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THE YENTNA DISTRICT
ALASKA

BY

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ILLUSTRATIONS.

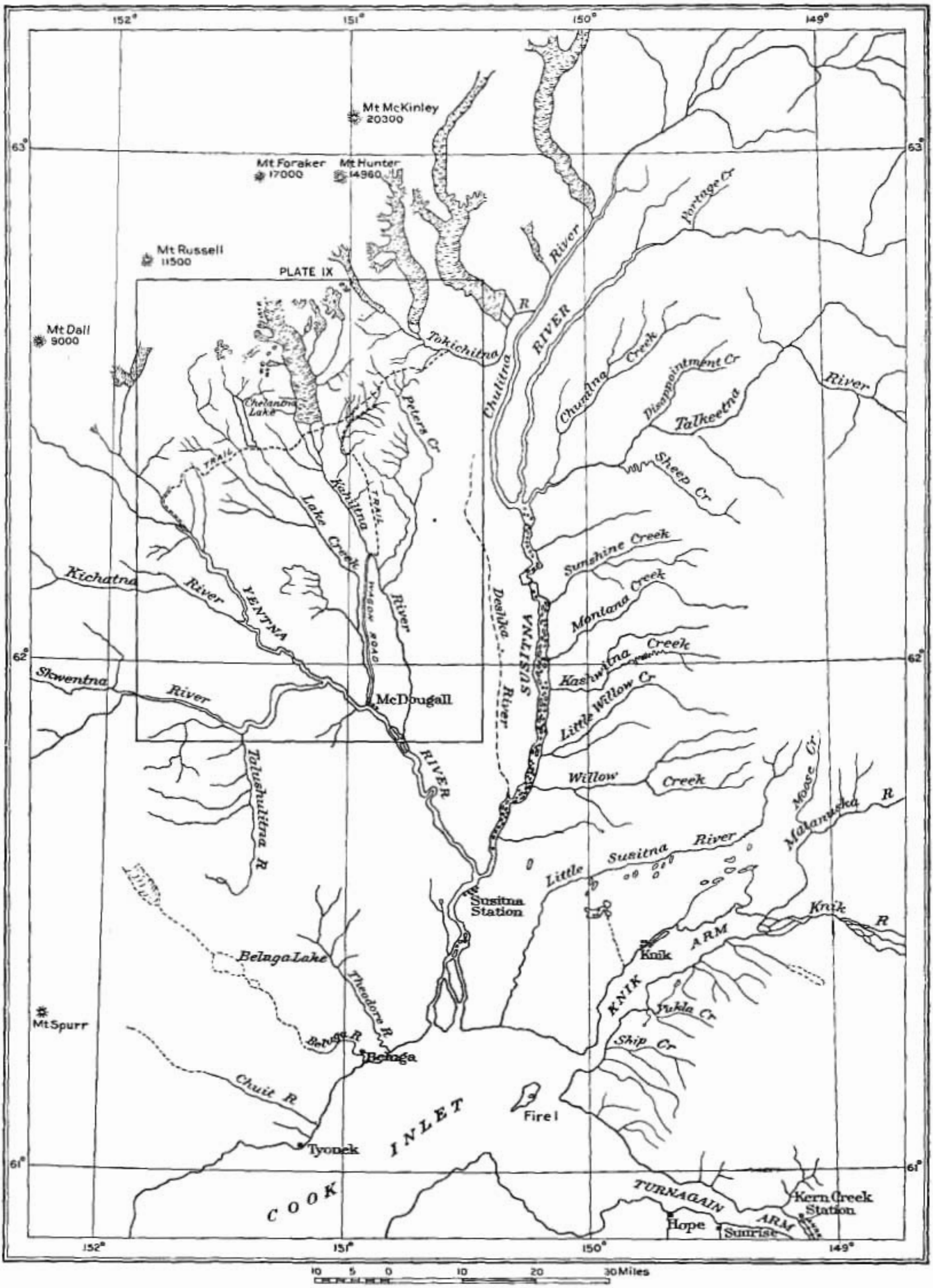
PREFACE.

By Alfred H. Brooks.

The several exploring expeditions which have traversed the Susitna basin since 1898 have determined its larger geographic and geologic features. Some areal mapping has also been done in the eastern part of the basin. Up to 1911, however, but little was known of the geology and mineral resources of the western part of the basin, including the Yentna placer district, which has made an annual gold output since 1905. The investigation the results of which are here set forth was undertaken as a part of the general plan to survey the productive mining districts as rapidly as funds permitted.

In the course of a very brief field season Mr. Capps has been able not only to map the larger stratigraphic units of the district but also to study in detail most of the occurrences of auriferous gravels. An important result of this investigation is the determination of the relations of the gold placers of Cache Creek to the recent physiographic history, including the advance and retreat of the ice sheet. Mr. Capps has also obtained evidence of the Tertiary age of the gravel sheet which overlies the Eocene beds of the region. These gravels were formerly regarded as Pleistocene. This affords additional evidence of the Tertiary age of the Nenana gravel in the Bonnifield district,[1] located on the north side of the Alaska Range. The assignment to the Tertiary instead of to the Quaternary of the heavy gravels which mantle the foothills on both sides of the Alaska Range will necessitate considerable change in the published interpretations of the physiographic history of central Alaska.

[1] Capps, S. R., The Bonnifield region: Bull. U. S. Geol. Survey No. 501, 1912, pp. 32-34.



SKETCH MAP OF THE SUSITNA BASIN, INCLUDING THE YENTNA DISTRICT.

THE YENTNA DISTRICT, ALASKA.

By Stephen R. Capps.

LOCATION AND AREA.

The Yentna district received its name from Yentna River, the largest tributary of Susitna River from the west, the junction of the two rivers being about 25 miles above the mouth of the Susitna. The area embraced in the Yentna district, as that term is commonly used, lies along the southeast base of the Alaska Range and includes all the drainage basin of Yentna River above the mouth of the Kahiltna, except the basin of the Skwentna, a large tributary from the southwest. The position of the district and its relations to Susitna River and Cook Inlet are shown in Plate I. The accompanying map (Pl. II, in pocket) shows what is known of the geography between meridians 150° and 152° west longitude and parallels 61° and 63° north latitude, but the descriptions in the following pages are confined to a triangular area of about 2,050 square miles (Pl. I), shown in the center of the map and bounded roughly by Yentna River on the southwest, the Susitna lowland on the east, and the rugged portion of the Alaska Range on the northwest.

PREVIOUS WORK.

Before the work was done on which this report is based little was known of the geology of the region between Yentna and Susitna rivers beyond a few facts of a general nature which had been gained from various sources. No attempt had been made to map the geology or to learn the relations between the various formations. In 1898 Spurr [1] ascended the Yentna to the mouth of the Skwentna and traveled up the valley of that stream, but in his journey along the Yentna he was able to obtain little information about the geology of the country to the north. During the same year Eldridge [2] made

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

[2] Eldridge, G. H., A reconnaissance in the Susitna basin and adjacent territory, Alaska, in 1898: Idem, pp. 1–30.

an exploratory trip up the Susitna and into the Tanana basin and recorded many facts about the geology of the range in the northern part of the Susitna basin. In 1902 Brooks and Prindle, in their exploration of the north side of the Alaska Range, went up Kichatna River and secured a geologic section of the range along their route. The results of all these early investigations have been embodied in a recently published report.[1]

The conditions under which these explorations were carried on, however, rendered it impossible for the geologic work to be extended more than a few miles on either side of the route of travel, and as both Yentna and Susitna rivers lie in broad, alluvium-filled basins, in which there are few bedrock exposures along the streams, the geologic conditions in the upland area between them were unknown, except for a few facts gleaned from reports of prospectors and miners who had visited the region.

In 1906 a reconnaissance topographic map, covering approximately the area considered in this report was made by R. W. Porter under private auspices. This map has already been published [2] and with a number of additions and corrections by the writer is again published here (Pl. II, in pocket), and is used also as the base for the geologic map (Pl. III, in pocket).

Gold was first discovered in the Yentna district in 1905 by a party of men who started up the Susitna by boat, intending to go to Valdez Creek, a headwater tributary of the Susitna from the northeast. Above the main forks of the river they encountered such difficulties that they changed their plans and ascended the Chulitna and Tokichitna to Home Lake, where they established a base camp from which they made prospecting trips that resulted in the discovery of gold in the Peters and Cache Creek basins.

Since 1905 prospecting and mining have been carried on continuously, and although gold has been found to have a widespread distribution throughout the area, it has been obtained in paying quantities only in the so-called Cache Creek country, in the basin of Twin Creek, and at a few points in the valleys of Lake Creek and Kahiltna River. During the season of 1911 a new impetus to prospecting was given by the discovery of rich placer ground in the benches above Dollar Creek. At present the whole economic value of the district is in its placer gold, no valuable lodes being known. Lignitic coal occurs at many places, but its quality is too poor to attract much attention, as better and thicker coal beds occur at easily accessible points on Cook Inlet. The coal has, however, some value as fuel for local use.

[1] Brooks, A. H., The Mount McKinley region, Alaska: Prof. Paper U. S. Geol. Survey No. 70, 1911.
[2] Idem, Pl. XV.

PRESENT INVESTIGATION.

As developments over a period of several years showed that the placer gold production from the Yentna district was steady, and the mining population was gradually increasing, it became desirable to learn more accurately the conditions under which the gold occurs, to discover if possible the source from which it was derived, and to ascertain as far as possible the extensions of the area in which paying concentrations of gold were likely to occur, as well as to map areally the distribution of the rock formations, and to learn their relation to one another. For this investigation the writer was detailed, accompanied by J. M. Charles, packer and cook. McDougall, at the mouth of Lake Creek, was reached on June 9, 1911, by launch up Susitna and Yentna rivers. At this point three horses were procured as pack animals, and the party proceeded directly to the placer-mining district on Cache Creek, where actual field work began on June 26 and was continued until September 13, a period of 80 days, during which an area of 2,050 square miles was mapped. It will thus be seen that time was available only for a hasty investigation of the conditions at the various placer mines, and for determining the more important facts about the surface distribution of the different rock formations. The boundaries given on the map (Pl. III, in pocket) can therefore be regarded as accurate only in so far as they show the general distribution of the formations. The smaller but none the less important details of structure, distribution, and relation of the various formations remain for a later, more detailed investigation, which will doubtless be made if developments in the region justify it. A preliminary report on the mineral resources of the Yentna region has already been published.[1]

The writer wishes to express his sincere thanks to the miners and prospectors of the region for their hearty cooperation and unfailing hospitality, especially to Mr. C. P. Morgan, who made a considerable sacrifice of time to aid in the work and supply information, and to Mr. B. M. Mathieson, who furnished a traverse of Cache Creek and parts of its more important tributaries.

GEOGRAPHY.

DRAINAGE.

SUSITNA RIVER.

The Susitna is the master stream that receives all the southward drainage of the Alaska Range for nearly 300 miles, measured along the crest of the range. From the west it is fed, in the region under discussion, by Chulitna River and its tributary the Tokichitna, by Deshka

[1] Capps, S. R., Gold placers of the Yentna district: Bull. U. S. Geol. Survey No. 520, 1912, pp. 174-200.

River, and by the Yentna. The Tokichitna is a short stream—little more than 25 miles in length—which receives the drainage from one small and two very large glaciers. In the mountainous upper portion of its course it occupies a broad glacial trough, which extends eastward to the east base of Peters Hills, beyond which the valley walls become lower, and the stream enters the lowlands of the wide Susitna basin. Below the small glacier in which the river heads it has the character of most glacial streams, being heavily charged with gravel and silt and spreading in a multitude of channels across a wide valley floor. The channels shift constantly, the stream cutting away the banks at one place to redeposit the materials at another. Of the Deshka little is known except that it receives no water from the mountains and that its course lies wholly in the Susitna lowland, roughly parallel to that of the Susitna. It joins the Susitna about 10 miles above the mouth of the Yentna.

YENTNA RIVER.

Yentna River is the largest tributary of the Susitna. It rises in the rugged mountains of the Alaska Range near Mounts Russell and Dall and flows southeastward to its junction with the Susitna, about 25 miles from the coast. It receives much of its waters from the glaciers and snow fields of the higher portions of the range, but as the mountain mass at the head of the main forks of the Yentna is lower than that portion which lies farther north, the glaciers there are smaller and the valley is free from ice much farther into the mountains than are the neighboring valleys to the north. Above the junction of the two main branches which form the river both streams have the characteristics of other glacial streams, with many branching channels and wide expanses of bare gravel and sand bars. Below the junction of the headward forks the river maintains a more definite channel, with few islands, and is easily navigable by light-draft launches. The principal tributary of the Yentna from the north is Kahiltna River, which heads in the great Kahiltna Glacier. This glacier lies in a basin which is difficult of access and much of which is still unexplored. It is believed, however, that the glacier receives ice from the slopes of Mount Foraker, and it is possible that it drains some of the snow fields on the southern slope of Mount McKinley. The glacier sends its terminus out beyond the confines of the higher mountains and at its lower end is nearly 4 miles wide. Below it Kahiltna River is turbid and spreads with many channels and sloughs across a broad flat which lies at an elevation less than 600 feet above sea level. This flat narrows noticeably about 15 miles below the glacial source of the stream, and for much of the remainder of its course to the Yentna the river flows as a single stream through a narrow canyon-like valley. Between the glacier and the Yentna the river receives water from several large creeks whose basins lie below the level of perpetual snow. Lake Creek, which joins the Yentna 8 miles above the Kahiltna, heads in high mountains between Kahiltna and Yentna glaciers, and although its basin contains no large glacier many of its headward tributaries are fed by small ice fields. A number of these drain into Chelantna Lake, a body of water 7½ miles long and 1 mile wide, which occupies the lower end of the mountain valley and which at its lower end gives rise to Lake Creek. Above the lake the glacier-fed streams are muddy with glacial silt, but below it Lake Creek is clear and flows, with a sluggish current, to the southeast as far as Willow Mountain in a shallow valley, across the surface of the upland plateau. East of Yenlo Hills the stream has entrenched itself and lies in a gorge which at the mouth of Yenlo Creek is 250 to 300 feet deep. Through this gorge the creek is swift and runs in a series of rapids over large bowlders. Near the mouth of Lake Creek the valley widens, and the stream gradient becomes more gentle. The most important tributaries of the Yentna from the south are Skwentna and Kichatna rivers, but they lie outside the area with which this report is concerned.

Yentna, Kahiltna, and Tokichitna rivers all have their sources in large glaciers, and their upper portions have many characteristics in common, due to their mode of origin. During spring and summer the glaciers melt rapidly, and large volumes of water are discharged, the floods usually reaching their culmination late in June or early in July. The waters on emerging from beneath the ice are heavily charged with gravel, sand, and silt, and to this load is added whatever material the streams are able to pick up from the moraines and gravels of the upper valleys. This heavy load of débris can be carried by the streams only where their gradients are steep, and as the valley slopes diminish downstream the materials are deposited, the coarse materials being dropped first and the finer farther downstream. Such rapid deposition causes the streams to shift their channels frequently, and for many miles below the glaciers the streams are characterized by a network of branching channels, and bare gravel and sand bars. This deposition causes the gradual upbuilding of the valley floors with heavy beds of stream-laid deposits, and the widening of the valley floors over which the streams spread. An excellent example of this process is to be seen immediately below Kahiltna Glacier, at which place a flat almost treeless expanse of bare gravel and sand stretches across the valley for a distance of nearly 4 miles. Glacial streams are especially subject to rapid fluctuations of volume during the summer, and warm clear days or warm rains always cause the glaciers to melt rapidly and the streams to swell. On the other hand, a cold, crisp night will cause the streams to shrink, and the early morning after such a cold night is preferred for fording the rivers by those acquainted with the conditions. In the late fall and in winter, when glacial melting is at a minimum, the rivers are low and the waters are clear.

RELIEF.

LOWLANDS.

The Yentna district, bounded by Susitna and Yentna rivers and the crest of the Alaska Range, may be roughly divided into three distinct topographic provinces—the lowlands, the foothill belt, and the Alaska Range. Of these the first includes the lowlands of Yentna, Susitna, and Tokichitna rivers (Plate III, in pocket). It stretches west from the base of the Talkeetna Mountains on the east side of the Susitna to the foothills of the Yentna district, a distance of nearly 50 miles, and has irregular projections which extend up the valleys of Yentna, Kahiltna, and Tokichitna rivers. Most of the lowlands lie within 600 feet of sea level. They are characterized by broad, almost flat stretches along the main streams and by slightly rolling interstream areas. The lowlands are nearly everywhere covered with spruce or cottonwood timber, and between the trees willow, alder, and other bushy plants grow in profusion. The larger streams which cross the lowlands have well-defined valleys and most of them flow with a swift current and are turbid. The smaller streams, on the other hand, are clear and commonly sluggish and meandering; they flow in poorly defined channels that drain the many marshes and small lakes with which the lowland is dotted. As the lowland is marshy and difficult to penetrate on account of the heavy growth of brush, it has been little explored, for it offers no attraction for either the prospector or the geologist.

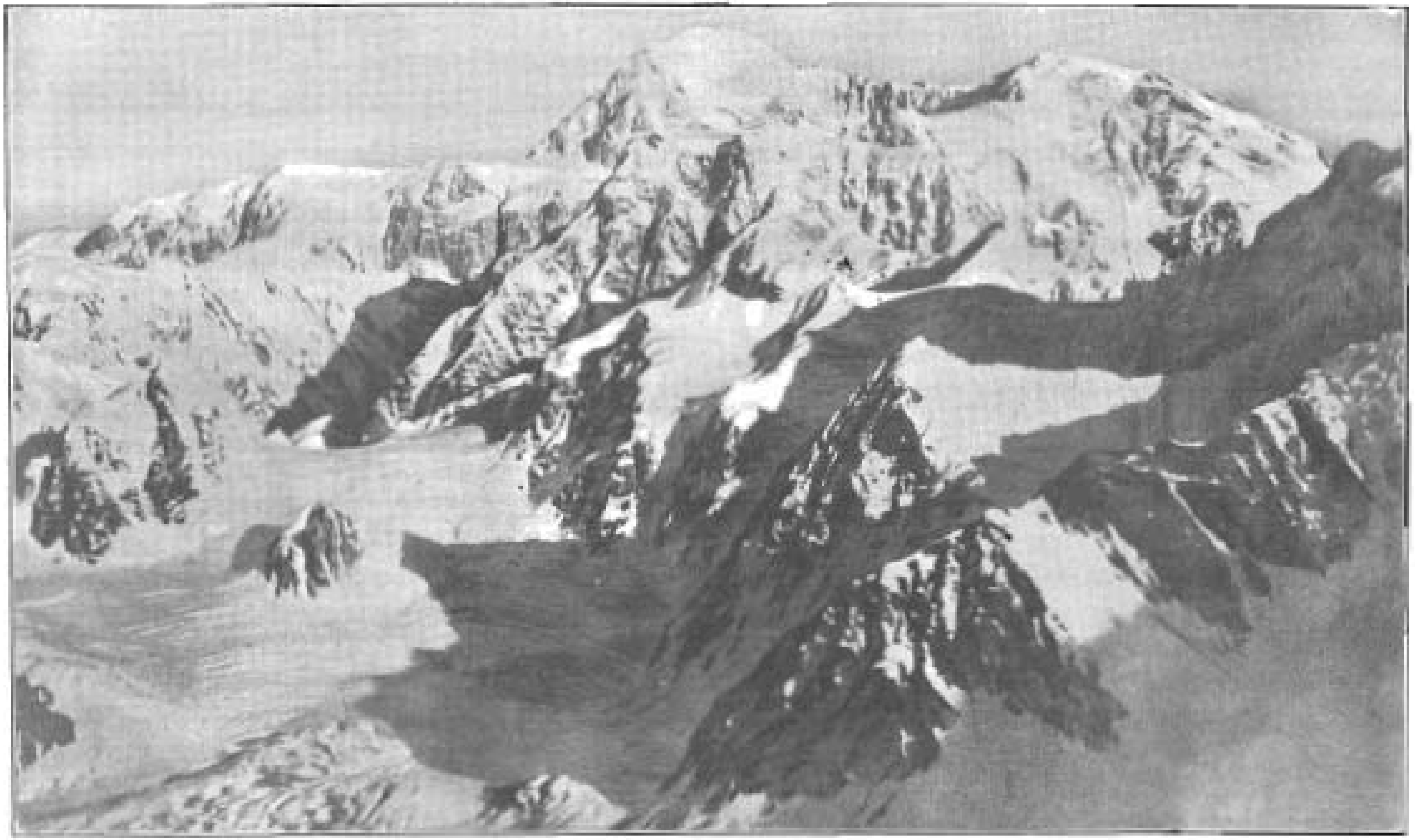
FOOTHILLS.

The second topographic province includes the foothill belt that lies between the lowland and the rugged mountains to the northwest. In this belt are the Dutch, Peters, and Yenlo hills and the hills at the head of Twin and Camp creeks. In general, all of these hills are smooth in outline (Pl. IV, *A*), and their summits reach elevations of 3,000 to 4,000 feet, although at the north end of the Dutch Hills somewhat rougher peaks rise to a height of 5,000 feet. Between the hill ranges and around their margins is a high upland plain cut transversely by the Kahiltna Valley and sharply trenched by many of the streams which cross it, but which still retains enough of its old surface to be recognizable. Between Yentna and Kahiltna rivers this plain lies at an elevation between 800 and 1,600 feet, and at its upper edge gives place to the rugged mountains of the Alaska Range (Pl. IV, *B*); in the basin of Cache Creek it rises to a height of about

A. PETERS HILLS, WITH CACHE CREEK TROUGH IN FOREGROUND.

B. CHELANTNA LAKE AND THE ALASKA RANGE, LOOKING NORTHEAST.

Mounts McKinley and Foraker in the distance, at the left. The lake lies in a glacially scoured valley behind a moraine dam, its lower end marking the boundary between the alpine belt and the uplands that surround the foothills.



MOUNT McKINLEY FROM THE SOUTHEAST.

(Photograph by La Voy.)

2,000 feet and is bordered by the foothill ranges. Very little of this high plain is heavily timbered. Scattered groves of spruce occur in favorable localities, but most of the vegetation consists of low bushes, grasses, and sphagnum mosses. All the producing placer mines are within this belt.

MOUNTAINS.

The third region, of very different character from the others, comprises the rugged alpine portion of the Alaska Range. The dividing line between it and the foothill belt extends from the lower end of Tokichitna Glacier southwest to Yentna River at a point a few miles above its forks. The mountains in the lower southeast portion of the alpine belt have elevations of about 4,000 feet, but to the northwest the range increases rapidly in height and ruggedness, culminating in the two great mountains which on clear days may be seen to dominate the whole Susitna basin—Mount Foraker, 17,000 feet, and Mount McKinley, 20,300 feet in elevation, the loftiest peak of the continent (Pl. V). Between the foothills and the crest of the range is a belt averaging about 25 miles in width and including an area of many thousand square miles of unexplored territory that is most difficult of access on account of the sharp, toothlike character of the ridges and the glacier-filled valleys. The Alaska Range, considered as a whole, forms a great crescentic curve, its trend being in a north-south direction west of Cook Inlet and in an east-west direction between the Copper River basin and Tanana River. The Yentna drains an intermediate portion of the range, in that part where its trend is from southwest to northeast. Here, for a distance of 150 miles measured along the crest, the massive mountains are unbroken by passes, and the only practicable routes from Susitna basin to the interior are across the range at one of the three neighboring passes at the heads of Kichatna and Skwentna rivers into the Kuskokwim basin, or across one of the passes at the head of the Chulitna or the Susitna into the Tanana basin.

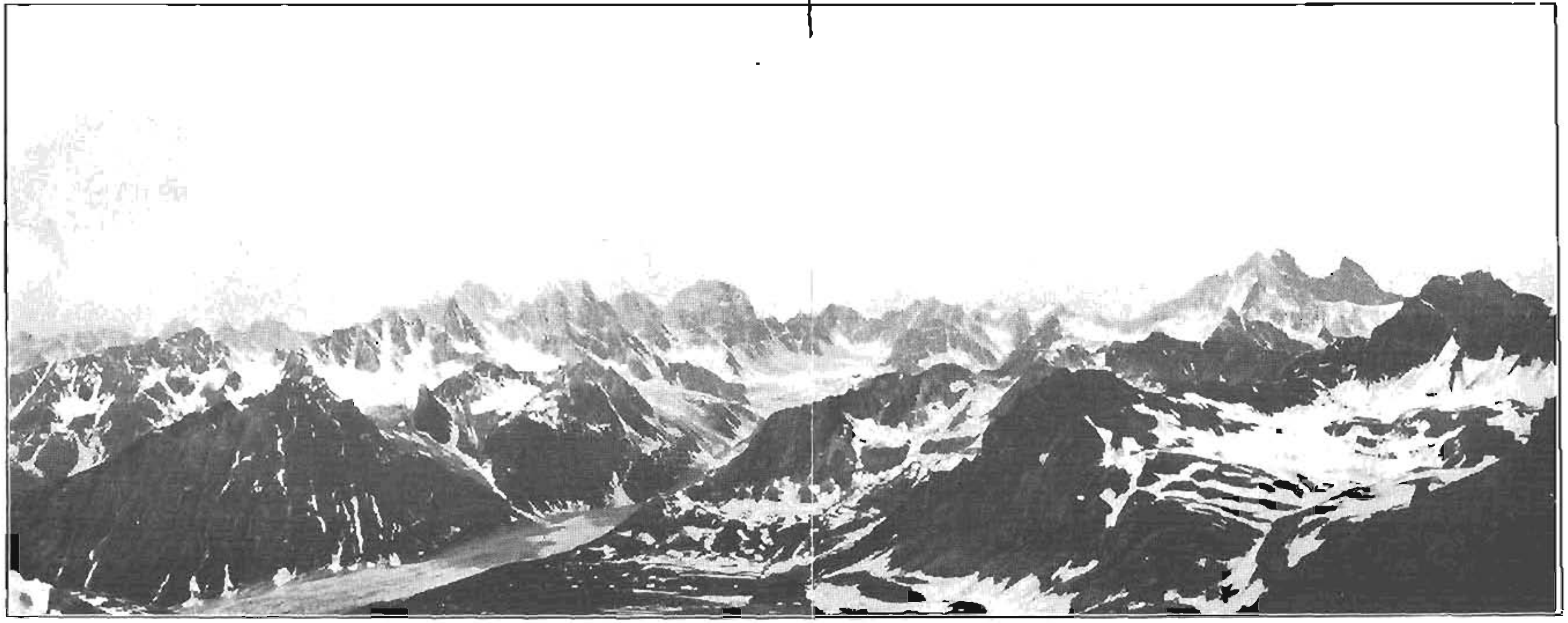
Both the topographic and geologic mapping of the high, mountainous area of the Yentna district have been limited to its more accessible portions, along the flanks of the range. The topographic map thus gives undue emphasis to the rounded and smoothed forms of the foothill ranges and presents an inadequate idea of the extreme roughness and scenic grandeur of the heart of the range. The location and elevation of only a few of the most conspicuous mountains are given, although hundreds of unnamed and unrecorded peaks from 8,000 to 14,000 feet in height are distributed throughout the unmapped area between the front of the range and its crest. If the map were complete, it would show that these peaks occur along narrow, steep-sided ridges, the space between them being occupied by great glaciers and their branching tributaries (Pl. VI, *A*). The erosive action of the extensive ice bodies which still remain and of the much greater glaciers of which these are the shrunken remnants has been of prime importance in shaping the mountains to their present forms. By the removal of spurs and irregularities along their sides the glaciers have reduced the valleys in which they lay to deep straight-sided troughs, which, where they bend, swing in broad, sweeping curves. In both the tributary and the main valleys the same development of broadly U-shaped, straight valleys has taken place. In the small valleys the headward growth of opposing cirques has reduced the divides to serrate, pinnacled ridges.

INFLUENCE OF ROCK TYPES ON TOPOGRAPHY.

Although the tendency of glacial erosion is to reduce all the divides to sharp ridges, the character of the rocks of which the mountains are composed has exercised an important influence on the mountain forms. In the higher parts of the range the most widespread rocks are of granitic character, and from these are produced acute, almost needle-like summits and pinnacles. The slates along the flanks of the range also take on rugged forms but in a lesser degree than the granitic rocks. Most of the foothill ranges are composed of slates and graywackes, but these were probably at one time completely overridden by glacial ice, and their summits smoothed off and rounded, to be later dissected by the erosion of many small valley glaciers along their sides. Cirques were developed by these valley glaciers, but their growth was not sufficient to obliterate the smooth outlines of the hills or to notch the crest lines in any conspicuous way. The gravel hills between upper Lake Creek and Yentna River have their own distinctive topographic form, although the erosive effects of the glacier which once overrode them are still visible. These hills are smooth in outline, but sharply incised gulches mark the slopes which have been most subjected to postglacial stream erosion. In the plateau region surrounding the foothills, and in the lowland toward the east, the larger topographic features are due to the form of the underlying deposits left by the ice, but the smaller details of surface configuration are due to the manner in which the surface materials were laid down, being of a mild hummock and kettle topography where morainal deposits occur and flat and featureless in those places where stream deposits are present.

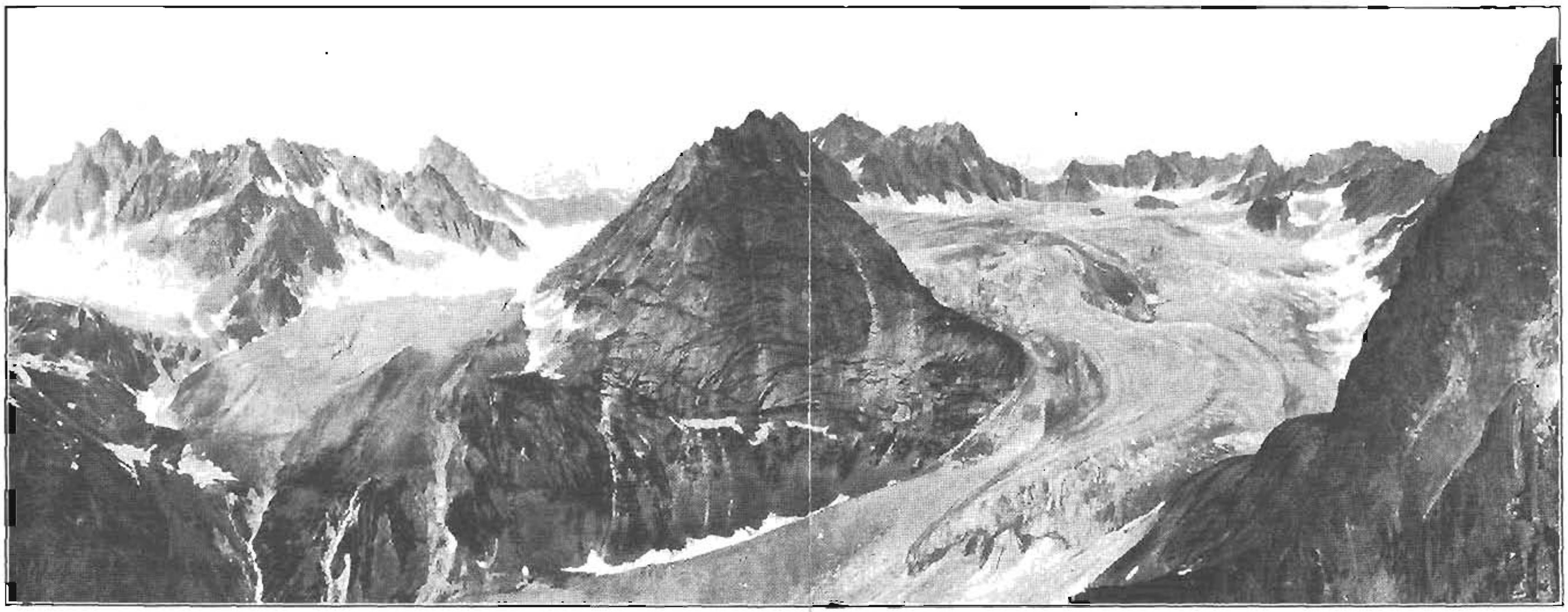
CLIMATE.

The placer camps of the Yentna district, though only about 80 miles from tidewater at the head of Cook Inlet, are more than 200 miles from the main line of the Pacific coast and have a climate more like that of interior Alaska than of the coastal region. No systematic



A. RUGGED MOUNTAINS AT THE HEAD OF GRANITE CREEK.

The dark-colored rocks in the right foreground are slates and graywackes; the lighter colored rocks are granitic.



B. GLACIERS AT THE HEAD OF HIDDEN CREEK, WEST OF GRANITE CREEK.

The glacier at the right lies along the contact between the granitic rocks and the slates.

records of temperature or precipitation are available for the Susitna basin, but it is known that the winters are colder and the summers warmer than along the coast, where the ocean currents have an equalizing effect on the temperature. The snowfall in winter is less than on the coast, but is heavier than in the Yukon basin in the interior. The region is surrounded by high mountains on all sides except where Cook Inlet makes a narrow opening, and these mountains greatly influence the distribution of the precipitation. The number of rainy days and the amount of rainfall during the summer seems to vary greatly in different seasons. R. W. Porter notes that in 1906 it rained 50 days of the 110 he spent in the field. The summer of 1911 is admitted by the miners to have been unusually dry, but during 100 days spent in the area above Cook Inlet it rained steadily on 16 days and for parts of 9 other days.

The seasons consist of a long winter of about seven months, from October to April, during which the streams are frozen; a period of a month or so in the spring, the so-called "break-up," during which the streams become free from ice, and most of the snow melts in the lowlands; a short summer of about three and one-half months, during which the days are long and warm and vegetation grows with remarkable luxuriance; and a fall of a few weeks, when the days are clear and crisp and the nights cold, which lasts until the rivers freeze up for the winter. In the fall the streams become low, and slush ice usually forms between the 20th of September and the middle of October, closing navigation on the rivers until about the middle of the next May. The rivers, however, become free from ice in the spring long before the snow disappears from their banks. The spring of 1911 was said to be unusually late, but at the mouth of Lake Creek, only 200 feet above sea level, snow still lay in the timber, in sheltered places, on the 10th of June and on the Cache Creek Plateau, at an elevation of 2,000 feet, there were large patches of snow in early July. The discharge of the streams is very low in midwinter but increases with the melting of the snow and even after the snows from the lowlands have largely disappeared. The higher portions of the Alaska Range are occupied by perpetual snow fields and by great glaciers, and the periods of greatest floods for the glacier-fed streams come in the middle of July, when the days are warmest and melting is most rapid in the glacial fields. As fall approaches and the nights become longer and colder this melting decreases, and the streams in consequence shrink; for a short time before the freeze-up glacial activity becomes so reduced that little water is discharged, and the streams become clear, in contrast to their turbid state in times of high water.

In those streams that do not receive water from melting glaciers the high-water period comes earlier, in June, when the melting of the winter snows is greatest. Heavy rains during the summer cause floods in these streams, but the general tendency is toward a gradual diminution of flow after the first of July, and when the snows have disappeared from their basins many of the smaller creeks dwindle or go dry completely, unless the run-off is augmented by rains.

VEGETATION.

As the snow melts away in the spring and the days become long the growth of vegetation is astonishingly rapid. Scarcely has the ground become bare of snow before the plants spring up, and a line of green follows the edges of each diminishing snow patch, separated from it by only a few feet of bare ground. From that time until frost in the fall the growth is of almost tropical luxuriance. Grass of a variety known as "red top" appears soon after the snow has gone, and affords good forage for horses until withered by frosts in the fall, after which it yields little nourishment to stock. It is abundant throughout the Yentna district, from the lowlands of Susitna River up to elevations of 3,000 feet on the mountain sides, and grows to a height of 4 or 5 feet. Many areas hundreds of acres in extent were seen in which this grass grew densely. It makes good hay when cut before frost and properly cured. Between the 1st and 10th of June grass sufficient to supply forage for horses appears at McDougall, but in the higher basins, such as that at the head of Cache Creek, the snow does not always disappear until early July, and horse feed is not abundant until that time. Horses also feed freely on plants of the genus Equisetum, locally known as horsetail rushes, and on various other plants, but the forage fails in late September, and horses can not be worked after that time unless fed on hay and grain.

The distribution of timber in the region is shown in figure 1. Throughout the lowlands of the larger river valleys there is an abundant growth of spruce and cottonwood timber, with some birch on the well-drained hillsides. Timber is found in the main valleys of the mountains and up to an elevation of about 2,000 feet, although there is much untimbered territory below this level. The largest trees grow on the lower ground; there the spruce reaches a maximum diameter of about 24 inches, and cottonwood trees 5 feet through at the base were seen. Near timber line the trees are generally small and scrubby and unfit for lumber. Above timber line there is in most places a belt of dense alder or willow brush, which is difficult to penetrate and which necessitates much chopping for the passage of horses. Alders and willows also grow thickly in the lowlands among the timber and here attain large size, making it a laborious task to chop a trail through them. Even in those places where a trail has been cut out, continuous travel and chopping are winter snows is greatest. Heavy rains during the summer cause floods in these streams, but the general tendency is toward a gradual diminution of flow after the first of July, and when the snows have disappeared from their basins many of the smaller creeks dwindle or go dry completely, unless the run-off is augmented by rains.

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Some edible berries grow within the region, the most important of which are blueberries and cranberries above timber line and some raspberries, currants, and high-bush cranberries in the timbered areas.

POPULATION.

Until the discovery of gold in 1905 there were no permanent settlements of white men in the whole Yentna district, and very few white men had visited it at all. In 1905 there were less than a dozen men prospecting on the various creeks, and in 1906 it is reported that about 50 men were prospecting and mining on Peters and Cache creeks and their tributaries, an unrecorded number being similarly engaged on the headwaters of Lake Creek. No records have been kept for the years 1907 to 1910, but in 1911 about 100 men were working on Cache and Peters creeks, 10 men in the area between Lake Creek and the Yentna, and perhaps half a dozen on Kichatna and Nakochna rivers, south of the Yentna, or a total of about 116 within the Yentna district. There are no permanent native settlements in the Yentna basin, the nearest being at Susitna and at Alexander, on Susitna River. The Indians spend the summer and most of the winter on the main river, where they have rather comfortable log cabins. The summers are largely occupied in catching and drying fish, an occasional hunting trip being undertaken for fresh meat. The natives along the Susitna are familiar with the country drained by the Yentna, and make hunting and trapping expeditions into it in the fall and winter.

SUPPLIES AND TRANSPORTATION.

The only practicable route to the Yentna district is by way of Susitna and Yentna rivers. During the summer months the Alaska Northern Railroad may be used from Seward to the head of Turnagain Arm. From the terminus of the railroad, as well as from Seldovia and other points on Cook Inlet, launches carry both passengers and freight up Susitna River to Susitna Station, which is the center of supplies for the Yentna country. Launches make occasional trips during the summer from Susitna Station up the Yentna, which is navigable for light-draft boats almost all the way to the forks of the river. A trading station was formerly maintained on the Susitna near the mouths of Talkeetna and Chulitna rivers, and a stern-wheel steamboat plied up the river to that point. This station has now been abandoned, and the steamboat taken to another part of Alaska. The route most followed to the placer camps in the neighborhood of Cache Creek leaves the Yentna at McDougall, a small village at the mouth of Lake Creek. From McDougall a wagon road required to keep it open, for the winter snows press down the brush from either side, and new branches spring out to fill the openings, so that in a few years a trail, if left to itself, will be obliterated. Sphagnum mosses grow profusely both in the timber and brush and

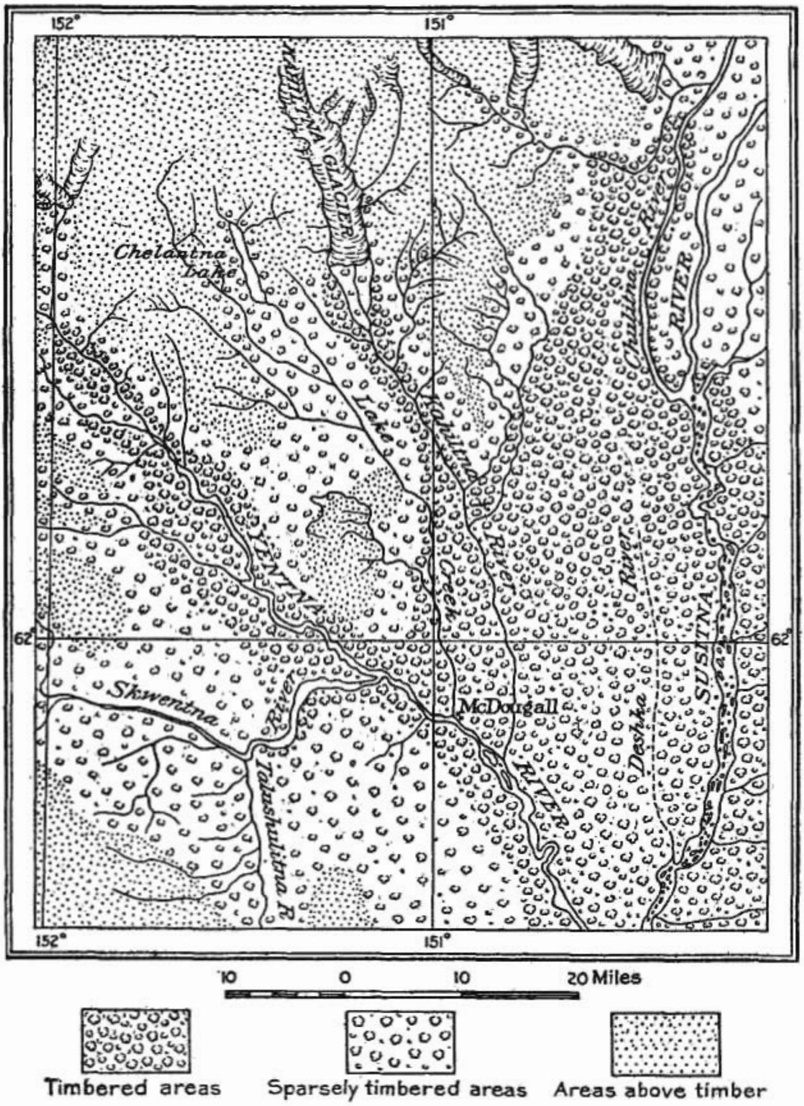


FIGURE 1.—Sketch map showing the distribution of timber in the Yentna district.

above timber line. They absorb and hold large quantities of water and by their protective covering keep the ground frozen in the spring long after the bare ground has thawed out. Above timber line the has been built, which follows the east bank of Lake Creek upstream for about 15 miles and then swings across to Kahiltna River. A bridge which was built across the Kahiltna was washed out in the spring of 1911, so that it was necessary to swim horses at this point, passengers crossing in rowboats. Beyond the Kahiltna the trail follows the high ground along the west slope of Peters Hills and across several miles of marshy ground, which in summer may be crossed by horses with difficulty. Cache Creek valley is reached at the mouth of Spruce Creek and followed upward from that point. As supplies can be transported overland much more cheaply by sled in winter than by any means in summer, and as the winter is the season during which the miners have most leisure, open-cut mining methods being impossible until the streams run free of ice in the spring, almost all of the freighting is done in winter, either from Susitna Station or from McDougall. From the former point the sled route follows Susitna and Yentna rivers either to the mouth of Kahiltna River or to McDougall, depending on the part of the country to be reached. Much of the freight for Peters Creek and its tributaries has been taken up Kahiltna River and Peters Creek. Practically all of the freighting for Cache Creek is done by way of McDougall and the wagon road to the Kahiltna. From the trail crossing at Kahiltna River the winter route most used ascends Kahiltna Valley for some miles and then swings up the slope to meet the summer trail a few miles south of Cache Creek. Until 1907 this region was supplied in summer by a pack train, which used a trail from a point on Yentna River near the forks and, following a course parallel with the base of the mountains, crossed the Kahiltna just below the glacier. It then lay along the northwest edge of the Cache Creek basin and terminated at Home Lake, in the Tokichitna Valley. This trail is now little used, and though portions of it can still be distinguished it is for most of its length so overgrown by brush and grass that one not familiar with its course would have difficulty in following it.

The diggings in the basin of Twin Creek are most often reached by following the Yentna to McDougall, from which supplies are sledded up the wagon road to a point more than half way to the Kahiltna. Here a winter trail branches to the westward and follows up Lake and Camp creeks. In leaving the country in the fall the miners from Twin Creek usually build boats or rafts and float down the Yentna. From Cache Creek the trail and road are used to McDougall and launches are taken from that point to Susitna Station. From the headwaters of Peters Creek the trail to Tokichitna River is often followed, and boats are built to descend this stream and the Chulitna to Susitna River.

One of the serious problems which confront the miners in the various camps is the difficulty of obtaining timber suitable for sawing into lumber for sluice boxes and for other mining uses, as most of the mines are located above timber line. Cache Creek valley and its branches formerly contained some spruce timber up to the point where a sawmill was built, a mile or more above the mouth of Thunder Creek. The heavy demand for logs for the sawmill has caused the cutting away of all the best trees as far downstream as the mouth of Spruce Creek, so that a haul of at least 7 miles to the sawmill is now necessary. A toll of half the logs brought in is charged the miners for sawing at this mill. Peters Creek is timbered below the lower canyon, and logs for lumber and fuel are brought from that locality to the diggings on upper Peters Creek and its affluents. Some logs are also procured for these camps from the Tokichitna Valley. Lumber and fuel for the mines on Mills and Twin creeks are obtained from the lower reaches of these streams, a few miles below the camps.

GEOLOGY.

PRINCIPAL FEATURES.

The distribution of the geologic formations represented in the region is given on the accompanying map (Pl. III, in pocket), and the relations of the various formations to one another are shown in figure 2. The oldest rocks of the district consist of a series of slates and graywackes, which form the cores of all the foothill ranges and are an important element of the Alaska Range, especially along its southeastern flank. The slates and graywackes are interbedded, in some places in about equal amounts, in other places one or the other phase predominates. The slates vary in character from place to place, ranging from fissile, thin-cleaving rocks to more massive argillites, and the high development of the lines of schistosity in many localities makes it difficult to determine the original bedding of the sediments. The graywacke is generally hard and massive and in some of its phases is with difficulty distinguished from fine-grained dike rocks, for which it is often mistaken by the miners. This slate and graywacke series forms the hard bedrock of the placer camps in the Cache Creek basin.

After the sediments of which the slates and graywackes are composed were deposited they were metamorphosed almost to their present state, the changes consisting of an alteration from muds and sands into hard slates and graywackes. This was accompanied or followed by rather intense folding and faulting, which probably took place while the materials were buried beneath a heavy covering of later sediments. The metamorphosed series was then intruded by large masses of granitic rocks, which formed great laccoliths in the slates and which sent out many dikes into the surrounding rocks and still further metamorphosed the materials near the contacts. The whole mass was then uplifted, and erosion exposed the intrusive masses which now form much of the high part of the Alaska Range. The effects of the intrusion are seen in the abundant veins of quartz which are found in the slates for several miles from the borders of the

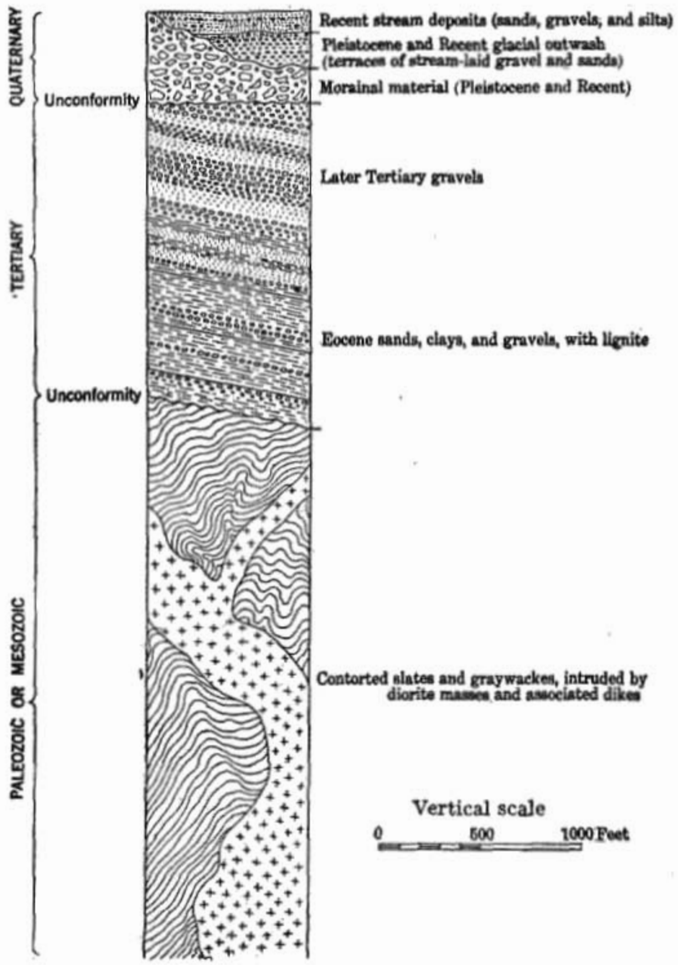


FIGURE 2.—Generalized columnar section of the rocks of the Yentna district.

intrusives, and it is probable that these veins are the source from which the placer gold of the district has been derived. The evidence at hand regarding the age of the slates and of the granitic rocks will be discussed in a later paragraph.

Tertiary beds, composed of little-consolidated sands, shales, gravels, and some lignitic coal, overlie the slates in the more favorably situated depressions between the foothill ranges and extend eastward from these hills, the beds forming the so-called "soft bedrock" of the miners. They disappear beneath the later deposits of the Susitna basin, but their structure along the slopes of the Yenlo and Peters hills, and their presence in the deep canyons of Kahiltna River and Lake Creek indicate that they probably underlie much of the broad Susitna basin. Coal that probably formed a part of these beds has been mined on the south bank of Yentna River, about 7 miles above its mouth. In the area near the head of Twin and Camp creeks the coal-bearing series is overlain by a heavy deposit of stream-washed gravel, much coarser than anything seen in the coal-bearing series itself. Exposures of this gravel series are also found on the west side of Treasure Creek. The gravels are many hundred feet thick and seem to be structurally conformable on the coal-bearing beds.

Next younger than the Tertiary sediments and the associated gravels is the widespread blanket of glacial materials that masks the older formations throughout a great part of the area outside of the high mountains. The glacial beds consist of morainic materials deposited directly by glacial ice and of gravels which were laid down by the glacial streams. The morainic material in most places consists of tough blue clay, in which gravels, bowlders, and angular pieces of rock are embedded and in which there is a complete lack of assortment of materials such as is found in water-laid beds. Glacial striations are particularly abundant on the rocks in the glacial till in this region. The glacial gravels form most of the benches along the sides of the stream valleys. The glacial deposits shown on the map (Pl. III) vary greatly in thickness from place to place, but over the area shown they are of sufficient thickness to conceal the underlying formations. The latest deposits considered are the gravels of the present streams, which form narrow strips along most of the creek valleys and cover large areas in the basins of the more important rivers.

SEDIMENTARY ROCKS.

SLATE AND GRAYWACKE SERIES (PALEOZOIC OR MESOZOIC).

Distribution and character.—A thick series of slates and graywackes forms the underlying hard bedrock throughout a large part of the area here considered. Its surface outcrops (Pl. III, in pocket) extend from Yenlo Hills to a point far up the Yentna, probably to the glaciers on the East Fork and from the Yentna in a northeast direction beyond Tokichitna River. As will be shown later, what are probably the extensions of this series stretch both north and south of the Yentna region. Within the limits defined, however, the slates and graywackes form an important part of the alpine portion of the Alaska Range, especially along its flank, and form the cores of both Dutch and Peters hills (Pl. VII, *A*). They consist chiefly of black to gray slates and phyllites, in many places carbonaceous, and beds of graywacke, which range from fine-grained to coarse gritty rocks. In some places the rocks are massive, with argillites instead of slates, but the foliated types are much more widespread than the massive types. It is difficult to estimate just what proportion of the whole series is formed by the graywacke beds. Many sections show great thicknesses of the slaty phases, with very little graywacke present. At other localities the graywackes preponderate, occurring in thick, massive beds that show little foliation or schistosity and that are often mistaken by the miners for fine-grained dike rocks, which they closely resemble. The whole series is much jointed, the graywackes less closely than the slates, which are in many places broken into long prismatic pieces by sets of intersecting joints. In the Yenlo Hills, in addition to the usual slates, phyllites, and graywackes, there are certain siliceous beds of the series that are almost quartzites and that are intricately and closely cut by tiny veinlets of quartz. Evidences of mineralization are widespread in these rocks. A characteristic phase of the slates in many places throughout the region contains small cubical cavities, the largest a quarter of an inch in diameter, formed by the leaching out of cubes of iron pyrite, the rock being discolored for some distance around each cavity. Some of the graywacke beds also show the presence of much finely disseminated pyrite.

Glaciation in the slate area has been so severe and the mechanical weathering of the high mountains in postglacial time has been so rapid that few opportunities are afforded for the study in place of the residual materials formed from these rocks. At several places, however, where the slate series was overlain by Tertiary deposits, the old pre-Tertiary weathered surface has been preserved, to be exposed by recent stream cutting. At these localities the slates, when deeply decayed, break down into whitish and bluish kaolinic clays, and the graywacke beds, by the removal of the cementing material, yield soft arkosic sandstones.

In the higher mountains a great mass of granitic rocks has been intruded into the slates, and for several miles from its borders dikes of various kinds of rock occur. Most of the dikes are narrow and of no great length, and no attempt has been made to map any but the larger masses. Nevertheless, the intrusions as a whole have had an important influence on the economic development of the district. The intrusive rocks will be described in another section of this report. Along the contact with the great intrusive mass of the main range the slates and graywackes have been profoundly metamorphosed into hard dense rocks, which under the microscope show, besides carbonaceous material and quartz, such secondary minerals as biotite, muscovite, garnet, andalusite, and cordierite. The extreme effects of contact metamorphism appear for only a short distance beyond the contacts, but an unusual amount of mineralization is present for several miles from the intruded bodies. The abundance of quartz veins is also dependent on nearness to the contact, the number and size of the veins being greatest near it, and decreasing with distance. Few veins which might be called true fissure veins were seen, most of them being small gash veins of irregular shape or even minute leaf-like stringers. In the rocks of the slate series, within 8 or 10 miles of the intrusive contact, all of the gold-producing streams of the Cache and Peters creeks region have their heads, and the mineralization of the slates is in large measure due to the influence of the granitic intrusions and of the associated dikes. Though as yet no gold has been found in veins in place, pieces of small quartz veins with adhering slate walls, containing free gold, have been found in the sluice boxes on several creeks, and this and other known facts point to the veins in the slate and graywacke series as the source of the gold which is now being recovered by placer methods from the streams in the Cache Creek region.[1]

Structure and thickness.—Structurally the slates and graywackes are everywhere folded and faulted, though in varying degree in different places. In some localities the folds are gentle, and for some distance the beds appear to have uniform dips and seem to be merely tilted. Other exposures show intense folding in more than one direction, a wide range of strikes and dips being seen within short distances. Even hand specimens of the rock may show complex systems of minute folds. The development of a slaty cleavage and of well-defined systems of joints adds to the difficulties of working out the structure of the series, as either the direction of cleavage or of a pronounced system of joints may be mistaken for the planes of bedding. The most reliable readings of the true strike and dip in any locality were found to be those taken on beds of graywacke interbedded with the slates, for these denser beds are less readily metamorphosed than the slates and seldom show foliation or schistosity. A large number of strike and dip readings show that the trend of the strike is almost everywhere in a general northeast-southwest direction, the average being N. 62° E., parallel with the trend of the Alaska Range. There is greater variance in the direction and angle of dip of these rocks, as is to be expected from the presence of minor folds, but the majority of the dips were to the southeast, away from the high mountains, the average dip being about 60° in that direction.

[1] A quartz vein containing visible free gold is said to have been found on upper Nugget Creek since this report was written. This discovery strengthens the conclusion already reached—that the quartz veins in the slates and graywackes are the source of the gold found in the stream placers.

It will thus be seen that the slate and graywacke series lies on the limb of a great structural anticline which parallels the axis of the mountain range. In the southward continuation of this series Brooks[1] has found similar conditions to prevail in the Kichatna basin. In addition to the folding the rocks have also been severely affected by faulting. One fault is known in which the displacement must be measured in thousands of feet, and doubtless there are many other faults which escaped detection, as the character of the beds is so uniform throughout the series that offsets are inconspicuous, and the surface scarps have as a rule been removed by glacial erosion. The facts known are not sufficient to justify estimates of the thickness of the series. The dips may be fairly uniform through considerable distances, but the problem is complicated by the possibilities of unknown faults which may reduplicate the beds. It is certain, however, that the series is several thousand feet thick. Brooks[1] gives a provisional estimate of 2,000 to 3,000 feet for the section along the Kichatna Valley, and this seems a very moderate estimate for the Yentna region.

Age and correlation.—Within the area studied the formations which underlie the slates and graywackes were nowhere seen and nothing was learned about them. The metamorphism and erosion which the slates and graywackes have suffered indicate that a long period intervened between the deposition of these rocks and those next younger, the Tertiary coal-bearing beds. A careful search for fossils in many places failed to reveal anything which might aid in the determination of their age. Nothing was learned, therefore, to establish their age beyond the fact that they are pre-Tertiary. On the continuation of this belt in the Kichatna Valley, Brooks[2] has made the following statement:

> The slates above described are overlain by rocks assigned to the Middle Jurassic. They resemble somewhat the argillites on the west side of the Alaska Range which form a part of the Tonzona group and are assigned to the Silurian or Devonian. They are also somewhat similar to the metamorphic sediments of the Knik Arm region, which have been described on page 61. The structure of the cross section of the Alaska Range between the Kichatna and the Kuskokwim is that of a synclinorium whose center is occupied by the Mesozoic beds. The above facts all point to the conclusion that these slates are of Paleozoic age, and if a more definite assignment should be made they would probably be correlated with a part of the Tonzona group (Devonian or Silurian) of the Kuskokwim Valley. As the slates have yielded no organic remains, their age can not now be more definitely determined. It should be noted, however, that these supposed Paleozoic slates are not very different lithologically from some of the overlying Jurassic beds, and it is by no means impossible that they may be Mesozoic. They differ from the Jurassic rocks in being some-

[1] Brooks, A. H., The Mount McKinley region, Alaska: Prof. Paper U. S. Geol. Survey No. 70, 1911, pp. 67–68.
[2] Idem, p. 68.

what more altered and in the fact that the fragmental beds, such as graywackes, form only a small percentage of the bulk of the material, whereas in the Tordrillo formation the grits and sandstones are more abundant than the slates.

It has been shown that the northeastern extension of this belt would carry it parallel to the Alaska Range, and slates have been reported by prospectors in this general region. Similar rocks were observed by Eldridge along the headwaters of the Susitna, though these are associated, as will be shown, with some heavy limestone. It is probable that the slates of the Kichatna section are synchronous with some of the rocks found by Eldridge near Broad Pass, but at present no more definite correlation can be made.

The work in the Yentna region in 1911 has served to confirm the conclusion reached by Brooks—that the same slate series is continuous from the Kichatna in a northeast direction along the front of the range. Although the mapping in the Yentna region was not extended quite far enough to the northeast to connect with the area visited by Eldridge, the gap left is scarcely 10 miles in width, and it seems justifiable to presume that the slates of the Kichatna and Yentna regions are the same as those noted by Eldridge in the headwater region of Susitna River and mapped by Brooks in the report quoted above as "undifferentiated metamorphic rocks of unknown age but probably chiefly Paleozoic."

In the lack of conclusive evidence of their age the rocks of the slate and graywacke series can only be provisionally assigned to the Paleozoic or Mesozoic.

Intrusive rocks.—It has already been stated that the slate and graywacke series is cut in the higher parts of the mountains by a large intrusive mass and that dikes of various kinds are also found in many places. As these intrusives cut the slates and contain inclusions of them, they are known to be younger than the slate series. Furthermore, as intrusive rocks were nowhere seen to cut the Tertiary beds, it is concluded that the intrusives are older than the Tertiary. The description of the various types of intrusive rocks is given on pages 45–47.

TERTIARY SYSTEM.

EOCENE SERIES (COAL BEARING).

Distribution.—Between the slates and graywackes and the next younger sediments of the region, the Tertiary beds, there is a break in the geologic succession, representing a long period of time during which the slates were indurated, folded, and faulted and then intruded by great bodies of igneous rock. After the cooling of the intrusions the rocks were subjected to erosion and an unknown amount of material was removed. It is even possible that great thicknesses of rocks of various kinds were laid down over this area to be completely removed by erosion before the beginning of Tertiary times. The relief of the Alaska Range at the end of this interval is believed to have been less sharp than at present, and broad drainage basins had probably been established, one of them in a position somewhat similar to that of the present Susitna River. The change from conditions of erosion to those of deposition was probably brought about by a gradual subsidence, which caused the materials eroded in the headwater regions of the streams to be deposited, in Eocene times, in the lower portions of the basin as estuarine, fluviatile, or lacustrine beds. These sediments now occupy considerable areas in the Yentna region, extending from the base of the high mountains toward the lowlands. Their areal distribution is shown on Plate III (in pocket), but the mapped areas indicate only those places where the Eocene beds outcrop at the surface. It is certain, however, that the Eocene deposits underlie large areas in the lowlands, where they are covered by morainal material and by recent stream gravels. Beds of this age outcrop at many places where deep stream valleys have cut through the overlying materials, as in the gorges of lower Lake Creek and Kahiltna River, so that it is justifiable to presume that the Eocene beds are continuous between these streams and extend for some distance both to the east and west of them, and also that they underlie much of the high plateau north and west of Yenlo Hills. Furthermore, exposures show their presence at many points around the borders of the great Susitna basin, as on the Skwentna opposite the mouth of Hayes River; on the lower Kichatna; along the east base of Peters Hills; between Chulitna and Susitna rivers; on lower Matanuska River, and at many points around the head of Cook Inlet. In the central portion of this basin the beds are exposed at Susitna Station, and on Yentna River about 7 miles above its mouth. A more complete knowledge of this little-known region will unquestionably show many more occurrences of these rocks, and the evidence already at hand lends strong support to the presumption that the Tertiary beds underlie much of the lower Susitna basin below the borders of the surrounding mountains.

In the territory bordering the mountains in the Yentna district the Eocene beds were deposited over a considerably larger area than that which they now occupy, to be subsequently removed by erosion. They may once have been continuous between Martin and Cache creeks, over what are now the Peters Hills, and their preservation in the northwest extensions of the field is in most places due to a favorable location protected from severe erosion by glacial ice and by streams. The edges of the areas of Eocene deposits almost everywhere show the effects of erosion, for the materials are soft and are easily removed by streams or by glacial ice. In most places it is now impossible to determine how much of the surface was formerly covered by these beds, but all of the processes of erosion have tended to cut back the edges of the coal-bearing sediments, and their present distribution is certainly much more restricted than were the original basins in which the materials were deposited.

Character.—The character of the Eocene beds is more or less uniform in the many outcrops examined, even in widely separated localities. Most of the exposures show only a small part of the total thickness of the series, but even where the outcrops are small little difficulty is encountered in identifying them. The beds consist predominantly of unconsolidated or loosely consolidated clays and sands, containing layers of fine pebbles, and commonly some lignitic coal. Even where the surface is covered with vegetation pieces of lignite in the stream beds often serve to indicate the presence of these deposits. At the few localities where the relation between the Eocene sediments and the underlying slates could be studied, the slates and graywackes have been deeply weathered and decayed, the slates having broken down to a bluish-white kaolinic clay and the graywackes changed to a soft gritty sandstone before the overlying materials were deposited. It is often difficult to determine the point at which the clay shales of the Tertiary succeed the residual clays of the slate series. The coal-bearing sediments consist of alternating clays, sands, and fine gravels, the beds in most places being little consolidated, though here and there a coarser layer has been cemented into a rather fine conglomerate or grit. At a bluff on the east bank of Susitna River at Susitna station there is an outcrop of a coarse-grained conglomerate which Spurr [1] refers provisionally to the Kenai formation, of Eocene age, but nothing similar to this rock was seen in the Yentna region.

Lignitic coal occurs in the Tertiary rocks in many places. All of the coal examined was rather fibrous and woody, of a brown to black color, and is of little value except as a source of local fuel supply. The beds examined are from a few inches to 12 feet in thickness.

The most complete section of the Eocene beds examined is found on the head of Cottonwood Creek, northwest of Fairview Mountain, between Lake Creek and the Yentna (Pl. VIII, *A*, and fig. 3). The heavy deposit of gravels that overlies the coal-bearing series, although it seems to be structurally conformable with it and to be a continuation of the Eocene sedimentation, may be of Eocene or later Tertiary age, and is discussed on pages 33–36 of this report.

Structure and thickness.—The Eocene sediments of the Yentna region, considered as a whole, have not been greatly deformed. On lower Lake Creek the beds lie nearly flat, and it is probable that this condition prevails throughout much of the Susitna lowland. On

[1] Spurr, J. E., A reconnaissance in southwestern Alaska in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, p. 172.

the east base of Peters Hills the dips are a few degrees to the east, away from the hills. The beds there have been cut by minor faults, a displacement of about 10 feet being observed at the mouth of the Peters Creek canyon. In the area at the head of Slate, Twin, and Mills creeks, also, the beds dip to the southeast, away from the mountains, but with steeper angles, ranging from 6° to 22°. Faulting has here played an important part in determining their attitude and by influencing the direction of flow of the earlier glaciers and of the streams has indirectly influenced the shape and distribution of the areas which these beds now occupy. The most prominent fault follows the line of Pass Creek valley, and the displacement at this place has probably been over 2,000 feet (fig. 4). The present topography of the hills at the head of Twin and Mills creeks suggests that there are other faults, parallel with the one on Pass Creek, which have served to duplicate the Eocene deposits in this locality, giving them a greater apparent than actual thickness. The faulting and tilting have failed to metamorphose the beds noticeably, even in those places where the movement has been greatest, and most of the materials are unconsolidated or loosely consolidated clays, sands, or gravels. At one exposure, on upper Mills Creek, the sands have been cemented to form a soft sandstone, and at other places the coarser pebbly layers have been locally cemented to form rather firm rocks, but in general the Eocene sediments are still incoherent. No intrusive rocks were found to cut the Tertiary beds, and it is believed that they are all older.

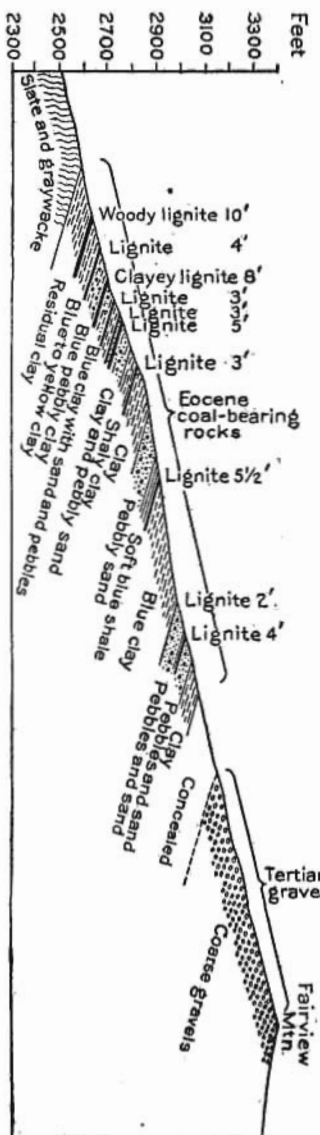


FIGURE 3.—Structure section at head of Cottonwood Creek, north of Fairview Mountain, showing relations of the slates and graywackes, the Eocene coal-bearing sediments, and the overlying Tertiary gravels.

The complete series of the Eocene coal-bearing beds is probably nowhere exposed in the Yentna region, and any estimates of its thickness, based on the sections examined there, are likely to fall short of the original maximum thickness of the series. In many places in the Cache Creek valley 250 to 300 feet of the beds are exposed without showing their base, and at these places erosion has without doubt removed the upper portion of the series. The most complete section examined is that on the north side of Fairview Mountain (fig. 3, p. 31), at which locality over 900 feet of Eocene beds overlain by the Tertiary gravels are exposed. As Fairview Mountain is probably near the northwest border of the area which received Eocene sediments, and as the deposition of Eocene beds is believed to have commenced in the lower parts of the Susitna-Cook Inlet depression and to have gradually extended to its borders, it is entirely possible that the series at Fairview Mountain is incomplete; lacking the lowest members represented around the borders of Cook Inlet.

Age and correlation.—The determination of the age of the coal-bearing series has been based on lithologic, stratigraphic, and paleontologic grounds. The distinctive character of the sediments, which differ from all other rocks of the region, suggests at once their correlation with the coal-bearing beds of Cook Inlet. This similarity is emphasized by the occurrence of lignitic coal in the series at both places. At Tyonek, on Cook Inlet, similar beds have been determined by Arthur Hollick and F. H. Knowlton, on the evidence of fossil plant remains, to be of Kenai age, now assigned to the Eocene. In the Yentna region, fossil plant remains were found at only a few localities, and as they occur in soft clayey shales, it was difficult to preserve them unbroken until they could be brought back for identification. In the material collected, however, enough forms were identifiable to correlate the coal-bearing series of the Yentna region definitely with the Kenai formation of

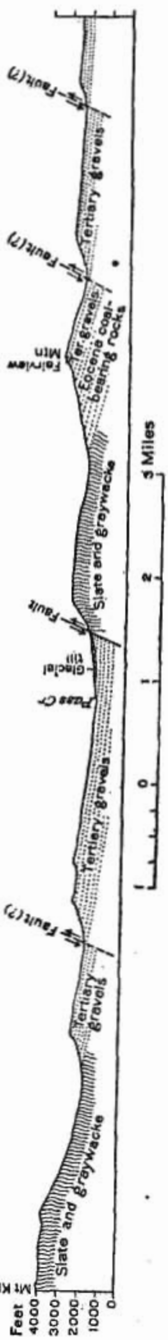


FIGURE 4.—Cross section through Fairview Mountain and Mount Kliskon, showing structural relations between the slate and graywacke series, the Eocene coal-bearing sediments, and the overlying Tertiary gravels, and the positions of known and probable faults.

Cook Inlet. The collections were examined by Arthur Hollick, who made the following determinations:

Collection No. 1.

From Cache Creek, one-half mile above Cache Creek Mining Co.'s camp. From bed 280 feet below top of series as here exposed.

The matrix is a very friable clay. Many of the specimens were broken in fragments and of no value. The following identifications were made:

Taxodium tinajorum Heer.
Populus arctica Heer.
Corylus macquarrii (Forbes) Heer? Fragment.
Corylus? Fragments.
Alnus kiefersteinii Goepp.
Juglans acuminata Al. Braun.
Quercus pseudocastanea Goepp.
Planera ungeri Ettingsh.? Fragment.
Acer arcticum Heer? Fragmentary.
Fruit of Acer arcticum Heer?
Grewia crenulata Heer? Fragmentary.
Rhamnus, perhaps new species, like R. salicifolia Lesq.

Age, Tertiary (Eocene).

Collection No. 2.

From bed of Cache Creek, three-quarters of a mile below collection No. 1, in approximately the same horizon.

This collection consists of a single piece of hardened ferruginous clay, containing on one side poorly preserved remains of a conifer (Sequoia langsdorfii (Brongt.) Heer?) and on the other a fragmentary angiosperm leaf, possibly Corylus sp.

Age, apparently Tertiary (Eocene).

Collection No. 4.

From bed of creek in Chicago Gulch, Mills Creek basin.

Matrix, friable clay, containing one species (Betula prisca Ettingsh.).

Age, Tertiary (Eocene).

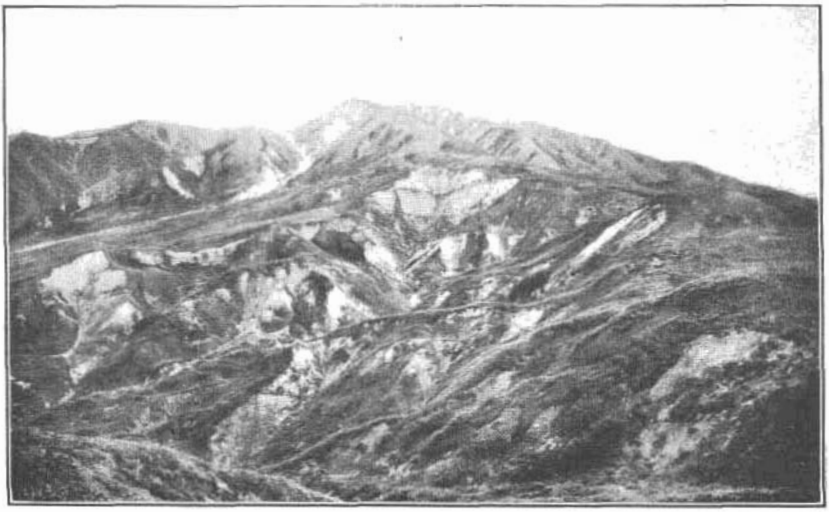
The above determinations show that the coal-bearing beds of both the Cache Creek and Mills Creek valleys are of Eocene age. More complete collections, taken from the upper and lower parts of the series, would limit more sharply the portion of Eocene time represented by these deposits, but the age determination is sufficiently definite to show that the beds were laid down at the same time that much of the Susitna basin and Cook Inlet area, as well as extensive regions in other parts of Alaska, were receiving similar deposits.

GRAVELS

Character and distribution.—At a number of localities within this district there occurs a thick deposit of coarse, stream-washed gravels lying above the sands and clays of the Eocene coal-bearing series. These gravels are best exposed in the hills between the heads of Slate and Pass creeks, and on Cottonwood Creek along the north side of Fairview Mountain (Pl. VIII, *B*). Similar deposits exist at a number of places, including upper Treasure Creek (Pl. IX, *A*), Nugget Creek at the mouth of the canyon, and Cache Creek at the mouth of Windy Creek, but the relations of the gravels to the coal-bearing series at these localities are not clear. In the excellent exposure on the head of Slate Creek the section shows 1,100 feet of beds, composed almost entirely of coarse gravels (Pl. IX, *B*), but containing a very small proportion of finer sandy beds. The gravels are rudely stratified, as though by streams, the largest bowlders being about 1 foot in diameter, but most of the pebbles measure from 2 to 4 inches through and are mixed with much sandy material. A large variety of rocks is represented by the pebbles—slates, graywackes, black and gray conglomerates, and quartz are present, as well as diorites and many other types of igneous rocks. The deposit throughout its thickness shows a yellowish color due to oxidation, but the yellow color is evidently only a coating on the pebbles, for it has disappeared from the materials that have been rehandled by streams. The great age of these gravels is attested by their decayed condition, many of the pebbles being so rotten that they crumble and fall to pieces when disturbed, although they must have been hard and firm when they were rounded and deposited by the streams.

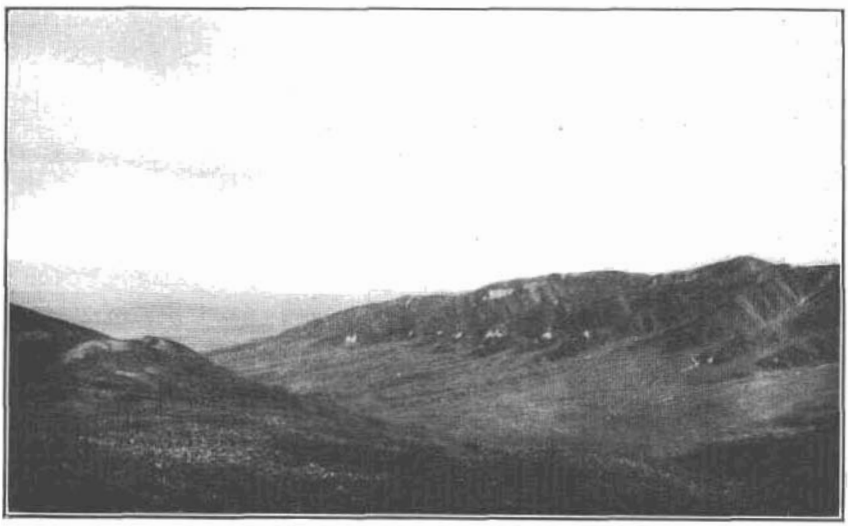
Structure and thickness.—Evidences of the stream-laid character of the gravels were seen at all the exposures examined. The imperfect assortment, with lenses of coarse sand and some silt, is remarkably like that seen in the deposits of the present streams. The great thickness of the beds, however, and the width of the area over which they are supposed to have once been continuous, indicate that they were laid down as a sloping plain of alluvial outwash along the flanks of the range, their original slope being a few degrees southeast. Since their deposition the gravels have been uplifted and faulted, and the present slope of the beds, though in the same direction as the original slope, is much greater, the observed dip being 11° SE. at the head of Slate Creek, decreasing away from the mountains to 5° or 6° near Pass Creek, 16° SE. on Fairview Mountain, and 5° to 6° S. on Treasure Creek. At the Pass Creek locality and on Treasure Creek the depositional angle of dip has been increased by the uplift of the mountain range, the uplift having involved the foothills also in the general elevation. The still steeper dips on Fairview Mountain are due to a strong upward movement of the rocks on the south side of the Pass Creek fault.

The original thickness of the gravels is not known, as the complete series is probably nowhere present in this district. At all the exposures examined the beds have suffered much from erosion, and a part of the series has been removed. The greatest thickness noted



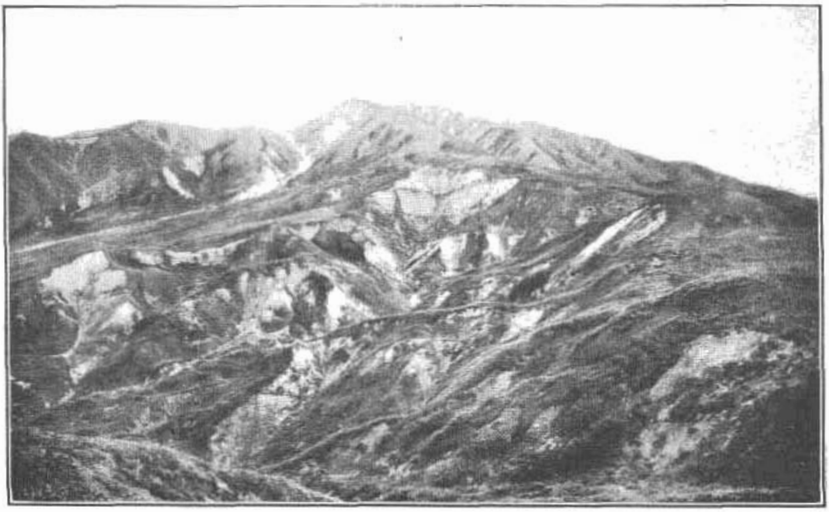
A. THE EOCENE COAL-BEARING SERIES AND OVERLYING TERTIARY GRAVELS ON THE NORTHWEST SIDE OF FAIRVIEW MOUNTAIN.

The immediate foreground is composed of slate. The Eocene beds, containing lignitic coal, are overlain by Tertiary gravels, which form the upper part of the mountain.



B. TERTIARY GRAVELS ON THE SOUTHEAST SIDE OF COTTONWOOD CREEK NEAR FAIRVIEW MOUNTAIN.

Postglacial erosion has cut deep gulches in the gravels and formed an alluvial apron at their base, whereas the slate (in the foreground) shows little erosion.



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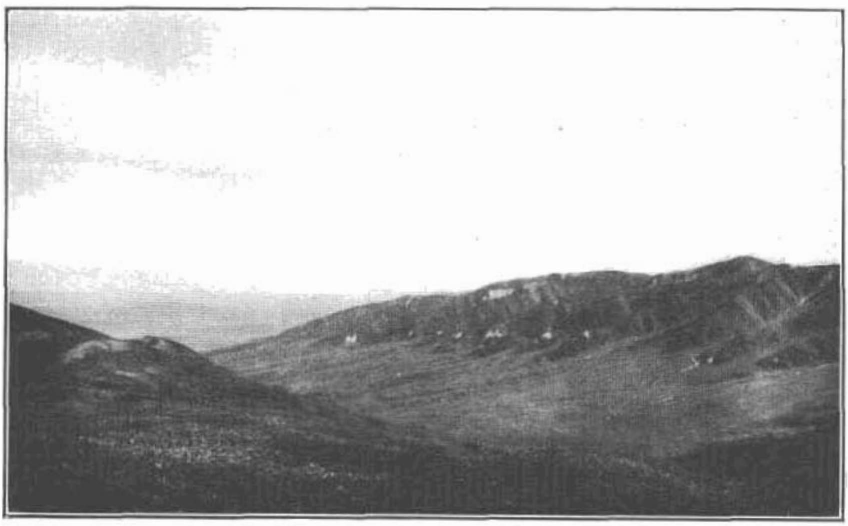

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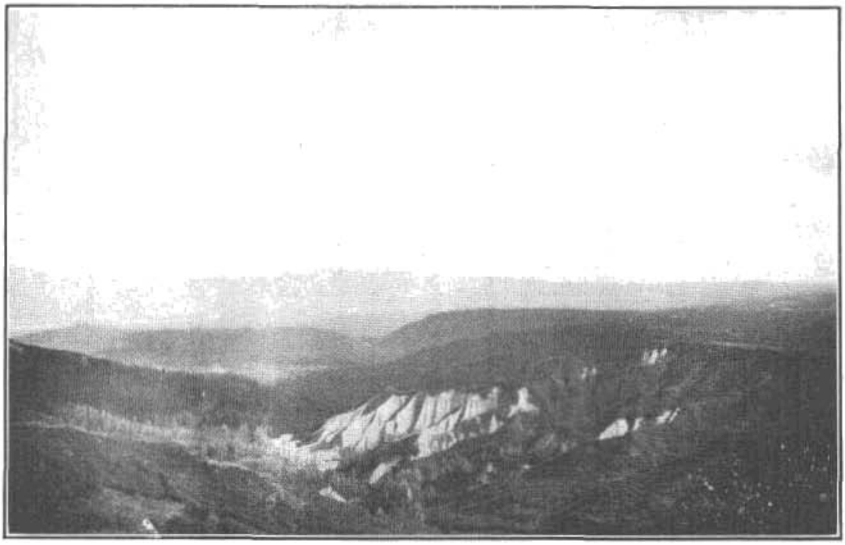
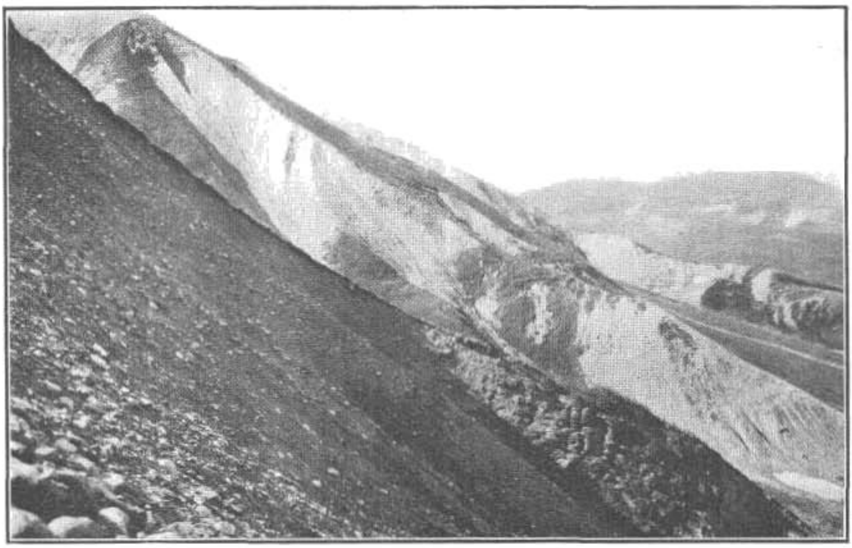


A. TERTIARY GRAVELS ON THE UPPER PART OF TREASURE CREEK.



B. TERTIARY GRAVELS AT THE HEAD OF SLATE CREEK.

The hills in the distance at the right are of slate and graywacke, upon which the gravels lie unconformably.

localities the beds have been tilted and dip away from the mountains. In the Bonnifield region, near Wood River, the writer found the Nenana gravel lying unconformably on coal-bearing beds, but there was no evidence that these beds represented the top of the coal-bearing sediments, and the unconformity might be only a local variation, and the succession from the coal series to the gravels continuous, both structurally and chronologically, throughout most of the area. The writer was inclined to believe that in the Bonnifield region there was a time break between the coal series and the gravels. A later study of the Yentna region, where structural conformity exists between the Eocene coal-bearing series and the gravels, has shaken this conclusion and given additional weight to the view held by Prindle that if the two series of deposits were separated by a time interval at all it was relatively short.

It has been shown that the gravel series is younger than the Eocene coal-bearing beds. The next younger deposits seen are of glacial origin, probably of Pleistocene age, and these in many places overlie the gravels. Furthermore, the gravels and the coal-bearing sediments are cut along Pass Creek valley by a fault which displaced the beds some thousands of feet. (See fig. 4.) The high slate scarp of this fault, on the southeast side of the valley, was overridden by ice at the time of the maximum glaciation and was smoothed and sculptured by the glacier into characteristic and unmistakable forms. There has been no considerable movement along this fault since the disappearance of the glacial ice. If, then, a fault of some thousands of feet displacement had taken place before glacial times, it appears evident that the gravels cut by this fault must be considerably older than Pleistocene, and this conclusion is supported by the advanced stage of oxidation and decay of the gravels, as compared with the deposits of known glacial origin.

It can therefore be stated definitely that the gravel series is older than the time of the last great glaciation and is younger than the Eocene coal-bearing beds. Its stratigraphic conformity with the Eocene deposits, both in this region and in other parts of the Alaska Range, seems to justify its assignment to the Tertiary.

QUATERNARY SYSTEM.

PREGLACIAL CONDITIONS.

The elevation of the area now occupied by the Alaska Range, which rejuvenated the streams and caused them to build the gravel outwash plains along the mountain foot, continued after the gravels described in the preceding pages had been deposited and in time affected also the foothill areas which had previously received a gravel covering. This widespread uplift ultimately caused the larger streams to intrench themselves in the gravel filling in great valleys running at right angles to the axis of uplift. The movement tilted the gravels in some places and folded or faulted them in others. How long this elevation continued, or whether or not it is even now completed, is not known, but it is believed that the more important topographic features, such as the main mountain range, the foothill ridges, and the larger river valleys were all developed by the end of Tertiary time. In the details of surface configuration, however, the appearance of the region must have been greatly different from that of to-day. The land forms had been developed chiefly by weathering and by stream erosion, and the valleys were no doubt of the usual stream-cut type, V-shaped in cross section, and with interlocking spurs. There must also have been great accumulations of talus at the base of the steep slopes and of deeply decayed rock and soil in the regions of less relief.

GLACIAL EPOCH.

ADVANCE OF THE ICE.

The glacial epoch was inaugurated by a decided change in climatic conditions, either a lowering of the temperature, an increase in precipitation, or a combination of the two. At any rate, there was a gradual accumulation of snow in favorable situations, probably taking place first on the peaks of the highest mountains. As each winter added its quota of unmelted snows the snow fields became of wider extent and of greater thickness, until sufficient ice had accumulated in the valley heads to form small glaciers and start glacial movement. These smaller glaciers gradually extended down their valleys, joining in the main drainage lines to form great ice tongues.

Whether or not there was more than one important stage of glaciation in the Alaska mountains is still uncertain. Recent studies in the high mountains of Colorado have shown that there were at least two, and probably three, distinct glacial advances, separated from one another by long periods of time, and that the first one was much more extensive than the last two, the evidences of which are distinct and unquestionable. In the Yentna region, as well as in other parts of the Alaska Range, the last great ice advance was so extensive that it destroyed or covered up all deposits of earlier glaciations, if they existed there, and although future detailed work may prove that there have been earlier glacial periods in Alaska, there are as yet no data on which such an assumption can properly be based.

The glaciers, as they grew and advanced farther and farther from the valley heads, were able by their erosive action to profoundly alter the topography of their basins. They removed first the loose soil, talus, and residual materials and then attacked the hard rock surfaces that they had uncovered. Heavy, constantly moving glaciers shod with rock fragments are agents admirably adapted to remove any obstructions which may oppose their advance or restrict their channels. They removed all hills, projecting spurs, and other irregularities of their beds, and changed the normal V-shaped cross section of stream-cut valleys in high mountains to the broad U shape characteristic of glacially sculptured basins. In this region the most conspicuous examples of straight, steep-sided U-shaped valleys are those of Yentna, Kahiltna, and Tokichitna rivers, though there are great numbers of smaller but no less perfectly developed glacial troughs, both in the foothills and on the flanks of the main range.

EXTENT OF GLACIATION.

That the glaciers in this region were formerly of much greater extent than now is shown by the distribution of glacial deposits and by the topography of the area over which the ice spread. It has long been known that Susitna basin was once occupied by a great glacier which reached tidewater in Cook Inlet. Brooks[1] has noted the presence of glacial till along the shores of Cook Inlet and has stated that the ice moved far down this depression, it being possible that the glacier terminated not far from the mouth of the inlet. It received ice from the mountains of Kenai Peninsula and from the Chigmit Mountains west of Cook Inlet, and important tributary ice streams came down Turnagain Arm and the Matanuska Valley, but the great supply of ice must have come from the high mountains which surround the Susitna basin. Glacial deposits are also known to exist throughout the area of Copper River basin and in the broad depression along the upper Susitna between Copper and Susitna basins, so that a great connected ice field must at one time have occupied all of the area between the coastal mountains and the Alaska Range, broken only by the high mountain masses which projected above its surface. There was at that time a continuous glacier reaching from Broad Pass to the head of Cook Inlet and an unknown distance down it. It certainly had a length of 200 miles and may have been over 300 miles long. All the lowland area of the Yentna region was covered by this glacier. Brooks[2] has noted glacial terraces along Kichatna River, at an elevation of 2,400 feet, which he considers to mark the upper limit of glaciation at that place. On Yenlo Hills, however, at a point farther from the mountains that supplied the ice, glacial erratic bowlders were found at an altitude of 3,300 feet, and the rounded and smoothed form of the hills indicates that the glacier overrode all of this ridge, except possibly the highest peak, so that its surface there had an elevation of at least 3,600 feet.

[1] Brooks, A. H., The Mount McKinley region: Prof. Paper U. S. Geol. Survey No. 70, 1911, pp. 126-127.
[2] Idem, p. 127.

Fairview Mountain, about 3,000 feet high, has foreign bowlders on its top. In the valley of Granite Creek, a tributary of the Kahiltna, there are definite evidences of glaciation at an altitude of 4,200 feet. It therefore seems reasonable to attribute the rounded outlines and smooth crest line of Peters Hills and of most of the Dutch Hills south of Peters Creek to the erosive action of an overriding ice sheet. There the Dutch Hills reach elevations of 4,600 feet, and it may be that the crest of the ridge rose above the level of the surrounding ice sheet, but if so it was probably covered by a dome of ice which originated upon it. Peters Hills barely exceed 4,000 feet in height and were probably overridden by the glacier. The chief lines of glacial movement were from northwest to southeast, along the Yentna, Kahiltna, and Tokichitna valleys, as far as the east front of the foothills, where the ice joined the southward-moving ice sheet in Susitna basin. On the flanks of the main range the surface of the glacier, at the time when the glaciation was most intense, stood at an elevation of about 4,000 feet. The ice then probably had a thickness of 3,600 feet in Yentna valley at the forks of the river, 2,600 feet on the plateau between the Yenlo Hills and Fairview Mountain, 3,500 feet in Kahiltna Valley at the mouth of Cache Creek, and 2,000 feet at the mouth of Nugget Creek. It is believed that glacial ice from the Tokichitna Valley flowed to the southwest through the basin of Cache Creek and through the divide from Bear into upper Peters Creek.

There is a strong contrast between the development reached by the ice on the south and east sides of the Alaska Range and that reached on the inland front of this range. Brooks[1] records that in the Kuskokwim basin the ice moved from the mountains far out into the lowland and that northwest of Mount McKinley it probably reached as far as Lake Minchumina, a distance of about 65 miles from its source. In the Bonnifield region, between Nenana and Delta rivers, the writer[2] found that on the main drainage lines the outermost moraines lie 30 to 40 miles from the valley heads, but the glaciers failed to coalesce into any such continuous ice field as that which occupied the opposite side of the range. The much greater development of ice on the south side of the Alaska Range is probably due to the fact that in glacial time, as now, the moisture-laden winds from the Pacific dropped their burden as snow on the south slope of the mountains and were relatively dry by the time they crossed the range to the interior. Another factor which favors the Pacific slope glaciers is the greater area of their accumulating grounds. On the south slope the average distance from the crest line to the base of the main range is more than 25 miles, whereas on the north it is only half this

[1] Brooks, A. H., op. cit., p. 126.

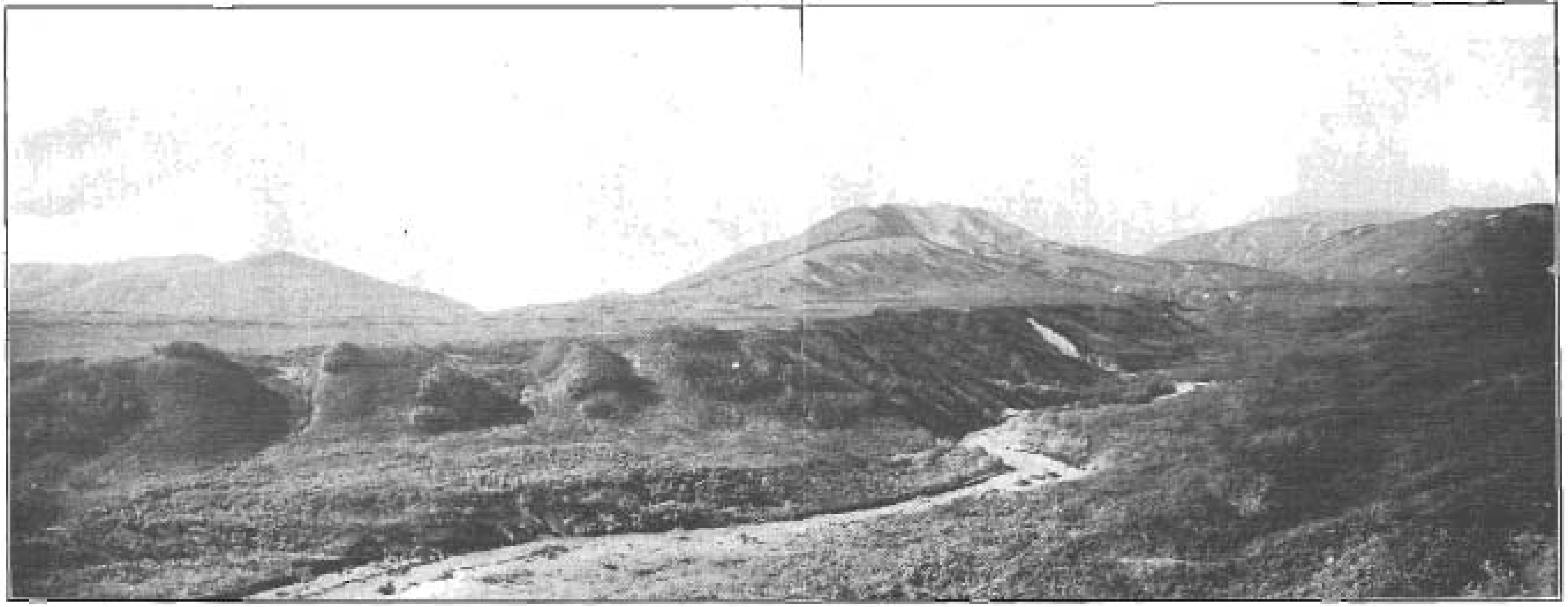
[2] Capps, S. R., The Bonnifield region, Alaska: Bull. U. S. Geol. Survey, No. 501, 1912, pp. 36–38.

distance. The area of accumulation of those glaciers which lie on the north slope is therefore much more restricted and the glaciers are correspondingly smaller.

The erosive action of the glacial ice in the mountain valleys of the Yentna region was very great, as is shown by the perfectly developed cirques and straight, broad, U-shaped valleys. Kahiltna Valley at the lower end of the glacier lies about 1,000 feet below the level of the plateau on either side of it, and glacial scour was certainly the cause of a considerable portion of this deepening, though perhaps not of all. Yentna Valley also shows the effects of profound erosion, as does the Tokichitna Valley. In the areas between these great troughs there is evidence that glacial scour was much less severe. The broad basin between Tokichitna and Kahiltna rivers, occupied in part by Cache Creek, is floored with soft, easily eroded deposits, as is also the plateau between Yenlo Hills and Chelantna Lake. These areas were glacier covered and may have been stripped of some material, but by virtue of their protected positions escaped such vigorous grinding as that to which the main valleys were subjected. It is doubtful if the glacier removed any great quantity of sediments in the lowland or scoured the hard bedrock except at those places where hills of hard rock projected through the Eocene sediments. In the lowland in many places glacial till and stream gravels overlie soft Eocene beds, which would have been removed if erosion had been as intense as it was in the higher valleys.

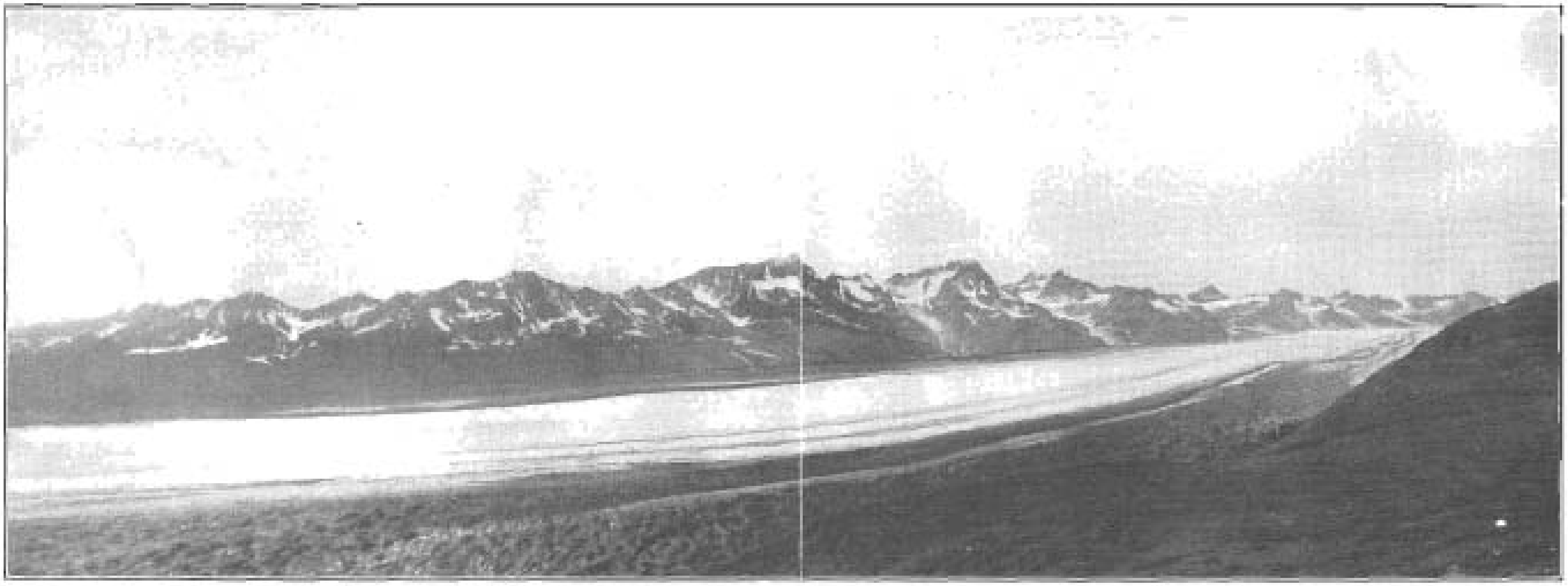
RETREAT OF THE ICE.

The period of maximum glaciation was ended by a progressive change in the climate, which became less favorable for ice accumulation, so that the glaciers gradually decreased in area and thickness. This shrinking of the glaciers caused the ice tongue in Cook Inlet to retreat, and at the same time the glacier in the Yentna region became thinner. It is probable that the glacial retreat was neither rapid nor continuous but consisted of a series of recessional phases alternating with advances, the sum total of which was a gradual shrinking of the ice flood. The first rock masses to emerge from beneath the ice were the ridges of Yenlo, Peters, and Dutch hills. These were still in the area of glacial accumulation, and on them were formed local glaciers, which joined the greater ice sheet below and became longer as its border retreated. At a still later stage the ice tongues from the main valleys became separated from one another, and the plateaus between were laid bare, causing the valley glaciers in the foothills to become separated from the main ice tongues. A still further retreat brought about the withdrawal of the glaciers to their present positions and caused the complete disappearance of the glaciers in the foothills from the cirques which they had carved for themselves.



A. SLATE CREEK, WITH MOUNT KLISKON IN THE DISTANCE.

The creek heads between hills of Tertiary gravel (in the foreground, at left, [illegible] center) and the slates of Mount Kliskon (in the background, on the right).



B. KAHILTNA GLACIER FROM MOUNTAIN NORTH OF THE MOUTH OF GRANITE CREEK.

The glacier is here more than 3 miles wide.

Many valleys on the flanks of the Alaska Range also became free from glacial ice.

PRESENT GLACIERS.

Yentna glaciers.—Both of the headward forks of Yentna River rise in glaciers. The mountains that surround the West Fork are comparatively low and their glaciers are small. The East Fork heads in two large glaciers, one of which seems to flow from the east slope of Mount Dall, and the other probably drains the southeast side of Mount Russell. Their upper basins are still unexplored and their area is not known. Below the junction of these two tributary valleys the main trough is wide and deep, having straight-sided walls which give evidence of the severity of the glacial scour. No large tributaries enter for some miles below the forks, though post-glacial erosion has notched the valley walls with sharp canyons along some of the stream courses. At the base of the mountains the old Yentna Glacier joined the ice streams which emerged from the Nakochna, Kichatna, and Skwentna drainage basins and with them poured a broad ice flood out on the Susitna lowland.

Kahiltna Glacier.—One of the largest glaciers of the range occupies the upper portion of the Kahiltna basin. It extends to the edge of the mountains and at its lower end has a width of nearly 4 miles. Nothing is known of its length nor of the area which it drains, but from the size and position of its lower end it is evident that the supply basin is large and probably includes the southern slopes of Mount Foraker. The lower 20 miles of this glacier may be seen from favorably situated mountains along its sides, but a bend in the valley cuts off the view of the headward portion (Pl. X, *B*). Below the bend the ice stream is 2 to 3 miles wide and has a rather uniform surface slope with a low gradient. A number of small tributary glaciers join the main ice stream from either side. Ribbon-like bands of moraine that stripe the surface become broader and more conspicuous toward the lower end of the glacier, but the surface is remarkably free from morainal covering, and white ice shows all the way to the glacier foot. There is no evidence that Kahiltna Glacier is retreating at present. Spruce trees many inches in diameter grow close to the glacier front, showing that the ice is either advancing or stationary and that its terminus is now as far advanced as at any time for perhaps 200 years.

At about the position of its present terminus the old Kahiltna Glacier joined the ice flood which at that time spread along the flanks of the range and connected with the glacial outflow from Yentna and Tokichitna glaciers. For much of the lower 25 miles of its course the river now flows through a postglacial cut in the lowland deposits.

Granite and Hidden creeks flow through severely glaciated valleys which join the Kahiltna 6 and 7 miles above the end of the glacier.

which cut the slates, but they are for the most part too small to be shown on a map of this scale.

The rocks of the main intrusion are of granitic textures and range in composition from granites with orthoclase feldspar predominating through granodiorites and quartz diorites to diorites in which the feldspars are largely plagioclase. The rocks are composed for the most part of quartz, alkali and lime-soda feldspar, biotite, muscovite, hornblende, and accessory minerals. Rocks of all textures from fine-grained rocks to coarse granites were seen, and a small amount of pegmatite was observed in the granite.

The dike rocks that cut the slates show wide variations in both composition and texture. Most of them are so altered as to be determinable with difficulty under the microscope, the feldspars having been replaced by calcite, but the most common type is a quartz porphyry, which probably had an original composition much like that of the diorites. Others are basic dark-colored rocks, which in their fine-grained phases are not distinguishable in the field from the graywackes.

AGE.

The facts observed in the Yentna district in regard to the age of the various intrusive rocks are insufficient for the accurate determination of the time during which the igneous activity took place. The great intrusive mass of granites and diorites is certainly younger than the slates and graywackes of the region, for it cuts these rocks and contains inclusions of them. Furthermore, the slates had already been consolidated and metamorphosed before the injection of the granitic magma, as is shown by the character of the included fragments and by the fact that, though the slates are everywhere deformed and commonly schistose, the intrusive masses show little evidence of having been submitted to deformational stresses since they were injected. On the other hand, the Eocene sediments, although occurring in areas surrounded by slates which have been intruded by dikes, were themselves nowhere observed to have been cut by intrusive rocks. The evidence available therefore points to the conclusion that the intrusives are younger than the slates and graywackes (Paleozoic or Mesozoic?) and older than the Eocene. Brooks[1] states that the granites and diorites of the Alaska Range cut rocks as young as the Middle Jurassic. In southeastern Alaksa similar granitic masses are considered by Spencer[2] to have been intruded between Lower and Upper Cretaceous time. The Wright brothers[3] concluded from their work in southeastern Alaska that

[1] Brooks, A. H., The Mount McKinley region, Alaska: Prof. Paper U. S. Geol. Survey No. 70, 1911, p. 91.

[2] Spencer, A. C., The Juneau gold belt, Alaska: Bull. U. S. Geol. Survey No. 287, 1906, p. 19.

[3] Wright, F. E. and C. W., The Ketchikan and Wrangell mining districts, Alaska: Bull. U. S. Geol. Survey No. 347, 1908, p. 76.

the intrusions there are of pre-Cretaceous age and continued to at least Middle Jurassic time. In the Matanuska Valley Paige and Knopf[1] found the granitic rocks cutting beds which they believed to be of lower Middle Jurassic age, but which have more recently been determined to be Lower Jurassic. From his studies in the Iliamna region, Martin[2] makes the following statement:

> Regarding the age of at least part of the granitic rocks the evidence is conclusive even to a rather close time interval. Quartz diorite of the normal type for this region was intruded into the Upper Triassic rocks on Bruin Bay subsequent to their close folding. Near-by are broad areas of Upper Jurassic rocks which were not involved in this close folding and which were not cut by the granites. Middle Jurassic rocks are nowhere on Cook Inlet known to be cut by granitic rocks. The granites cut the porphyries and tuffs of Iliamna Bay, which are Lower Jurassic or older, and probably also cut rocks of similar lithology on Tuxedni Bay and north of Mount Douglas. From this evidence it may be concluded that the granitic rocks are certainly younger than the Triassic and older than the Upper Jurassic, and that they are probably older than the Middle Jurassic, and possibly younger than part of the Lower Jurassic.

From evidences of the age of similar rocks in various other parts of Alaska the age of the granitic intrusives of the Yentna region is provisionally assigned to late Lower Jurassic or Middle Jurassic time.

Some of the diabase and greenstone dikes which cut the slates have been deformed and metamorphosed with them and they are therefore younger than the slates but older than the granitic masses, which are little or not at all deformed. Nothing more definite is known of their age.

MINERAL RESOURCES.

GOLD PLACERS.

GENERAL FEATURES.

Placer gold was first discovered in the Yentna district in 1905, and since that year both mining and prospecting have been active. The indefatigable prospector has pushed into almost all the valleys which cut into the margin of the Alaska Range, yet it is worthy of note that the number of producing streams has received no additions since 1906 and that almost all of the production up to the present time has come from ground which was staked in those early years. It may be well to review briefly at this place the factors which have controlled the distribution of placer ground and have limited it to such small areas. These areas are confined to the so-called Cache Creek country and the Mills Creek diggings. The former includes, besides Cache Creek and its tributaries, the headwaters of Peters Creek, and

[1] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: Bull. U. S. Geol. Survey No. 327, 1907, p. 20.

[2] Martin, G. C., and Katz, F. J., A geologic reconnaissance of the Iliamna region, Alaska: Bull. U. S. Geol. Survey No. 485, 1911, p. 76.

Long Creek, which flows to Tokichitna River; all of these creeks, however, lie in the Dutch and Peters hills, and in the broad depression between them, bordered on the south and north by Kahiltna and Tokichitna valleys. The Mills Creek placer mines are all in the headward basins of Mills and Twin creeks, which join and flow eastward to empty into Camp Creek, a tributary of Lake Creek.

ORIGIN AND DISTRIBUTION OF PLACER GOLD.

The factors which bear on the distribution of placer gold in paying quantities can not be adequately discussed for this region without first considering in some detail the former extent of the glaciers which reached so great a development along the Alaska Range. The glaciation of the region as a whole has already been discussed in the preceding pages, but the effects of glaciation, in so far as they influenced the distribution of placer gold, are again summarized here. The present glaciers are only remnants of a vast ice sheet which once filled the Susitna basin and extended far down Cook Inlet. This great glacier was several thousand feet thick in the lower parts of the Yentna region, perhaps completely covering the Yenlo Hills and leaving only the upper portions of the Peters and Dutch hills exposed, if indeed these two ranges were not also covered by the ice. At the time of the greatest glaciers an ice tongue moved southward through the broad valley of Cache Creek, and a portion of this glacier pushed across the Peters Hills along the valley now occupied by Peters Creek and greatly eroded and deepened this valley, which perhaps owes its existence to the erosion of glacial ice. Later, when the thickness of the vast glacial sheet had diminished somewhat, the many valleys of the foothill ranges were each occupied by a vigorous valley glacier. The erosive action of such great, slowly moving ice tongues was enormous, especially along the larger valleys which head in the high mountains, and any concentration of placer gold which may have existed in these valleys was scattered and mixed with the glacial deposits which now lie spread over the lowlands. It is only in the places which were protected by their topographic position from great ice erosion so that the preglacial placers could survive; where an unusual amount of postglacial erosion has permitted the reconcentration of the glacially scattered gold; or where erosion since the ice retreated has effected a new placer concentration, that gold in quantities sufficient to justify mining is now found. So little is known of the more rugged portions of the Alaska Range that nothing can be said of the possibility of lodes existing there which might have supplied gold to the stream gravels. In the district around Cache Creek, where the geologic conditions are known, it is a recognized fact that all of the streams which carry placer gold have their heads in valleys eroded in the slate and graywacke series. The rocks of this series contain many veins and stringers of quartz, and, although up to the present time these have not been found to contain gold, this may be due to the small amount of prospecting for gold lodes which has been done. Some pieces of quartz float containing free gold have been found, and the sluice boxes have yielded much gold with quartz attached, even small pieces of quartz stringers with free gold, showing the slate which formed the walls of the quartz vein. As almost all the streams which cut the slates contain some gold, it appears highly probable that the placer gold has been derived from quartz veins in the slate and graywacke series. (See footnote, p. 26.)

GENESIS OF GOLD PLACERS.

The genesis of the placer gold in the Yentna district is believed to be as follows:

Under the influence of the granitic intrusive masses and their associated dikes the slate and graywacke series, which forms the bedrock along the flanks of the main range and in most of the foothills, was cut by quartz veins and stringers, some of which contained free gold. Most of the gold probably occurred in small discontinuous veins, for no valuable lodes have so far been discovered. Stream erosion in Tertiary time developed an extensive drainage system in the slate hills, concentrating in the stream beds some of the gold from the rock removed and scattering some gold through the extensive gravel deposits which were laid down along the base of the mountains. The mineralization of the slates was irregular, and though in some places the concentration of gold was sufficient to form workable placer deposits, in other valleys the rock removed contained but little gold and no placers resulted. The Eocene coal-bearing beds, which underlie the Tertiary gravels, were also deposited after the mineralization of the slates, but they consist for the most part of fine sediments and have nowhere been shown to be auriferous.

The uplift of the Alaska Range, which caused the rejuvenation of the streams and brought about the deposition of the thick gravel series that now forms the hills at the head of Mills Creek, continued after these gravels were deposited, giving them an increased dip away from the mountains. Stream cutting proceeded rapidly, and a well-developed drainage system was established. It is now impossible to reconstruct accurately this drainage system, but it is believed that the larger rivers then followed much the same courses that they do now. Yentna, Kahiltna, and Tokichitna rivers were the main drainage lines, but their smaller tributaries may have had a very different arrangement from the present.

With the approach of the time of greatest glaciation the ice tongues in the main valleys became constantly thicker and were augmented by tributary glaciers from all the larger valleys along the mountain flanks and from the foothills, until the ice flood spread in an unbroken sheet throughout the whole Susitna lowland. At the culmination of the glacial advance the surface of the ice sheet stood at an elevation of about 4,000 feet along the base of the mountains, and perhaps completely submerged all the foothills below this level. Glacial erosion widened and deepened the main valleys to a remarkable extent, and in the smaller valleys its effects were strongly felt. All loose material and much hard rock was removed, and the placer gold was picked up and scattered through the débris which the glaciers carried, being deposited wherever the glacial material was dropped. It is this glacial scattering of the gold from the higher valleys which accounts for the widespread distribution of gold throughout the Susitna basin, but glaciers fail to concentrate the gold which they pick up, and it is only where streams have rehandled and reconcentrated the gold from the glacial deposits that it can be profitably recovered.

Though the sequence of events just given was the same throughout the Yentna district, certain special conditions in the valleys of Cache and Peters creeks account for the placer deposits in their basins. When the glaciers reached their greatest development, ice from the Tokichitna Valley overflowed its basin and moved southwest down the depression between Dutch and Peters hills. Small glaciers formed in the valleys of both of these ranges of hills and joined the ice in the Cache Creek basin. There the great ice movement from the Alaska Range was down the Kahiltna and Tokichitna valleys, at right angles to the Cache Creek trough, and the ice which lay between the Dutch and Peters hills is believed to have been relatively stagnant and to have eroded the Cache Creek trough but little. The tributary glaciers from the hills on either side, however, were vigorous, for they had steep gradients, and in their upper portions they scoured deeply into bedrock, having first removed all the loose materials, including any placer gold which had been previously concentrated in their valleys by the streams. At the points of junction with the stagnant Cache Creek glacier the tributary ice streams lost their power to erode, and most of the material which they had picked up from their upper valleys was dropped. After the retreat and disappearance of the glaciers the valleys within the hills were left bare and smooth and contained little placer gold, that which they had formerly contained having been scoured out by the ice and incorporated with the glacial materials which lay scattered over the broad Cache Creek valley. The streams now had increased gradients, for Cache Creek had a fall of 1,400 feet from the mouth of its interhill basin to the level of Kahiltna River. It therefore rapidly cut a canyon for itself through the glacial materials and into the Eocene sediments, and this gorge grew headward until it had worked back up the main stream and the larger tributaries into the slate hills. Canyons were cut in the slate at the points where the streams crossed from the slates to the softer deposits of the Cache Creek valley. In cutting these deep channels the streams rehandled much of the material which the glaciers had dropped and reconcentrated any gold which it had contained. They also at some places cut through their old preglacial channels, which had been buried under glacial deposits, and reconcentrated the old placer gold contained in these channels. The result of all this postglacial cutting has been the redeposition of placer gold. The placers are commonly richest at the slate canyons of the streams because it was there that erosion by the valley glaciers became ineffective and much of the glacially removed gold was dropped and because in the narrow canyon bottoms the concentration has been greatest. The absence of workable placers in the upper slate valleys is due to the intensity of the glacial scouring and to the short period which the streams have had, in postglacial time, for the development of new placers by the erosion of the slate bedrock. In the lower courses of the small streams and of Cache Creek there is much workable ground, but at these places the gold is chiefly in small particles, indicating that it has been brought from the upper valleys by the streams, and the occasional recovery of coarser pieces of gold shows that the glacial materials contain some gold, even at considerable distances from the slate hills.

In the basin of Twin Creek the conditions are different, for the gulches which have yielded the placer gold are cut into the Tertiary gravels and the sands and shales of the coal-bearing series. It seems certain that the placer gold on these streams has been derived by a reconcentration of gold from the gravels of the upper part of the series. Whether or not those gravels originally received their gold from the slates is still a matter for conjecture.

DEVELOPMENTS.

PRESENT CONDITIONS.

All the streams of the Yentna district on which mining is now being carried on have been worked steadily or intermittently for several years, and no new locations of importance have been made. The most notable development of 1911 was the discovery of rich ground in an old preglacial channel on Dollar Creek. This discovery suggests the possibility of the existence of similar old channels in the benches of other near-by streams and will be discussed in the following pages. The streams which were being mined during the summer of 1911 are Cache Creek and its tributaries—Dollar, Falls, Thunder, Nugget, and Gold creeks; Peters Creek and its tributaries—Bird, Willow, and Poorman creeks; Long Creek, in the Tokichitna basin, and Mills and Twin creeks and the small gulches which they drain.

CACHE CREEK BASIN.

FEATURES OF THE STREAMS.

Cache Creek is a rather large stream which joins Kahiltna River about 13 miles below Kahiltna glacier. Together with its larger tributaries it heads in Peters and Dutch hills, and its course lies between these hill ranges (Pl. IV, *A*) through a broad, elevated trough

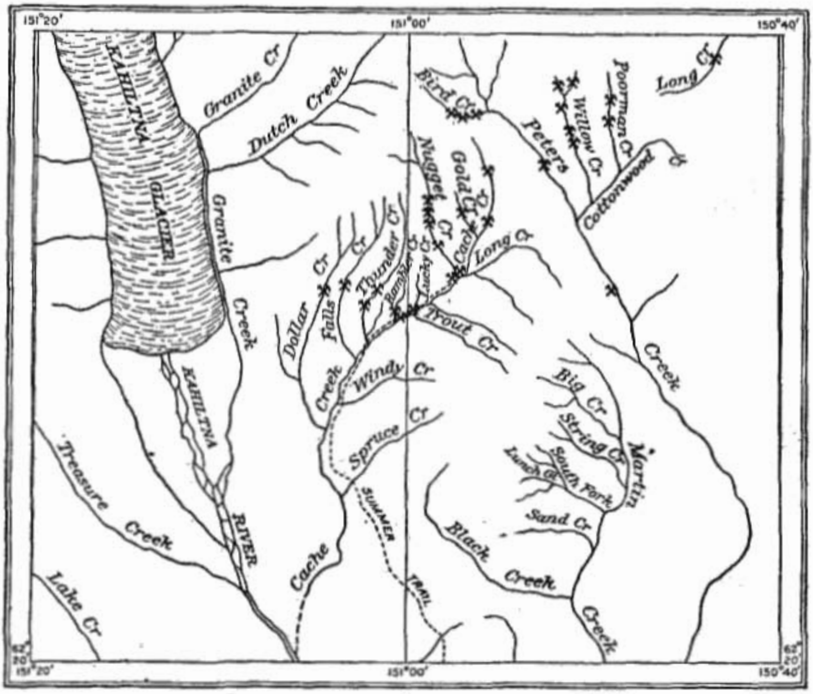
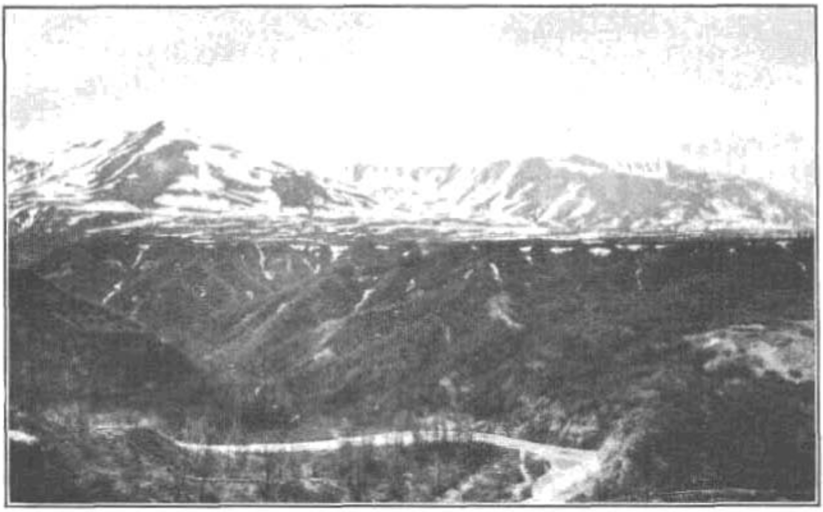


FIGURE 5.—Drainage map of Cache Creek and neighboring streams, showing location of gold-placer mines.

which is continuous from the Tokichitna to the Kahiltna, sloping gently toward the latter. Cache Creek drains the southwestern part of this trough. The many tributaries head in glaciated valleys in the hills, but on entering the broad interhill trough they pass from the slate and graywacke series, or hard bedrock, out upon the loosely consolidated beds of the coal-bearing series, which forms the so-called "soft bedrock." As Cache Creek in the upper part of its broad basin has an elevation of about 2,000 feet, and its junction with Kahiltna River is less than 600 feet above sea level, it falls 1,400 feet in 18 miles. It has therefore been able to intrench itself into the soft underlying



A. CACHE CREEK AND ITS GORGE, CUT THROUGH EOCENE DEPOSITS.

The Peters Hills, which border the basin, are composed of slates and graywackes.

B. SLUMPING GROUND ON THE NORTHWEST WALL OF THE CACHE CREEK GORGE.

A. PLACER MINING ON DISCOVERY CLAIM, CACHE CREEK.

B. SLUICING WITH HYDRAULIC GIANT ON CACHE CREEK NEAR THE MOUTH OF RAMBLER GULCH.

formation and flows through a gorge whose walls in places rise 300 feet above the creek (Pl. XI, *A*). Its tributaries also have made deep cuts where they cross the basin. Mining has been confined altogether to the main creek and to the largest tributaries, which enter the stream from the northwest. Figure 5, a sketch map of the Cache Creek and the neighboring streams, gives the location of the gold placer mines.

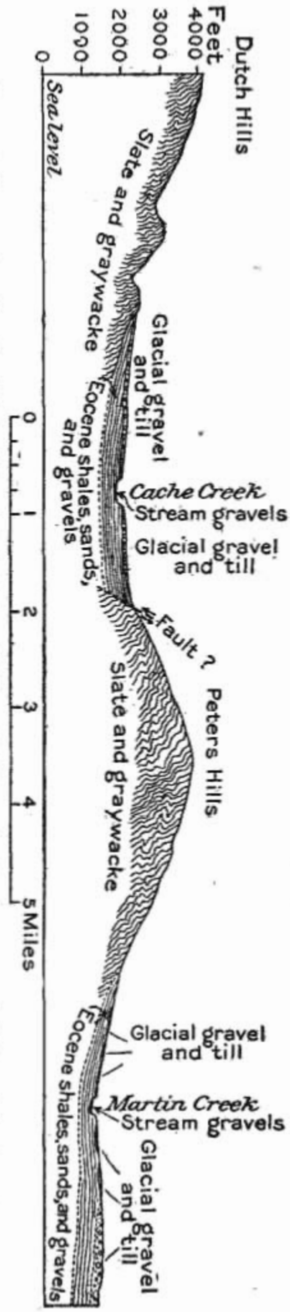


FIGURE 6.—Cross section of Dutch and Peters hills and of the basins of Cache and Martin creeks, showing structural relations of the formations.

CACHE CREEK.

Cache Creek heads in a small glacial valley in the Dutch Hills, through which it flows for only 2 miles before it emerges into the broad and wide valley which it follows to Kahiltna River. In the hills its valley is cut in the slate and graywacke series, and the stream gravels lie on "hard bedrock." Near its head the stream has eroded its valley but little in postglacial time, though for a short distance back from the base of the hills it has cut a sharp canyon into the slates. This canyon ends abruptly at the contact between the slate series and the sands and shales of the coal-bearing formation, and from this point downstream the creek, though intrenched below the level of the broad plateau, has a wider valley floor. Figure 6 shows a section drawn across both Dutch and Peters hills, indicating the structural relations of the various formations. The valley walls, or benches, are about 50 feet high at the mouth of the canyon. At the mouth of Nugget Creek the stream bed is about 250 feet below the level of the surrounding deposits, and the depth increases to nearly 300 feet between Nugget and Spruce creeks (Pl. XI, *A*). Below Spruce Creek the stream has a steep gradient through a bowlder-filled canyon, below which it reaches the Kahiltna flats.

Gold was first discovered on Cache Creek in 1906, the year after the first discoveries in this region were made on the headwaters of Peters Creek. The first ground mined was at the canyon near the head of the stream on Discovery claim, which has been worked every year since. During the summer of 1911 two men were mining a short distance below the mouth of the canyon (Pl. XII, *A*). The ground worked was that of the present stream flat, and the gravels moved range from 4 to 7 feet in depth and lie on slate bedrock. There are some large bowlders present, but most of them can be handled by one man. A short distance below the canyon the slate bedrock gives place to the materials of the coal-bearing series, which change character within short distances, ranging from a fairly firm, gritty sandstone to soft clay shales. The pay streak is said to be rather well defined in the canyon and for a short distance below it but soon spreads out in the wider valley below and is difficult to trace. The gold is rather unevenly distributed, for, though most of it is found on bedrock, the degree of its concentration depends somewhat on the character of the bedrock, the harder strata having retained it better than the softer. No records have been kept which would show the gold content of the gravels to the cubic yard or to the square yard of bedrock, but it is reported that the returns have averaged about $10 a day for each man employed. The sluice boxes, 14 inches wide, are set on a grade of 5 inches to the box length. The gravels are groundsluiced to a depth within a foot or so of bedrock by the aid of canvas hose and water under pressure from the bench to the southwest, the rest of the gravel being shoveled in and bedrock cleaned by hand. The stream at Discovery claim can be depended upon to run a sluice head of water for the boxes used throughout the season, and most of the time it flows two sluice heads. The gold is coarse, bright, and somewhat worn, though many pieces are rough and some cubes of crystalline gold have been found. Pieces worth $20 have been taken from this claim, and only about one-third of the gold recovered will pass through a 16-mesh screen.

The coarseness of the gold and the roughness of some of it indicate that it has traveled no great distance from its bedrock source. It must originally have come from the quartz veinlets of the slate and graywacke series in the upper part of the Cache Creek valley, or at the head of Bird Creek, for the upper valley at one time contained a vigorous glacier and ice also came into it from the head of Bird Creek, across a low divide. This glacier eroded its basin and doubtless scattered and removed any preglacial gold which may have been concentrated in its upper portion. No ground carrying paying quantities of gold has been discovered above the canyon of Cache Creek. Toward the mouth of the slate valley the ice scour was less severe, as the glacier joined a large sluggish ice sheet in the broad basin between Dutch and Peters hills. Here the valley deepening was not pronounced, and a part of the material picked up by the ice in the upper valley was dropped. It may be that the glacial deposits here covered up portions of the preglacial channel of Cache Creek without disturbing them. When the glacier melted away the stream cut through the glacial deposits and at and below the canyon intrenched itself into the slates and the softer beds to the east. In the rehandling of the glacial material any gold that it contained was concentrated in the stream bed, and if the valley was cut through any undisturbed portions of the old preglacial channel these, too, would have contributed to the richness of the present placer deposits.

The possibility that remnants of the old channel still exist in the benches is suggested by several facts which have been learned during the years that mining has been carried on here. It is said that the pay streak terminates rather abruptly at its upstream end in the canyon, although some gold has been found farther upstream. In the spring of 1911 a cut was run into the high bench at the point where the pay streak failed. The bench consists of gravels lying on decayed rocks of the slate series and is overlain by 15 to 20 feet of glacial till. In groundsluicing the upper portion of this cut some gold was recovered, but most of it lay on or in bedrock. The gold was coarse, the largest nugget being worth $9. It may be that at this place there is a portion of a preglacial stream channel which contained workable placers. At the time of visit the development work on the bench was insufficient to show definitely the presence of such an old channel or to give any reliable clue as to its length or direction.

In 1911 two men were mining on Cache Creek, about a mile above the mouth of Nugget Creek. The ground worked was on the present stream flat and ranged in depth from 4 to 7 feet. The usual number of coarse bowlders was encountered, but most of them could be readily thrown from the pit. The gravels lie on "soft bedrock," composed of the clay, sand, and soft conglomerates of the coal-bearing series. At one place the creek is crossed by a bed of lignite, which held the gold and yielded good returns. The gold in the gravels is mostly found on bedrock, the richness of the ground depending to an important degree on the character of the beds crossed. In the beds of clay little gold is found, but the sandy and gravelly beds have retained the gold much better. A grade of 5 inches to the box length is maintained, this being less than the fall of the creek. The sluice boxes in use are 20 inches wide, and the creek at this point supplies enough water for them throughout the summer. Water under pressure is obtained from Columbia Gulch, a small tributary of Cache Creek from the north, and is carried by ditch over the bench to a point opposite the pit, to which it is conducted through 6-inch canvas hose. A working head of about 75 feet is thus obtained, and a 2½-inch nozzle is used in piping the gravel into the boxes. It is reported that the returns from the season's work on this ground were not large.

In the main valley of Cache Creek mining operations were carried on at a number of points between the mouths of Nugget and Spruce creeks from 1906 to 1908. In some places the ground worked was in the present stream flat, but in others the gravels on benches along the valley sides were mined. In 1908 the Cache Creek Mining Co. was organized and purchased all of the main creek valley from a point 2½ miles below Spruce Creek to the mouth of Gold Creek, a distance of more than 12 miles, as well as a number of claims on the more important tributaries. The total holdings of the company embrace more than 3,000 acres, and extensive preparations have been made for developing the ground. A sawmill which has been built on the main creek one-half mile above the mouth of Thunder Creek, furnishes lumber for buildings, penstocks, flumes, and sluice boxes. Several thousand feet of hydraulic pipe, some as large as 34 inches in diameter, has been placed on the ground. During the seasons of 1910 and 1911 the energies of the company were in large part directed to procuring an adequate supply of water under pressure so that their ground could be mined by hydraulic methods. A ditch, originally designed to carry 1,500 miner's inches of water, was surveyed to tap Nugget Creek on claim "No. 7 above," but was only partly completed. Its connection with Nugget Creek was never made, but during the period of the spring run-off it receives a considerable volume of water from the melting snows on the Dutch Hills and on the broad high bench which it traverses. Construction on a second ditch, to carry 2,300 miner's inches of water, was pushed in 1910, and was almost completed. This ditch was to draw water from Cache Creek a short distance below the mouth of Nugget Creek and carry it for nearly 2 miles to a penstock, from which it was to be taken through a 34-inch steel pipe to the point where needed. The working head at the penstock was 120 feet, to be increased to 180 feet at the sawmill. In building this ditch some slumping ground was encountered, so that during the summer of 1911 the lower portion of the ditch was abandoned, and the water was carried from the completed portion to the so-called Pineo Bar through steel pipe.

In 1910 mining was carried on at two localities by the Cache Creek Mining Co. The upper locality, on Pineo Bar, lies about halfway between the mouths of Nugget and Thunder creeks. The ground worked is a few feet above the present level of Cache Creek, and the gravels lie on the sands, clays, and conglomerates of the coal-bearing series. In the bluffs on either side of Cache Creek the beds lie almost horizontal, but on the northwest side of the stream there has been extensive slumping (Pl. XI, *B*), and the strata shown in the exposures of bedrock in the cut stand nearly vertical. The bench gravels here are certainly deposited on a slumped portion of the valley wall. In 1911 work was continued at this place, but nothing was learned in regard to the amount of gold recovered to the cubic yard of gravel moved.

In 1910 a portion of the bed of Cache Creek was worked at a point near the mouth of Rambler Gulch. The creek here flowed close to bedrock, and by diverting the stream from its channel during low water bedrock could be cleaned by removing only a thin layer of gravel. Gold was recovered in this locality in considerable amounts, but its distribution was irregular, depending on the character of the bedrock. Wherever the stream crossed a sandy or conglomeratic bed the gold had lodged, but the clayey beds were almost bare, the gold having passed on over them to find a more favorable resting place on the rougher bedrock. It is said that one working upstream could predict when a clayey bed was to be crossed by the exceptional richness of the sandy or gravelly portion of the bedrock just below. In 1911 a cut was run from the mouth of Rambler Creek up that stream for about 700 feet. A portion of the ground at the mouth of the creek was mined by pick and shovel, but that farther up was piped in by means of hydraulic giants. The depth of gravel was irregular, ranging from 18 inches to 10 or 12 feet, and the surface of the soft bedrock was uneven. At the stream mouth the gold was recovered from a bedrock of rather firm conglomerate, called cement rock by the miners, but farther upstream the beds of the coal-bearing series were encountered, the clayey shales predominating, together with some sandy and gravelly beds and a little lignitic coal. These beds are tilted at various angles and have evidently been affected by slumping. For the lower end of the cut water was supplied to the 3-inch nozzles from Rambler Creek with a head of about 60 feet. Later in the season water was procured from the upper end of Lucky Gulch with a head of 230 feet at Cache Creek. The dirt was piped into 24-inch boxes, set on a grade of 6 inches to the box length. At the upper end of the cut the gold is reported to have decreased and work was discontinued, the plant being shifted to a bench on Cache Creek (Pl. XII, *B*), about 400 feet above the mouth of Rambler. At this place the surface of the gravels lay about 10 feet above the level of Cache Creek and the depth to bedrock averaged about 6 feet. Large bowlders were not common in this cut, and those encountered all lay on bedrock. The value of the gold recovered is said to have averaged approximately $1.50 to the cubic yard of dirt moved.

GOLD CREEK.

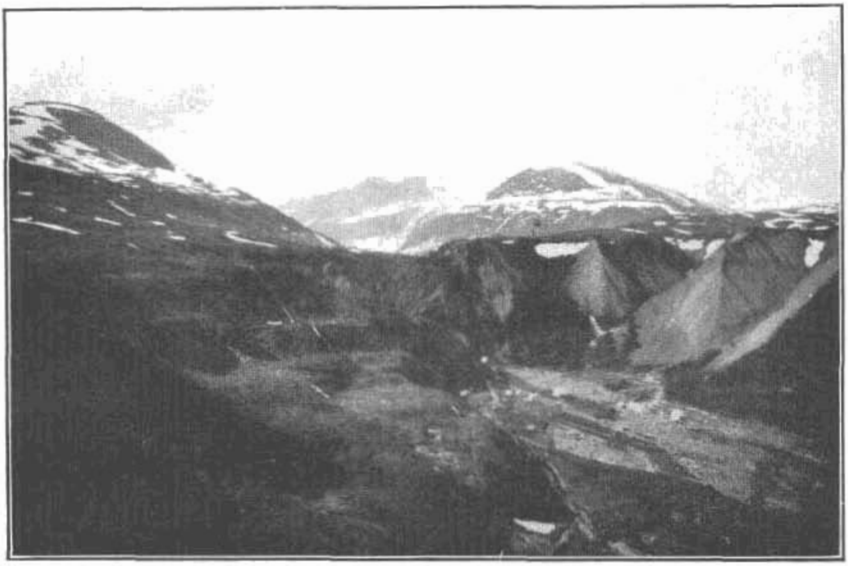
Gold Creek is the uppermost tributary of Cache Creek from the north; it lies between the head of Cache Creek and Nugget Creek and is a small stream, only 1¼ miles in total length. It heads in the slate hills and its lower portion flows through a valley cut in the coal-bearing series. Gold was first discovered in 1909 near the point at which the creek passes from the slates to the softer deposits. At this point the valley is narrow and V-shaped, the gravels to be mined rarely having a width of more than 20 feet. The depth to bedrock ranges from 2 to 6 feet, the gold being found on bedrock or in the crevices of the slates, which here stand on edge. The gold is coarse and shotty, pieces up to $14 in value having been found. Its assay value is $17.81 an ounce, of which 6 cents is in silver. No mining was being done on this ground in 1911.

NUGGET CREEK.

Nugget Creek is the uppermost large tributary of Cache Creek, joining it a few miles below its head. Its source is in the Dutch Hills, through which it flows in a wide, straight, U-shaped valley, which shows strongly the erosive action of the great glacier that once occupied it. In the hills the basin of Nugget Creek is composed of the rocks of the slate and graywacke series, and the stream flows in a postglacial canyon, which is shallow toward the valley head but narrower and deeper downstream. At the point where it leaves the slate hills the creek occupies a canyon cut 200 feet into the rocks, but at the base of the hills the slates give place to the softer rocks of the coal-bearing series, and through these the stream has widened its gorge, though the valley walls are high and steep throughout the remainder of its course to Cache Creek.

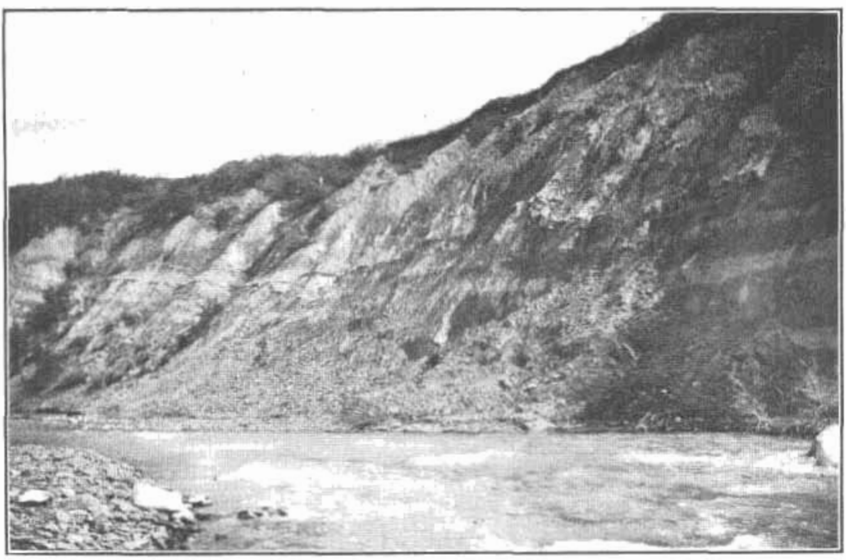
Gold was first discovered on Nugget Creek in 1905, and the ground first worked was in the lower portion of the rock canyon. Since that year mining has been carried on in the valley each summer. The claims lying immediately above the mouth of the canyon, known as "Nos. 1, 2, and 3 below," have yielded the greatest part of the production, and are now practically worked out, but a considerable area of ground which is known to contain paying quantities of gold remains unworked.

During the summer of 1911 mining operations were being conducted on this creek by four different parties. The largest camp, consisting of 10 men, was on "No. 4 below," the ground worked lying a short distance below the mouth of the slate canyon (Pl. XIII, *A*). The stream gravels are 6 to 8 feet thick, and lie on the soft bedrock of the coal-bearing series. The gold is recovered principally from the gravel within a foot of bedrock and on the bedrock itself, which is of sandy or clayey material or loose conglomerate. The gold is very



A. MOUTH OF NUGGET CREEK CANYON.

The benches on the left, showing old levels of the creek, contain workable placers, as does the present bed of the creek.



B. EOCENE SEDIMENTS ON PETERS CREEK, ON THE EAST SIDE OF PETERS HILLS.

coarse, somewhat rusty, and moderately worn and smoothed. Nuggets worth $16 have been found below the canyon and in the canyon one worth $60 was recovered. Simple mining methods are used, the upper portion of the gravels being groundsluiced off by means of water under pressure, delivered through canvas hose, the head being 70 feet. The gravel immediately above bedrock and a portion of the bedrock itself are shoveled by hand into 14-inch sluice boxes.

Above the present stream flat, at the mouth of the canyon, portions of the former valley floor of Nugget Creek appear as terraces or benches, seven of which can be distinguished (Pl. XIII, *A*). Workable placer has been found on a number of these benches, and one bench, 170 feet above the stream, was being mined at the time of visit. The gravel here, which was 1 to 6 feet deep, lay on slate bedrock and is said to have yielded much gold. None of the benches, however, are of large size, and the amount of paying ground on them is small.

Three men were engaged in mining at the junction of claims "Nos. 1 and 2 above," at which place Nugget Creek lies in a slate canyon about 70 feet deep. The stream is crooked and its flat narrow, only small patches of gravel appearing between the creek bed and the base of the canyon walls. The ground worked ranged from 5 to 6 feet in depth and contained a good many bowlders, most of which, however, could be moved by hand. Hydraulic methods were employed for stripping away the upper portion of the gravels, the water being obtained from a small tributary on the northeast side of the creek and conducted through a ditch over a thousand feet long to a point above the cut, where it was delivered through canvas hose at a head of 70 feet. Bedrock here consists of slates and graywackes, which stand at high angles and strike in the general direction of the course of the creek. The gold is coarse and somewhat worn, and is unevenly distributed over the bedrock. Where the bedrock is rough good returns are found, but where it is smooth the gold recovered is not sufficient to pay for the handling of the ground.

On claim "No. 3 above," two men were mining on a bench which lies about 10 feet above the level of the stream. Pick and shovel methods were used for getting the lower part of the gravels into the sluice boxes after the upper portion had been removed by groundsluicing. Sluice boxes 12 inches in width were set on a grade of 8 inches to the box length, and sufficient water was had during the entire season. Most of the gold recovered was found on bedrock, which is here slate or graywacke. The gold is coarse, nuggets ranging in value from $1 to $6 being common. It is planned to build a ditch in 1912 to bring water under a head of 70 feet to the cut and to install 24-inch boxes, so that a larger quantity of ground may be handled.

Claim "No. 4 above" was purchased by a party of three men, who commenced mining in the spring of 1911. A wing dam was constructed, which diverted Nugget Creek for about 300 feet, and the bed of the creek was mined by shoveling the gravel into the sluice boxes. The ground ranges in depth from 2 to 9 feet, most of the gold being found on or near bedrock, here formed by the uptilted beds of the slate and graywacke series. Much of the gold is coarse, somewhat rusty and worn, and although some fine gold was recovered the greater part occurred in pieces worth from 10 cents to $3.50. The results of the season's work on this claim are reported to have been fairly satisfactory, and it is the intention of the owners to obtain water under pressure by building a ditch and to enlarge their sluice boxes in 1912.

Two parties were mining during the summer of 1911 on the Jumping Jack claim, in the valley of Nugget Creek close to its junction with Cache Creek. Two men were working on the south side of the creek and one man on the north side. The gravels here range from 3 to 5 feet in depth, lie on soft bedrock, and are comparatively free from large bowlders. The bedrock surface is irregular, being cut by shallow grooves which diverge like the rays of a fan, showing the old channel which Nugget Creek once followed as it left its own valley to join Cache Creek. The gold is irregularly distributed over bedrock, the ground being "spotted," as the miners say. The gold is brighter and finer than that found in upper Nugget Creek. The season's work showed the gold tenor of the gravels in lower Nugget Creek to be too low to warrant working by pick and shovel methods.

LUCKY GULCH.

About 1½ miles below the mouth of Nugget Creek a small valley known as Lucky Gulch joins the Cache Creek valley from the northwest. This valley is sharply V-shaped and has a steep gradient. It heads on the broad bench in which Cache Creek has intrenched itself. and is scarcely more than a mile long. Lucky Gulch lies exclusively within the area of the soft coal-bearing series, capped with glacial till and gravels, and throughout its length the stream flows over "soft bedrock," which is covered by only a shallow filling of stream gravels. At times mining has been done in this gulch in a small way, but its total production has not greatly exceeded $1,000. No work was being done on it at the time it was visited in 1911.

RAMBLER GULCH.

Rambler Gulch joins the Cache Creek valley three-fourths mile below Lucky Gulch from the same side. Like Lucky Gulch it is short and steep and lies altogether in coal-bearing sediments with a capping of glacial materials. In its upper portion the ground was shallow and easily worked, and the creek bed was exhausted in the early years of the camp, a few thousand dollars in gold being recovered. In 1911 mining was resumed on the lower portion of the creek under conditions already described (p. 57).

THUNDER CREEK.

Thunder Creek heads in the slates and graywackes of the Dutch Hills, near Nugget Creek. On leaving the hills it bends to the south, following the general direction of the Cache Creek valley, and joins Cache Creek 3½ miles below the mouth of Nugget Creek. In its course below the hills it is intrenched below the level of the surrounding plateau, its valley lying for the most part in the beds of the coal-bearing series. For a portion of its length, however, it has cut through the softer sediments into a ridge of underlying slates. The bedrock, therefore, varies in different portions of the stream's course. During the summer of 1911 one man was mining on claim "No. 3 below." The gravels, which are 2 to 3 feet deep, were ground-sluiced and the lower portion was shoveled into the boxes. Bedrock here consists of the soft materials of the coal-bearing series. Some lignite outcrops in the high bluffs of the stream. The gold is bright and fairly coarse, but the pay streak is irregular and the gold content varies greatly from place to place, so that the returns are uncertain. The lower mile of Thunder Creek has been staked as an association claim, and four laymen were mining on the upper half of it. The gravels average about 5 feet in depth and contain few bowlders which a man can not roll from the pit. The bedrock is of varying character, at places being of the soft coal-bearing beds and at other places appearing to be a much weathered and decayed phase of the slate series. Sluice boxes 32 inches in width, set on a grade of 6 inches to the box length, were in use, and a 1,200-foot ditch supplied water from Thunder Creek with a head of 35 feet at the cut. Canvas hose and a nozzle were used for piping off the upper portion of the gravels, and the ground near bedrock was shoveled in by hand. The gold is bright and rough, many pieces having quartz attached, and seems to have traveled no great distance from its source. It assays $17.80 to the ounce, and the ground worked ran from $2 to $2.50 a cubic yard. Toward the end of the season the work was retarded by a shortage of water. In the fall of 1911 the ownership of this association group of claims changed hands, and the purchaser has signified his intention to install a hydraulic plant for the mining of the gravels on a more extensive scale.

FALLS CREEK.

Falls Creek is the next important tributary of Cache Creek south of Thunder Creek. It heads in the slates and graywackes of the Dutch Hills, flows in a course roughly parallel to that of Thunder Creek, and joins Cache Creek about three-fourths mile south of it. At the point where it passes from the slates to the beds of the coal-bearing series it has developed a narrow canyon and a waterfall, which suggested its name. Gold was first mined on Falls Creek in 1905, in the canyon cut through the slates, and the stream afforded considerable production for a few years. In the narrower portion of the canyon the difficulties of diverting the creek prevented mining except for a short time in the spring when the volume of the stream was small. At the time this creek was visited in 1911 two men were preparing to sluice ground on a high bench on the northeast wall of the valley, on claim "No. 3 above." A ditch 2,000 feet long, to supply water under pressure, was almost completed, but aside from a few small prospect pits no mining had yet been done.

DOLLAR CREEK.

Dollar Creek, the lowest large tributary of Cache Creek from the west, joins Cache Creek 2 miles below the mouth of Falls Creek. The geologic and topographic conditions in its basin are much like those on Thunder and Falls creeks. Dollar Creek flows from the slate hills at its head out onto the Cache Creek plateau in a sharply incised valley, which gradually becomes deeper downstream until at the mouth of the creek the valley bottom lies over 300 feet below the general level of the surrounding country. Even below the border of the Dutch Hills the slate bedrock is exposed by the stream cut for some distance out upon the plateau, showing that the old slate surface on which the soft bedrock sediments were laid down was uneven. Placer gold was discovered in this stream in 1905, and a few thousand dollars have been recovered from the stream gravels in the slate canyon since that time. In previous years, however, the gravels have yielded only moderate returns for the expense and labor required to work them. During the spring of 1911 two men began mining on claim "No. 2 above," but finding that the pay streak in the creek ended abruptly upstream, they ran a cut into the high bench on the northeast side in the hope of finding the source of the gold. In working up the valley side the miners found that slates and graywackes extended to an elevation of about 70 feet above the creek. In the creek channel the beds of the slate series are hard and firm, but toward the top they are weathered and appear as fairly soft sandstones and shales. The beds of the coal-bearing series, which are only a few feet thick, appear above the slates. Some pieces of lignite were found in the cut. Above the soft bedrock lies a bed of stream-washed gravels from which rich pans could be obtained, as much as $2.50 being taken from a single pan. Above the stream gravels the exposure showed 20 feet of typical bowlder-studded glacial clay. At the time the place was visited too little work had been done to determine exactly the conditions at this place, but the facts gathered seem to show that the stream gravels were laid down in an old channel, perhaps a former channel of Dollar Creek, before the great glacial advance, as is shown by the overlying layer of glacial bowlder clay. It is also of interest to note that there was a good concentration of placer gold in preglacial time. The gravels in the old channel are of the same materials as are now found in the stream bed, the largest bowlders being 18 inches in diameter. The material is oxidized to a yellow color and the pebbles are somewhat decomposed, the whole being cemented into a loose conglomerate, which yields with difficulty to hydraulic methods of mining. The gold is coarse, rusty, and very angular. Some pieces, which seemed to be small nuggets, were found on close examination to consist of a large number of small colors cemented together by iron oxide. It is reported that the developments later in the summer showed that the gravels occupy a distinct channel which diverges upstream from the present valley of Dollar Creek, although it was traced for only a short distance. It is also reported that two distinct pay streaks were found in the gravels, one a few feet above the other, and that the gold was associated with much broken, angular quartz, indicating the possibility that it came from a vein at no great distance. The season's output from this mine is said to have been highly satisfactory, and preparations were being made to install a hydraulic plant so that operations could be conducted on a larger scale.

PETERS CREEK BASIN.

PETERS CREEK.

Peters Creek occupies a valley intermediate between Kahiltna and Tokichitna rivers and in its upper portion is roughly parallel to these two streams. It heads in a broad, severely glaciated, U-shaped valley in the Dutch Hills, turns at a right angle to cross the Cache Creek plateau, crosses the Peters Hills through a deep transverse trough, and enters the broad lowland of the Susitna Valley, the west edge of which it follows to its junction with Kahiltna River. Its total length is more than 35 miles. In its course through the higher parts of the Dutch Hills it flows in the bottom of the glacial trough in a channel which has been notched little or not at all into the slates and graywackes of the hills. In the more easily eroded coal-bearing beds of the Cache Creek plateau it has intrenched itself deeply in a canyon-like valley that extends headward into the slates for some distance above the mouth of Bird Creek, and a similar canyon extends for more than a mile up Bird Creek. The downward slope of the Cache Creek plateau toward Peters Hills causes the stream valley to become shallower and wider in that direction, but on entering the valley through these hills the creek again flows through a rock canyon. This second slate canyon terminates at the east border of the Peters Hills, the stream once more flowing between valley walls of the coal-bearing series (Pl. XIII, *B*) and the banks gradually becoming lower downstream through the little-known area of the Susitna lowland to the south and east.

Gold was discovered at a number of places on Peters Creek and its affluents in 1905, and mining has been done on that creek each summer since that time. In 1911 work was in progress at two places on the main stream. At the mouth of the canyon through Peters Hills, a short distance above the point at which the stream passes from the slates onto the soft bedrock, two men were mining on a bench about 30 feet above the stream level, where a few feet of gravel lie on a slate bedrock. Water under a pressure of 70 feet, brought by ditch and canvas hose, was used for piping the gravels into the sluice boxes. The gravels contain rather abundant bowlders. At the time the place was visited some of the ground was still frozen. The gold, which is for the most part concentrated on bedrock, is coarse, flat, worn, and somewhat rusty, and gives evidence of having traveled some distance from its source. The largest nugget found weighed 9 pennyweights, and the gold assays about $17.75 to the ounce. The ground worked in 1910 was a short distance downstream from that worked in 1911, on a bench only a few feet above the stream. The bedrock at this place is a hard, rusty dike intruded into the slates. Prospect holes in the creek gravels below the canyon show placer gold on a soft bedrock, but the gradient of the creek is too low and the ground too deep to permit mining by pick and shovel methods.

The bedrock source of the gold in lower Peters Creek is still open to question, but this gold, like that in the other parts of this district, was doubtless derived from the quartz stringers in the slates and graywackes. In lower Peters Creek some of the gold may have come directly from the rocks of Peters Hills, through which the valley is cut, but as gold is found in the stream gravels above Peters Hills and up to the head of the stream it seems probable that the present placers are in large part the product of reconcentration of gold that was scoured from the upper tributaries of the stream by glacial ice, scattered throughout the valley, and again reconcentrated by postglacial erosion.

About three-fourths mile below the mouth of Bird Creek, at the lower end of the upper rock canyon of Peters Creek, two men were mining in 1911 near the contact of the slates with the soft bedrock. A dike of a crystalline intrusive rock crosses Peters Creek at this place. The creek gravels average about 6 feet in depth and the gold values are concentrated on or near bedrock. At the time the creek was visited in 1911 little ground had been mined, but the claims between the mouth of the canyon and Bird Creek are said to have produced a few thousand dollars altogether.

BIRD CREEK.

The valley of Bird Creek, a tributary of Peters Creek, lies altogether in the slates of Dutch Hills and is but little more than 2 miles long. Its head is a broad cirque, which was once occupied by a glacier that evidently joined the valley of upper Cache Creek. Bird Creek, however, turns northward from this broad valley and in the last mile of its course flows through a narrow postglacial canyon. The canyon walls show excellent exposures of the slate and graywacke series, which are at several places cut by light-colored dikes. Gold is mined at three places in the canyon. At the upper place, on the fourth claim above the mouth of the creek, the stream flows in a narrow gorge, which is 80 feet deep. The gravel benches are 1 to 3 feet deep and are of small area, as in many places the stream fills the canyon bottom. Most of the gold mined has been recovered by diverting the stream with wing dams and cleaning the bedrock in the stream channel, much gold having penetrated a foot or two into the crevices of the slates. The gold is coarse and rough, and assays about $17.90 an ounce. One man was working on this ground in 1911. The gold is irregularly distributed, an exceptionally rich spot being succeeded up stream or down by barren ground, so that the returns are uncertain.

One man was mining on claim "No. 3 above" and one on "No. 2 above" under conditions much like those described for claim "No. 4 above." The ground is 4 to 5 feet deep and is worked by ground-sluicing and shoveling. The slates are very irregularly bedded and great care must be exercised in cleaning bedrock, as the gold penetrates deeply into the cracks. At one place where a dike crosses the creek gold was found in crevices 5 feet below the stream bed. The gold is bright and coarse, and although many pieces are worn smooth much of it is rough and angular. The great drawbacks to mining are the irregular distribution of the gold and the large proportion of bowlders in the stream gravels.

The rock walls of the canyon of Bird Creek are in many places capped by a heavy layer of glacial clay from which some gold has been recovered but not enough to encourage its further exploitation.

COTTONWOOD CREEK.

The only important tributary of Peters Creek from the north is Cottonwood Creek, which flows close to the west base of the Peters Hills and which itself has two western tributaries of economic importance.

Willow Creek.—The lower tributary of Cottonwood Creek is Willow Creek, which heads on the southeast flank of Dutch Hills and flows for about a mile through a slate valley, below which it is intrenched in the coal-bearing beds to its mouth. Gold was first found on Willow Creek in 1906, near the contact between the slates and the soft bedrock, and mining has been in progress on this stream each season since. In 1911 claim "No. 1 below" was being worked by five men. As the volume of the stream diminishes greatly toward the end of the summer it is the practice to groundsluice off as great an area in the period of early spring flood waters as can be mined during the remainder of the season and to clean up bedrock later, when the water is low. Water from a high ditch that gave 30 feet pressure at the cut was used in stripping off the upper gravels. The gravels mined are 6 to 8 feet deep, and the gold is recovered from a soft, sandy bedrock. It is coarse, rusty, and somewhat worn and assays $17.85 an ounce.

On Discovery claim 11 men, working in two shifts of 10 hours each, were mining by pick and shovel methods on ground a short distance below the mouth of the slate canyon. The ground was 6 to 8 feet deep, and most of the gold was concentrated on soft sandy or gravelly bedrock. The work at the cut was hampered by the low grade at which the boxes had to be set, as it had been necessary to build a wall at the lower end of the claim and to pile tailings in order to keep from covering the ground on claim "No. 1 below." The gold is bright, somewhat worn, and very coarse, nuggets worth $30 having been found and pieces weighing one-half ounce being common. The operations on this claim in both 1910 and 1911 were very successful, although a shortage of water in the fall of 1911 reduced the output below what it otherwise would have been.

A number of small tributary streams of Willow Creek, known as Rocky, Snow, Slate, and Falls gulches, all in the slates of the upper portion of the basin, have at times been mined in a small way. The total production of all four, from 1906 to 1911 inclusive, is estimated to have been between $7,000 and $8,000.

Poorman Creek.—Poorman Creek lies northeast of Willow Creek and is roughly parallel to it, joining Cottonwood Creek about 2 miles above the mouth of that stream. The gulches at its head are cut down into the rocks of the slate and graywacke series, but for most of its length the stream crosses the soft coal-bearing beds and is intrenched into them. Discovery claim lies across the contact between the slates and the soft bedrock. It was staked in 1906 and has been mined every year since that time. The greatest production was in 1907, when six men, working for only a short season and with a very small supply of water, recovered 1,329 ounces of gold. The gravels mined that year lay on slate bedrock, and the ground was very shallow, so that it was quickly worked out. Since that year most of the work has been done on the lower portion of the claim, where the gravels are in places 11 feet deep and lie on soft bedrock. Some mining has been done on the benches above the present stream flat, and paying ground has been found on them. The creek gold is coarse and much of it is dark colored and rusty in appearance. Pieces valued at $33 have been found. The bench gold is brighter and not so coarse as that in the stream bed.

Claim "No. 1 below" and a fractional claim between "Nos. 1 and 2 below" have been mined by the owner since 1906, but at the time the place was visited he and another man were working on the upper end of "No. 2 below" by groundsluicing and shoveling. The gravels are 8 to 11 feet deep and lie on a loose conglomerate of the coal-bearing series. A bed of lignite, which crosses the creek on claim "No. 1 below," has furnished some fuel for the camp. The gravels are nowhere exceptionally rich, but the gold is said to be evenly distributed in them across the whole width of the flat, a distance of 150 feet in places, and might be profitably recovered if some more economical methods of mining could be employed. Most of the gold occurs in the lower 3 feet of gravels and is coarse, rusty, and worn smooth. The largest nugget found had a value of $28. The small flow of Poorman Creek has always hindered mining during the later half of the season.

TOKICHITNA BASIN.

LONG CREEK.

A tributary of the Tokichitna, known as Long or Dog Creek, heads in the broad plateau near the head of Cottonwood Creek. In 1908 three men mined successfully on this stream, the gold being found on slate bedrock. In 1910 an attempt was made to continue mining here, but the depth of gravels increased abruptly in the stream bed, and a deep excavation made by groundsluicing with an automatic dam failed to reach bedrock. The production in 1911 was therefore light.

LAKE CREEK BASIN.

LAKE CREEK.

Lake Creek is a large stream, 40 miles long, which heads in a lake in the high mountains between Yentna and Kahiltna rivers and flows over a high plateau in the upper half of its course. Throughout the lower half of its course it is intrenched in glacial materials and beds of the soft coal-bearing series and flows in a canyon which in places has a depth of 300 feet. In the headward portions of its basin gold has been found in many places, but in sufficient quantities to mine only in the basin of Mills Creek. In the lower intrenched portion of the valley some gold was recovered from the stream bars several years ago, but no permanent camps were established. It is reported that in 1911 one man was mining gravels on a bench 50 feet above the stream, about 12 miles from its junction with Yentna River. All the gold taken from lower Lake Creek is fine and has evidently traveled far from its source. Much of it was probably taken up by the glacial ice from the higher mountains and deposited in the glacial clays, being later reconcentrated by the stream.

MILLS CREEK BASIN.

General features.—Mills Creek is a tributary of Camp Creek from the west; Camp Creek empties into Lake Creek and drains a portion of the foothills and of the high plateau between that stream and Yentna River. In the upper portion of Mills Creek basin only the soft beds of the coal-bearing series and their associated gravels are exposed, the rocks of the slate and graywacke series which are seen in the basins of the streams of the Cache Creek region not appearing at the surface. Gold in paying quantities has been found only in the gulches of the hills that surround the two main forks of the stream. These hills were formerly covered and smoothed by the great glacier which mantled the region, but since its retreat the streams have cut considerable valleys in the easily eroded materials of which the hills are composed. Figure 7, a sketch map of the upper part of Mills Creek basin, shows the location of the gold-placer mines.

Wagner Gulch.—Gold was first discovered in this basin in 1906, in Wagner Gulch, a small tributary of Mills Creek, near its head. The gulch is steep and narrow and contains only a small stream. The ground to be mined averaged only 20 to 30 feet wide in the valley bottom and was 3 to 10 feet deep. The gold was found on a somewhat consolidated bed of gravels in the stream bed, or on the sands and clays of the coal-bearing series. It is bright in color and is flat and much worn, showing that it has been transported some distance from its bedrock source. This gulch is about mined out, as the pay streak terminated rather abruptly upstream. No work was done on it in 1911.

Chicago Gulch.—In Chicago Gulch, another tributary of upper Mills Creek, the conditions for mining are much like those on Wagner Gulch, except that the valley is smaller and steeper. The fall of the creek is about 1 foot in 6, and the stream gravels average about 20 feet in width from one valley wall to the other. Bowlders are numerous, but few are too large for one man to handle. The flow of the stream becomes small during the later part of the summer, and sluice boxes 12, 10, or 8 inches wide are used, according to the supply of water. The gold is coarse but flat and flaky, and few large nuggets have been found. The pay streak in this gulch, like that on Wagner Creek, played out abruptly upstream. One man was mining on Chicago Gulch in 1911.

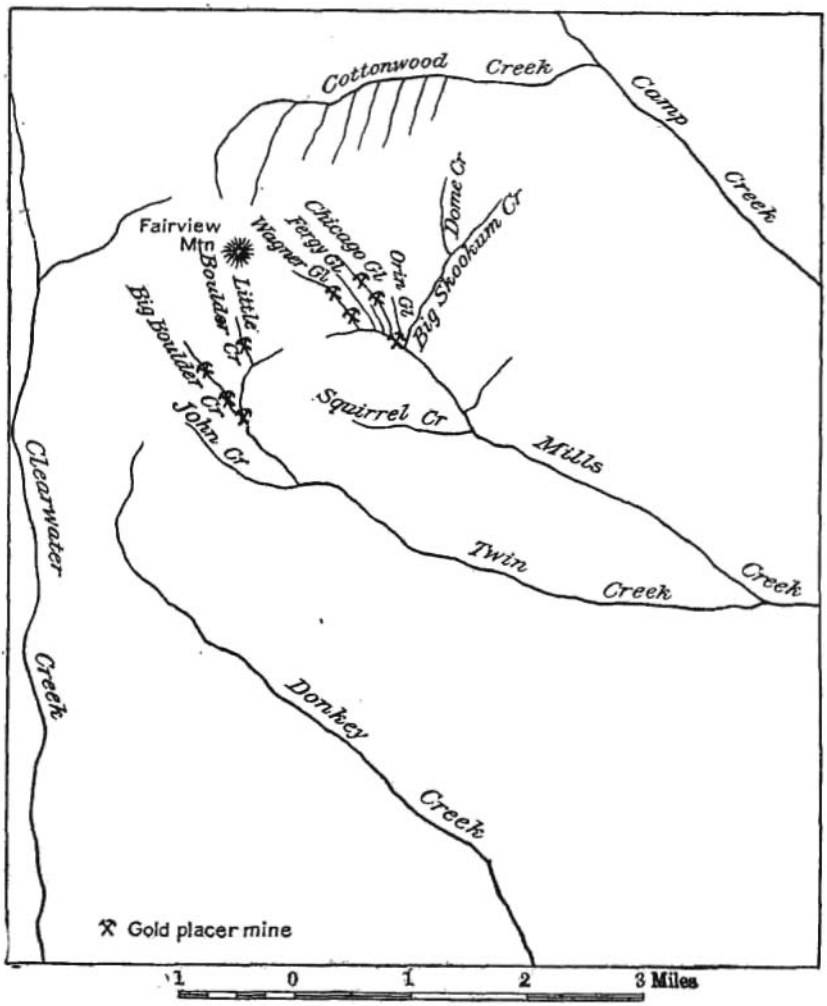


FIGURE 7.—Sketch map of upper part of Mills Creek basin, showing location of gold-placer mines.

Mills Creek.—Little work has been done on Mills Creek proper, as prospectors there have always had difficulty in reaching bedrock. The dryness of the season of 1911 put an end to mining on the smaller gulches at an earlier date than usual, and a number of men thus found opportunity to sink a bedrock drain in the main creek valley a short distance above the mouth of Chicago Gulch. Bedrock was reached at a depth of 12 feet, and it was reported that sufficient gold to warrant mining was found.

Twin Creek.—Twin Creek forms one of the headward forks of Mills Creek, and like it lies in a basin composed solely of the gravels, sands, and clays of the coal-bearing series. Gold has been mined on three small tributaries, known as Big Boulder, Little Boulder, and Johns creeks. They are all small, steep-sided gulches cut into the soft bedrock, with steep gradients and narrow valley floors. The conditions in these gulches are like those in Wagner and Chicago gulches already described. The stream gravels have been mined for the last six years by various people, and the production, though never large, has been fairly steady.

Origin of the gold.—The bedrock in the basins of Mills and Twin creeks is quite different from that in the heads of the streams in the Cache Creek region, and the same explanation of the origin and distribution of the placer gold can not be applied to both areas. In the Cache Creek district all the producing creeks head in the slates and graywackes of the foothills ranges, or flow through materials which have come from these hills, and the gold was certainly derived from the slates. The basins of Mills and Twin creeks lie altogether in the sands and shales of the coal-bearing series and the associated gravels, and the present valleys of the streams have been eroded in postglacial time. It seems certain, therefore, that the placer gold of the creeks was scattered through the deposits in which the streams are eroding and has been concentrated by them to form workable placer Sufficient prospecting of the materials of which the hills are composed has not been done to determine their gold content, but the manner in which the pay streaks terminate rather abruptly upstream in the several gulches suggests that most of the gold is derived from certain well-defined strata of the hills, and is found in the creeks only below the point at which these strata are crossed by the streams. The gold is flat and worn, having been rehandled by the streams. Its original source may have been the slates in the mountains to the northwest, but of this there is no definite evidence.

PROSPECTS.

In addition to the producing creeks already described, prospecting has been done on many streams of the Yentna district, some of which give considerable promise and may soon support a mining population. Kichatna River and its tributary, the Nakochna, which lie southwest of Yentna River, above the Skwentna, have been prospected by a number of men and have yielded some fine gold. It is reported that these streams afford extensive areas of gold-bearing gravels suitable for dredging. Independence Creek, a small tributary of the Yentna below its forks, contains some gold and has been prospected for several seasons.

The streams between Mills Creek and Kahiltna River, including Camp, Sunflower, and Lake Creek basins, have been prospected, and though gold is present on all of them no paying ground has so far been found. Unsatisfactory prospects have also been found on the streams between Dutch Hills and the main mountain range.

On the east side of Peters Hills, on the headward tributaries of Martin Creek, coarse gold has been found, although this drainage basin has received little attention from prospectors. The geologic conditions are somewhat similar to those on the producing tributaries of Cache Creek, and from this it would appear that this neglected area is at least worthy of more thorough prospecting. If the quartz veins of Peters Hills carry a gold content equal to that of the veins in Dutch Hills there should be workable ground on the tributaries of Martin Creek. On the other hand, it should be remembered that in general the mineralization of the slates decreases with distance from the granitic intrusions of the higher mountains, and it remains to be proven whether or not the Peters Hills were sufficiently mineralized to produce workable placers.

The recovery of considerable fine gold from the bars of Lake Creek and Kahiltna River and reports of encouraging amounts of gold in the wide flats on the lower courses of these streams give hope that at some future time these streams may support a dredging industry.

SUMMARY OF PLACER MINING.

Placer gold has been mined in the Cache Creek district since 1905 and in the basin of Mills Creek since 1906. Though the region has at no time been the scene of great activity or of large production, its output has been steady and the interest in it has steadily grown greater. The population has increased from a few men in the early years to more than 100 men in 1911, most of whom were actively engaged in mining or in development work. The total output up to the present time, as shown in the accompanying table of production, is estimated at \$383,000, of which about \$63,000 was produced in 1911.

Estimated production of placer gold from the Yentna region from 1905 to 1911.

Cache Creek	\$30,000
Gold and Nugget creeks	152,000
Lucky and Rambler gulches	4,200
Thunder, Falls, and Dollar creeks	44,800
Peters and Bird creeks	28,000
Poorman, Willow, and Long creeks	106,000
Mills and Twin creeks and tributaries	15,000
Lower Kahiltna River and Lake Creek	3,000
	383,000

The estimated production of the district by years is also given in the succeeding table:

Placer production in Yentna district.

Year.	Gold.		Silver.	
	Ounces.	Value.	Ounces.	Value.
1905	1,693.27	$35,000	237	$144
1906	1,693.27	35,000	237	161
1907	3,434.93	71,000	481	317
1908	2,660.86	55,000	372	197
1909	2,902.75	60,000	406	211
1910	3,096.27	64,000	433	233
1911	3,047.63	63,000	427	230
	18,528.98	383,000	2,593	1,493

These figures should be encouraging if the lack of transportation and the freight charge of 10 to 15 cents a pound for all supplies and equipment brought to the mines are considered. Should a railroad penetrate the Susitna Valley and reduce the time and expense of landing supplies at the camps, much ground which is not now worked could be mined at a profit and the gold output of the region would be greatly increased.

COAL.

The accompanying map (Pl. III in pocket) shows the areas over which the beds of the coal-bearing series of rocks outcrop at the surface, but it by no means indicates all the area underlain by this series, which in many places is covered by glacial materials and stream gravels. It should not be understood that all the area so mapped contains workable coal beds, for in most places the exposures are imperfect, and only a portion of the series can be seen. At many localities in the Yentna district, however, there are outcrops of lignitic coal of varying thickness. All the coal examined was of low grade and was light and woody in texture, with a black to brownish color, and would be classed as medium to low grade lignite. No coal has been mined commercially, and no extensive openings have been made which show it in an unweathered state. The best natural exposures of coal are on Cottonwood Creek, a small stream near the Mills Creek mining camps; on Short Creek, a small tributary of Cache Creek; and on Peters Creek below the lower canyon. At these localities coal beds ranging in thickness from 3 to 12 feet are exposed. Coal taken from them has been used for fuel by miners in places where timber is scarce but has no other present commercial value.

INDEX.

RECENT SURVEY PUBLICATIONS ON ALASKA.

[Arranged geographically. A complete list can be had on application.]

All these publications can be obtained or consulted in the following ways:

1. A limited number are delivered to the Director of the Survey, from whom they can be obtained free of charge (except certain maps) on application.

2. A certain number are delivered to Senators and Representatives in Congress for distribution.

3. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they can be had at prices slightly above cost. The publications marked with an asterisk (*) in this list are out of stock at the Survey but can be purchased from the Superintendent of Documents at the prices stated.

4. Copies of all Government publications are furnished to the principal public libraries throughout the United States, where they can be consulted by those interested.

GENERAL.

*The geography and geology of Alaska, a summary of existing knowledge, by A. H. Brooks, with a section on climate, by Cleveland Abbe, jr., and a topographic map and description thereof, by R. U. Goode. Professional Paper 45, 1906, 327 pp. $1.

*Placer mining in Alaska in 1904, by A. H. Brooks. In Bulletin 259, 1905, pp. 18–31. 15 cents.

The mining industry in 1905, by A. H. Brooks. In Bulletin 284, 1906, pp. 4–9.

The mining industry in 1906, by A. H. Brooks. In Bulletin 314, 1907, pp. 19–39.

*The mining industry in 1907, by A. H. Brooks. In Bulletin 345, 1908, pp. 30–53. 45 cents.

*The mining industry in 1908, by A. H. Brooks. In Bulletin 379, 1909, pp. 21–62. 50 cents.

The mining industry in 1909, by A. H. Brooks. In Bulletin 442, 1910, pp. 20–46.

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Railway routes, by A. H. Brooks. In Bulletin 284, 1906, pp. 10–17.

*Railway routes from the Pacific seaboard to Fairbanks, Alaska, by A. H. Brooks. In Bulletin 520, 1912, pp. 45–88. 50 cents.

Geologic features of Alaskan metalliferous lodes, by A. H. Brooks. In Bulletin 480, 1911, pp. 43–93.

*Tin resources of Alaska, by Frank L. Hess. In Bulletin 520, 1912, pp. 89–92. 50 cents.

*Administrative report, by A. H. Brooks. In Bulletin 259, 1905, pp. 13–17. 15 cents.

Administrative report, by A. H. Brooks. In Bulletin 284, 1906, pp. 1–3.

Administrative report, by A. H. Brooks. In Bulletin 314, 1907, pp. 11–18.

*Administrative report, by A. H. Brooks. In Bulletin 345, 1908, pp. 5–17. 45 cents.

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*Geographic dictionary of Alaska, by Marcus Baker; second edition by James McCormick. Bulletin 299, 1906, 690 pp. 50 cents.
*Water-supply investigations in Alaska in 1906–7, by F. F. Henshaw and C. C. Covert. Water-Supply Paper 218, 1908, 156 pp. 25 cents.

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*Alaska, topographic map of; scale 1:2,500,000; preliminary edition, by R. U. Goode. Contained in Professional Paper 45. $1. Not published separately.
*Map of Alaska showing distribution of mineral resources; scale, 1:5,000,000; by A. H. Brooks. Contained in Bulletin 345. 45 cents.
Map of Alaska; scale, 1:5,000,000; by Alfred H. Brooks.
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Map showing distribution of mineral resources in Alaska, by A. H. Brooks; scale, 1:5,000,000. Price 20 cents. Also included in *Bulletin 520. 50 cents.

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*Preliminary report on the Ketchikan mining district, Alaska, with an introductory sketch of the geology of southeastern Alaska, by Alfred H. Brooks. Professional Paper 1, 1902, 120 pp. 25 cents.
*The Porcupine placer district, Alaska, by C. W. Wright. Bulletin 236, 1904, 35 pp. 15 cents.
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*Lode mining in southeastern Alaska in 1907, by C. W. Wright. In Bulletin 345, 1908, pp. 78–97. 45 cents.
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The Eagle River region, southeastern Alaska, by Adolph Knopf, including detailed geologic and topographic maps. Bulletin 502, 1912, 61 pp.
The Sitka mining district, Alaska, by Adolph Knopf. Bulletin 504, 1912, 32 pp.
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Topographic maps.

Juneau special map; scale, 1: 62,500; by W. J. Peters. For sale at 10 cents each or $3 for 50.
Berners Bay special map; scale, 1 : 62,500; by R. B. Oliver. For sale at 10 cents each or $3 for 50.
Topographic map of the Juneau gold belt, Alaska. Contained in *Bulletin 287, Plate XXXVI, 1906. 75 cents. Not issued separately.
Kasaan Peninsula, Prince of Wales Island. No. 520–A; scale, 1 : 62,500; by R. H. Sargent, D. C. Witherspoon, and J. W. Bagley. For sale at 10 cents each or $3 for 50.
Copper Mountain and vicinity, Prince of Wales Island, scale, 1: 62,500; by R. H. Sargent. For sale at 10 cents each or $3 for 50.

CONTROLLER BAY, PRINCE WILLIAM SOUND, AND COPPER RIVER REGIONS.

*The mineral resources of the Mount Wrangell district, Alaska, by W. C. Mendenhall. Professional Paper 15, 1903, 71 pp. Contains map of Prince William Sound and Copper River region; scale, 12 miles=1 inch. 30 cents.
*Bering River coal field, by G. C. Martin. In Bulletin 259, 1905, pp. 140–150. 15 cents.
*Cape Yaktag placers, by G. C. Martin In Bulletin 259, 1905, pp. 88–89. 15 cents.
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Petroleum at Controller Bay, by G. C. Martin. In Bulletin 314, 1907, pp. 89–103.
Geology and mineral resources of Controller Bay region, by G. C. Martin. Bulletin 335, 1908, 141 pp.
*Notes on copper prospects of Prince William Sound, by F. H. Moffit. In Bulletin 345, 1908, pp. 176–178. 45 cents.
*Mineral resources of the Kotsina and Chitina valleys, Copper River region, by F. H. Moffit and A. G. Maddren. In Bulletin 345, 1908, pp. 127–175. 45 cents.
Mineral resources of the Kotsina-Chitina region, by F. H. Moffit and A. G. Maddren. Bulletin 374, 1909, 103 pp.
*Copper mining and prospecting on Prince William Sound, by U. S. Grant and D. F. Higgins, jr. In Bulletin 379, 1909, pp. 87–96. 50 cents.
*Gold on Prince William Sound, by U. S. Grant. In Bulletin 379, 1909, p. 97. 50 cents.
*Mining in the Kotsina-Chitina, Chistochina, and Valdez Creek regions, by F. H. Moffit. In Bulletin 379, 1909, pp. 153–160. 50 cents.
*Mineral resources of the Nabesna-White River district, by F. H. Moffit and Adolph Knopf. In Bulletin 379, 1909, pp. 161–180. 50 cents.
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Geology and mineral resources of the Nizina district, Alaska, by F. H. Moffit and S. R. Capps. Bulletin 448, 1911, 111 pp.
Headwater regions of Gulkana and Susitna rivers, Alaska, with accounts of the Valdez Creek and Chistochina placer districts, by F. H. Moffit; including geologic and topographic reconnaissance maps. Bulletin 498, 1912, 82 pp.
The upper Susitna and Chistochina districts, by F. H. Moffit. In Bulletin 480, 1911, p. 127.
*The Taral and Bremner districts, by F. H. Moffit. In Bulletin 520, 1912, pp. 93–104. 50 cents.
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Controller Bay region; No. 601 A; scale, 1:62,500; by E. G. Hamilton. Price 35 cents a copy or $21 per hundred.
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Outline of the geology and mineral resources of the Iliamna and Clark lakes region, by G. C. Martin and F. J. Katz. In Bulletin 442, 1910, pp. 179–200.
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A geologic reconnaissance of the Iliamna region, Alaska, by G. C. Martin and F. J. Katz. Bulletin 485, 1912, 138 pp.
Geology and coal fields of the lower Matanuska Valley, Alaska, by G. C. Martin and F. J. Katz; including detailed geologic and topographic maps. Bulletin 500, 1912, 98 pp.
*Gold deposits of the Seward-Sunrise region, Kenai Peninsula, by B. L. Johnson. In Bulletin 520, 1912, pp. 131–173. 50 cents.

*Gold placers of the Yentna district, by S. R. Capps. In Bulletin 520, 1912, pp. 174–200. 50 cents.

The Yentna district, Alaska, by S. R. Capps. Bulletin 534, 1913, 75 pp.

Preliminary report on a detailed survey of part of the Matanuska coal fields, by G. C. Martin. In Bulletin 480, 1911, p. 135.

A reconnaissance of the Willow Creek gold region, by F. J. Katz. In Bulletin 480, 1911, p. 152.

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*Kenai Peninsula, northern portion; scale, 1:250,000; by E. G. Hamilton. Contained in Bulletin 277. 25 cents. Not published separately.

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*Gold mine on Unalaska Island, by A. J. Collier. In Bulletin 259, 1905, pp. 102–103. 15 cents.

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*Notes on the petroleum fields of Alaska, by G. C. Martin. In Bulletin 259, 1905, pp. 128–139. 15 cents. (Abstract from Bulletin 250.)

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The Balboa-Herendeen Bay and Unga Island region; scale, 1:250,000; by H. M. Eakin. Contained in Bulletin 467. Not issued separately.

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*The gold placers of the Fortymile, Birch Creek, and Fairbanks regions, by L. M. Prindle. Bulletin 251, 1905, 89 pp. 35 cents.

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*Occurrence of gold in the Yukon-Tanana region, by L. M. Prindle. In Bulletin 345, 1908, pp. 179–186. 45 cents.

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*Water-supply investigations in Alaska, 1906 and 1907, by F. F. Henshaw and C. C. Covert. Water-Supply Paper 218, 1908, 156 pp. 25 cents.
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Placer mining in the Yukon-Tanana region, by C. E. Ellsworth. In Bulletin 442, 1910, pp. 230–245.
Occurrence of wolframite and cassiterite in the gold placers of Deadwood Creek, Birch Creek district, by B. L. Johnson. In Bulletin 442, 1910, pp. 246–250.
Water supply of the Yukon-Tanana region, by C. E. Ellsworth. In Bulletin 442, 1910, pp. 251–283.
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Placer mining in the Yukon-Tanana region, by C. E. Ellsworth and G. L. Parker. In Bulletin 480, 1911, p. 172.
Water supply of the Yukon-Tanana region, 1910, by C. E. Ellsworth and G. L. Parker. In Bulletin 480, 1911, p. 217.
Mineral resources of the Bonnifield region, by S. R. Capps. In Bulletin 480, 1911, p. 235.
Gold placer mining developments in the Innoko-Iditarod region, by A. G. Maddren. In Bulletin 480, 1911, p. 270.
*Placer mining in the Fortymile and Seventymile river districts, by E. A. Porter. In Bulletin 520, 1912, pp. 211–218. 50 cents.
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*The Rampart and Hot Springs regions, by H. M. Eakin. In Bulletin 520, 1912, pp. 271–286. 50 cents.
*The Ruby placer district, by A. G. Maddren. In Bulletin 520, 1912, pp. 287–296. 50 cents.
*Gold placers between Woodchopper and Fourth of July creeks, upper Yukon River, by L. M. Prindle and J. B. Mertie, jr. In Bulletin 520, 1912, pp. 201–210. 50 cents.
The Bonnifield region, Alaska, by S. R. Capps; including geologic and topographic reconnaissance maps. Bulletin 501, 1912, 162 pp.
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The Iditarod-Ruby region, Alaska, by H. M. Eakin, with geologic and topographic reconnaissance maps. Bulletin ——. (In preparation.)

Topographic maps.

Fortymile quadrangle; No. 640; scale, 1: 250,000; by E. C. Barnard. Price, 10 cents a copy or $3 for 50.

Fairbanks quadrangle; No. 642; scale, 1: 250,000; by T. G. Gerdine, D. C. Witherspoon, and R. B. Oliver. Price, 20 cents a copy or $6 for 50.

Rampart quadrangle; No. 643; scale, 1: 250,000; by D. C. Witherspoon and R. B. Oliver. Price, 20 cents a copy or $6 for 50.

Fairbanks district; No. 642A; scale, 1: 62,500; by T. G. Gerdine and R. H. Sargent. Price, 20 cents a copy or $6 for 50.

*Yukon-Tanana region, reconnaissance map of; scale, 1: 625,000; by T. G. Gerdine. Contained in Bulletin 251, 1905. 35 cents. Not published separately.

*Fairbanks and Birch Creek districts, reconnaissance maps of; scale, 1: 250,000; by T. G. Gerdine. Contained in Bulletin 251, 1905. 35 cents. Not issued separately.

Circle quadrangle, Yukon-Tanana region; scale, 1: 250,000; by D. C. Witherspoon. Price 50 cents a copy. Also contained in Bulletin 295.

SEWARD PENINSULA.

*A reconnaissance of the Cape Nome and adjacent gold fields of Seward Peninsula, Alaska, in 1900, by A. H. Brooks, G. B. Richardson, and A. J. Collier. In a special publication entitled "Reconnaissances in the Cape Nome and Norton Bay regions, Alaska, in 1900," 1901, 180 pp. 50 cents.

*A reconnaissance in the Norton Bay region, Alaska, in 1900, by W. C. Mendenhall. In a special publication entitled "Reconnaissances in the Cape Nome and Norton Bay regions, Alaska, in 1900," 1901, 38 pp. 50 cents.

*A reconnaissance of the northwestern portion of Seward Peninsula, Alaska, by A. J. Collier. Professional Paper 2, 1902, 70 pp. 30 cents.

*The tin deposits of the York region, Alaska, by A. J. Collier. Bulletin 229, 1904, 61 pp. 15 cents.

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The Kougarok region, by A. H. Brooks. In Bulletin 314, 1907, pp. 164–181.

*Water supply of Nome region, Seward Peninsula, Alaska, 1906, by J. C. Hoyt and F. F. Henshaw. Water-Supply Paper 196, 1907, 52 pp. 15 cents.

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The Nome region, by F. H. Moffit. In Bulletin 314, 1907, pp. 126–145.

Gold fields of the Solomon and Niukluk river basins, by P. S. Smith. In Bulletin 314, 1907, pp. 146–156.

Geology and mineral resources of Iron Creek, by P. S. Smith. In Bulletin 314, 1907, pp. 157–163.

The gold placers of parts of Seward Peninsula, Alaska, including the Nome, Council, Kougarok, Port Clarence, and Goodhope precincts, by A. J. Collier, F. L. Hess, P. S. Smith, and A. H. Brooks. Bulletin 328, 1908, 343 pp.

*Investigation of the mineral deposits of Seward Peninsula, by P. S. Smith. In Bulletin 345, 1908, pp. 206–250. 45 cents.

*The Seward Peninsula tin deposits, by Adolph Knopf. In Bulletin 345, 1908, pp. 251–267. 45 cents.

*Mineral deposits of the Lost River and Brooks Mountain regions, Seward Peninsula, by Adolph Knopf. In Bulletin 345, 1908, pp. 268–271. 45 cents.

*Water supply of the Nome and Kougarok regions, Seward Peninsula, in 1906–7, by F. F. Henshaw. In Bulletin 345, 1908, pp. 272–285. 45 cents.

*Water-supply investigations in Alaska, 1906 and 1907, by F. F. Henshaw and C. C. Covert. Water-Supply Paper 218, 1908, 156 pp. 25 cents.

Geology of the Seward Peninsula tin deposits, by Adolph Knopf. Bulletin 358, 1908, 72 pp.

*Recent developments in southern Seward Peninsula, by P. S. Smith. In Bulletin 379, 1909, pp. 267–301. 50 cents.

*The Iron Creek region, by P. S. Smith. In Bulletin 379, 1909, pp. 302–354. 50 cents.

*Mining in the Fairhaven precinct, by F. F. Henshaw. In Bulletin 379, 1909, pp. 355–369. 50 cents.

*Water-supply investigations in Seward Peninsula in 1908, by F. F. Henshaw. In Bulletin 379, 1909, pp. 370–401. 50 cents.

Geology and mineral resources of the Solomon and Casadepaga quadrangles, Seward Peninsula, by P. S. Smith. Bulletin 433, 1910, 227 pp.

Mineral resources of the Nulato-Council region, by P. S. Smith and H. M. Eakin. In Bulletin 442, 1910, pp. 316–352.

Mining in Seward Peninsula, by F. F. Henshaw. In Bulletin 442, 1910, pp. 353–371.

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A geologic reconnaissance in southeastern Seward Peninsula and the Norton Bay-Nulato region, by P. S. Smith and H. M. Eakin. Bulletin 449, 1911, 146 pp.

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Surface water supply of Seward Peninsula, Alaska, by F. F. Henshaw and G. L. Parker, with a sketch of the geography and geology, by P. S. Smith, and a description of methods of placer mining, by Alfred H. Brooks; including topographic reconnaissance map. Water-Supply Paper 314, 1913, 317 pp.

Topographic maps.

The following maps are for sale at 10 cents a copy or $3 for 50:

Casadepaga quadrangle, Seward Peninsula; No. 646 C; scale, 1:62,500; by T. G. Gerdine.

Grand Central quadrangle, Seward Peninsula; No. 646 A; scale, 1:62,500; by T. G. Gerdine.

Nome quadrangle, Seward Peninsula; No. 646 B; scale, 1:62,500; by T. G. Gerdine.

Solomon quadrangle, Seward Peninsula; No. 646 D; scale, 1:62,500; by T. G. Gerdine.

The three following maps are for sale at 50 cents a copy or $15 for 50:

Seward Peninsula, northeastern portion of, topographic reconnaissance of; scale, 1:250,000; by T. G. Gerdine.

Seward Peninsula, northwestern portion of, topographic reconnaissance of; scale, 1:250,000; by T. G. Gerdine.

Seward Peninsula, southern portion of, topographic reconnaissance of; scale, 1:250,000; by T. G. Gerdine.

Seward Peninsula, southeastern portion of, topographic reconnaissance of; scale, 1:250,000. Contained in Bulletin 449. Not published separately.

NORTHERN ALASKA.

*A reconnaissance from Fort Hamlin to Kotzebue Sound, Alaska, by way of Dall, Kanuti, Allen, and Kowak rivers, by W. C. Mendenhall. Professional Paper 10, 1902, 68 pp. 30 cents.

*A reconnaissance in northern Alaska across the Rocky Mountains, along the Koyukuk, John, Anaktuvuk, and Colville rivers, and the Arctic coast to Cape Lisburne, in 1901, by F. C. Schrader and W. J. Peters. Professional Paper 20, 1904, 139 pp. 40 cents.

*Coal fields of the Cape Lisburne region, by A. J. Collier. In Bulletin 259, 1905, pp. 172–185. 15 cents.

*Geology and coal resources of Cape Lisburne region, Alaska, by A. J. Collier. Bulletin 278, 1906, 54 pp. 15 cents.

The Shungnak region, Kobuk Valley, by P. S. Smith and H. M. Eakin. In Bulletin 480, 1911, pp. 271–305.

The Squirrel River placers, by P. S. Smith. In Bulletin 480, 1911, pp. 306–319.

*Geologic investigations along the Canada-Alaska boundary, by A. G. Maddren. In Bulletin 520, 1912, pp. 297–314. 50 cents.

*The Alatna-Noatak region, by P. S. Smith. In Bulletin 520, 1912, pp. 315–338. 50 cents.

The Noatak-Kobuk region, by P. S. Smith. Bulletin 536. (In preparation.)

Topographic maps.

*Fort Yukon to Kotzebue Sound, reconnaissance map of; scale, 1:1,200,000; by D. L. Reaburn. Contained in Professional Paper 10. 30 cents. Not published separately.

*Koyukuk River to mouth of Colville River, including John River; scale, 1:1,200,000; by W. J. Peters. Contained in Professional Paper 20. 40 cents. Not published separately.

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