).		

[a] Schrader, F. C., Reconnaissance along the Chandlar and Koyukuk rivers, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 471–482.
[b] Mendenhall, W. C., Reconnaissance from Fort Hamlin to Kotzebue Sound, Alaska, by way of Dall, Kanuti, Allen, and Kowak rivers: Prof. Paper U. S. Geol. Survey No. 10, 1902, pp. 31–48.

MINERAL RESOURCES.

GENERAL STATEMENT.

Under the head of geology, it has been shown that the rocks forming the mountains about the head of the Koyukuk Basin comprise several metamorphic series, namely, the Skajit, Totsen, Fickett, Bettles, Lake quartz-schist, and West Fork series. In these mineralization has taken place. It is in the southern part of the region that the efforts of the prospector are being rewarded, and, in some cases, handsomely.

Though indications of mineralization occur to some extent nearly all the way northward through the Endicott Mountains, the principal producing region is on the upper parts of Middle and North forks of the Koyukuk. Though the region also contains coal and some lead, copper, and antimony, thus far gold only has proved to be of economic importance.

GOLD.

Placer gold has been known in the Koyukuk Basin since the early nineties, if not before. It was first discovered in the bars of the river, of which the most noted seem to have been Hughes and Florence bars, both far below the present placer diggings. Tramway Bar, above the sixty-seventh parallel, about 570 miles above the mouth of the river, is among the earliest discoveries. The discovery of Slate, Myrtle, and the other creeks that have been among the chief producers for the last four years was made during and subsequent to the spring of 1899. These are mostly above Tramway Bar.

Roughly considered, the Koyukuk gold district, or gold diggings, frequently referred to as the most northern mining camp in the world, as known at present is contained in a rectangular area of about 3,500 square miles, lying between latitudes 66° 55′ and 67° 55′ and longitudes 149° 30′ and 151° 20′.[a] It accordingly trends north and south. Its length is about 70 miles and its width about 50 miles. Diagonally through it from northeast to southwest flows Middle Fork of Koyukuk River, while the northwest portion is drained by North Fork and the southeast portion by South Fork. The principal field of present operations is near the middle of the district, on the middle drainages of Middle and North forks.

It is only in certain localities in this area, however, that profitable gold placers have been found. The formations on which these placers lie, so far as known, are the Lake quartz-schist, the West Fork schist, the Bergman series, and probably also the Skajit formation, for some of the later discoveries are reported to occur on mica-schist, limestone, and marble;[b] but whether any or all of these formations are the original source or mother rock of the gold can not yet definitely be stated, as the season's work afforded no facility for visiting the diggings. The Slate Creek

[a] For location and outline of the district, see geologic map, Pl. III.
[b] On Clara and Emma creeks the country rock is reported to be mica-schist and marble.

gold, however, is probably derived from the Lake quartz-schist.[a] These schists are traversed by quartz veins of considerable size, the larger of which are not known to carry more than a trace of gold, but a series of smaller veins or veinlets and small lenticular quartz bodies or leaflets contained in the schist are to some extent auriferous. Nearly all quartz specimens which have been assayed show at least a trace of gold.

The principal diggings when the region was visited by the writer in 1899 were those of Slate Creek and Myrtle Creek, which lie along the zone where the Lake quartzite-schist gives way to the West Fork[b] series on the south. This zone is also along the line where the mountains give way to the dissected supposed Yukon Plateau. Here in March, 1899, coarse placer gold was discovered in paying quantities on Slate Creek, an east side tributary of Middle Fork of the Koyukuk, which it joins 16 miles above Tramway Bar. The country rock is a series composed of mica-schist, quartz-schist, and slate, and is cut by some igneous intrusives. It is uplifted and stands on edge. The gold occurs as shallow creek and gulch diggings, and is found principally near or on bed rock in joints, fissures, and crevices. The gravels rarely exceed 3½ feet in thickness. The diggings begin about 9 miles above the mouth of Slate Creek, at the confluence of the two main forks, of which the north one is known as Myrtle Creek, and the south one as Slate Creek proper. From this point the diggings extend to the head of Myrtle Creek, a distance of 5 or 6 miles, and considerably farther up Slate Creek.

Two mining districts had been organized and are known as the Slate Creek and Myrtle Creek districts. The gold, as seen here, is bright, clean looking, coarse, and considerably rolled or flattened, denoting transportation. The largest nugget taken out had a value of nearly $20. The bench gravels along these creeks are also auriferous and are reported to prospect from 3 to 5 cents per pan. Considerable mining was also being done near the sixty-seventh parallel on various tributaries of South Fork with fair success; here at present the principal camp is that of Gold Bench.

Though the Slate and Myrtle creek districts, with a few others, are reported to have yielded well during the season of 1899 and 1900, and are still producing, subsequent exploitation has resulted in the discovery of much richer deposits farther up the river, all occurring, according to reports of the miners, in much the same class of metamorphic rocks as those noted for Slate and Myrtle creeks.

Of these newer discoveries, the principal are Emma, Clara, and Gold creeks, and other smaller streams tributary to Hammond Creek, while the discovery of gold on Union Gulch, about 15 miles above Slate Creek, is reported to have been made

[a] Schrader, F. C., Reconnaissance along the Chandlar and Koyukuk rivers, Alaska, in 1899: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 474–483.

[b] Ibid., p. 475.

during the summer of 1901. Other new creeks, reported to be producing, are Vermont, Swift, and Nolan. The two best producers thus far are reported to be Emma and Gold creeks. The gravels on Hammond Creek are reported to contain much iron pyrites, which, in sluicing, rapidly fills up the riffles, and in some specimens visibly exhibits embedded bodies and particles of free gold—a fact of no small economic importance, as it seems to point very strongly to deposits of gold-bearing pyrites or ore probably present within the Hammond Creek Basin as the source of the gold. During the summer of 1902 very promising prospects were discovered also on North Fork of the Koyukuk about 35 miles above its mouth. Here the belt containing gold-bearing gravels, locally considered, is said to have a width of about 20 miles and to trend in a general east-west direction about parallel with the mountains. The principal streams on the Fork are Mascot, Washington, and Big Four creeks. The discovery was made on Washington Creek in August, but the principal producer seems to be Mascot, a west-side tributary, which was discovered in September (1902), and during the season of 1903 yielded nearly $100,000 in gold. This gold is coarse. It contains several $100 nuggets, and other large ones of less value. The gravels are shallow; they range from a few inches to several feet in thickness, and contain a little black sand. Their shallowness enables the ground to be worked at a profit of about 70 per cent of the yield, which is much greater than that in most of the creeks of the Koyukuk district. The gold is found mostly on bed rock and in the extreme basal part of the overlying gravels, and where the bed rock is rotten or decayed the gold frequently extends a foot or more into it. The bed rock is mica-schist. It contains stringers of quartz and is occasionally cut by porphyry dikes. Gold prospects have also been found west of the above, on tributaries of the Hokotena.

The Tramway Bar diggings are bench placers, consisting apparently of deposits of auriferous river gravels resting on a bench of bed-rock conglomerate and sandstone, at about 80 to 100 feet above the level of the river. The gravels are mostly coarse, consisting largely of rolled cobbles and pebbles of quartz-schist and other rocks composing the mountains to the north. Several attempts have been made to work these deposits, but thus far with only moderate success. This is owing apparently to the remoteness of the region, the difficulty of transportation, and more especially to the lack of capital to utilize the water supply, which could readily be drawn from the river above the placers or from lakelets said to occur on higher ground lying westward.

The Tramway conglomerate has not as yet been found to be a fossil placer, as was formerly supposed, nor does it seem to bear any relations to the richer diggings occuring in the region of metamorphic rocks much farther up the river.

Prospects of gold are also reported to have been found on some of the tributaries of John River. Colors were obtained here by the writer from gravels in the mouth of a small creek near the north edge of the Totsen series, and specimens of vein quartz collected in place from sandstone and schist near the middle of the Fickett series assayed 0.03 ounce, or about 60 cents per ton. Though this may not be promising from an economic point of view, it seems to denote the presence of gold in the Endicott Mountains and points to the quartz as its probable source.

Coarse placer gold is reported to have been found by prospectors on the Arctic side of the divide, opposite the head of the Koyukuk Basin and farther eastward. Further investigations are contemplated here by men who have visited the region. This reported occurrence suggests the northward continuation of the auriferous schists of the Koyukuk district.

So far as observed by the writer, and learned from the accounts of prospectors, some of whose observations in the district have been extensive, the Koyukuk diggings in general are shallow, the gravels being but a few feet thick. Owing to this fact the placers are essentially what is known as summer diggings. Burning and drifting have been tried, but with only moderate success. About the only streams on which any winter work was done during the winter of 1902-3 are Hammond and Gold creeks. The richest placers are those in the creek beds and gulches; but gold-bearing gravels, sometimes of promising grade, occur also at higher elevations on the benches. Much of the gold occurs in the bed-rock cavities or in joint and cleavage crevices. It is coarse, much flattened, and ranges in size from that of a lima bean down to small grains. It is of high grade, being much purer than most of the Alaskan placer gold, and runs from $19 to $19.60 per ounce.

An exception to the flattened form of the gold occurs at Gold Bench on South Fork. Here the principal diggings are on a gently sloping bench at from 30 to 60 feet above the stream. On the bench the gold is all flattened, similar to that of the Koyukuk district in general, and is nearly all found within 8 to 10 feet of the surface. At the foot of the bench, however, the gold found in the high-water gravels of the present stream is of totally different character. It is not flat and smooth, but is round or angular, some particles being so sharply angular, rough, and honeycombed as to suggest little, if any, transportation since it was released from the mother rock.

Coarser gold than has been mentioned in the preceding paragraphs has also been found at various localities in the Koyukuk district. The largest piece found in 1900 is an 18-ounce nugget, having a money value of about $350, and is reported to be from Clara Creek. The largest found during the season of 1901 is a $660 nugget, said to have come from Union Gulch. In 1902 a much larger nugget, having a money value of about $1,100, was brought out. It is reported to have been found on Hammond Creek. This nugget was seen by the writer. It is flat, oblong in outline, having somewhat the shape of a man's hand. It consists of almost pure gold, very little quartz being present. It presents a clean, bright surface and is of a deep, rich color. Another nugget, nearly as large as the above, having a weight of 50 ounces and valued at about $1,000, was found on Hammond Creek during the same year, but was not brought out of the country until this fall (1903). It is described by Mr. Prindle as oblong and elongated in outline, flat on one side and rounded on the other.

According to the most reliable information obtained, the production of the Koyukuk district from 1899 to 1903 was about $717,000, distributed among the various creeks and gulches, principally as follows:

Production of gold in the Koyukuk district from 1900 to 1903.

	1900.	1901.	1902.	1903.
Myrtle Creek	$40,000	$7,000		
Gold Bench	25,000	60,000		
Slate Creek	1,000?			
Emma Creek	27,000	40,000		
Clara Creek	1,000	2,000		
Gold Creek	2,000	50,000		
Tramway Bar	5,000			
Twelvemile Creek	1,000	1,500		
Porcupine Creek	500	1,000		
Ironside Bench and Eagle Bluff	1,000			
California Creek		1,000		
Union Gulch		1,500		
Total	103,500	164,000	[a]100,000	[b]300,000

[a] Season's yield, including new discoveries. [b] Season's yield, including North Fork and new discoveries.

The total of the above table is $667,500. To this should be added $40,000, which is known to be the approximate output of sundry smaller diggings, not given in the above list in 1901; about $6,000 output in 1899 derived mostly from Slate and Myrtle creeks and various points on South Fork, and $3,000 to $4,000 won from the Tramway and other bars in previous years, all of which to date gives an aggregate yield for the Koyukuk district of about $717,000.

The relatively low yield, not much exceeding $100,000 for the year 1902, is reported to be due to the exceptional dryness of the season and consequent lack of water for operations on most of the creeks. On Gold Creek but little sluicing could be done, but while the water lasted the yield was rich. On one claim the owners are reported to have washed out $12,000 in ten days.

In connection with the above statement concerning gold should be mentioned the reported recent discovery of supposedly promising pyritiferous gold-bearing ore near the head of Alatna River, principally on the divide between it and Noatak River, which flows westward into Kotzebue Sound. The locality is northwest of Bergman, in approximate latitude 67° 40′, longitude 155°. The men who made the discovery state that the locality is 170 miles from Bergman, but this must be by the river route where the distance traveled is necessarily greatly increased by the very tortuous course of the Alatna. Our knowledge concerning the geography of this region is not definite, but the distance across country in a straight line from Bergman to the Koyukuk can hardly exceed 100 miles, and it is probably less.

The discovery seems to have been made by a party of prospectors and miners who visited the region by sled during the winter of 1902–3, and in company with others continued to prospect there during the summer of 1903. At present a score or more men are reported to be interested in the holdings.

The country rock is described as quartzite, slate, and schist, and is inferred by the writer to be in all probability a westward extension of the Fickett series (Carboniferous) which is prominently developed on John River, 60 miles distant, and in which, as indicated on the map (Pl. III) and on page 106, a mineralized zone in the slate and quartzite was observed by the writer in 1901. Without here affirming that the mineral deposits of these two regions are connected, it should be noted that the newly discovered Alatna deposits seem to lie directly in the trend of the John River deposits and have the same strike. This suggests that the deposits of the two regions may represent the same mineral belt.

The Alatna ore deposits are reported to consist of six or more veins, or ledges, known as the Copper King, Copper Queen, Lucky Six, Mammoth, Iowa, Gray Eagle, Silver King, and Ground Hog. They are on an average about 1 mile apart, and are accordingly included in a belt about 6 or 7 miles in width. They lie nearly parallel and trend in a northeast-southwesterly direction, and, so far as prospected, are in general nearly vertical, or dip about 75° NW.

About half of the veins are reported to have a width of approximately 75 feet, while the minimum width of the smallest is given as 10 feet. Some of the veins have been traced by croppings for distances varying from several thousand feet to 2 miles.

Through the courtesy of Mr. Prindle the writer has received for study six of these Alatna ore specimens, brought out by the miners in the fall of 1903. In these specimens the ore consists essentially of iron pyrites and quartz, with also chalcopyrite (copper pyrites) which is conspicuous in two specimens. With the chalcopyrite is associated a little bornite and a trace of malachite. Another specimen is composed essentially of stibnite or sulphide of antimony and epidote. One specimen contains feldspar as a gangue mineral in addition to quartz, and is locally stained reddish brown by hematite or iron oxide, which is seemingly an alteration product of the pyrites.

The quartz is largely of the finely granular sugary type, and often remains as a porous honeycombed or coralline-like mass where the metallic contents of the ore have been leached out of the more exposed croppings. This "skeletonized" mass is occasionally traversed by small discontinuous stringers of firmer, greasy-lustered, and evidently younger quartz, producing a semibanded appearance, which, considered in connection with slickensiding and planes of weakness exhibited by other specimens, shows that ore deposition was followed by rock movement and consequent crushing, which produced fractures, into which the barren stringers were subsequently deposited by silica-charged solutions.

The specimens at hand contain both white and yellow iron pyrites, which is mostly fine-grained and normally occurs massive with the quartz, but in a few cases an imperfect parallelism, or banding, apparently representing depositional layers of quartz and pyrites in varying amounts, is perceptible.

The value of the ore rests in its auriferous content. At least three of the larger veins are reported, from assays made for the owners in San Francisco, to carry from $40 to $90 per ton in gold.[a] The gold seems to be contained, very finely disseminated, in the pyrites, for so far as known no free gold is visible. None was seen in the specimens examined by the writer.

Should these deposits prove to be of economic value, it is noteworthy that besides being easily accessible by land, they can be approached at high water by way of the Alatna River with flat-bottom steamboat to a point within 6 miles of the locality, and at low water to a point within 20 miles. The region is reported to contain a large amount of small timber having a stumpage of about 1 foot in diameter.

COPPER.

The only indications of copper seen in this northern country by the writer were in detached fragments of quartz, apparently derived from veins, and carrying some iron pyrites, copper pyrites, malachite, and a trace of bornite. Such specimens were found sparingly in the river gravels on the upper Chandlar in 1899.[b] Some, seen in the possession of prospectors, were reported to have been collected on Mineral Creek, at the head of Chandlar Lake, on the west side. A ledge is also reported to have been found on East Fork of the Chandlar, which assayed well in copper. But the ore is not known to occur in quantities of commercial value.

In the Koyukuk Basin the indications are much the same as above described, the occurrences being on the upper waters or the tributaries heading in the limestone mountains. The principal specimens seen by the writer during the recent work consisted of waterworn fragments found in the John River gravels and derived apparently from quartz veins. They contained some copper pyrites and a little bornite. Similar specimens were seen in the hands of Kowak natives on John River. What is supposed to be a vein of considerable size, containing iron and apparently copper pyrites, was observed in a steep limestone cliff of the Skajit formation overlooking the river, where no examination or collection could be made.

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[a] The Survey has just completed the assay of four of the above-described ore specimens, with the following results, in ounces per ton: Specimen B, gold 0.05; silver none. Specimens C and D, gold, trace; silver, trace. Specimen F, gold 0.10; silver, 0.08. These results are not promising.

[b] Op. cit., p. 482.

LEAD.

Galena is known to occur in the Bettles limestone on the upper waters of the Chandlar and the Koyukuk. It is also reported on East Fork of the Chandlar. Specimens have been seen from Bettles River. Some reported to be from the upper part of Hokotena River or Wild Creek, which is the next large river above John River, were presented to the writer by Messrs. Windrick and Bettles. In one instance the Wild Creek galena is associated with, or partly incloses, quartz crystals five-eighths inch in diameter and an inch or more in length, while in another instance the associated quartz seems to be chalcedonic. The ledge occurs on Michigan Creek (the large east-side tributary of the Hokotena), 3 miles above its mouth, and is supposed to be in the Skajit formation. It is reported to be of considerable size. Those who have prospected it are hopeful that it may prove to be of economic value. It is reported to assay some silver and several dollars in gold per ton.

On the east side of the divide between Middle Fork and South Fork, opposite the head of Minnie Creek, a limestone mountain of considerable size is reported by prospectors, in which galena is said to occur in large quantity.

ANTIMONY.

Pebbles and angular fragments of antimony sulphide, sometimes several inches in diameter, are found in the gravels of Gold Creek. A specimen of this mineral was determined in the chemical laboratory of the Survey to be a good grade of relatively pure stibnite. It is traversed by quartz stringers. Judging from the resemblance of the quartz to that seen in the Lake quartz-schists and the locality at which the antimony occurs it is inferred that this rock is probably the source of the ore.

Owing to the remoteness of the region the copper, lead, and antimony ores are not in themselves likely to prove of economic value unless the deposits are very exceptional in quantity and character.

ZONES OF METALLIFEROUS MINERALIZATION.

In the Totsen series.—About 40 miles above the mouth of John River, near the northern edge of the Totsen series, as shown on the geologic map (Pl. III), the mica-schists, in an area several miles wide trending northeast and southwest, across the valley, are stained a pronounced reddish-brown or hematite color, denoting apparently a zone in which iron pyrites and other sulphides occur more or less abundantly in the schist. Though the rock could not be examined in detail, it seems probable that the stain is due to iron oxide derived from the sulphides by oxidation. The residuary soil formed by the disintegration of the schist in this belt is not nearly so red as the rock itself, but is rather of a yellow-ocher or limonite color, which seems to be due to more extensive oxidation and weathering or to leaching out of the mineral matter.

In the Fickett series.—Toward the northern edge of the Fickett series, east of John River, in the Fork Peak region, where the country rock consists of heavy-bedded gray and pinkish quartzite and slate, there is a belt about 2 miles wide which is stained bright reddish brown, purple, and some other colors. As shown on the map, this belt also trends northeastward a distance of apparently about 15 miles to a point where the Fickett series gives way to the Lisburne formation. It seems also to extend southwestward beyond John River, but in that direction it is apparently not so conspicuous.

Here again the stain, which is surficial, is due to iron pyrites acted on by the process of weathering. A fresh fracture surface in hand specimen shows the zone of stain or weathering to be nearly always definitely marked, but in its penetration of the rock it may vary in different cases from a mere film to a zone nearly one-fourth inch in thickness. As the rock is known to contain iron pyrites very finely disseminated, and all of the five stained specimens tested by the chemical laboratory were found to contain ferric oxide (Fe_2O_3), with some sulphuric oxide (SO_3) present in four cases, the stain seems undoubtedly to be iron oxide derived from the pyrites by process of weathering. The brilliant peacock or bornite color, which by the inexperienced prospector would readily be mistaken for indications of copper, is iridescent hematite. The specimen in which no sulphuric oxide occurs was found to contain also siderite ($FeCO_3$).

Whether these zones of mineralization may prove to be of economic value can not be affirmed at present, as the rapid progress of the party through the country did not permit opportunity for examination. It may be noted, however, that both zones are closely related to formational boundaries, the southern being near the unconformable and probably deformational contact of the Totsen series with the Skajit formation, while the northern lies along the fault contact of the Fickett series with the Stuver series and Lisburne formation; and both zones trend in a general way parallel with the dominant jointing or major structure of the mountain range. The localities at which placer gold claims have been staked by prospectors, and gold colors panned by the writer on John River, lie within the southern zone.

COAL.

GENERAL STATEMENT.

Coal in one form or another, and varying in age from Tertiary to possibly Carboniferous, is more or less widely distributed in northern Alaska. It occurs in the Koyukuk drainage on the south side of the mountains, in the plateau on the Anaktuvuk, in the coastal plain on the Colville, and on the northwestern coast, in what is commonly known as the Cape Lisburne region, at Wainwright Inlet, Cape Beaufort, and several points between Cape Beaufort and Cape Lisburne (Pl. V).

KOYUKUK REGION.

Koyukuk River.—On Koyukuk River, in what was formerly supposed to be the Kenai[a] series, lignite and coaly material in small amount is common in the sandstone, grit, and especially in the conglomerate. The best occurrence is just above Tramway Bar, where there is a vein nearly 12 feet thick, of which the middle 9 or 10 feet seems to be relatively pure fuel. Its analysis is given under No. 187 in the table on page 114, which shows it to be a low grade of bituminous coal. There seems to be no reason why with development this vein should not prove serviceable for local use.

John River.—Coal detritus in considerable quantity and of a character to suggest the probable occurrence of coal of economic value somewhere in the region north of this locality was seen in the John River gravels near the base of the Endicott Mountains. This coal may apparently with safety be called a good grade of bituminous. It breaks with a conchoidal fracture and has a bright shiny or glossy black surface.

ARCTIC SLOPE.

Coal has been found also at several points on the Arctic slope, notably on Anaktuvuk and Colville rivers.

Anaktuvuk River.—Coal was first encountered by our party on the Anaktuvuk, in the east bank, about 5 miles above the mouth of Tuluga River, about 130 miles from the Arctic coast, in latitude 69° 11′, longitude 151° 4′. This coal is of Upper Cretaceous age, forming part of the Nanushuk series, from which the fossils at this locality were collected. As shown in Pl. XII, *B*, the rocks here dip steeply south, at an angle varying from about 80° to nearly vertical, and rise to a height of 100 or more feet above the river flats. The coal is conformable with the rocks of the series of which it forms members and occurs in several beds, each a foot or more thick. It is laminated parallel with the bedding, apparently denoting pressure. Though in the weathered state it has the appearance of lignite, it is shown by No. 607 in the table of analyses on page 114 to be a bituminous coal, having a fuel ratio of about 1.20. The quantity thus far observed, however, is hardly sufficient to lead to the belief that the bed will prove of economic value in so remote a region.

Colville River.—At about 30 miles north of the above locality and at a distance of 100 miles from the coast, on the Colville, in the region of the mouth of the Anaktuvuk, in latitude approximately 69° 32′, longitude 151° 30′, lignitic coal appears in considerable quantity. It is found in the Colville series, which underlies the Arctic Coastal Plain in this region, and here rises 200 feet above the river nearly to the surface of the plain, forming bluffs along the left or west side of the river for 10 miles both above and below the mouth of the Anaktuvuk. (See Pl. VIII.)

[a] Schrader, F. C., Reconnaissance along Chandlar and Koyukuk rivers, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 477 and 485.

Here the coal is abundant and conspicuous. In the talus at the foot of the bluffs it is strewn about in detached blocks and bowlders ranging from 1 to several feet in diameter. Its occurrence in place in the bluffs is for the most part in the lower half of the section, where it appears in half a dozen or more beds that are from 1 to 3 or more feet in thickness, and are conformable with the Colville series, of which they form members. The beds lie for the most part nearly horizontal or dip very gently northward, and are well exposed for a distance of probably 10 or more miles along the river. They are represented by the dark or black layers in Pl. VIII.

The associated rocks, of which a fuller description is given under the head of geology, consist in general of heavy beds of partially consolidated silt, soft shale, soft sandstone, very impure limestone, and intermediate types of deposits.

So far as observed in ascending the geologic section, the coal layers in most cases are underlain by a heavy bed of soft sandstone or shale 3 to 6 feet thick, with an intervening thin 6 to 8 inch layer of shaly under clay. The shale bed often contains fragmental lignitic plant remains.

As shown in the table of analysis (p. 114), where it is indicated by No. 620, the coal seems to be a good quality of lignite, with volatile matter 30.33 and fixed carbon 30.27. As the specimen was considerably weathered, it is probable that the analysis here given may fall somewhat short of representing the average efficiency of the coal. On several occasions the coal was used by the party in camp fires, and gave good satisfaction. It burned readily and yielded considerable heat.

The coal in general presents a dull-black appearance, and at first appears massive, but on closer observation is found to contain nearly horizontal, more or less discontinuous beds and thin layers of highly metamorphosed material, which is of a deeper black and has a somewhat high anthracitic luster. The main body of the coal seems to be composed largely of a mass of similarly well-metamorphosed, short, and glistening needles or spicules, variously compressed together in horizontal arrangement, presenting somewhat the appearance of an imperfect fibrous or woody structure.

From the known occurrence of such lignite and lignitic plant remains in the Kenai (Oligocene) elsewhere in Alaska, and from the position of this coal in the beds above the Upper Cretaceous and below fossil-bearing Pliocene beds, the coal is inferred to be Oligocene. The vegetable fragments collected from the shale beneath the coal were examined by Doctor Dall, who suggests that they are probably the needles of *Sequoia langsdorffii* or some related conifer. He also suggests that the mass of this coal is probably composed of the trunks of *Sequoia*.

From an economic point of view, it should be stated that this coal is probably not suitable for export or for steaming purposes, and, though it is abundant it is unlikely, from its remoteness, under present conditions of the country, to prove to be of value for local use. It is not difficult of access, however, and could readily be brought to the coast on river barges by way of the Colville, and probably on river steamers at high water; or over a cheaply constructed railroad across the coastal plain. Owing to the shallowness of the coast, however, difficulty would probably be experienced in loading it on ocean vessels.

Judging from the report of Howard, and that of Reed, coal or lignite apparently occurs also on the headwaters of the Colville. Concerning the region above the native village of Etivolipar, in latitude approximately 68° 20′, longitude 156°, Mr. Howard makes the following statement:

"During the forenoon we passed a hill, about 500 feet in elevation, with outcrops of coal. On the sides of this hill beyond the coal were also found pieces of a substance called wood by the natives. It was hard, brittle, light brown in color, very light in weight, and burned readily, giving out quantities of gas. This material was scattered about in all shapes, sizes, and quantities."[a]

Mr. Howard's visit to the region was a hasty overland trip made in the closed season when the ground was covered with snow and ice, and it embraced but a small section, probably 40 to 50 miles, of the Colville. That of Mr. Reed was made in the open season when conditions were most favorable for observing and making investigations. Mr. Reed, who, in company with Mr. Lucas, is reported to have explored and prospected along the river for a distance of 200 or more miles, mostly downstream from the mouth of the "Killik" (see p. 31 of this paper), likewise reports that thick veins of bituminous coal crop out in the sandstone formation along most of the creeks, and states that the coal was burned by his party also in their camp fires.

From the topographic description given by Messrs. Howard and Reed, and from the geographic position of the region, being practically on a line with, and about intermediate in distance between the Cape Beaufort and Corwin regions on the northwest coast, and that of the upper Anaktuvuk in the interior, at which points the rocks are known to be coal bearing, or at least of Mesozoic age, the writer infers the sandstone formation in which the coal or lignite occurs on the upper Colville to be in all probability Mesozoic, and possibly also like the Corwin series, Jura-Cretaceous. And since the Mesozoic coals of the Territory are usually a good grade of bituminous character, it would not be surprising to find the upper Colville region to contain fuel of substantial economic value, similar to the coal produced by the Corwin and Thetis mines on the northwest coast, next to be described.

NORTHWEST COAST.

Coal has been known in the vicinity of Cape Lisburne (see sketch map, Pl. V) for half a century, and since 1879 whaling vessels have replenished their supply from this locality. It occurs also at several places along the coast to the northeast as far

[a] Stoney, Lieut. George M., Naval explorations in Alaska, U. S. Naval Institute, Annapolis, Md., 1900.

as Wainwright Inlet, a distance of about 200 miles. It is not certain, however, that the beds at these various points represent the same coal field or even that they all occur in the same formation. Though these coals have been somewhat exploited, and numerous fossils, ranging from early Paleozoic to Mesozoic, have been reported from the region, no definite conclusion has been reached concerning the geologic age of the rocks in which the coals occur.

Wainwright Inlet.—The most northerly occurrence of the coal yet reported along this coast is at Wainwright Inlet, latitude 70° 37′, longitude 159° 45′. Here it is said by Mr. Woolfe,[a] who discovered it in 1889, to occur on the banks of Koog River, which flows into the inlet. As the river is shallow at its mouth, flat-bottomed boats or lighters would be required for getting the coal to the sea. The coal is described by Mr. Woolfe "as being of better quality and containing less detritus than the Cape Lisburne mineral. It appears to be a light but hard lignite, burning briskly, with but little ash." It is somewhat surprising that this coal should excel the Cape Lisburne coal in fuel efficiency, as the latter is believed to be the older, more highly metamorphosed, and carbonized. Though the writer was not able to visit the Wainwright Inlet exposure, at a point about 20 miles southwest of the inlet paleontologic evidence showed the country rock to be probably Jura-Cretaceous (p. 74). Judging from topographic criteria, the same formation seems to extend beyond Wainwright Inlet. Samples of apparently good coal were found near the place where the fossils were collected. Analysis of one of these, however, No. 653 in the table (p. 114), shows that it is a lignite.

Though coal float is found in the beach gravels at several localities along the coast, actual outcrops of coal were not seen and are probably not numerous.

Cape Beaufort.—Cape Beaufort, in latitude about 69° 10′ and longitude 163° 36′ (see Pl. V), marks the coastal terminus of the line of demarcation between the very gently rolling or nearly flat lowland tundra country on the north and the more hilly and low mountainous region on the south which merges with mountains that terminate in Cape Lisburne. It lies about 70 miles northeast of Cape Lisburne. The term cape is hardly applicable to Beaufort, however, as there is here no real promontory, but only a ridge rising to a height of about 800 feet above the uniform shore line.

A 6-foot vein of coal occurs in the folded and faulted sandstone of this ridge. It is probably best exposed about one-eighth to one-fourth of a mile from the coast, whence it seems to extend farther inland and with care can probably also be traced to the coast. So far as observed, the vein dips gently southward with the rocks of the region. As shown in the table of analyses under No. 665, page 114, this is a good bituminous coal.

It may be well to note that Doctor Dall, in his report on Alaskan coal and

[a] Report on population and resources of Alaska at the Eleventh Census, 1890, Washington, 1893, p. 133.

lignites, includes under the name of "Cape Beaufort coal measures" all the coal from near Cape Lisburne to Cape Beaufort, inclusive, covering a stretch of more than 40 miles in extent. As the coal throughout this region may possibly, on further investigation, all be found to be of the same geologic age, it may for the present fittingly be referred to under the one name. It should be remarked, however, that the vein at Cape Beaufort, which is the extreme northern limit of the field, is relatively little known, while that which is most familiar as the source of supply for the whalers is in the extreme southwestern part of the field. Doctor Dall's basis for thus including the coal of this entire region under one head is probably the description and extent of the occurrence of the coal given by Mr. Henry D. Woolfe, whose report, as condensed by Doctor Dall, is here quoted:[a]

"Along the beach and coast line from Cape Lisburne for at least 40 miles an extensive and well-defined coal field exists. I was engaged for two seasons in exploiting these deposits. Research developed the existence of a body of coal extending over an area of 25 square miles. There are along the coast line for the distance mentioned numerous veins of coal from which the whalemen obtain supplies of fuel. The coal is of the type of semibituminous lignite. It makes steam quickly, but there is a very large percentage of ash and clinker, and its constant use causes an early burning out of the furnace bars. * * * At present the whalemen dig out their supplies from the surface veins, climbing the cliffs to obtain it. * * * With any wind, except from the coast or southeast, there is no protection on the coast mentioned, and the work of boating the coal off to a vessel lying at some distance from the shore is difficult, and in windy weather dangerous. With the ice pack offshore a lee is obtained which makes smooth water and facilitates coaling. The limit of the important coal-bearing area to the north is at Cape Beaufort, though small seams are seen farther on. Between the seams bands of clear ice intervene, and I have noticed on the shelving banks of a small creek that runs through the coal land an oily exudation resembling petroleum."

Until the past few years Mr. Woolfe had seen more of this coal field than any other man, and we are fortunate in having the benefit of his observations, though the field may not prove so large or rich as he inferred.

Thetis and Corwin mines.—Turning our attention to the southwestern and apparently most important part of the field, we find here the Thetis and Corwin coal mines, old supply points of the whalers and United States revenue vessels. These names, Thetis and Corwin, which have appeared on the charts for many years, are taken from vessels of the revenue service which replenished their coal bunkers at these mines on their annual cruises in the Arctic.

The Thetis mine is situated near the mouth of Thetis Creek and east of Cape Sabine, a low and unimportant promontory, shown in Pls. V and X, *C*. The coal here is said to occur in sandstone and shale.

[a] Dall, W. H., Report on coal and lignite of Alaska: Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, p. 820.
[b] Ibid.

The Corwin mines, which at present seem to be by far the most important, accessible, and productive, are situated farther to the southwest, near the southwestern limit of the coal measures referred to by Dall, and about 30 miles east of Cape Lisburne (see Pl. V). Coal is reported to have been obtained here by the whaling vessels as early as 1879. Its occurrence, so far as observed, is in 10 or 12 beds, varying from 1 to 16 feet in thickness, all being apparently quite persistent. The edges of these beds are exposed for a distance of about three-eighths of a mile along the coast, which cuts them diagonally, forming a steep cliff that rises from 30 feet on the west to more than 100 feet above tide on the east, where it attains its maximum in a low prominence known as Corwin Bluff. The coal beds, conformable with the country rock in which they occur, strike N. 45° W. and dip southwestward at an angle of 36°, as shown in Pl. XIII, *B;* but eastward, in Corwin Bluff, where the rocks are more disturbed, the dip steepens.

The country rock in which the coal occurs, as shown in the above view, is sandstone, shale, and slate, and is probably Jura-Cretaceous. It is more fully described under the head of geology, page 72. As noted, it very much resembles the rocks of the Anaktuvuk series, but is supposed to be older.

Some of the coal in the Corwin mines has been partially crushed, but not greatly damaged, by rock movement. In mining much of it is taken out in large blocks, 1 to 2 or more feet in diameter, and nearly all of the beds are comparatively pure. Average samples collected by the writer gave the analyses under numbers 669 and 671 in the accompanying table, page 114, showing the product to be a bituminous coal of fair grade, with a fuel ratio of 1.10 and 1.30. It is, however, hardly satisfactory for blacksmithing or steaming purposes. It was used on the steamship *Arctic*, on which the party took passage for Nome, but with much the same results as indicated by Mr. Woolfe. Though it burns readily and produces steam quickly, it is of low specific gravity and not lasting. It takes about double the amount of this coal as compared with Comax coal to maintain a given steam pressure. It burns with little smoke, but produces a large amount of ash and clinker. This instance, however, can hardly be considered a fair trial, as, owing to the want of timber, the facilities for mining were so poor that much "bone," rock, and dirt, or foreign débris found its way into the coal and thence into the furnace. The coal is reported to be good for cooking and household purposes.

Mr. Charles L. Norton,[a] of the Massachusetts Institute of Technology, is said to have made the following report to the Corwin Trading Company on "Cape Lisburne coal," which was probably collected at or in the region of the Corwin mines:

"I find that the specimens of Alaska coal which you recently sent me have a calorific power of 7,560 calories per gram. This is quite as good as the average western coal, and is not more than 10 per cent inferior to the best eastern coals."

[a] Brooks, A. H., The coal resources of Alaska: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, p. 566.

The Corwin mines were operated to some extent during the summer of 1901 by the Arctic Development Company, who disposed of the coal in the Nome market, mostly for domestic purposes, where it is said to readily command $18 or $20 per ton in competition with the Comax or Washington coal at $25 per ton.

As it is only on the exposed edges of the veins in the face of the beach bluff that mining has thus far been carried on, it may be that the quality of the coal will improve somewhat with depth, but presumably not to an important extent, since at a distance of 10 to 15 feet below the surface the coal appears bright, firm, dry, and unweathered.

There is undoubtedly a large amount of coal in the region of the Corwin mines, but there are no harbor facilities. The beach is exposed to heavy surfs, much as it is at Nome, and the water is shallow, so that ocean vessels do not often approach within three-eighths of a mile of the shore. The coal is loaded aboard the vessels by lighters, as at Nome, which, as it can be accomplished only at periods of quiet weather or favorable wind, is, to say the least, expensive, uncertain, and tedious. A project of constructing an aerial tramway for loading purposes, from the bluff out to the anchorage of the vessels, is said to be under consideration.

The claims in the vicinity of the mines have been taken up, mostly by the Arctic Development Company of San Francisco, whose reported plan of future development work includes the sinking of a shaft on one of the large middle veins, and cross-cutting to the others.

Area south of Cape Lisburne.—Westward, toward Cape Lisburne, the Corwin series, in which the coals of the Thetis and Corwin mines occur, is supposed to give way to Paleozoic rocks, for the limestone cliffs 4 miles south of Cape Lisburne are known to contain Devonian corals and other forms. At about one-third of a mile north of this limestone locality, according to Mr. A. G. Maddren, who explored this section of the coast in 1900, there is a 4- to 5-foot vein of coal in shale, which dips north at an angle of 60°. This is at a point about one-third of a mile north of the coral limestone locality. This coal, Mr. Maddren thinks, is considerably older than that of the Corwin and Thetis localities. He reports:

"It is hard and breaks with a bright fracture. It was tried in the galley stove and gave a more intense fire than Nanaimo coal. The engineers said there was not enough underdraft beneath the main boiler to burn this coal fast enough for steaming purposes, that it was too hard and needed forced draft. The only point that seems to be against this coal is its lack of weight. It seems to have a low specific gravity, but this may be only at the surface, where it is leached out by the weather."

The low specific gravity here mentioned would seem to place this coal in the same class with the Corwin coals, and suggests its possibly being a specimen somewhat more highly altered by metamorphism. Whether it is of greater geologic age than the Corwin, as supposed by Mr. Maddren, can not definitely be stated, but it should be noted that in the shale associated with the coal there is reported to have been found by Mr. Dumars a small specimen of *Lepidodendron*, which has been determined by Mr. David White, who states that it is related to *Lepidodendron chemungense*, and that it indicates an age for the shale either of Upper Devonian or Lower Carboniferous.

Mr. Maddren also reports that in the valley between Cape Dyer and The Ears (shown in fig. 1) a syncline of shales occurs containing at least one exposure of coal along the low sea bluff that rises from 50 to 100 feet above tide. He also states that just south of Cape Lewis there is a bluff of shales that seem to contain "coal blossom."

ANALYSES OF COAL.

The following analyses were made by Mr. George Steiger, chemist of the Survey:

Table of coal analyses.

	187 Koyukuk River above Tramway Bar.	607 Anaktuvuk River.	620 Colville River.	653 Wainwright Inlet.	665 Cape Beaufort.	669 Corwin mines.	671 Corwin mines.	Cape Lisburne.[a]
Moisture	4.47	6.85	11.50	10.65	7.18	10.47	7.23	3.75
Volatile matter	34.32	36.39	30.33	42.99	36.38	40.12	38.68	43.75
Fixed carbon	48.26	43.38	30.27	42.94	51.23	46.16	50.05	47.39
Ash	12.95	13.38	27.90	3.42	5.21	3.25	4.04	5.11
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Sulphur	....	.54	.50	.62	.48	.27	.23	.36
Phosphorus pentoxide	....	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	....
Coke	....	None.	None.	None.	None.	None.	None.	....
Fuel ratio	1.40	1.20	....	....	1.4	1.10	1.30	1.08

CLIMATIC CONDITIONS.

METEOROLOGIC RECORD FOR 1899.

The following is a record of meteorologic observations made by the writer on a reconnaissance along Chandlar and Koyukuk rivers in 1899, mainly in latitude 65° to 68°, longitude 145° to 158°. The localities at or near which they were made are designated by the position of the dates (month and day) on the map.[b]

The thermometer used in this work is an H. Green, cylindrical bulb, Fahrenheit scale.

[a] Brooks, A. H., The coal resources of Alaska: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, p. 565.

[b] Schrader, F. C., A reconnaissance along the Chandlar and Koyukuk rivers, Alaska, in 1899: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, opposite p. 448.

The localities refer to camps pitched by the party en route at the close of its day's traverse. Hence the morning observation of any given date was usually made at the camp preceding the one of the date by which the observation is designated on the map, and the 2 p. m. observation of the same date was made at a point about midway between the two camps.

The meaning of the abbreviations used in the table to denote the kind and amount of clouds is as follows:

A-cu =alto-cumulus.
A-s =alto-stratus.
Ci =cirrus.
Ci-cu=cirro-cumulus.
Ci-s =cirro-stratus.
Cu =cumulus.
Cu-n =cumulo-nimbus.
N =nimbus.
S =stratus.
S-cu =strato-cumulus.
0 =clear sky.
1 =sky one-tenth cloudy.
5 =sky five-tenths or one-half cloudy.
10 =sky all cloudy.

The wind velocities here given were determined by estimate, but as some judgment had previously been acquired by the observer in forming estimates of wind velocity by noting the impressions it makes upon the person and the speed of light objects transported by it, and then comparing the estimates thus formed with the readings of standard anemometers, with which he had several years' experience, the estimates here given are believed to be approximately correct.

Since the barometric readings here given were made on an aneroid, where there were no field facilities for its comparison with a mercurial barometer, they purport to be of minor value only.

In the preparation of the table for publication, suggestions have been contributed by Dr. Cleveland Abbe, jr.

Meteorologic observations along Chandlar and Koyukuk rivers essentially at 7 a. m. and 2 and 9 p. m., from June 19 to September 23, 1899.

Locality and date.	Temperature.	Clouds: Kind and amount.	Wind: Direction and velocity in miles per hour.	Barometer. (Aneroid.)	Weather.	Remarks.
Fort Yukon:	*Degr. F.*					
June 19	58 to 60	Cu. 9	High.	29.2	Blustery	
20, 2 p. m.	59	Cu. 8	High.	29.15	Blustery, showery	
21, 9 a. m.	58.9	Ci-cu. 3	Moderate.	29.1	Fine	
2 p. m.	64	Ci-cu. 5	Moderate.	29.15	do	
9 p. m.	63	Ci-cu. 8	0	29.14	do	
22, 7 a. m.	63.8	Ci-cu. 8	0	29.12	do	
Mouth of Chandlar River:						
June 22, 2 p. m.	74.5	Ci-cu. 4	SW. 10.	29.16	do	
9 p. m.	56.6	Ci-cu. 7	0	29.1	Fair	
23, 7 a. m.	64.2	Ci-cu. 4	SW. 15.	29.07	Showery	
2 p. m.	63	Ci-cu. 3	SW. 15.	29.01	do	
9 p. m.	55	Ci-cu. 7	0	28.98	do	

Meteorologic observations along Chandlar and Koyukuk rivers essentially at 7 a. m. and 2 and 9 p. m., from June 19 to September 23, 1899—Continued.

Locality and date.	Temperature.	Clouds: Kind and amount.	Wind: Direction and velocity in miles per hour.	Barometer. (Aneroid.)	Weather.	Remarks.
Chandlar River:	*Degr. F.*					
June 24, 7 a. m.	52	Ci. 8	SW. 15.	28.98	Threatening	
2 p. m.	60	Ci. 2	SW. 15.	29.05	Bright and fine	
9 p. m.	50	Ci. 4	SW. 20.	29.06	do	
25, 7 a. m.	51	Ci. 1	SW. 20.	29.15	do	
2 p. m.	55.6	Ci. 6	SW. 15.	29.15	do	
9 p. m.	54	Ci. 2	SW. 10.	29.16	do	
26, 7 a. m.	51	Ci. 1	SW. 5.	29.12	do	
2 p. m.	57.5	N. 9	SW. 4.	29.6	Showery and rain.	
9 p. m.	54.6	N. 8	SW. 15.	29.6		Temperature water, Chandlar River = 54.5°.
27, 7 a. m.	48	Ci. 1	SW. 20.	29.12	Bright	
2 p. m.	55	Ci-cu. 8	SW. 10.	29.1	Bright (?)	(?).
9 p. m.	48	Ci-cu. 4	0	29.11	Bright	
28, 7 a. m.	53	Ci-cu. 2	SW. 2.	29.05	do	Two good showers last night.
2 p. m.	59.5	Threaten'g 8	SW. 3.	29.0	Showery	
9 p. m.	53	N. 10	NNW. 5.	28.9	do	Stormy on mountains.
29, 7 a. m.	54	N. 9	W. 5.	28.9	do	Do.
2 p. m.	59	Cu-S. 8	W. 2.	28.92		Mountains smoky; temperature river = 52°.
9 p. m.	52.5	N. 10	SW. 20.	28.8	Showery	Blustery.
30, 7 a. m.	44.5	Cu-n. 9	SW. 20.	28.8		Do.
2 p. m.	46.5	N. 10	SW. 15.	28.85	Steady rain	Showery all a. m.
9 p. m.	46.5	N. 10	SW. 10.	28.85	do	Rained all p. m.
July 1, 7 a. m.	44	N. 10	SW. 5.	29.8	do	Rainy all night.
2 p. m.	47	N-cu. 8	SW. 8.	29.06	Showery	Clearing (?).
9 p. m.	49	N-cu. 6	0	29.05	do	Do.
2, 7 a. m.	53	Ci-cu. 5	W. 20.	29.1	Bright	Temperature river = 49°.
2 p. m.	54	N. 8	SW. 30.	28.9	Showery	Showers.
9 p. m.	52	N. 7	SW. 20.	28.9	do	Do.
3, 7 a. m.	54	N. 3	SW. 20.	29.04		Blustery.
2 p. m.	57	Ci-cu. 2	SWW. 20.	29.1	Clear	Clear and fine; sunset at 10 p. m.
9 p. m.	49	Ci-cu. 1	S. 77° W. 1.	29.2	do	Clear and fine.
4, 7 a. m.	50	Ci. 2	S. 77° W. 5.	29.30	Bright; hazy	Hazy; bright.
2 p. m.	62.5	Ci. 3	S. 77° W. 20.	29.20		Threatening.
9 p. m.	55	N. 8	SW. 20.	29.0	Threatening	
5, 7 a. m.	56.5	Ci. 2	SW. 20.	28.90	Bright	Bright.
2 p. m.	58	Ci. 2	W. 30.	28.1	do	Bright. On lava butte at edge of mountains and Yukon flats.
9 p. m.	64	Ci. 3	W. 20.	28.9	do	Bright.
6, 7 a. m.	60.5	Ci-cu. 4	W. 20.	28.9	do	Bright; temperature river below Forks=55°, 11 a. m.; temperature Lake Fork = 55.5, 11.30 a. m.
2 p. m.	66.5	N. cu. 8	W. 20.	28.7		Cloudy; temperature above Forks=55.8, 12 m.
9 p. m.	56		W. 1.	28.18	Heavy shower at 5 p. m.	Bright.
7, 7 a. m.	52	3	W. 10.	28.9		Hazy.
2 p. m.	65	0	W. 5.	28.8		Fine warm day.
9 p. m.	55	0	0	28.8		Do.
8, 7 a. m.	53	0	W. 2.	28.75		Fine warm morning.
2 p. m.	69	0	W. 10.			Warm day; temperature river =56°.

Meteorologic observations along Chandlar and Koyukuk rivers essentially at 7 a. m. and 2 and 9 p. m., from June 19 to September 23, 1899—Continued.

Locality and date.	Temperature.	Clouds: Kind and amount.	Wind: Direction and velocity in miles per hour.	Barometer. (Aneroid.)	Weather.	Remarks.
Chandlar River—Continued.	*Degr. F.*					
July 8, 9 p.m.	61.5	0	0			Warm day.
9, 7 a.m.	58	Hazy 9	0			Sultry.
2 p.m.	73.5	0	W. 20.			Clear.
9 p.m.	61	0	W. 2.			Do.
10, 7 a.m.	56.5	N. 10	0		Showery	Dark and rainy.
2 p.m.	57	N. 9	W. 30.		do	Location: Station 3 at 4,000′ on Granite Creek.
9 p.m.	62.5	N. 9	W. 20.		do	
11, 7 a.m.	53	N. cu. 8	SW. 20.		do	Stormy and blustery.
2 p.m.	56	N. 10	SW. 10.		do	Showery.
9 p.m.	50	N. 10	0		do	Do.
12, 7 a.m.	49	N. 10	SW. 5.		do	Showery; temperature river=46.5°.
2 p.m.	55	N. 8	0		do	Showery.
9 p.m.	52	Ci-s. 6	SW. 5.			Showery till 5 p. m.
13, 7 a.m.	58.5	Ci. 2	SW. 10.		Bright and sunny.	
2 p.m.	54	Ci. 1	SW. 15.		do	Temperature river=49°.
9 p.m.	53.5	Ci. 1	SW. 2.		do	
14, 7 a.m.	55.5	0	SW. 3.		do	
2 p.m.	58	S. 4	SW. 10.		do	
9 p.m.	59	N. 7	SW. 1.			
15, 7 a.m.	50	N. 10	0		Raining steadily.	Rained during night.
2 p.m.	53	N. 10	0		Raining	
9 p.m.	53	N. 10	0		Showery	
16, 7 a.m.	51.5	N. 10	SW. 5.		Raining	Rainy all night.
2 p.m.	54	N-cu. 8	SW. 15.		Showery?	Temperature river=45°.
9 p.m.	46.5	0	SW. 30.			
17, 7 a.m.	48	Ci-cu. 2	SW. 20.			Bright and sunny.
2 p.m.	54	2	SW. 10.			Do.
9 p.m.	48.5	N. 9	SW. 15.			Threatening.
18, 7 a.m.	45.5	N. 9	SW. 10.		Rainy and foggy	Rained during night.
2 p.m.	55	N. 9	SW. 5.		Foggy	Temperature river = 45°.
9 p.m.	51	N. 10	SW. 10.		Rainy and foggy	
19, 7 a.m.	47	N. 9	SW. 6.			Dubious.
2 p.m.	53	N. 9	SW. 20.		Threatening; showery.	Dubious. Location: Chandlar Lake.
9 p.m.	47	Ci-cu. 8	SW. 15.		Dubious	Showery in p. m.
20, 7 a.m.	47	Ci-cu. 6	SW. 15.		Clearing	Somewhat cloudy on mountains.
2 p.m.	54	Ci. 1	SW. 20.		Bright	Very windy.
9 p.m.	44	Ci-cu. 3	SW. 5.			Cool.
21, 7 a.m.	48	Ci-cu. 5	SW. 10.		Dull	Do.
2 p.m.	59	Ci-cu. 4	S. 10.		Bright	Do.
9 p.m.	49	Ci. 9			do	Do.
22, 7 a.m.	59	0	0		do	Warming.
2 p.m.	70	Ci. 2	SW. 2.		do	Warm; temperature river = 50°.
9 p.m.	55	N. 5	0		do	Cooling.
23, 7 a.m.	59	Ci. 5	SE. 10.		do	Warming.
2 p.m.	67	Ci-cu. 2	NWW. 10.		do	Comfortable.
9 p.m.	56	Ci-cu. 5	W. 5.		do	Cooling.
24, 7 a.m.	51	0	SWW. ½.		do	Warm.
2 p.m.	74	Ci-cu. 4	NEE. 4.		do	Do.
9 p.m.	55	N. 7	NEE. 3.			Cooling.

Meteorologic observations along Chandlar and Koyukuk rivers essentially at 7 a. m. and 2 and 9 p. m., from June 19 to September 23, 1899—Continued.

Locality and date.	Temperature.	Clouds: Kind and amount.	Wind: Direction and velocity in miles per hour.	Barometer. (Aneroid.)	Weather.	Remarks.
Chandlar River—Continued.	*Degr. F.*					
July 25, 7 a. m.	56	Ci-cu. 2	SWW. 5.		Bright	
2 p. m.	68	Ci. 1	SWW.			Fine, comfortable day.
9 p. m.	59.5	Ci-cu. 2	0			Do.
26, 7 a. m.	59.5	0	SWW.			Fine; somewhat hazy.
2 p. m.	71	0	SWW. 5.			Fine.
9 p. m.	55	0	0			Fine; moonlight.
27, 7 a. m.	61	Ci. 3	NW. 10.			Fine; warm.
2 p. m.	73	Cu-n. 5	NW. 15.		Showery about lake.	Do.
9 p. m.	60	Cu-n. 6	0		Showery in p. m.	Fine; comfortable.
28, 7 a. m.	60	Cu-n. 5	NW. 5.			Warming.
2 p. m.	61	Ci-cu. 3	NW. 15.			Fine day.
9 p. m.	46	0	NW. 5.			Do.
29, 7 a. m.	49	0	0			Warming.
2 p. m.	58	0	0			Location: Summit of Chandlar-Koyukuk portage at 3,500′.
9 p. m.	48	0	0			
30, 7 a. m.	37	0	0			
2 p. m.	68	0	NW. 5.			
9 p. m.	50	Hazy	0			
31, 7 a. m.	41	Hazy	0			
2 p. m.	61	Hazy	0		Showery	
9 p. m.	52	N. 1	0		Raining	
Aug. 1, 7 a. m.	51	Ci-cu. 5	0		Rain in night	Clearing.
2 p. m.	74	Ci. 2	NW. 5.		Hazy; bright	Fine.
9 p. m.	62	N. 6	0			
Koyukuk River:						
Aug. 2, 7 a. m.	67	Ci-cu. 4	NW. 5.		Hazy; bright	Fair.
2 p. m.	74	Ci-cu. 6	NW. 8.			Cooling.
9 p. m.	60	N. 7	NW. 5.		Showery	Comfortable.
3, 7 a. m.	57	N. 10	NW. 4.		Rained hard 49 minutes.	Rainy and foggy.
2 p. m.	52	N. 10	0		Rainy	
9 p. m.	45	Ci-cu. 4	W. 4.		Clearing	Clearing and cool.
4, 7 a. m.	52	0	W. 4.			Warming fast (?).
2 p. m.	46	S. 3	SW. 7.			Cold. Location: Mount Horace at 5,600′.
9 p. m.	45	Cu-n. 5	0			Do.
5, 7 a. m.	54	Cu. 4	0			Heavy frost.
2 p. m.	56	Cu-n. 9	SW. 4.			Cool.
9 p. m.	54	Cu-n. 9	0			Comfortable.
6, 7 a. m.	48.5	N. 10	0		Rainy	Cool.
9 p. m.	54	N. 9	0		do	Comfortable.
7, 7 a. m.	53.5	N. 9 and fog.	W. 5.		Raining all night.	Clearing (?) and colder; river rose 2 inches.
2 p. m.	65	N. 9 and fog.	0			Clear(?) warming (?).
9 p. m.	50	Ci-cu. 2	0			Evening clearing (rained during night).
8, 7 a. m.	50	0	0			Bright and warming.
2 p. m.	67.5	Ci-cu. 8				
9 p. m.	51	Ci-cu. 4	0			Showery 5 to 8 p. m.
9, 7 a. m.	63	0	NW. 4.			Bright.
2 p. m.	67.5	Ci-cu. 4	NW. 5.			Temperature creek=55°.
9 p. m.	45	Ci. 3	0			Cool.

Meteorologic observations along Chandlar and Koyukuk rivers essentially at 7 a. m. and 2 and 9 p. m., from June 19 to September 23, 1899—Continued.

Locality and date.	Temperature.	Clouds: Kind and amount.	Wind: Direction and velocity in miles per hour.	Barometer. (Aneroid.)	Weather.	Remarks.
Koyukuk River—Continued.	*Degr. F.*					
Aug. 10, 7 a. m.	57	Ci-cu. 2	NW. 4.			Comfortable.
2 p. m.	68	Ci-cu. 3	NW. 2.			Cool. Location: Fault Mountain at 5,000′.
9 p. m.	58	Ci-cu. 4	0			Do.
11, 7 a. m.	49	Ci-cu. 2	NW. 2.			Do.
2 p. m.	69	Ci-cu. 4	NW. 4.			Fine day.
9 p. m.	58.5	Ci-cu. 4	W. 4.			Do.
12, 7 a. m.	53.5	Ci-cu. 6	W. 2.		Rain little in night.	Fair morning.
2 p. m.	74	Ci-cu. 3				Fine warm day.
9 p. m.	54	Ci-cu. 4	NNE.			Fair evening.
13, 7 a. m.	52.5	N. 9	NNE. 5.		Sprinkled	Threatening.
2 p. m.	54	N. 8	NNE. 4.		Sprinkled	Do.
9 p. m.	56	N. 10	NNE.		Raining	Do.
14, 7 a. m.	56.5	Ci-cu. 4	NNE.		Rainy night	Clearing.
2 p. m.	69	Ci-cu. 4	NNE.		Fair	
9 p. m.	48.5				do	On Myrtle Creek.
15, 7 a. m.	49	Ci-cu. 2			do	On Myrtle Creek.
2 p. m.	68	Ci-cu. 6				On Myrtle Creek.
9 p. m.	52	Ci-cu. 10			Raining	
16, 7 a. m.	50	Ci-cu. 10				Fog.
2 p. m.	66.5	N. 10	NNE.		Showery	
9 p. m.	57	N. 10	SW. 6.		do	
17, 7 a. m.	46	N. 10	SW. 4.		Raining	Rained all night.
2 p. m.	52	N. 10	SW. 3.		do	Rainy day.
9 p. m.	50	N. 10	0		Misty and fog	Rainy and foggy all day.
18, 7 a. m.	46.5	N. 10	0		Rainy night	Misty and foggy.
9 p. m.	34	0	0			Some fog.
19, 7 a. m.	48	S. 2	0			Bright, temp. rising.
2 p. m.	63	Ci-cu. 3	NE. 3.			Do.
9 p. m.	53.5	S. 2	NE. 3.			Do.
20, 7 a. m.	52.5	S. 2	NE. 4.			Do.
2 p. m.	61	Ci-s. 2	E.			Fine day.
9 p. m.	50.5	N. 9	SW.		Raining	Threatening.
21, 7 a. m.	49.5	Cu-s. 7	0		Rainy night	Clearing(?).
2 p. m.	59	Cu-n. 8	0			Threatening SW.
9 p. m.	49	N. 10	0		Rainy	
22, 7 a. m.	44.5	Ci-s. 8	SW. 4.			Cool and clearing(?).
2 p. m.	55	Cu. 7	SW. 6.			Fine day.
9 p. m.	46	Cu-s. 8	0			Cool and dull.
23, 7 a. m.	43	Cu-s. 9	SW. 3.			Do.
2 p. m.	52	Cu-n. 4	SW. 4.		Showery	Do.
9 p. m.	43.5	S. 2	0		Fine	Do.
24, 7 a. m.	43	Cu-s. 8	SW. 4.		Showery in night.	Do.
2 p. m.	50.5	Ci-s. 2	SW. 4.			Cool; fine day.
9 p. m.	38	0	SW. 4.			Do.
25, 7 a. m.	43	Ci-cu. 3	SW. 10.			Do.
2 p. m.	52	Ci. 3	SW. 9.			Do.
9 p. m.	45	Ci-cu. 2	0			Do.
26, 7 a. m.	41	Ci. 2	SW. 2.			Hazy; cool; fine day.
2 p. m.	53	Ci. 2	SW. 4.			Do.
26, 9 p. m.	53	S. 8	SW. 2.		Showery	Warm; hazy.

Meteorologic observations along Chandlar and Koyukuk rivers essentially at 7 a. m. and 2 and 9 p. m., from June 19 to September 23, 1899—Continued.

Locality and date.	Temperature.	Clouds: Kind and amount.	Wind: Direction and velocity in miles per hour.	Barometer. (Aneroid.)	Weather.	Remarks.
Koyukuk River—Continued.	*Degr. F.*					
Aug. 27, 7 a. m.	54	N. 10	SW. 3.	....	Rainy all night	Warm.
2 p. m.	56	N. 10	SW. 4.	....	Showery	Do.
9 p. m.	53	N. 10	SW. 5.	....	Raining	Rainy all day.
28, 7 a. m.	48	N. 10	SW. 2.	....	Rainy	Rainy morning and last night.
2 p. m.	48.5	N. 10	SW. 6.	....	....do	Rainy.
9 p. m.	47.5	Ci-n. 8	SW. 7.	....	....	Clearing (river rising).
29, 7 a. m.	47	Ci-n. 8	SW. 6.	....	....	Clearing (?).
2 p. m.	52	Ci-n. 7	SW. 10.	....	Stormy	Clearing (?) (river rising).
9 p. m.	47	Cu. 5	SE. 4.	....	....	Showery all day; clearing.
30, 7 a. m.	42	Ci-n. 7	0	....	Some fog	Clearing (?).
2 p. m.	54	Cu-n. 8	SW. 8.	....	....do	Showers in a. m.
9 p. m.	46.5	Cu-n. 7	0	....	....do	Stormy in p. m.
81, 7 a. m.	43	Cu-n. 5	0	....	....do	Fine morning; clearing (?).
2 p. m.	51	Ci-s. 4	SW. 10.	....	....	Fair.
9 p. m.	89	Ci-s. 3	SW. 2.	....	....	Fine mackerel sky in north.
Sept. 1, 7 a. m.	36	Hazy	NE. 3.	....	Some fog	Fine morning; frost.
2 p. m.	60	Hazy 3	SW. 2.	....	....	Fine mackerel sky in S. and SE.
9 p. m.	50.5	Cu-n. 8	0	....	....	Threatening.
2, 7 a. m.	45.5	Cu-n. 7	0	....	....	
2 p. m.	52.5	Ci-cu. 2	SSW. 3.	....	....	Fair day, somewhat hazy.
9 p. m.	45	Ci-cu. 3	SWW. 2.	....	....	Fair evening.
3, 7 a. m.	45	Ci. 3	0	....	....	Fair morning.
2 p. m.	61	Ci-s. 4	E. 7.	....	....	Fair day.
9 p. m.	52	Cu-s. 7	0	....	....	Dubious.
4, 7 a. m.	51	N. 9	0	....	Showery during night.	Do.
2 p. m.	57	Cu-n. 8	0	....	....	Dubious (river 40°).
9 p. m.	51.5	N. 10	0	....	Rainy p. m	River fell 1 foot in 24 hours.
5, 7 a. m.	51	N. 10	0	....	Rainy all night	
2 p. m.	58	N. 10	SE. 4.	....	Rainy all a. m	River still falling.
9 p. m.	49.5	N. 10	0	....	Rainy p. m	River still falling; fell several inches since.
6, 7 a. m.	45	N-s. 9	0	....	Rainy all night	Do.
2 p. m.	55	Cu-n. 8	SW. 8.	....	....	
9 p. m.	47	Cu-s. 5	SW. 1.	....	....	Fair day and cooler.
7, 7 a. m.	47.5	Cu-s. 7	0	....	....	Cool.
2 p. m.	61	Ci-cu. 3	SW. 10.	....	....	Fine day (river 50°).
9 p. m.	47.5	Cu. 2	0	....	....	Fine day.
8, 7 a. m.	44	Ci. 1	NE. 12 (?).	....	....	Fine morning.
2 p. m.	58.5	Cu-s. 7	NE. 12 (?).	....	....	Fine day a. m. (river 51.5°).
9 p. m.	49	Ci-s. 1	NW. 2.	....	....	Fine evening.
9, 7 a. m.	44	Ci-s. 2	N. 3.	....	....	Fine a. m. (river 48°).
2 p. m.	50.5	S-n. 8	E. 8.	....	....	Fine a. m.; threatening now.
9 p. m.	48.5	S-n. 8	0	....	....	Moderately fair evening.
10, 7 a. m.	44.5	S-n. 9	0	....	....	Dubious (river 49°).
2 p. m.	54.5	Ci-cu. 2	NE. 1.	....	....	Cloudy a. m.; p. m. hazy, but fine (river 49°).
9 p. m.	48	N. 8	0	....	Showery	Fine day.
11, 7 a. m.	47	N. 10	SW. 4.	....	....do	Very foggy and misty.
2 p. m.	53	Cu-s. 4	S. 15.	....	....	Fair day (river 50°).
9 p. m.	49	S. 2	0	....	....	Fine, cool evening.
12, 7 a. m.	34	Ci-s. 4	0	....	Fog, low and dense	Fine morning (frost).

Meteorologic observations along Chandlar and Koyukuk rivers essentially at 7 a. m. and 2 and 9 p. m., from June 19 to September 23, 1899—Continued.

Locality and date.	Temperature.	Clouds: Kind and amount.	Wind: Direction and velocity in miles per hour.	Barometer. (Aneroid).	Weather.	Remarks.
Koyukuk River—Continued.	*Degr. F.*					
Sept. 12, 2 p. m.	52.5	S-Cu	E. 2.		Threatening	Threatening (river 48.5°).
9 p. m.	49.5	Cu-n. 10	0		Rainy	
13, 7 a. m.	44.5	Ci-s. 2	0			Clearing; fair morning.
2 p. m.	52	S-n. 9	SW. 12.		Showery	Showery and threatening.
Lower Yukon River:						
Sept. 13, 9 p. m.	47.5	Cu-n. 6	SW. 16.			Stormy. Location; Koyukuk Station.
14, 7 a. m.	41.5	Cu-s. 4	SW. 20.		Rained hard in night.	Stormy, but clearing.
2 p. m.	51	Cu-s. 5	SW. 20.		Stormy (?)	Storming.
9 p. m.	39	S-n. 6	SW. 10.			Stormy at Nulato.
15, 7 a. m.	37	S-n. 8	SW. 15.		Showery (?)	Storming.
Nulato:						
Sept. 15, 2 p. m.	48	S-n. 9	SW. 10.		Showery	Do.
9 p. m.	32	S-n. 4	NW. 3.			Cold.
16, 7 a. m.	21	S-cu. 1	NE. 2.			Ice ½-inch thick; fine morning.
2 p. m.	33	S-cu. 2	NE. 9.			Hazy.
9 p. m.	31	10	NE. 8.		Snowing hard	Snowed since 3 p. m., and snowing hard now.
Steamer Weare:						
Sept. 17, 7 a. m.	29.5	10	NNW. 3.		do	Snowed hard all night; 3 inches.
2 p. m.		10			do	Snowed most of the day.
9 p. m.						
18, 7 a. m.						
2 p. m.						
Holy Cross:						
Sept. 18, 9 p. m.						
19, 7 a. m.	32.5	9	SW. 2.		Snowing; scatteringly.	Clearing (?).
2 p. m.	37	6	SW. 1.		do	Do.
Andreafski:						
Sept. 19, 9 p. m.	33.5	Ci-cu. 4	0			Fair, moonlight evening.
20, 7 a. m.	27.5	Ci-cu. 8	0		Fog	Boat stopped by fog.
Steamer Weare 50 miles below Andreafski:						
Sept. 20, 2 p. m.	37	Ci-cu. 6	S.		Some fog	Blustery.
9 p. m.	34	10	10.		Snowing hard	Wintry.
Aphoon mouth:						
Sept. 21, 7 a. m.	33.5	N. 8	0			Fog.
Norton Sound:						
Sept. 21, 2 p. m.	39	Ci-s. 4	SW. 5.		Snowing	Fair p. m.
St. Michael:						
Sept. 21, 9 p. m.	35	10	W. 2.		do	
22, 7 a. m.	34	Ci-s. 10			Snowy	Threatening.
2 p. m.	35	10	Nearly calm.		Snowing	Snowed all a. m.
9 p. m.		10	Nearly calm.		do	Cold.
23, 9 a. m.	Frozen hard.	Ci-cu. 7	Nearly calm.			Do.
2 p. m.		Ci-cu. 4	SW. 10.		Snowing	Do.
9 p. m.		Ci-cu. 6	0		do	Do.

METEOROLOGIC RECORD FOR 1901, BY W. J. PETERS.

Snow was found to average about 6 feet deep in the Koyukuk Valley in April, and as the preliminary expeditions ascended the north tributaries flowing from the Endicott Mountains in April the depth was found to decrease until the grasses were visible in the floor of the passes. By June this deep snow had practically disappeared from the lowlands. Natives report that north winds blow through the passes of the Endicott Mountains with great force in winter, during which season it is dangerous to travel. It is not only dangerous to face the wind, but there is risk of the sled being broken by its being blown against projections in the smooth ice. Fogs were found on the pass in April and dense haze in July. In both cases this seems to have been blown in from the coast.

The following table, showing the temperatures at Uglaamie, 9 miles from Point Barrow, is taken from the report of the Ray expedition, 1881–1883:

Temperature observations at Uglaamie.

[In degrees Fahrenheit.]

Month.	Mean.	Maximum.	Minimum.
1881.			
November	0	30	–28
December	–18	....	....
1882.			
January	–15	20	–45
February	–23	– 2	–52
March	– 4	23	–30
April	– 4	32	–23
May	22	37	– 2
June	34	53	24
July	43	65	27
August	38	59	27
September	31	51	19
October	9	41	–22
November	– 7	29	–35
December	–17	8	–42
1883.			
January	–17	12	–42
February	– 6	24	–34
March	–13	26	–51
April	– 3	16	–30
May	23	38	–14
June	32	51	18
July	36	53	27
August	37	60	22

The highness of the minimum temperatures given here for the winter months, which are 30° to 40° above those of the Koyukuk country in the interior, is obviously due to the moderating influence of the ocean. At Cape Bathurst, northeast of the Mackenzie, in longitude 127° 30′, and latitude nearly as far north as that of Point Barrow, the lowest temperature experienced for the past two winters is reported by Mr. Fox, one of the white keepers of a trading post here, to be —36°.

Thunder is rare at Point Barrow, but is known by the natives to occur.

Precipitation at Uglaamie, 9 miles from Point Barrow; taken from the report of the Ray expedition, 1881–1883.

Month.	1881.	1882.	1883.
	Inches.	*Inches.*	*Inches.*
January	....	0.44	0.14
February	....	.04	1.02
March	....	.51	.14
April	....	.39	.55
May	....	.44	.31
June	....	.61	.30
July	....	1.39	1.04
August	....	1.46	1.66
September	....	1.10	....
October	....	1.05	....
November	0.73	.34	....
December	.44	.24	....

METEOROLOGIC RECORD FOR 1885-86, BY LIEUT. G. M. STONEY.

The following temperatures and notes were taken by Stoney[a] on upper Kowak River, principally at Fort Cosmos, about 120 miles from the coast, in approximate latitude 66° 53′, longitude 157° 23′. As they are continuous throughout a year, they cover a more extended period of time than any other data yet made in the interior of this northern country, and are regarded as one of our most important and reliable records concerning it.

Temperatures on Kowak (Putnam) River.

July, 1885:	
Lowest temperature during month	32° F.
Highest temperature during month	70
Mean temperature during month	49
August, 1885:	
Lowest temperature during month	32° F.
Highest temperature during month	68
Mean temperature during month	47

[a] Stoney, Lieut. George M., Naval Explorations in Alaska, U. S. Naval Institute, Annapolis, Md., 1900, pp. 104–105.

September, 1885:	
Lowest temperature during month	5° F.
Highest temperature during month	69
Mean temperature during month	39
October, 1885:	
Lowest temperature during month	− 4° F.
Highest temperature during month	46
Mean temperature during month	16
November, 1885:	
Lowest temperature during month	−44° F.
Highest temperature during month	15
Mean temperature during month	− 9.5
December, 1885:	
Lowest temperature during month	−65° F.
Highest temperature during month	29
Mean temperature during month	−12.4
January, 1886:	
Lowest temperature during month	−70° F.
Highest temperature during month	31
Mean temperature during month	−13.5
February,[a] 1886:	
Lowest temperature during month	−65° F.
Highest temperature during month	26
Mean temperature during month	−22.5
March, 1886:	
Lowest temperature during month	−38° F.
Highest temperature during month	36
Mean temperature during month	− 3.8
April, 1886:	
Lowest temperature during month	−22° F.
Highest temperature during month	49
Mean temperature during month	13
May, 1886:	
Lowest temperature during month	14° F.
Highest temperature during month	65
Mean temperature during month	35
June, 1886:	
Lowest temperature during month	32° F.
Highest temperature during month	74
Mean temperature during month	49

"*Note.*—During the month of December, 1885, in one hour the temperature rose 29° F., barometer remaining quite steady. This sudden rise in temperature was closely followed by a terrible gale of wind. The thermometer, not the barometer, indicates an approaching gale. It is dead calm when the thermometer stands low, and during the gales the temperature always goes above zero. The more sudden the rise of thermometer the harder the wind blows and the more quickly it hauls. One should watch the thermometer closely and get under shelter if a gale is coming; for neither man nor dog can stand these gales. You must be under shelter. Have seen it snowing—that is a fine snow falling—when there was not a cloud in the sky and very light wind. It is advanced by some that there was a higher wind that carried the snow from the mountain peak.

[a] Mean temperature February 1 to 20 −33° F.

"When the thermometer is minus, it is denoted (—).

"The temperatures during the months of July and August were taken partly at Fort Cosmos and while at work on the river. The others were taken at Fort Cosmos and an accurate temperature taken every hour by spirit thermometers remaining outside. These were the best (registered) spirit thermometers, made specially for the Government for arctic observation.

"A person can't be too much impressed with the importance of watching the thermometer. I would recommend that the spirit thermometer have the liquid colored, as the white liquid is hard to read. The thermometer should also be protected by a wooden case, leaving only the bulb exposed, and even that should be screened. My observations were the mean of three excellent spirit thermometers."

TEMPERATURES IN 1901.

Following are lists of temperatures encountered by the party. The record was kept by Gaston Philip. As the primary objects of the expedition could be obtained only by making daily moves, which were necessarily made at irregular hours during the twenty-four, these notes are not so complete as might be desired, but they will serve to give a fair idea of the general conditions that prevailed.

Temperatures on Dawson trail at 8 a. m., February to May, 1901.

Date.		Deg. F.	State of atmosphere.	Locality.
Feb.	19	—55	Calm	White Horse.
	20	—40	do	Do.
	21	—25	do	Do.
	22	—32	do	Lake Laberge.
	23	—22	do	Do.
	24	—23	do	Do.
	25	—28	do	On cut-off from Lake Laberge to Five Fingers.
	26	—14	do	Do.
	27	—10	do	Five Fingers.
	28	—10	Calm	Below Five Fingers.
Mar.	1	0	do	Near Fort Selkirk.
	2	0	High wind	Fort Selkirk.
	3	—45		Do.
	4	—10		30 miles below Fort Selkirk.
	5	—10		50 miles below Fort Selkirk.
	6	0		Stewart River.
	7	8		Near Dawson.
	8	16		Dawson.
	9	16		Do.
	10	16		Do.
	11	—12		Near Fortymile.
	12	0		Fortymile.

Temperatures on Dawson trail at 8 a. m., February to May, 1901—Continued.

Date.		Deg. F.	State of atmosphere.	Locality.
Mar.	13	13	....	Near Eagle City.
	17	−23	....	Mouth of Washington Creek.
	18	−22	....	Do.
	19	10	Snowstorm	Charlie River.
	20	−10	....	Do.
	21	− 8	....	Circle.
	22	− 4	....	Near Circle.
	23	2	....	Near Fort Yukon.
	24	0	....	Do.
	25	0	....	Fort Yukon.
	26	0	....	Do.
	27	−20	....	Mouth of Chandlar River.
	28	6	....	On Chandlar River.
	29	3	....	Do.
	30	2	High wind.......	Do.
	31	2	....	Do.
Apr.	1	24	....	Do.
	2	8	....	Do.
	3	6	....	Do.
	4	3	....	Do.
	5	4	High wind.......	Do.
	6	14	....	Do.
	7	18	....	Do.
	8	8	....	Do.
	9	4	....	Do.
	10	6	....	Do.
	11	4	....	Divide between Chandlar and South Fork, Koyukuk River.
	12	4	....	On South Fork, Koyukuk River.
	13	8	....	Slate Creek.
	14	3	....	Koyukuk River near Bettles.
	24	4	....	John River.
	25	10	....	Do.
	26	8	....	Do.
	27	2	....	Do.
	28	18	....	Do.
	29	16	....	Do.
	30	14	....	Do.
May	1	12	....	Do.
	2	22	....	Do.
	3	16	....	Do.
	4	18	....	Bettles.

Temperatures on Dawson trail at 8 a. m., February to May, 1901—Continued.

Date.	Deg. F.	State of atmosphere.	Locality.
May 5	20	....	Bergman.
6	22	....	Do.
7	24	....	Do.
8	27	....	Do.
9	12	....	Do.

Temperature at morning, noon, and evening at localities between Bergman and Arctic coast.

Date.	a. m.	Noon.	p. m.	Atmosphere.	Locality.
	Deg. F.	*Deg. F.*	*Deg. F.*		
May 1	19	33	26	....	Bergman.
2	14	44	....	....	Do.
9	19	33	26	....	Do.
10	14	44	24	....	Do.
11	14	34	24	....	Do.
12	34	35	25	....	Do.
13	33	36	31	....	Do.
14	35	38	31	....	Do.
15	35	....	36	....	Do.
16	30	....	31	....	Do.
17	31	40	26	....	Do.
18	28	....	38	....	Do.
19	35	39	42	....	Do.
20	43	56	....	....	Do.
21	48	44	40	....	Do.
22	37	45	41	Rain, 0.02 inch; light wind north ..	Do.
23	37	45	38	....	Do.
24	40	45	43	Fair...........................	Do.
25	49	51	46	.....do	Do.
26	44	46	42	.....do	Do.
27	46	52	40	.....do	Do.
28	43	49	43	Rain	Do.
29	50	48	38	Snow for 36 hours................	Do.
30	32	43	33	Snow; precipitation to date, 0.67...	Do.
31	41	42	41	....	Do.
June 1	36	39	....	Rain	Do.
2	42	45	42	....	Do.
3	51	52	51	....	Do.
4	53	57	54	....	Do.
5	58	50	45	Wind southwest, cloudy; rain, 0.03.	Do.
6	38	44	37	Snow............................	Do.

Temperature at morning, noon, and evening at localities between Bergman and Arctic coast—Continued.

Date.	a. m.	Noon.	p. m.	Atmosphere.	Locality.
	Deg. F.	*Deg. F.*	*Deg. F.*		
June 7	35	45	....	Snow	Bergman.
13[a]	55	....	40	Fair	Do.
14	42	....	62	.....do	John River.
15	51	....	55	.....do	Do.
16	60	....	63	Fair, light wind southwest	Do.
17	67	67	52	Rain 6. p. m. to 8 p. m., 0.01	Do.
18	57	....	60	Cloudy	Do.
19	62	68	64	Fair	Do.
20	63	....	64	.....do	Do.
21	61	....	60	Cloudy	Do.
22	56	....	58	Fair	Do.
23	56	....	55	.....do	Do.
24	56	....	49	Fair; rain, 0.09	Do.
25	48	....	48	Rain, 0.26	Do.
26	42	52	52	Rain, 0.20; wind south	Do.
27	48	68	62	Fair	Do.
28	58	71	62	Fair; temperature (water) 52°	Do.
29	51	....	54	Rain, 0.02	Do.
30	58	60	....	Fair	Do.
July 1	56	....	55	.....do	Do.
2	....	....	....	Rain, 0.04	Do.
3	57	....	57	Light snow	Do.
4	50	....	44	Rain, 0.08	Do.
5	50	....	57	Fair, wind northwest	Do.
6	60	....	65	Fair	Do.
7	60	....	54	.....do	Do.
8	64	....	64	.....do	Do.
9	57	....	52	Drizzling rain	Do.
10	50	....	49	.....do	Do.
11	47	....	49	....	Do.
12	53	....	55	....	Do.
14	44	....	42	Rain, 0.20; strong wind north	Do.
15	44	....	51	Fair, light wind north	Do.
16	5	....	....	....	Do.
18	....	....	61	Fair, cloudy, wind south	Do.
19	....	....	63	....	Do.
20	62	....	....	Fair	Do.
21	68	80	70	.....do	Koyukuk-Colville divide.
22	72	74	72	.....do	Do.
23	68	....	60	.....do	Do.

[a] Most of the dates that follow appear on the accompanying maps, Pls. II and III, and designate the localities at or near which the respective observations were made.

Temperature at morning, noon, and evening at localities between Bergman and Arctic coast—Continued.

Date.		a. m.	Noon.	p. m.	Atmosphere.	Locality.
		Deg. F.	*Deg. F.*	*Deg. F.*		
July	24	76	85	80	Light showers	Anaktuvuk River.
	25	68		83	Cloudy	Do.
	26	66		60	Fair	Do.
	27	62		52	Rain, 0.20	Do.
	28	54		50	Rain, 0.17	Do.
	29	34	36	36	Rain, 0.27	Do.
	30	41		50	Rain, 0.05	Do.
	31	44			Fair	Do.
Aug.	1	55		64	do	Do.
	2	62	74	69	Fair, hazy	Do.
	3	44	69	64	Fair, smoky	Do.
	4	52	67	62	do	Do.
	5	54	63	58	Fair	Do.
	6	60	65	60		Do.
	7	60	58	64	Cloudy	Do.
	8	44	52	48	Rain 0.04	Do.
	9	46	50	44	River temperature 52°	Colville River.
	10	43	48	47	Cloudy, drizzling rain; river temperature 50°.	Do.
	11	48	52	42	Cloudy	Do.
	12	43	52	60	do	Do.
	13	48	55	51	do	Colville River delta.
	14	40	45	52	Light showers	Do.
	15	38	42	40	Cloudy, sleet and rain; wind south.	Do.
	16	38	42	42	Fair	Do.
	17	38	40	43		Harrison Bay.
	18	38	38	38	Cloudy, snow	Do.
	19	52	44	42	Fair	Do.
	20	44	46	44		Do.
	21	39	50	52	Fair	Near Cape Halkett.
	22	38	42	40		Pitt Point.
	23	42	42	42		Smith Bay.
	24	42	39	39	Cloudy, wind east	Do.
	25	37	38	36	Cloudy, rainy, strong wind east	Do.
	26	36	36	33	Snow squalls, all day strong wind east	Do.
	27	32	33	32	Snow squalls, strong wind	Do.
	28	32	32	32	Strong wind east	Do.
	29	31	34	32	Cloudy, wind east	Do.
	30	32	32	32		Do.
	31	33	33	32	Cloudy, snow squalls	Do.
Sept.	1	32	32	32	Wind northeast	Do.

Temperature at morning, noon, and evening at localities between Bergman and Arctic coast—Continued.

Date.		a. m.	Noon.	p. m.	Atmosphere.	Locality.
		Deg. F.	*Deg. F.*	*Deg. F.*		
Sept.	2	31	33	35	Snow squalls	Sinclair River.
	3	35	35	35	Clear	Off Dease Inlet.
	4	36	36	36	do	Cape Smyth.
	5	36	36	36	do	Near Refuge Inlet.
	6	37	35	32	do	Do.
	7	34	34	34	do	Do.
	8	35		35	do	Peard Bay.
	9	33		31	do	Off Belcher Point.
	10	30		30	do	Off Wainwright Inlet.
	11	32		33	do	Near Wainwright Inlet.
	12	33		33	do	Do.
	13	32		32	do	Off Icy Cape.
	14	35		38	do	Off Point Lay.
	15	38		38	do	Near Cape Beaufort.
	16	36		36		Do.
	17	31		30		Cape Beaufort.
	18	36				Off Cape Sabine.

The minimum temperatures recorded for the Koyukuk district at Coldfoot are reported to be $-80°$ and even lower, but the instruments on which these records are based are not known. It is hardly to be supposed, however, that it becomes much colder here than at Circle, Dawson, and other points on the Yukon. Though grass and other feed was scarce, a horse is reported to have wintered at large on North Fork of the Koyukuk, on Mascot Creek, in 1902–3, and appeared to be in fair condition in the spring.

ARCTIC PLANTS COLLECTED.

The following plants, collected on the trip mostly by G. H. Hartman, have been identified, with the exception of the grasses, by Frederick V. Coville and W. F. Wight, botanists of the U. S. Department of Agriculture. The grasses were identified by Mr. Elmer D. Merrill. The localities of collections are designated by camp dates, which latter will be found on the topographic and geologic maps (Pls. II and III).

EQUISETACEÆ. (Horsetail family.)

Equisetum arvense L.

At camp, August 12.

POACEÆ. (Grass family.)

Arctagrostis latifolia (R. Br.) Griseb.
Point Barrow, September 4.

Poa arctica R. Br.
At camp, August 12.

Bromus arcticus Shear.
At camp, August 6.

Elymus innovatus Beal.
Cape Smyth, September 5.

MELANTHACEÆ. (Bunch-flower family.)

Zygadenus elegans Pursh.
At camp, August 5.

SALICACEÆ. (Willow family.)

Salix.
Cape Smyth, September 5.

Salix.
Point Barrow, September 4.

Salix.
At camp, August 12.

Salix.
At camp, August 5.

Salix.
At camp, John River, altitude 1,800 feet, June 20–21.

Salix alaxensis (Anders.) Coville.
John River, June 24; John River Valley flats, July 8; at camp, John River, July 10; at camp, August 5; at camp, August 6; at camp, August 12.

Salix arbusculoides Anders.
At camp, John River, June 28; John River, 1,000 feet above valley, July 8; at camp, John River, July 10; at camp, August 6.

Salix glauca L.
John River, 1,000 feet above valley, July 8; at camp, Arctic slope, July 21; at camp, August 6; at camp, August 12.

Salix niphoclada Rydb. (apparently).
At camp, John River, July 10; at camp, Anaktuvuk River, August 5.

Salix ovalifolia Trautv.
At camp, Colville delta, August 14.

Salix pulchra Cham.
John River, June 24; John River, 1,000 feet above valley, July 8.

Salix richardsoni Hook.
At camp, East Fork of John River, July 16–17.

BETULACEÆ. (Birch family.)

Betula.
At camp, Arctic slope, July 21.

POLYGONACEÆ. (Smartweed family.)

Polygonum plumosum Small.
At camp, July 21; at camp, August 12.

Polygonum viviparum L.
At camp, August 12.

SILENACEÆ. (Pink family.)

Alsine longipes (Goldie) Colville.
At camp, Colville delta, August 14.

Arenaria laricifolia L.
At camp, John River, July 10.

Ammodenia.
Cape Smyth, September 5.

RANUNCULACEÆ. (Buttercup family.)

Anemone.
At camp, Arctic slope, July 21.

Anemone.
Low ground near John River, June 15.

Anemone richardsoni Hook.
Low ground near John River, June 15.

PAPAVERACEÆ. (Poppy family.)

Papaver radicatum Rottb.
At camp, August 12.

BRASSICACEÆ. (Mustard family.)

Cochlearia.
Cape Smyth, September 5.

Eutrema edwardsii R. Br.
At camp, Colville delta, August 14.

SAXIFRAGACEÆ. (Saxifrage family.)

Saxifraga hirculus L.
At camp, Colville delta, August 14.

Saxifraga oppositifolia L.
At camp, John River, June 26 and 28.

Saxifraga tricuspidata Retz.
At camp, John River, July 10.

Parnassia palustris L.
At camp, Anaktuvuk River, August 5.

ROSACEÆ. (Rose family.)

Potentilla fruticosa L.
At camp, John River, July 10.

Potentilla villosa Pall.
At camp, John River, July 10.

Dryas integrifolia Vahl.
At camp, John River, June 26.

FABACEÆ. (Bean family.)

Lupinus.
At camp, John River, June 28.
Astragalus.
At camp, August 6.
Astragalus.
John River, June 28.
Astragalus.
At camp, John River, June 28.
Astragalus alpinus L.
At camp, August 6.
Aragallus.
At camp, John River, June 28.
Aragallus.
At camp, July 21.
Aragallus.
John River, June 28.

ELÆAGNACEÆ. (Oleaster family.)

Lepargyrea canadensis (L.) Greene.
At camp, John River, June 28.

ONAGRACEÆ. (Evening primrose family.)

Chamaenerion latifolium (L.) Sweet.
At camp, August 5.

APIACEÆ. (Celery family.)

Bupleurum americanum Coult. and Rose.
At camp, August 6.

PYROLACEÆ. (Wintergreen family.)

Pyrola rotundifolia L.
At camp, John River, June 28.

ERICACEÆ. (Heather family.)

Ledum decumbens (Ait.) Lodd.
At camp, Arctic drainage, July 21.
Rhododendron lapponicum (L.) Wahl.
At camp, John River, June 28.
Cassiope tetragona (L.) D. Don.
At camp, John River, altitude 1,800 feet, on north slope, June 20.
Andromeda polifolia L.
At camp, John River, altitude 1,800 feet, on north slope, June 20.
Arctous alpina (L.) Niedenzu.
At camp, August 12.

PRIMULACEÆ. (Primrose family.)

Androsace.
At camp, John River, June 28.
Androsace.
At camp, John River, July 10.
Dodecatheon frigidum Cham. & Schlecht. Shooting star.

SCROPHULARIACEÆ. (Figwort family.)

Pedicularis.
At camp, July 21.
Pedicularis verticillata L.
At camp, Anaktuvuk River, August 5.

CICHORIACEÆ. (Chicory family.)

Taraxacum.
At camp, Colville delta, August 14.
Crepis nana Richards.
At camp, August 6.

ASTERACEÆ. (Aster family.)

Solidago multiradiata Ait.
At camp, Anaktuvuk River, August 5.
Aster.
At camp, Anaktuvuk River, August 5.
Aster sibiricus L.
At camp, August 12.
Erigeron.
At camp, John River, July 10.
Tanacetum.
At camp, August 12.
Artemisia.
At camp, John River, July 10.
Artemisia norvegica Fries.
At camp, August 6.
Artemisia tilesii Ledeb.
At camp, August 12.
Petasites.
At camp, August 12.
Arnica.
At camp, John River, July 12.
Arnica.
At camp, August 12.
Arnica.
At camp, Arctic slope, July 21.
Arnica lessingii (Torr. and Gr.) Greene.
At camp, Anaktuvuk River, August 5.
Senecio.
Point Barrow, September 4.
Senecio lugens Richards.
At camp, August 6.

INDEX.

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[Professional Paper No. 20.]

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Correspondence should be addressed to

THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
WASHINGTON, D. C.

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O