Please do not destroy or throw away this publication. If you have no further use for it, write to the Geological Survey at Washington and ask for a frank to return it

DEPARTMENT OF THE INTERIOR
Roy O. West, Secretary

U. S. GEOLOGICAL SURVEY
George Otis Smith, Director

Bulletin 797—B

THE SKWENTNA REGION, ALASKA

BY

STEPHEN R. CAPPS

Mineral resources of Alaska, 1926—B

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON
1929

Please do not destroy or throw away this publication. If you have no further use for it, write to the Geological Survey at Washington and ask for a frank to return it

DEPARTMENT OF THE INTERIOR
Roy O. West, Secretary

U. S. GEOLOGICAL SURVEY
George Otis Smith, Director

Bulletin 797—B

THE SKWENTNA REGION, ALASKA

BY

STEPHEN R. CAPPS

Mineral resources of Alaska, 1926—B

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON
1929

CONTENTS

ILLUSTRATIONS

THE SKWENTNA REGION

By Stephen R. Capps

INTRODUCTION

The region discussed in this report lies for the most part in the basin of Skwentna River, which with the Yentna drains a great area along the southeast face of the Alaska Range. The Yentna joins Susitna River some 25 miles above the junction of the Susitna with Cook Inlet. About 40 miles above its mouth the Yentna is joined by the Skwentna, which enters from the west and which probably discharges more water than the Yentna above their junction. As the lower Yentna and the Skwentna, as far up as Portage Creek, had been traversed in former years by members of the Geological Survey, the area of primary interest in the present investigation included the headward portions of the Skwentna Basin, above Portage Creek, and adjacent portions of the Alaska Range on the Kuskokwim side of the divide. This area has been little visited by white men and is a part of an unexplored region of many thousand square miles that drains in part to the Skwentna, in part to Lake Clark and Bristol Bay, and in part to the Kuskokwim by way of South Fork of Kuskowim River and Stony River. It is planned to continue the geologic and topographic mapping of this unknown region as funds and personnel permit. The region studied in the present investigation occupies a narrow belt extending up Skwentna River from its mouth to Portage Creek and includes the basin of Portage Creek and the entire basin of the Skwentna above Portage Creek, as well as a small area on the Kuskokwim slope of the range, in the basin of South Fork of Kuskokwim River. It does not include the basins of the tributaries of the Skwentna below Portage Creek. The area shown on the accompanying geologic map lies between 61° 14′ and 62° 25′ north latitude and 50° 20′ and 53° 33′ west longtitude.

PREVIOUS SURVEYS

Until 1898 the great region lying between Susitna River and the lower Kuskokwim was virtually unexplored. Possibly a few white prospectors had penetrated into parts of it, but they had left no written record of their travels, and the crude sketches and vague reports obtained from natives were conflicting and unreliable. The Alaska Commercial Co. had established a trading fort at Susitna Station, on Susitna River some 2 miles below the mouth of Yentna River, but its trade was mainly with natives, and little or no attempt had been made by white men to penetrate into the upper reaches of the Yentna Basin.

The discovery of gold in the Klondike and the resulting stampede in 1897 and 1898 aroused public interest in Alaska, and in 1898 a number of expeditions, under the direction of the United States Geological Survey, were dispatched to Alaska to carry on explorations. One of these parties, in charge of J. E. Spurr and W. S. Post, went up Susitna, Yentna, and Skwentna Rivers by canoe as far as Portage Creek, portaged across a high pass to the Kuskokwim Basin, and descended the Kuskokwim to its mouth. This expedition, though carrying only a single-line traverse across the region, acquired a large amount of information concerning the geography and geology of a wide territory on each side of the route of travel, and the published report and maps[1] furnished the first authentic description of a great area that up to that time had been entirely unknown.

The next expedition to enter this region was carried out in 1899 by Lieut. Joseph S. Herron, of the Army. The party, equipped with pack horses, proceeded by boat up the Yentna and some distance up the Kichatna, from which they traveled overland up the Kichatna to cross the range at Simpson Pass. No accurate surveys were made, but Herron's sketch map[2] added considerably to the knowledge of the area he traversed.

A third expedition, to which must be credited a large part of even our present-day knowledge of the Alaska Range, was that of the Geological Survey in 1902, headed by Alfred H. Brooks. This party, including D. L. Reaburn as topographer and L. M. Prindle as assistant geologist, landed with pack horses and supplies at Tyonek, on Cook Inlet, proceeded overland to Skwentna River at the mouth of Canyon Creek, crossed that river and ascended the Kichatna to its head, discovered a new pass (called by them Rainy Pass) through which they crossed the summit of the range, and thence proceeded northward along the face of the range to Nenana River. The traverse of this expedition ended that fall at Rampart, on the Yukon. Its

[1] Spurr, J. E., A reconnaissance in southwestern Alaska in 1898: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 31–264, 1900.

[2] Herron, J. S., Explorations in Alaska in 1899, for an all-American route from Cook Inlet, Pacific Ocean, to the Yukon: War Dept., Adjt. General's Office, No. 31, pp. 1–77, with maps, 1901.

results were later published in a monumental report on the Mount McKinley region,[3] which for the first time gave precise information about the Alaska Range between Skwentna and Nenana Rivers.

In 1903 an expedition of a different sort, organized for the purpose of climbing Mount McKinley, traversed the region here under discussion. This party, in charge of Dr. Frederick A. Cook, landed with pack horses at Tyonek and followed the route traversed the preceding year by the Brooks party. No accurate surveys were conducted by this expedition, and in the region here considered no important additions to our knowledge of the geography were made.

In 1906 Cook made a second attempt to scale Mount McKinley, this time from the southeast side. He was again unsuccessful in attaining his objective, but to his party was attached a topographer, R. W. Porter, who made a creditable topographic map of a considerable area in the basins of Yentna and Tokochitna Rivers.

A Geological Survey party, in charge of S. R. Capps,[4] worked in the Yentna region in 1911, mapping the geology and making some additions and corrections to Porter's topographic map. That same year the Alaska Road Commission began the work of opening a winter trail from Susitna River to the mining camps at Innoko and Iditarod by way of Skwentna River and Rainy Pass. This trail was later completed, road houses were established along it at intervals of about 20 miles, and it was the common route of winter travel between the coast and lower Yukon and Kuskokwim points for many years, being abandoned only in 1924 with the opening of a new trail that leaves the Alaska Railroad at Kobe and reaches the Iditarod by way of the Kantishna mining district. Travel over the trail from Susitna Station through Rainy Pass was confined almost exclusively to winter by dog sled, as the marshy nature of the route and the large rivers to be crossed made it impracticable in summer, especially as summer travel by way of Yukon River and its tributaries was much quicker and easier.

Although the establishment of a winter route up Skwentna River and across Rainy Pass caused many people to traverse this region, nevertheless it resulted in very little exploration of the area away from the trail. The heavy snows and strong winds that prevail there in winter made the country unattractive to winter prospectors, and in summer it was shunned because of the difficulties of transportation and travel during the period when rivers, lakes, and marshes were unfrozen. Except for trail surveys by the Alaska Road Commission along the actual route followed, no systematic surveys were

---

[3] Brooks, A. H., The Mount McKinley region, Alaska: U. S. Geol. Survey Prof. Paper 70, 234 pp., 1911.

[4] Capps, S. R., The Yentna district, Alaska: U. S. Geol. Survey Bull. 534, 75 pp., 1913.

carried out in or south of the Skwentna Basin between the time of the Brooks expedition in 1902 and the work with which this report deals.

PRESENT INVESTIGATION

One of the largest unexplored areas in Alaska is included in the region that lies between the east-west portion of the Skwentna on the north and Lake Clark on the south, and between the west front of the Alaska Range and Cook Inlet. This region is entirely occupied by rugged, glaciated mountains except for a narrow strip of low, marshy land between Cook Inlet and the mountains. It is difficult of access, and not only have no systematic surveys been carried on in it, but it has also been largely avoided even by prospectors and trappers.

Plans have been under consideration for many years by the Geological Survey to carry out topographic and geologic surveys in this area, but other more pressing demands for surveys have interfered, and more recently funds have not been available. In 1926, however, an opportunity was offered by Mr. William N. Beach, of New York, a sportsman and photographer of game, to cooperate with him in a joint expedition into the headwaters of Skwentna River and adjacent portions of the Kuskokwim Basin. Mr. Beach provided a pack train of 17 horses and supplied additional equipment and services, his total contribution being about half the cost of the expedition. The survey party assembled at Anchorage early in June and included S. R. Capps, geologist, as chief of party; K. W. Trimble, topographic engineer; William T. Mulkey, recorder; Seward Old and Alfred H. Norman, packers; and Thomas R. Farrell, cook. Actual field work was to begin at Skwenta River, but in order to get the pack train and necessary provisions and equipment to the field of work it was necessary to send the horses and pack equipment, with four men, to Beluga by barge, thence to proceed overland to Skwentna River at Canyon Creek. Mr. Trimble was in charge of this branch of the expedition. The writer, with Mr. Mulkey and Jack Lean, one of Mr. Beach's guides, proceeded by launch to Susitna Station with most of the provisions and with a light boat and outboard motor in tow. At Susitna Station a part of the provisions were stored, and the launch took the party up the Yentna to the mouth of the Skwentna and some 7 miles up that stream to the head of launch navigation. From that point the provisions were relayed by boat up the Skwentna to Happy River. The river during this work was in flood stage, and the current had a velocity of 5 to 8 miles an hour. When the current was moderate progress could be made by the use of the outboard motor, but in swift stretches or in shallow water it was necessary to resort to lining. The average rate of travel upstream with a load was 6 to 7 miles a day. As a result of unexpected difficulty in taking loads up this river, the services of Jack Rimmer, a capable boatman, were procured at Skwentna Crossing, and he continued with the boat party to Happy River. A few miles above the mouth of Canyon Creek the pack team was met, and there the horses were swum across to the north side of the Skwentna, and the pack gear, equipment, and provisions were ferried over. From that point the pack train followed the route of the winter trail westward, while the boat party continued up the river, to join the pack train at Happy River.

At Happy River Lean and Rimmer returned downstream, and the combined geologic and topographic parties proceeded to the head of Skwentna River. Arrangements had been made to meet Mr. Beach at the mouth of Portage Creek on August 18, and upon his arrival by boat, accompanied by Andy Simonds and Jack Lean, guides, he joined the pack train, bringing with him the provisions previously left at Susitna Station. The entire party then spent a little more than two weeks on the Kuskokwim side of the range, in Ptarmigan Valley and the basin of Styx River. Upon completion of the field season, the pack train returned to Beluga, and Mr. Beach, the two guides, and the writer returned by small boat from Portage Creek to Anchorage.

As a result of the season's work, an area of about 1,200 miles was mapped geologically and topographically on a scale of 1:180,000. Of this area about 300 square miles was a resurvey of the area previously mapped by Spurr and Post, and 900 square miles, mostly in the headwaters of Skwentna River, was country that had been entirely unexplored.

The thin sections of the rocks collected during this expedition were studied in the office by J. B. Mertie, jr., and he is responsible for their identification.

GEOGRAPHY

The area here under discussion includes parts of two distinct geographic provinces. The basin of the South Fork of Kuskokwim River and the Skwentna Basin as far eastward as the mouth of Hayes River lie within the rugged mountains of the Alaska Range. The highest peaks along the ridge, which includes Mount Spurr, rise well above 11,000 feet and nourish glaciers many miles in length. West of the Skwentna the summit peaks have altitudes between 6,000 and 7,000 feet, and such few glaciers as are found among them are small. This portion of the Alaska Range, however, is all of rugged topography, the peaks rising steeply to sharp, narrow crests, 3,000 to 4,000 feet above the streams, which flow in flat-floored, steepsided valleys. All the larger streams are glacier-fed and are muddy during the summer season of glacial melting.

Below Hayes River the Skwentna emerges from the mountain province into the great lowland basin of Susitna River. At the mouth of Hayes River, a distance of about 100 miles by river from the ocean, the altitude of the Skwentna is 375 feet. Above that point the river has a much steeper grade, ranging from 18 to 30 feet to the mile. The Susitna lowland has a rolling surface, ranging in altitude from sea level to 500 or 600 feet at its margin in this region, and is broken by a few isolated mountains and ridges, which include the ridges of the Susitna and Beluga Mountains and Shell Hills. The surface deposits are mainly of glacial origin and include both glacial till and stratified outwash gravel. Into these materials the rivers have intrenched themselves, the Skwentna having cut its valley 25 to 100 feet or more below the general level of the lowland surface.

DRAINAGE

With the exception of a small area tributary to the South Fork of Kuskokwim River, on the west slope of the Alaska Range, the entire area here described lies in the basin of Skwentna River. Skwentna River is a tributary of the Yentna, which joins Susitna River some 30 miles above the mouth of that stream. The Skwentna is a typical glacial river, much of its waters originating in the melting glaciers of the Alaska Range. Like all streams that are mainly supplied by glacial waters, its volume is largely determined by the rate of melting of the glaciers. The high-water period occurs usually in June and July, when the days are long and warm and when some of the preceding winter's snow still remains in the mountains. As cold weather approaches in the fall, the volume of water diminishes rapidly, and with the decrease of glacial melting the streams become less heavily charged with débris. In the winter stream discharge is at a minimum and the waters run clear.

The problem of transporting supplies up the Skwentna during the summer is a serious one, for the current runs from 5 to 8 miles or more an hour, and the tendency of the heavily loaded stream to split up into many branches makes it difficult to find a continuous channel of sufficient depth for a boat drawing even a foot or two of water. Power launches drawing about 3 feet of water can be counted upon to ascend only a distance of 6 or 7 miles above the mouth of the stream even in periods of high water. Above that point loads have usually been taken only in poling boats, or by towing light boats from the banks and bars. In the expedition of 1926 a poling boat with a capacity of about a ton, equipped with a 6-horsepower outboard motor, was employed. Although the current was so swift or the water so shallow throughout much of the river that progress with a loaded boat by motor only was impossible, nevertheless there were many stretches where the motor could be used, and it was invaluable in making crossings from one bar to another and in ascending through the canyons or along brushy banks when towing or poling were especially difficult.

From its mouth to a point some 13 miles upstream, at Skwentna Crossing, the river flows over a wide gravel flat in many branching channels. Just above Skwentna Crossing is a canyon some 2 miles long, cut into hard rock, with steep bluffs on each side. Above this the river again widens out and is spread over a broad flat of alternating channels and sand bars. Great quantities of driftwood have accumulated on these bars, and snags and log jams add to the difficulties and dangers of boating. This flat extends upstream to a point about 8 miles above the mouth of Hayes River. From Hayes River to the mouth of the second canyon the Skwentna is for the most part so broken up into numerous shallow channels and the current is so swift that a motor is of little use, and lining must be resorted to.

In the second canyon, which has a length of about 4 miles, the river is swift but is well confined to a single channel, and much of this stretch can be run in a power boat. Above the second canyon the current is in general swifter than below, and although certain stretches can be run with a motor, an increasing proportion of towing must be done. The third canyon, some 16 miles above Happy River, is short but can be traversed by motor. Above this canyon there is little water in which a motor is of use, and the rapid current and coarse boulders render progress upstream increasingly difficult. The highest stretch of river which members of this expedition traveled by boat, that between Happy River and Portage Creek, was considered to be the most difficult portion of all. It is possible that a lightly loaded boat could be towed much farther upstream than the mouth of Portage Creek, but the work would be arduous and the progress slow.

The only large tributaries entering the Skwentna from the south between its mouth and Portage Creek are Talushulitna River, Canyon Creek, and Hayes River. Hayes River is a glacial stream; the others carry little glacial drainage. From the north and west the only notable tributaries are Happy River and Portage Creek. Both are almost clear, though each has some small glaciers in its basin.

Above Portage Creek the Skwentna has a general northward course. It is joined from both east and west by many tributary streams, some of which are sufficiently large to be difficult to ford on foot. At least four of these tributaries are glacial streams, three entering from the east and one from the west. Skwentna River itself heads in the Twin Glaciers, two large glaciers that lie in adjacent valleys and flow westward to the edge of the main north-south trough in which the Skwentna flows. This trough continues southward beyond Twin Glaciers, where a low divide separates the Skwentna drainage from that of another river which flows south-southeast and which also is fed by large glaciers. This river flows through an unexplored and unsurveyed area, and further than the fact that its valley could be seen to extend to the southeast for some 15 miles, its course is unknown.

A small area within the drainage basin of the Kuskokwim was surveyed by the expedition of 1926. That area includes the north end of Ptarmigan Valley and the lower valley of Styx River. Both of these valleys drain to the South Fork of Kuskokwim River. In preglacial time both, as well as the upper valley of the South Fork, were tributary to the Skwentna by way of Ptarmigan Valley and Happy River, but through the influence of the glacial ice a sharp canyon was cut by a glacial river across what was then the main divide of the Alaska Range, and the South Fork captured the drainage of a large area that had formerly belonged in the Susitna Basin.

CLIMATE AND VEGETATION

The climate of this region is in general like that of the Susitna Basin, though at any particular place it is strongly influenced by the local topography. In this part of Alaska the temperature and the rainfall vary so greatly from year to year that it is difficult to generalize, particularly as no reliable weather records are available for the region here under discussion. The winter of 1925–26 was unprecedentedly mild throughout Alaska, and the spring was early. The summer of 1926 was unusually warm and clear. From June 10, when the expedition took the field, until August 12, there was little rain, and most of the time the weather was clear and even the mounain peaks were free from clouds. From the middle of August until late September the sky was cloudy about half of the time, and there was considerable rain. It is said that during most summers this region has a large proportion of cloudy and rainy days.

The winters are said to be severe in the upper Skwentna Basin, and strong winds prevail, particularly near the mountain passes. It is reported to be difficult to keep trails open, as the snowfall is moderately heavy, and the snow drifts with the heavy winds.

The Susitna lowland bordering the lower Skwentna and the valley of Skwentna River are generally covered with a fair stand of timber up to an altitude of about 2,000 feet, with scattered trees up to 2,400 feet. The most prevalent tree is the spruce, which in favorable places reaches a diameter of 2 feet. Few clear logs of merchantable size are obtainable, and the timber has value only for local uses, or possibly for pulp. Of recent years the spruce in this region has been seriously attacked by a bark beetle, and over a large area perhaps half of the trees have been killed. Most of these dead trees are still standing, but within another year or two their roots will decay and they will begin to fall and thereby will add greatly to the difficulty of travel. Birch is abundant also on well-drained slopes, and cottonwood trees reaching a diameter of 3 feet or more grow on the stream bars. Figure 1 shows the areas in this district in which timber occurs.

Throughout the Susitna lowland alder brush grows among the timber and is especially abundant near and for some distance above timber line, necessitating much trail chopping for the passage of pack horses. Several varieties of willow brush also occur, and willows large enough to supply tent poles and camp fuel are usually found some distance up into the valley heads beyond the last trees. Within the timbered areas the underbrush includes high-bush cranberry, mountain ash, and a number of other shrubs.

Forage for horses is generally abundant throughout the summer and may be found at almost any place where fuel can be had for the camp fire. Below timber line the principal plants on which horses graze are redtop grass, which almost everywhere grows in profusion, bunch grass, and a vetch commonly known as "pea vine." Above timber line bunch grass can often be found. Horses are also particularly fond of the leaves and tender shoots of a certain variety of tree willow that is of widespread occurrence. The redtop grass is, however, much the most important forage plant, and it unfortunately loses its nutritive qualities as soon as it is heavily frosted in the fall. After heavy frosts, therefore, it is necessary to feed horses hay and grain to keep them in condition for work.

Blueberries grow profusely above timber line and form a welcome addition to the camp diet during August and September. An edible small flat-growing cranberry is locally abundant, and in places currants and raspberries may be found.

Practically no agriculture has been attempted in this region, but there can be little question that there are considerable areas along the Skwentna below Hayes River and in the lowland between Skwentna and Susitna Rivers that have the same agricultural possibilities as are present throughout the Susitna lowland. It is probable, however, that any attempts to develop farms in this difficultly accessible region will be delayed until areas nearer the railroad are taken up. The only tests that have been made of the possibilities

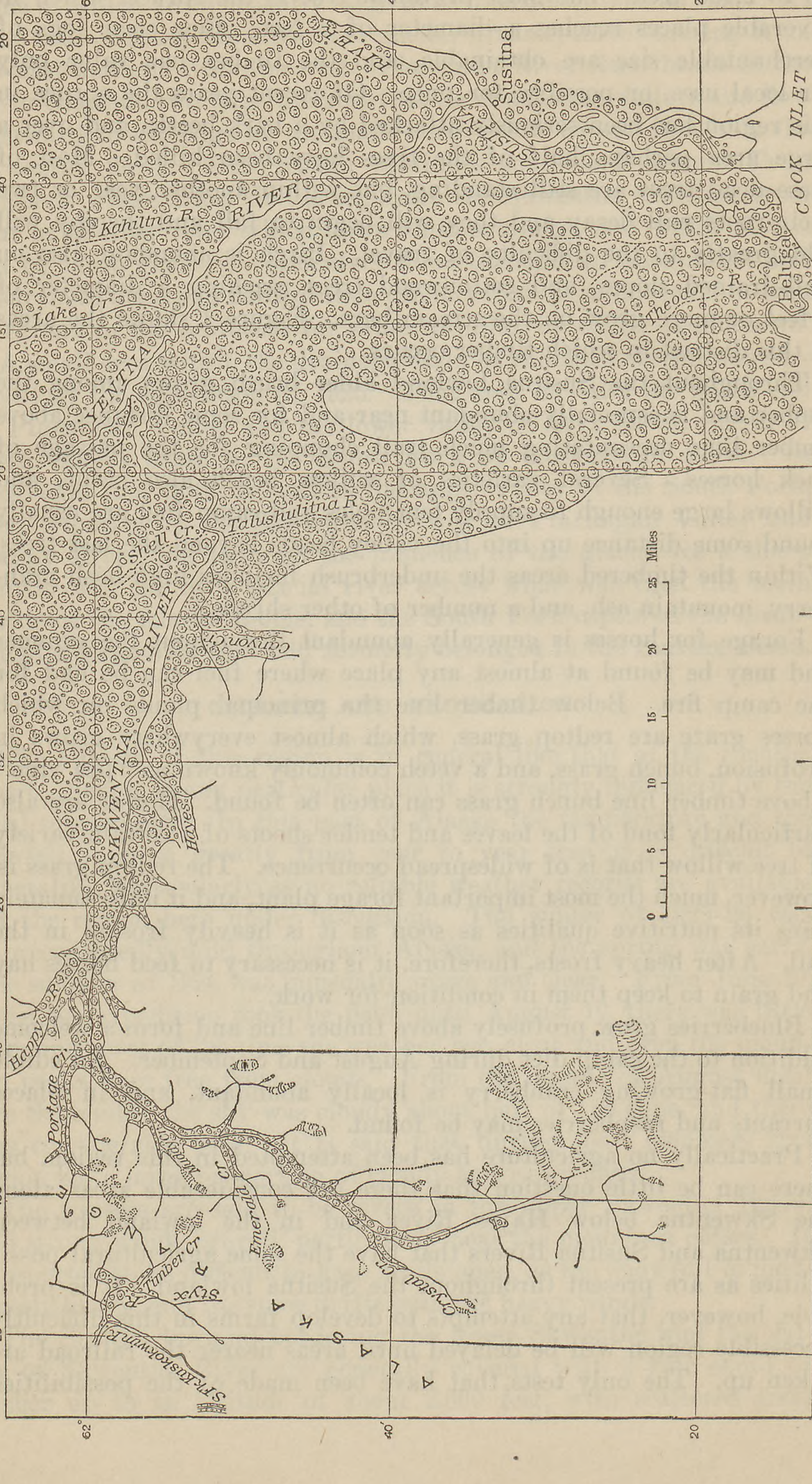


FIGURE 1.—Distribution of timber in the Skwentna region

of agriculture in this region are some small gardens that have been planted at the roadhouses along the now abandoned winter trail from Susitna Station to the Kuskokwim. At the old roadhouse at Skwentna Crossing, now occupied by trappers, a small garden is cultivated each year, and uniform success is reported in the raising of potatoes and other root vegetables and the common quick-maturing garden plants. Similar gardens that were planted some years ago as far up the Skwentna as Happy River are said to have done well. It is likely, however, that attempts to harvest hay or grain crops in this region would often meet with difficulty through rainy weather during the harvest season, an experience common in this part of Alaska.

GAME

The upper valley of Skwentna River is so little visited by men, either white or native, that its animal life is almost undisturbed. Both black and grizzly bears are plentiful, perhaps a hundred having been seen during the summer by members of the Geological Survey party. Caribou are numerous, especially in the timberless upper portion of the basin, though no large herds were seen. Moose are numerous in the timbered areas, and their trails add greatly to the ease of travel through timber and brush. Some mountain sheep range on the high, rugged ridges, but they are less plentiful in the Skwentna Basin than on the Kuskokwim slope of the range.

As a result of restrictions on trapping in recent years, beaver were exceptionally abundant, especially in the Susitna-Skwentna lowlands, and they are seen even in the high mountains, several miles from timber. Mink and a few land otter are taken along the lower stretches of the Skwentna, and lynx, fox, and wolverines are found, especially in the mountainous areas. Marten are said to be rare in this region. Small game includes rabbits and ptarmigan, which vary greatly in numbers from year to year. In 1926 neither rabbits nor ptarmigan were abundant.

Most of the streams are heavily charged with glacial silt and contain few fish. Salmon in considerable numbers run up the Skwentna as far as the Talushulitna and a few as far as Portage Creek. Such clear streams as there are contain Dolly Varden and rainbow trout and some grayling, but as a whole the region is poorly supplied with game fish.

POPULATION

The area chiefly concerned in this report—that is, the upper basins of the Skwentna and of the South Fork of Kuskokwim River—is entirely unpopulated. Between 1911 and 1924 there was considerable winter travel by dog trail between Cook Inlet and the mining camps at Iditarod and Innoko, and roadhouses were maintained at intervals of about 20 miles along this route, but with the establishment of a new winter trail to the lower Yukon and Kuskokwim region from Kobe, on the Alaska Railroad, the Skwentna-Rainy Pass route became little used, and the roadhouses were abandoned. In 1926 the only permanent residents in this entire region were three trappers who occupied the old roadhouse at Skwentna Crossing, some 13 miles above the mouth of the Skwentna.

The nearest permanent settlement of any size is Susitna Station, on Susitna River some 2 miles below the mouth of the Yentna, where 30 or 40 natives and a few whites reside. Occasionally a native family makes a hunting trip up the Skwentna, going up on foot and later descending the river in rough boats covered with the skins of animals killed during the hunt. Even such temporary visits by hunters have been rare of recent years, and in 1926 the members of the Geological Survey party were the only persons in the region west of Skwentna Crossing. The meager evidence of the presence of men indicates that for many years few natives and no white men have visited the Skwentna Valley above Portage Creek.

ROUTES OF TRAVEL

The old winter dog trail from the Alaska Railroad at Nancy to the Kuskokwim by way of Rainy Pass is still open and may be used during the winter to points on the Skwentna as far west as the mouth of Happy River. This trail, however, is now rarely used and offers no accommodations to travelers. Anyone now using it would be forced to break his own trail the entire way. In summer power boats of light draft can ascend Susitna, Yentna, and Skwentna Rivers to a point some 7 miles above the mouth of the Skwentna. Above that point the swift current and numerous riffles render much of the river unnavigable, even for light boats equipped with outboard motors, and poling and lining must be resorted to. Although it is possible to take light loads as far upstream as Portage Creek and possibly farther by this means, the work is arduous, progress is slow, and the attempt should not be made except by men experienced in this kind of work, for there is constant danger of swamping in the rushing water.

In summer the winter trail from Susitna Station to the Skwentna at Skwentna Crossing is said to be too swampy for travel by loaded pack horses. The Geological Survey expedition landed its horses at a point 2 miles above the mouth of Beluga River, on the west side of Cook Inlet, and with light loads proceeded northward around the head of Talushulitna River, reaching the Skwentna some 4 miles above the mouth of Canyon Creek. Parts of this route are brushy and require considerable trail chopping, and other stretches are difficult as the result of swamps and lakes caused by beaver dams. About 10 days should be allowed for traversing the 70 miles from Beluga to the Skwentna.

Having arrived at the Skwentna, it is necessary to cross that river, which is there too deep to ford. In summer stages of water there are likely to be two or more channels each at least 100 yards wide, and it would be hazardous to have the horses swim with their loads. It is therefore necessary to have a boat at the crossing to transfer the equipment and members of the party. From the north side of the river the winter trail can be followed westward by pack horses, though in places the ground is boggy.

Some 4 miles west of Happy River travelers into the upper Skwentna Basin leave all marked trails behind, but except for some brushy areas, where cutting must be done, pack horses can be taken almost anywhere without unusual difficulty. Frequent and well-traveled game trails are of great assistance and with a moderate amount of cutting can be developed into good trails for horses.

GEOLOGY

PRINCIPAL FEATURES

The areal distribution of the rock formations that have been differentiated in this region is shown on Plate 1. These formations have been studied only in a reconnaissance manner, during a short summer field season in which a large area was visited, so that it has been possible to outline the rock units only approximately. Furthermore, the topographic map used as a base for plotting the geology was in preparation at the same time that the geologic mapping was in progress and was not available in completed form until after the field season was over. As a consequence, the geologic boundaries as determined in the field were recorded on sketch maps and notebook plats and had to be adjusted to the final topographic map in the office, with a resulting loss of accuracy. On the whole, however, it is believed that the geologic boundaries are sufficiently accurate to show the main features of distribution of the several formations.

Only five assemblages of rocks are here mapped, two of which are of Quaternary age. A third consists of isolated patches of coal-bearing Tertiary (Eocene) beds. The remaining rocks are subdivided into two groups, one of which is dominantly igneous. Even this distinction, however, can not be relied upon consistently, for the sedimentary group contains much tuffaceous material of volcanic origin and is locally so intimately cut by dikes and sills that it is difficult to tell whether sediments or igneous rocks predominate. Likewise the igneous rocks, which are mainly of granitic habit, contain in places so much included sedimentary material that they might well be classified with the sediments. The boundaries shown on the map therefore show the writer's judgment as to which class of material predominates in any particular area.

A brief word of caution may well be given in regard to the series of sediments that is here grouped as a unit and that composes most of the mountains in this region. Up to the present time it has been found impossible to subdivide this group of rocks properly, although it comprises a thick series of volcanic tuff, shale and argillite, graywacke, and some conglomerate. Unquestionably the time will come when this series will be broken up into a number of separate formations. The rocks, however, are almost devoid of fossils and are of somewhat complex structure, being both folded and faulted. It is believed that the upper part of the series is of Cretaceous age. The lower part may be Cretaceous also, but it may possibly be much older. Until opportunity offers for detailed work in this region it has seemed best not to attempt to subdivide this series.

The igneous rocks that occupy so large a proportion of the upper Skwentna Valley are for the most part granite, though minor amounts of andesite porphyry, diabase, augitite, basalt, and basalt porphyry are also present. All these rocks cut the sedimentary series and are consequently younger. They are probably of Upper Cretaceous age. In general, also, it may be said that the basic rocks, which occur as relatively small bodies, are younger than the granite.

Structurally, the pre-Pleistocene rocks of this region are all more or less folded and faulted. The folding of the coal-bearing Tertiary materials is simple and of only moderate intensity. It is probable also that the faults which cut these beds are as a rule of small displacement. The deformation of the pre-Tertiary sediments, however, is much more severe and locally is intense, varying from great open folds to intricate crumpling. Along the main axis of the range, in the basins of Ptarmigan Creek and Styx River, the general strike of the folding is north-northeast. In the middle and lower portions of Skwentna Valley, however, the strike is from east-northeast to east, though there are locally wide variations from the prevailing structural trend. The closest crumpling was noted near the margins of large masses of granite and may well be the direct result of the intrusion. It is believed that the major portion of the deformation these rocks have suffered took place before the Tertiary coal beds were laid down and before the main uplift of the present Alaska Range.

The following table gives what is now known of the stratigraphic sequence for the region here described:

Quaternary:

Gravel, sand, and silt of the present streams; talus accumulations; peat and impure organic deposits and muck; soils and rock disintegration products in place; volcanic ash; deposits of existing glaciers.

Terrace and bench gravel, some of glaciofluvial origin.

Glacial deposits of Pleistocene glaciers.

Unconformity.

Tertiary (Eocene):

Coal-bearing beds, generally light-colored soft sandstone, clay, and gravel, little indurated, locally containing lignitic coal.

Pronounced unconformity.

Mesozoic:

Diabasic and basaltic intrusive rocks, as stocks, dikes, and sills.

Extensive granitic intrusive rocks.

Argillite, shale, and graywacke, all containing more or less tuffaceous material; bedded tuff, of coarse to fine texture, with varying amounts of water-laid sediments; minor amounts of conglomerate and calcareous shale.

The geologic history of this part of Alaska can be only outlined, and many pages are missing from the record. In this region no rocks that are certainly older than Mesozoic have been recognized, though investigations of areas to the north and west show the presence there of Paleozoic rocks of Ordovician and Devonian age. Furthermore, a widespread formation in the Alaska Range farther north and east, the Cantwell formation, of early Tertiary or possibly Upper Cretaceous age, has not been seen in the Skwentna Basin. The oldest rocks recognized here include the series of argillite, shale, graywacke, and tuff, a part of which has been determined to be not older than Upper Cretaceous. Below this portion of the series lies a great thickness of argillite and graywacke, with much interbedded tuffaceous material, probably mainly of Mesozoic age, and above it is a tuffaceous member that may also be Upper Cretaceous. After the deposition of the slate-graywacke-tuff series, at the end of Mesozoic time or the beginning of Tertiary time, there was widespread volcanism in this region, during which great masses of granitic rocks were injected into the sediments. These intrusions took place far beneath the surface. In places the igneous material may have broken out upon the surface as lava flows, but so far no flows of this age have been recognized. Still later dikes and sills of basic rocks cut both sediments and granite, but these intrusions were small in volume as compared with the earlier granite.

Above the series of argillite, shale, graywacke, and tuff is a pronounced structural unconformity, probably representing a time interval during which the Cantwell formation was deposited elsewhere, as well as the erosion interval that followed the deposition of the Cantwell beds. The next younger strata appearing in the Skwentna region are the coal-bearing Tertiary rocks, which have been assigned to the Eocene and correlated with the Kenai formation of Kenai Peninsula. These beds were laid down as fluviatile or estuarine deposits, and during their deposition there were recurring periods during which organic materials, now converted to lignite, accumulated in basins when little clastic débris was being brought in. At the end of Kenai time the vigorous growth of the present Alaska Range began. Locally great accumulations of gravel—the Nenana gravel—were formed along the flanks of the growing mountain mass, and as the uplift became more widespread the gravel also was uplifted and mildly deformed.

The Nenana gravel has not been recognized in the area here under discussion, although it is abundant on the north flank of the range east of Mount McKinley. If it was deposited in the Skwentna region it was later largely removed by stream and ice erosion or covered by the morainal deposits of the Pleistocene glaciers. The only deposits younger than Eocene that are present in this region in important amounts are the deposits of the Pleistocene glaciers, the Recent stream gravel and sand, a thin layer of volcanic ash, and the organic deposits, muck, soil, talus, and rock-disintegration products now in process of formation.

STRATIGRAPHY

MESOZOIC ARGILLITE-GRAYWACKE-TUFF GROUP

Character and distribution.—The portion of the Alaska Range here described is composed essentially of an undifferentiated group of Mesozoic rocks comprising argillite, shale, and graywacke that contain tuffaceous or fragmental volcanic materials, and tuff that includes varying amounts of clastic sediments. The whole group is cut by intrusive rocks of various types that over large areas exceed in volume the bedded materials. These rocks were first described by Spurr,[5] who divided them into the Skwentna "series," composed mainly of basic volcanic rocks and tuff, and the Tordrillo "series," composed of shale, arkose, and limestone but without tuffaceous material. Brooks[6] later described these two divisions, adding his own observations to those of Spurr. Both Spurr and Brooks believed that the Skwentna group and Tordrillo formation, as they

[5] Spurr, J. E., A reconnaissance in southwestern Alaska in 1898: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 149–155, 1900.

[6] Brooks, A. H., The Mount McKinley region, Alaska: U. S. Geol. Survey Prof. Paper 70, pp. 85–90, 1911.

are now known, were distinct lithologically, the former being composed predominantly of volcanic materials and the latter almost entirely free from them. In the present investigation, which included a large area visited by neither Spurr nor Brooks, it was found that their observations were accurate for the region they studied, except for the fact that the Skwentna group in places carries more sedimentary material than they had realized and that heavy tuff beds recur far up in the Tordrillo. In the entire series fossils are scarce or altogether absent, and their aid is lacking in the determination of the relative age of different parts of the series. The present writer, therefore, considers it impossible at this time to make a consistent separation of the rocks of Spurr's Skwentna and Tordrillo "series" and has therefore mapped them as a single group of undifferentiated rocks that can be properly subdivided only after much more detailed study than they have yet received.

In the wider portions of the Skwentna Valley, as far west as Happy River, there are exposures of bedrock here and there in the river bluffs, and in the three canyons there are nearly continuous exposures of the rocks of this group. Throughout this distance the rocks are fine grained, show what seems to be bedding, and closely resemble clastic sediments. In thin sections, however, many of them prove to be composed mainly of tuffaceous material, but this in many places contains a considerable admixture of clastic sand and mud, and some thin sections are of graywacke or argillite, with minor amounts of tuffaceous material. Farther west, above the mouth of Happy River, black argillite, shale, and graywacke, with some limy beds, are more abundant through a vertical range of several thousand feet, but these again are succeeded, a few miles above the mouth of Muddy Creek, by another thick series of tuff beds that crosses the Skwentna Valley as a syncline striking northeast. Still farther up the Skwentna the argillite and graywacke beds are present, but only in irregular areas partly surrounded or entirely inclosed by masses of granite. Near the intrusive rocks they have been contact metamorphosed, are much more siliceous than elsewhere, contain contact minerals, and are in many places of a rusty color due to the oxidation of iron pyrite that was introduced as one of the effects of the intrusion.

Structure and thickness.—Only a general statement can be made regarding the structure of the argillite-graywacke-tuff group, for nowhere have detailed structural studies been made. It is known, however, that although the beds are everywhere more or less folded and faulted, the degree of deformation varies greatly from place to place. Over considerable areas the beds lie in great open folds, cut by faults of unknown displacement. Elsewhere, particularly in some localities near the edge of granitic intrusives, they are intricately crumpled, mashed, and faulted. In the mountains west of the upper Skwentna the prevailing structural trend is northeast, parallel to the axis of the range. In the east-west portion of the Skwentna, however, this trend is not obvious and the general strike is more nearly east or east-northeast, though there are many departures from this general trend. The monotonous character of the rock succession in this group, the absence of conspicuous members that are readily recognizable over considerable distances, the complex structure, and the lack of fossils combine to make the study of these rocks difficult and their structure obscure. These same factors also make it difficult to make even a rough estimate of the thickness of the group. The basement upon which it lies is not known in this area, and there are doubtless many unrecognized faults which would make an estimate difficult even if the structure were much better known than it is now. All that can safely be said at present is that these rocks alone occupy the greater portion of an area of many thousand square miles of mountains having a vertical relief of nearly 10,000 feet, and that in places they may be seen in single mountains where through a vertical distance of 4,000 feet they appear to be little deformed and in normal sequence. The conclusion seems unavoidable that the group is at least 4,000 to 5,000 feet thick, and it may be much more.

Age and correlation.—The determination of the age, the structural relations, and the conditions of deposition of this group of rocks and of similar rocks elsewhere in Alaska is one of the great unsolved problems of Alaska geology. In the Alaska Range, extending from the head of the Skwentna northeastward to and beyond Broad Pass, on the south flank, and almost equally far on the north flank, there is this great group of sediments consisting mainly of argillite, shale, and graywacke, much metamorphosed and almost barren of fossils. Similar rocks form large parts of the coastal mountains of the Gulf of Alaska in the Kenai and Chugach Mountains. In the Alaska Range these rocks are known to be definitely older than the Eocene coal-bearing beds, which in places they underlie unconformably. They are also older than the Cantwell formation, which has been classified as Eocene but may be Upper Cretaceous. They are younger than the Middle Devonian limestone that occurs in a number of places along the range. In the present investigation only a single fossil was found, a fragment of a dicotyledonous angiosperm leaf that was determined by Arthur Hollick to be of Cretaceous or Tertiary age. This leaf came from a bed high in the group, though by no means at its top. It is the only definite evidence obtained in the region here described as to the age of this great rock group, and that evidence is by no means precise, for it only tells us that one part of this group belongs somewhere in the Cretaceous or Tertiary.

Additional evidence of the age of this group may be procured by an attempt to correlate it with similar beds elsewhere whose age is more certainly known. The structural trend of these rocks strikes northeastward from the Skwentna region across Happy River and Kichatna Valley to the Cache Creek district, in the Kahiltna Basin, and thence across the West Fork of Chulitna River to Broad Pass. In general lithology, stratigraphic position, and structure there is little doubt that this same group of sediments lies along the flank of the range throughout this area, and that the rocks of upper Happy River, the Cache Creek district, and the West Fork of Chulitna River are parts of the same group. In 1902 the Brooks expedition[7] found fossils in this group near Rainy Pass that were determined to be of Middle Jurassic age. In 1917 Mertie[8] found fossils in rocks in the Cache Creek district that belong to this group and that are probably of Upper Cretaceous age. That same year the writer[9] described a section in the upper Chulitna region in which a similar series of argillite, slate, and graywacke was found to occur above a Triassic limestone and below the Cantwell formation (Eocene?). Thus all the positive evidence so far obtained indicates that this group is of Mesozoic age and younger than Triassic.

The lower part of the group on Skwentna River, in which volcanic tuff is so prevalent, closely resembles a series of rocks in Matanuska Valley and the Talkeetna Mountains that has been described by Martin[10] as the Talkeetna formation, of Lower Jurassic age. In the Skwentna region the volcanic material consists mainly of fine-grained tuff, whereas in the Talkeetna region volcanic agglomerate and breccia are common. The stratigraphic relations of these volcanic rocks are so similar in the two places, however, that it is likely that in a general way they can be correlated.

From the above paragraphs it is apparent that the argillite-graywacke-tuff group of the Skwentna region probably includes beds ranging in age from Lower Jurassic to Upper Cretaceous. The astonishing fact is that these rocks are so barren of fossils, although they are in many places only moderately or little metamorphosed and should have retained fossils if these had ever been present, whereas the Mesozoic rocks in such neighboring regions as the Talkeetna Mountains and the Alaska Peninsula-Cook Inlet area carry

---

[7] Brooks, A. H., op. cit., p. 90.

[8] Mertie, J. B., jr., Platinum-bearing gold placers of the Kahiltna Valley: U. S. Geol. Survey Bull. 692, p. 237, 1919.

[9] Capps, S. R., Mineral resources of the upper Chulitna region: U. S. Geol. Survey Bull. 692, pp. 217–218, 1919.

[10] Martin, G. C., The Mesozoic stratigraphy of Alaska: U. S. Geol. Survey Bull. 776, p. 219, 1926.

an abundant and characteristic fauna. Until fossils are found in the several parts of this group in the Skwentna region, correlation of these parts will remain uncertain, and it seems best to consider the group as of undifferentiated Mesozoic age and probably including beds that range in age from Lower Jurassic to Upper Cretaceous.

TERTIARY (EOCENE) COAL-BEARING ROCKS

Character and distribution.—Tertiary coal-bearing rocks are widely distributed in the basins of Cook Inlet and Susitna River. Their character, structure, and age have been discussed in considerable detail in other publications [11] dealing with parts of this general region, and to avoid unnecessary repetition only a brief description will be given here. In the present investigation beds of this age were seen by the writer only in patches along Susitna, Yentna, and Skwentna Rivers as far west as the mouth of Hayes River, though exposures were seen by other members of the party in the upper basin of Talushulitna River. At these localities, as elsewhere in the Susitna Basin, the beds are characteristic and easily recognizable and consist of unconsolidated to moderately well indurated clay, sand, and gravel and commonly some lignitic coal. They are largely confined to the lowlands and are easily eroded as compared with the older rocks, so that exposures are found mainly in the cut bluffs of streams, the formation being elsewhere concealed beneath a covering of glacial and stream deposits and of vegetation. The patchy distribution and small area of the outcrops, as shown on the accompanying geologic map, by no means shows the actual area of these rocks, which are believed to have a widespread distribution in the Susitna lowland, where they are generally covered by younger unconsolidated materials. The beds are of fresh-water or estuarine origin and contain abundant organic matter as carbonaceous sticks and imprints, as well as coal, but no marine invertebrates. All the fossils that have so far been found are land plants.

None of the exposures of these rocks seen in the Skwentna region show more than a part of the complete section. The basement on which they lie was nowhere observed, and the top is everywhere an unconformable contact with glacial materials or stream gravel. The character of the beds, however, was much alike in the different exposures, the beds consisting of an alternation of clay or friable shale with sandy or gravelly layers and with lignite. At Susitna Station a bluff on the east bank of the river just above the town consists of a rather coarse, well-indurated conglomerate, harder than any beds

[11] Martin, G. C., Geology and mineral resources of Kenai Peninsula, Alaska: U. S. Geol. Survey Bull. 587, pp. 67–89, 1915. Brooks, A. H., op. cit., pp. 94–103. Capps, S. R., The Yentna district, Alaska: U. S. Geol. Survey Bull. 534, pp. 28–33, 1913.

of this formation seen farther west, but this conglomerate is associated with a lignitic bed that formerly was mined in a small way and no doubt belongs to this formation. On the south bank of the Yentna some 7 miles above Susitna Station there is another locality where mining was attempted many years ago on a lignite bed in this formation. Other exposures of these beds occur on the south bluffs of the Skwentna at the mouth of Quartz Creek, between Canyon Creek and the Talushulitna, and a few miles above Canyon Creek, though no coal was seen at these localities. It is said that considerable coal crops out along headward tributaries of the Talushulitna, and abundant float lignite on the bars of Canyon Creek indicates an area of this formation somewhere in that basin.

The most extensive exposures of these rocks seen in the Skwentna Basin occur along the southeast bluff of Hayes River just above its mouth and on the north bluff of the Skwentna above and below the mouth of Hayes River. The exposure on Hayes River shows about half a dozen coal beds, the thickest some 12 or 15 feet thick, interbedded with shale and soft standstone. The bedding is much disturbed, the beds dipping from 10° to 75° or 80° N. There has been considerable crushing of coal and sediments, and one fault displaces the formation for at least 50 feet and possibly much more. On the north bank of the Skwentna the exposure shows one coal bed 10 feet thick and one 2 feet thick dipping gently northward beneath a gravel covering.

Structure and thickness.—Outcrops of these beds are now known at many localities in the Susitna Basin, and a study of these occurrences has made it possible to reach rather definite conclusions concerning the distribution and structure of the beds. First of these is the conclusion that although the beds were formerly more widespread than they are now and have been removed by erosion from certain areas, nevertheless they were probably never deposited over the main region now occupied by the higher mountains that surround the basin but were orginally laid down in lowland basin areas as stream, lake, swamp, and estuarine deposits, at a time when the surrounding mountains were of milder relief than they are now. Secondly, in post-Eocene time the mountains surrounding the basins of Eocene deposition were uplifted, and in this uplift the Eocene beds were locally warped and mildly folded, and around the margins of the basins the beds were generally upturned, in places to high angles. Subsequent erosion by streams and glacial ice removed much material from the upturned edges, as well as from the more greatly deformed areas, and the remaining beds were later generally covered by deposits of glacial moraine and outwash gravel. As a result of this history the Eocene beds, as we now find them, are in general moderately to steeply tilted and faulted near the margins of the basins but more gently folded toward the center of the basins.

The meager exposures of the formation in this region do not permit an accurate estimate of its thickness here, for no exposure shows more than a part of the total thickness. The thickest section seen, just southeast of the mouth of Hayes River, shows several hundred feet of beds, but the stratigraphy is complicated by close folding and faulting. In the Fairview district, some 30 miles to the northeast, a section measured by the writer [12] shows this formation to be more than 1,000 feet thick. When it is considered that the formation was laid down over a lowland surface of irregular relief, the earliest beds being deposited in the lowest parts of the basin, but the formation becoming more widespread as the basin was filled, it is to be expected that the original thickness of the formation would have varied greatly from place to place, and later differential erosion has no doubt exaggerated that irregularity.

Age and correlation.—The Eocene beds of this part of Alaska have so far yielded no invertebrate fossils, but they contain abundant organic material, as lignitic coal and as carbonaceous imprints of plant fragments, and in places carry many imprints of fossil leaves. These generally are difficult to collect, for the sand and clay in which they are found are likely to be too soft and friable to retain their form. From a number of places, however, fossil plants have been collected, and in the aggregate a profuse flora has been identified. These plants have been determined to be of Eocene (Kenai) age, thus definitely fixing the age of the formation at those places that have yielded plant fossils. The general aspect of the beds is, however, so characteristic, being generally marked by the presence of lignite, that there is little uncertainty involved in correlating the scattered exposures throughout the Cook Inlet-Susitna region, and altogether similar beds, also correlated with the Kenai, occur at intervals along the entire north flank of the Alaska Range. The lignite-bearing beds of this part of Alaska are therefore considered to be of Eocene age.

IGNEOUS ROCKS

Character and distribution.—The rocks shown on Plate 1 as igneous rocks were intruded into the preexisting sediments and cooled at some depth beneath the surface. Although the tuffaceous material so abundant in the argillite-graywacke-tuff group is of igneous origin, nevertheless it was deposited as a bedded formation, intermixed and interbedded with clastic materials, and in this report the tuff is discussed in the section that treats of sedimentary rocks.

[12] Capps, S. R., The Yentna district, Alaska: U. S. Geol. Survey Bull. 534, p. 31, 1913.

The igneous rocks of this portion of the Alaska Range are mainly of granitic character, medium to coarse grained, and completely crystalline and range in color from pink through light to dark gray. When studied under the microscope in thin section they are found to include hornblende granite, hornblende granite porphyry, biotite granite, sodic granite, and andesite porphyry. All these rocks are readily recognized in the field as granitic rocks or as porphyry of the same general composition as the granitic rocks, and they are all believed to belong to the same general period of igneous activity. In addition to the acidic rocks just described there are also present in this region minor amounts of basic intrusive materials, including augitite or pyroxenite, diabase, basalt, and basalt porphyry, that occur as dikes and sills of moderate size. They are really unimportant as compared with the granitic materials.

Granite rocks are widely distributed throughout Alaska, and they form a conspicuous element in the Alaska Range. In the region here described they predominate over the sediments in the basin of the upper Skwentna, but it is probable that they are less abundant to the east and west than they are in this particular district. Farther north, to and beyond Mount McKinley, granite masses occupy large areas along the axis of the Alaska Range, though their total area is not known, for much of the range is still unsurveyed. Farther east outlying masses of granitic materials occur in the Shell Hills and in the mountain mass that includes Mounts Beluga and Susitna, and still farther east, beyond Susitna River, granitic materials form the major portion of the western Talkeetna Mountains.

Age and correlation.—In the absence of definite evidence of the age of the granitic rocks of the Alaska Range they have generally been correlated with similar rocks in the Talkeetna Mountains which are believed to be Lower Jurassic. In the present investigation the granitic rocks were found to cut sediments in which was found a fossil leaf that was identified as being of Cretaceous or Tertiary age, and rocks of this group in neighboring areas have yielded Upper Cretaceous invertebrates. It therefore follows that the granitic materials here described must be younger than the part of the Cretaceous represented by the plant-bearing sediments, and similar granites farther north are younger than the Upper Cretaceous beds that they intrude. The granitic rocks have nowhere been found to cut the Eocene sediments, and they are presumably older than these sediments, which contain granite pebbles. This limits the period of intrusion of these rocks to late Upper Cretaceous or early Eocene time and proves that some at least of the granitic rocks of the Alaska Range are younger than the granites of the Talkeetna Mountains. Whether the isolated intrusive masses of the Shell Hills and Beluga and Susitna Mountains are to be correlated with the intrusives of the upper Skwentna or with those of the Talkeetna Mountains is not known.

The more basic rocks of the upper Skwentna, including dikes and sills of pyroxenite, diabase, basalt, and basalt porphyry, are definitely younger than the granitic rocks, which they cut. They also are thought to be older than Eocene, and thus, like the granites, they can be placed in the time interval between the part of the Cretaceous represented by the latest beds of the argillite-graywacke-tuff group and the base of the Eocene beds.

QUATERNARY DEPOSITS AND HISTORY

PLEISTOCENE GLACIATION

Much more detailed studies must be made in this region before the history of the events of Pleistocene and Recent time can be written, but it is already possible to outline briefly at least some of the major geologic events. Thus we know that toward the end of Tertiary time the Alaska Range had grown to about its present dimensions, and that the distribution of mountain and lowland provinces was about as it is now, although in many details the altitude of the valley and the gradients and positions of the streams were quite different.

The Pleistocene epoch is characterized in Alaska, as in many other parts of the world, by the tremendous development of glaciers and is often referred to as the "Glacial period." It is quite likely that in the higher mountains of the Alaska Range there were mountain glaciers in pre-Pleistocene time, as there are to-day, but they were restricted to the high alpine valleys, and their areas were small. The Pleistocene epoch was inaugurated by a gradual climatic change, the relatively mild and temperate climate that characterized Tertiary time giving way to more rigorous conditions. This change of climate probably involved a lowering of the mean annual temperature and possibly also an increase in precipitation, so that each winter more snow fell than melted during the following summer. This caused such mountain glaciers as were already there to thicken, expand, and lengthen, and other glaciers formed in valleys that had not previously contained ice tongues. As these glaciers grew larger and longer they joined in the main valleys, pushed out of the mountains into the lowlands, and there coalesced with other glaciers draining from the mountains that surround the Susitna lowland, until that whole basin was occupied by a huge ice sheet fed from all sides and moving slowly toward the sea. Within the mountainous region of the upper Skwentna Basin the ice filling was so deep that only the highest peaks and ridges projected above its surface. There is clear evidence that at the Twin Glaciers, in which the Skwentna heads, the surface of the trunk glacier that occupied the main Skwentna Valley once stood at an altitude of about 6,000 feet, and this glacier discharged both to the north, to the Susitna Basin, and to the southeast across the low divide at the head of the Skwentna. Similarly, the glacier that occupied Ptarmigan Valley and the headwater basin of Styx River and the South Fork of Kuskokwim River reached a maximum height of at least 5,800 feet. The distance southward that this great glacier pushed down Cook Inlet is not accurately known, but it certainly reached as far as the Forelands, and possibly 100 miles or more farther south. At this time of greatest ice accumulation the entire Susitna lowland was deeply covered by glacial ice. Mounts Susitna and Beluga, the former with an altitude of over 4,000 feet, were entirely covered, as were the Shell Hills. On the Yenlo Hills, just north of the mouth of the Skwentna, there is evidence that the glacier surface stood at an altitude of at least 3,600 feet. Farther back into the Alaska Range the altitude of this ice surface gradually increased, so that only the highest peaks and ridges projected above it. This tremendous body of ice, thousands of feet thick and moving slowly seaward, had a very great influence in shaping the surface over which it rode. Vast quantities of material were plucked or ground from the mountain ridges and valleys and deposited in the lowlands or carried out to sea by the ice or by the swift rivers that drained from it. The present surface forms of the region, both in the mountains and in the lowlands, are in large part due to glacial sculpturing or to deposition by ice and by the glacial rivers.

There is evidence in many parts of the world that during the glacial epoch there were several successive ice advances, separated by interglacial stages during which the climate was milder and the glaciers receded. Doubtless this was true in Alaska also, but in the region here under discussion the glaciers during the last advance were so large and their erosion was so severe that they covered or destroyed much of the evidence of preceding glaciations. The deciphering of the sequence of events in a region that has had a complex glacial history requires much detailed, painstaking work, and in this region the geologic studies so far made have been of reconnaissance character only.

With the final gradual withdrawal of the glaciers of this region to about their present position, great areas emerged from beneath the ice and were exposed to ordinary erosion by streams. Their surface had been sculptured by ice scour or covered by glacial deposits and was not adjusted to normal stream drainage. As soon as it was bared from ice, however, the streams began to establish themselves upon it and to equalize their gradients. Many depressions were filled, and canyons were cut across rock barriers that lay athwart the valleys. At present this process is still active, being as yet far from completed. Many lakes and marshes are still undrained, and the streams flow through a succession of canyons, in which the current is confined and rapid, alternating with broader reaches in which the current is slacker and materials are being deposited.

The invasion of this region by glacial ice and the subsequent withdrawal of the glaciers have had profound effects upon the drainage pattern, and many of the rivers now occupy courses that are quite different from those they followed in preglacial time. None of these drainage changes have been worked out in detail, but certain generalizations can be made, and attention will be called to areas that deserve more careful study. For example, the course of the Skwentna below the mouth of the Talushulitna is probably different from its preglacial course. Some 15 miles above the mouth the river flows in a narrow canyon, cut in hard rock, whereas above and below this canyon the stream floor is wide and bordered by loosely consolidated materials. It is possible that the preglacial Skwentna flowed directly to Cook Inlet to the west of Beluga and Susitna Mountains, across what is now the lowland of Talushulitna River and the Theodore. Many other minor changes of drainage due to glaciation might be mentioned, but one conspicuous change, that involved the diversion of the drainage from a large area from the Susitna to the Kuskokwim Basin, occurred in Ptarmigan Valley, south of Rainy Pass. The name Ptarmigan Valley has been applied to the broad glacial trough in which occurs the imperceptible divide from which waters flow southward to the South Fork of Kuskokwim River and northward to Happy River, a tributary of the Skwentna. This valley, which follows the structure of the rocks in which it is carved, extends as an uninterrupted, broadly U-shaped trough northward across the low divide into the head of Happy River and at its south end forks into two great parallel valleys in which flow the South Fork and Styx River. It is obvious at first glance that these two valleys and Ptarmigan Valley, their northern extension, were formed as part of the same drainage system, and the effects of glacial excavation have emphasized this unity. During the time of the last great glaciation the ice streams that originated in the upper basins of the South Fork and the Styx joined and moved northward through Ptarmigan Valley to flow to Cook Inlet by way of Happy River and Skwentna Valleys. At some time during that glacial stage, however, a stream discharging from that glacier found a way westward across the mountain ridge that borders Ptarmigan Valley on the west and with the advantage of a steep gradient cut a canyon across that ridge. Upon the final withdrawal of the glacial ice the stream had established itself and had thus captured for the Kuskokwim drainage system a considerable area that had before been tributary to the Susitna. The steeper gradient on the Kuskokwim side has enabled the South Fork, the Styx, and the stream in Ptarmigan Valley to intrench themselves in steep-walled rock canyons, and the headward growth of the canyon in Ptarmigan Valley will eventually result in the capture of still more of the drainage of Happy River.

PRESENT GLACIERS

Although there are small glaciers on the flanks of many of the higher peaks in this region, and some that attain considerable size, nevertheless the glaciers in general are much smaller than those in portions of the range where the average altitude of the mountains is greater, as it is farther north. Probably the largest glacier in the area here considered lies at the head of Hayes River, which is the largest tributary of the Skwentna. This glacier can be seen from the Skwentna and probably has a length of 25 miles or more, but it lies in an unsurveyed area, and so far as known its upper reaches have never been explored.

In the basin of Black and Tan Creek there is an ice stream some 10 miles long that is peculiar for its great length as compared with its width, which averages only a fraction of a mile. Another glacier tributary to the Skwentna from the east, 12 miles south of Black and Tan Glacier, drains a rugged, intricate mountain mass from which it receives a large number of tributary glaciers. It has a length of at least 10 miles.

The Twin Glaciers, in which Skwentna River has its source, are two strikingly similar ice streams that rise against the Cook Inlet-Skwentna divide and flow westward in adjacent parallel valleys. Each is about 11 miles long, and the streams flowing from them join to form the Skwentna, which from its source is a good-sized river.

The broad glacial trough through the north end of which the upper Skwentna flows in a northerly direction is continuous southward across a low divide for at least 20 miles, and in that southern extension there is a large river, fed by at least two great glaciers that drain the east and southeast slopes of the mountain ridge of which Mount Spurr is the culminating peak. In the expedition here described only the northern of these two glaciers was visited, and it apparently heads directly against the southwest slope of Mount Spurr. The river that rises in these two glaciers could be seen to flow in a southeasterly direction for several miles, but its ultimate direction and the drainage system to which it is tributary are unknown.

There are numerous small glaciers on the mountain ridge that lies between the upper Skwentna and the Styx, but none of them exceed 2 or 3 miles in length. The clear waters of the Styx indicate that there are no large glaciers in its basin, whereas the South Fork is turbid and is probably fed by glaciers of considerable size.

GLACIAL DEPOSITS AND BENCH GRAVEL

The intense glacial erosion to which the mountains in this region were subjected in glacial time and which is even now going on, in a much diminished degree, resulted in the removal by the ice and by the glacial streams of immense quantities of rock waste. In the high mountains, where the valleys in which the glaciers were confined are steep walled and narrow, the rock waste was largely removed as it was loosened from the mountain slopes, and there now remain only small amounts of glacial deposits. Farther downstream, where the glaciers emerged from the confining valleys onto the broad lowlands of the Susitna Basin, the ice streams spread out, their motion became slower, active erosion decreased, and much of the material brought by the ice from the mountains was deposited as morainal material. During the final retreat of the glaciers, as the overridden area was gradually bared by the melting back of the ice front, the heavily loaded streams, discharging from the glaciers, spread a broad mantle of glacial outwash gravel over the lowland surface. On Plate 1 the glacial moraines and deposits of outwash gravel are shown only where they are present over considerable areas and of sufficient thickness to conceal the character of the underlying bedrock. The smaller and thinner deposits that occur here and there within the high mountains are not shown.

Since the final retreat of the ice the rivers have been ceaselessly engaged in establishing normal stream gradients throughout a region where, as a result of ice erosion and deposition, the preglacial stream gradients had been radically altered. In many places glacial deposits had filled the old valleys and left an irregular morainal surface. In other places, within the mountains, the ice had overdeepened portions of the valleys, leaving depressions inclosed by rock ridges, for unlike flowing water, a glacier can in places push uphill over opposing ridges and slopes. Upon the melting back of the ice front the streams began at once to remove the inequalities of their beds. Depressions, including lakes and swamps, were filled in with gravel and sand, and canyons were cut into rock ridges that lay athwart the stream courses. As the floors of the canyons were lowered the streams intrenched themselves into the more easily eroded gravel and morainal materials and in the downward cutting formed benches at various levels. Such benches—evidences of the levels at which the streams formerly flowed—are present throughout the basin of the Skwentna but are especially conspicuous in that portion below Happy River. Between Happy River and the Susitna the Skwentna and Yentna flow in a valley that ranges in width from less than a mile to 2 miles and that is intrenched from 50 to 200 feet below the level of rolling morainal lowland that borders it. Where the stream flows through rock canyons the valley is much narrower, in places no wider than the stream itself at high water.

PRESENT STREAM GRAVEL

The deposits shown on Plate 1 as present stream gravel include only the bars of the present streams that are inundated at periods of extreme flood. They resemble in all respects, except in topographic position and in age, the associated deposits of bench gravel and like them are composed largely of outwash from glaciers. The stream gravel ranges in coarseness from place to place, being generally finer in the lower reaches of the streams and coarser as their headwaters are approached. The coarseness, however, is controlled by the velocity of the current, and in the rock canyons the gravel averages much coarser than in the intermediate stretches where the current is less rapid. For example, in the swift stretch between Happy River and Portage Creek there are bars composed of cobbles as much as a foot in diameter, whereas in the wider portion of the valley, just below the Twin Glaciers, there are many bars of fine pebbles and sand. The present stream gravel may be considered as in transit to the ocean, although the time necessary for any particular rock fragment to be moved from its place of origin to the sea may range from a long period of years to only a few hours. In times of high water enormous amounts of detritus are supplied to the rivers by the glaciers, and similar amounts are discharged to the sea. A single pebble, however, may find a temporary resting place on some bar many times during its journey, being worn down to smaller and smaller size each time it is moved, so that only fine sand and silt reach tidewater.

VOLCANIC ASH

One of the most recent geologic events in this region was a volcanic eruption that resulted in the deposition of a layer of ash over a large area in the upper Skwentna Basin. The ash deposit is inconspicuous, as it was long ago entirely covered by vegetation, but in good exposures it can be detected as a layer from an inch or so to several feet thick, occurring immediately below the surface layer of plant roots and soil. It was noted at many places along the

Skwentna below Happy River and is a favorite layer for the excavation of burrows by ground squirrels. The thickest deposit of ash seen was on the point between Muddy Creek and the Skwentna, some 3 miles above their junction. A section there, measured in a freshly dug hole on a moraine-covered bench, is given below. It is not known how large an area was covered to this depth, or whether the thickness in this place was the result of drifting of the ash in the wind. The surface of the ground was sloping and gave no appearance of there having been a hollow into which the ash could have been carried by water.

Section of volcanic ash 3 miles above the junction of Muddy Creek and Skwentna River

	Inches
Vegetation and muck	8
Buff ash, mottled to black by vegetation stains	4½
Fine tan to buff ash	6¼
Gray ash, as coarse as coarse sand, with pieces as much as half an inch in diameter	2½
Fine dove-gray ash	⅝
Fine gray ash with buff mottling	1¼
Fairly fine dove-gray ash	¾
Medium fine gray ash	4½
Very fine blue-gray ash	1¾
Very fine rusty buff ash, mottled with blue-gray	4½
Fine buff ash	11
Coarse sand and fine gravel.	
Total thickness of ash	37⅝

Neither the location of the volcano from which this ash came nor the date of the explosion is known, but large spruce trees growing upon the surface of the ash indicate that it fell at least 100 or 200 years ago.

MINERAL RESOURCES

The mineral resources of the Skwentna region have been little prospected, and no systematic mining of any sort has been attempted there. In any region so difficult of access as this part of Alaska the first prospecting is likely to be limited to the search for gold placers. Such has been the case here, and even this work has been done in only a sketchy fashion. The discovery of placer gold in the Yentna district, in 1905, stimulated prospecting throughout this portion of the Alaska Range, and within the next few years prospectors "ran over" the upper Skwentna Basin. The almost complete absence there of old camp grounds and of cuttings on trees, however, indicates that such hasty prospecting as was done gave little encouragement, and since that time few white men have ascended the Skwentna far beyond Portage Creek. The unfavorable winter weather and the absence of fur-bearing animals in sufficient numbers have made the region unattractive also to the trapper, who is usually a prospector during the summer, and as a consequence the possibilities of the region for gold-placer deposits have not been completely determined.

Somewhat more attention has been paid to prospecting for gold placers in the headwaters of the Kuskokwim. It is reported that coarse gold has been found on the Styx, the South Fork of the Kuskokwim, and the Hartman, and that a small amount has been mined. In the region visited during 1926, on Styx River, some signs of old prospecting were seen but no evidences of mining.

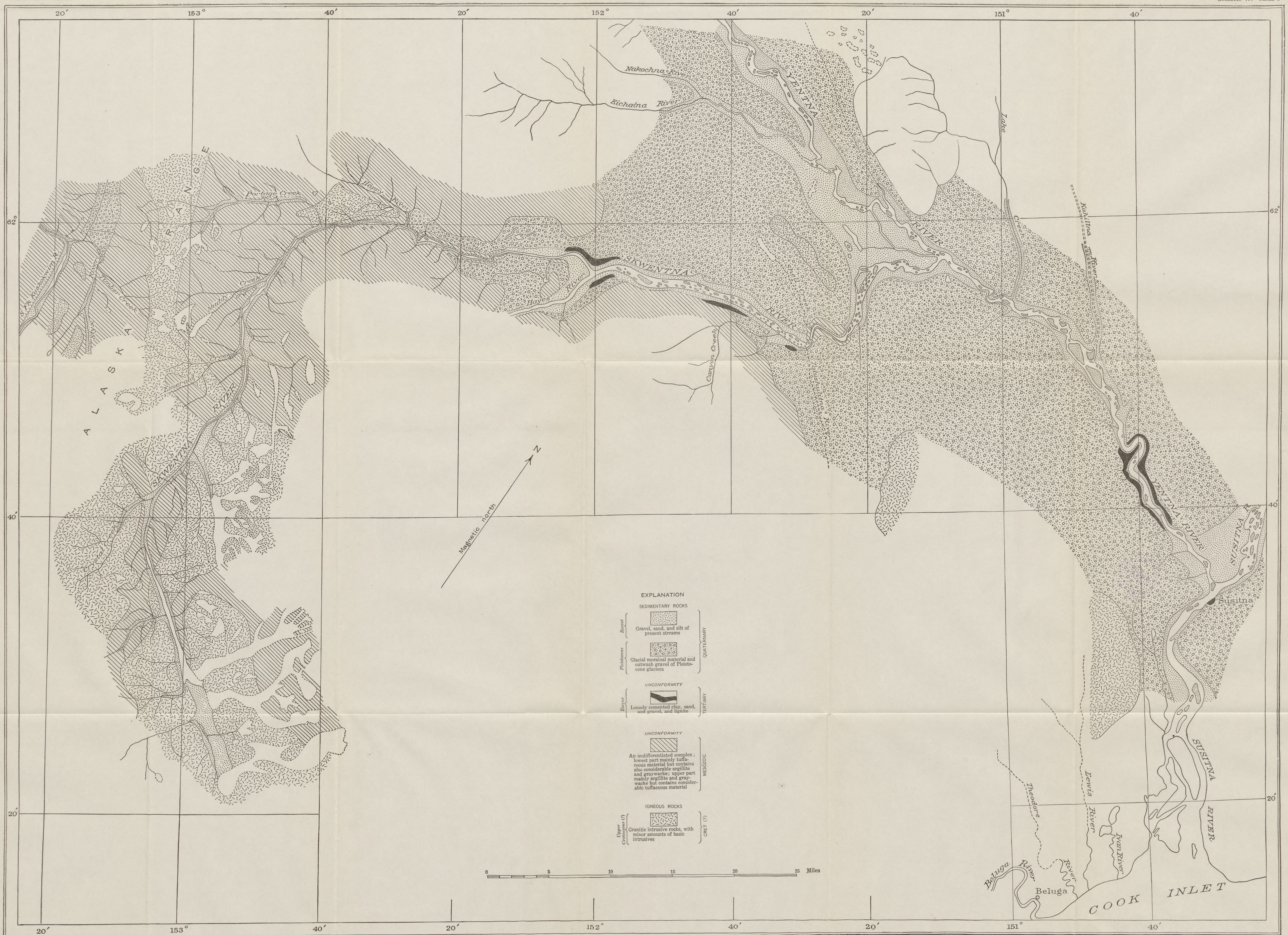
So far as is known to the writer, no systematic prospecting for lode deposits has been done in this region. Under present conditions of transportation no lodes could be mined at a profit here except those carrying precious metals, and even for lodes of high tenor in free gold the cost of transporting and erecting milling machinery and supplying a crew of men would require rich ore to be profitable. No such lodes have yet been found, though the general geologic relations, which show sediments cut by granitic intrusive rocks, suggest that lodes carrying gold, silver, and the sulphides of lead, zinc, and iron may well exist in the region. Pyritic mineralization in the argillite and graywacke near granitic intrusive bodies is common in the upper Skwentna Basin, and in many places the sediments near the contact with intrusive rocks are colored a rusty red by the oxidation of iron pyrite. Specular hematite was observed in altered sediments near the northern of the Twin Glaciers in which the Skwentna heads. On lower Styx River a conglomerate band in the sedimentary group is in places heavily impregnated with pyrite. It can therefore be definitely stated that the region shows considerable mineralization, though sufficient prospecting has not been done to determine whether or not commercially valuable lodes exist there.

As for the possibility of finding gold placer deposits of value, it should be borne in mind that in comparatively recent geologic time this region was subjected to severe glaciation, in which the valleys were filled with moving ice to a depth of several thousand feet. This glacial ice scoured out the valleys and carried away most of the stream gravel that lay in its path. Quite possibly this gravel in places contained concentrations of placer gold, but most of it was removed by the ice and scattered.

Since the retreat of the glaciers erosion has been active, but its results are small, and there has been little opportunity for the concentration of gold in paying amounts in the postglacial gravel. There may be places where remnants of preglacial placers through some unusually favorable situation escaped removal by the glaciers, and other places where through exceptionally rapid erosion of gold-bearing veins or postglacial concentration of gold-bearing detritus, workable gold placers have been concentrated in postglacial time, but such deposits are likely to be of small area and irregular distribution.

The areas in which beds of the Eocene coal-bearing rocks are known to crop out are shown on the accompanying geologic map, but the formation is without doubt present over much larger areas than here shown, being elsewhere covered with a mantle of younger deposits. At several localities, notably at Susitna Station, on the lower Yentna, in the upper Talushulitna Basin, and near the mouth of Hayes River, the formation is known to contain coal beds, and abundant coal float on the bars of Canyon Creek indicates a coal occurrence somewhere in the basin of that stream. At Susitna Station and at a point on the Yentna some 7 miles above its mouth openings were made some years ago on coal beds, and a small amount of coal was mined for local use. The openings are now caved in and inaccessible. It is reported that a coal bed about 4 feet thick, with a mild dip to the southwest, occurs on a headward tributary of the Talushulitna. High water and the swift current of the Skwentna at the mouth of Hayes River prevented a close examination of the coal outcrops there, but a considerable exposure on the southeast bluff of the river disclosed a number of coal beds of varying thickness, and on the north bluff two beds were seen, one about 10 feet thick and the other about 2 feet. Coal from these outcrops lies scattered along the bars of the Skwentna from Hayes River to the Yentna. It is a lignite of medium grade and burns readily in an open fire or in a camp stove. It is similar in quality and character to the lignite that occurs in this formation at dozens of localities around the margins of the Susitna lowland and Cook Inlet, and although it may sometime prove to be of value for local uses, the occurrences in this region are so remote from transportation that they have no present commercial value, especially because there are abundant supplies of equally good or better coal at more accessible points.

ADDITIONAL COPIES
OF THIS PUBLICATION MAY BE PROCURED FROM
THE SUPERINTENDENT OF DOCUMENTS
U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON, D. C.
AT
15 CENTS PER COPY
▽



Base prepared by Alaskan Branch from recent surveys by K. W. Trimble and other U. S. Geological Survey sources

GEOLOGIC MAP OF THE SKWENTNA REGION, ALASKA

By S. R. Capps

1928

6098°—29. In pocket