DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

BULLETIN 410

THE INNOKO GOLD-PLACER DISTRICT ALASKA

WITH ACCOUNTS OF THE

CENTRAL KUSKOKWIM VALLEY AND THE RUBY CREEK AND GOLD HILL PLACERS

BY

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WASHINGTON
GOVERNMENT PRINTING OFFICE
1910

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By Alfred H. Brooks.

The Innoko placer district has attracted much interest during the last two years, and it appears that there are now sufficient data to warrant a belief that it will become a producer of considerable gold. Mr. Maddren's investigations in this field, on which the following report is based, were carried out practically alone and under conditions of travel and time that did not permit exhaustive studies of the mineral resources. If this mining field continues to develop as it promises, a more elaborate survey will be undertaken as soon as circumstances permit.

There has been of late a considerable influx of prospectors to the Kuskokwim Valley, and this has led to many requests for information in regard to this field. Unfortunately, there have been no surveys in the Kuskokwim basin except of its headwaters since the hasty exploration by Spurr and Post in 1898. As Spurr's report is out of print, it seemed desirable to bring together in this volume the more important data concerning the general geology and mineral resources of the Kuskokwim. This compilation is based for the most part on Spurr's report, but use has been made of information obtained from prospectors.

Mr. Maddren's conclusion that there are considerable areas of more or less highly altered Paleozoic and pre-Ordovician rocks in this general field may be of far-reaching economic importance, for it is those formations which have yielded the rich placers to the northeast. Of significance also is the tracing of the source of the gold to mineralization associated with acidic intrusives, which bears out the theory advanced by Spurr over a decade ago.

THE INNOKO GOLD PLACER DISTRICT, ALASKA, WITH ACCOUNTS OF THE CENTRAL KUSKOKWIM VALLEY AND THE RUBY CREEK PLACERS.

By A. G. MADDREN.

INTRODUCTION.

The object of this paper is to summarize the available information about that part of Alaska stretching southward from the lower central Yukon River to the central part of Kuskokwim River. The region here to be described lies between meridians 154° and 160° west longitude and parallels 61° and 65° north latitude. The distinctive major geographic features it includes are the Kaiyuh Mountains, the entire Innoko Valley, and the central portions of the Kuskokwim Mountains and the Kuskokwim Valley.

Nearly all of the information here presented is the result of two hasty expeditions into different parts of the region, made ten years apart, by members of the United States Geological Survey.

In 1898, J. E. Spurr, geologist, and W. S. Post, topographer, made a reconnaissance along Kuskokwim River[a] from the upper part of its South Fork to Bering Sea. They entered the Kuskokwim Valley by coming across the Portage-Ptarmigan Creek valley pass from the watershed of the Susitna Valley by way of Yentna and Skwentna rivers. They traveled along the streams with canoes, and when they reached the main portion of the Kuskokwim, at the confluence of the North and South forks, their supplies had become so reduced that they were obliged to travel very rapidly downstream to Bethel, a missionary settlement 491 miles below the forks. This distance was traveled in fourteen days, and the necessity of proceeding without delay allowed only a hasty examination of the rocks along the immediate course of the Kuskokwim.

Most of the information on the Kuskokwim Valley here given is taken from Spurr's report. His descriptions have been freely incorporated with the information gathered by the writer, with the object

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

of presenting as complete an account as is possible with the material at hand. Only further investigations will make it possible to describe this country fully.

In 1908 a similar hurried trip through the Innoko Valley, from August 2 to September 25, permitted the writer to make a superficial examination of the region drained by Innoko River, more especially the area of its southern headwater tributaries, of part of the divide between the Innoko and Kuskokwim, and of the country immediately northwest of the Innoko basin, to the point where the Innoko flows into the Yukon. None of the territory covered by Spurr along the Kuskokwim was reexamined by the writer, so no direct comparisons of the rocks of these adjacent areas have been made. However, the general features of the geography and geology of the country lying between the middle course of the Kuskokwim and the lower-central portion of the Yukon may be outlined in a broad way, and in the present publication an attempt is made to present, in a combined form, the information that is now available as a result of the two expeditions mentioned above. The accompanying map (Pl. I, in pocket) has been compiled from all the information available, and includes a much larger area than is considered in the text, in order to convey an idea of the broader relations of the portion here described to the surrounding region. Its degree of completeness for the area discussed in the text is about the same as that of the written descriptions. The geographic and geologic information presented about the adjacent region is taken from various Geological Survey publications. Future work must supply more detailed information on this portion of Alaska and connect its features with those of the surrounding territory by an examination of the intervening country.

GEOGRAPHY.

LOCATION AND EXTENT OF THE REGION.

Plate I shows the location and extent of the region under discussion and its general relations. This map covers that part of Alaska between meridians 154° and 162° west longitude and parallels 61° and 65° north latitude, and includes in its central part the country here more particularly described.

This map is based on surveys of the Kuskokwim by W. S. Post and of the Yukon by the Alaska Road Commission and Arthur J. Collier, and on foot and boat traverses of the Innoko by J. L. McPherson and the writer. The course of Chulitna River is taken from a map furnished by W. R. Buckman.

The lower-central course of Yukon River, flowing westward, traverses the northern margin of the region to Nulato and thence runs southwestward. The main forks of the upper Kuskokwim are

located near the middle of the eastern boundary and thence this river flows diagonally across the area in southerly and westerly directions. The largest part of the region above described is occupied by Innoko River and its tributaries.

GENERAL FEATURES OF RELIEF.

This extensive area is primarily one of moderately mountainous character. Its most pronounced features are broad, undulating, rather even-topped ridges separated by broad major valleys and relatively narrow minor valleys. The average height of the ridges above the stream beds is from 800 to 1,200 feet. Isolated mountain masses rise above the general level of the ridges, more especially in the headwater region of the Innoko.

KAIYUH MOUNTAINS.

The Kaiyuh Mountains extend from the south side of the Yukon opposite the mouth of Melozitna River, in a southwesterly direction to the lower course of the Innoko, at a point where it is joined by Shageluk Slough, a distance of about 175 miles. These mountains are comparatively low, being little more than high hills at their northeast and southwest extremities. The higher parts of the Kaiyuh Range between the low passes rise to a maximum height of about 2,000 feet above sea level. Throughout their extent they present rather smooth, evenly rounded, and undulating outlines, with no sharp peaks. They are broken by several low passes, especially where the north fork of the Innoko lies opposite Yuko River, which drains into the Yukon, and also where Kluklaklatna River, a lower tributary of the Innoko, heads against a branch of the Khotol on the Yukon side.

INNOKO VALLEY.

Innoko River is about 500 miles long, and with its tributaries drains the largest part of an extensive area that lies between the central lower courses of Yukon and Kuskokwim rivers. (See Pl. I.) Its basin occupies a depression lying between the Kaiyuh Mountains on the northwest and the Kuskokwim Mountains on the southeast, these ranges separating it from the drainage of Yukon and Kuskokwim rivers, respectively. The Innoko is tributary to the Yukon from the east, joining it about 380 miles from Bering Sea.

PRESENT DRAINAGE FEATURES.

The Innoko Valley comprises two topographic provinces, corresponding approximately with the upper and lower halves of the valley. The upper province is characterized by hills and low mountains and is drained by clear streams that flow with currents of

moderate strength in valleys whose flood plains are well developed to a width commensurate with the amount of water now carried. In this province the streams flow for the most part over flat valley floors, composed mostly of well-washed gravels, but also locally, to some extent, of small areas of sands and here and there of deposits of silt. Toward the headwaters there are a few localities where the streams run directly upon bare bed rock. The upper province is one where erosion and transportation have been going on for a long time and are still in progress. The main upper valley and its tributary valleys appear to have been eroded down rather rapidly to their present levels out of a rolling plateau region that had an average elevation of about 1,000 feet, into which the present valley system is well incised. The interstream areas still remain as well-marked remnants of the former plateau surface in the form of flat-topped ridges, with rather steep sides and, in places, even escarpment declivities descending to the valley floors. In places a comparatively recent stage of sudden acceleration of the down cutting by the present streams is shown on the sides of the valleys by elevated gravel benches that are remnants of the filling of an older valley.

On the other hand, the lower half of the Innoko Valley is an area characterized by stream deposition. The main river and its principal tributaries in this province meander widely over a great extent of low, flat country, where the surface covering is silt and clay. The channels and banks are for the most part cut in these fine-grained waterlaid sediments, although in its lower course, where it passes around the southwest end of the Kaiyuh Range, the Innoko here and there touches low rock bluffs on its right-hand side in making its tortuous way to the Yukon. These low, flat, swampy plains, which are about 20 miles wide from east to west, lie between the Kaiyuh and Kuskokwim ranges, extending from the hilly country of the upper Innoko on the northeast to the great Yukon-Kuskokwim delta on the southwest. In fact, the lower half of the Innoko Valley is merely a reentrant tongue-like extension inland between two low mountain ranges of the vast coalescent coastal delta plains of the Kuskokwim and Yukon.

Where the Innoko emerges from its upper valley, its banks are on an average from 10 to 15 feet above the normal stage of the river. Here and there the river cuts banks of silt that are 20 to 25 feet high, but its banks gradually decrease in height downstream, and on the lower river they are in many places only 3 or 4 feet above the usual water level. During the spring freshets the whole lower valley is inundated, and after the floods have subsided large areas of swamps, shallow ponds, and lakes remain over its surface. Good examples of natural levees are built up along the banks of the main course of the lower Innoko as a result of floods and subsequent run-off. Dish-

kakat and the other settlements on the lower river are located on the higher silt banks to avoid the spring floods.

OLDER DRAINAGE FEATURES.

The group of mountains between Dishna River and Ganes Creek, which now rise to heights of about 4,500 feet, were in part probably during Pleistocene time occupied by snow and ice fields of considerable local extent. These glaciers eroded the mountains and laid down extensive moraines of unassorted angular rock blocks and bowlders, both about their bases and also for considerable distances out into the wide surrounding valleys. The large volumes of water from the subsequent melting of the ice sheet carried considerable quantities of cobbles, gravel, sand, and silt beyond the limits of glaciation and deposited them with some assorting.

The higher silt banks along the lower Innoko are believed to have been formed during the retreat of ice, and are therefore to be probably considered of Pleistocene age. Some of these high silt deposits occur along the present course of the river, and no doubt a number of areas of similar old silts are present in the extensive flats of the lower Innoko. Nearer the mountains Pleistocene deposits appear to be represented here and there by banks of gravel that stand from 20 to 30 feet above the present stream grades, and in other places the cut banks of the river show deposits of stream-bedded gravel at their base, rising for 2 or 3 feet above the river level. These gravels are cemented together firmly enough to withstand the wash of the current, and locally they stand out as narrow ledges. These partly cemented gravels are overlain by unconsolidated silts and muck to a height of about 10 feet.

The limits of glaciation are marked by morainal deposits of angular rock fragments and bowlders, within which, especially on the north side of the mountains, where the glaciers appear to have been most strongly developed, the present drainage is all relatively young, for it inherits its arrangement from the land forms eroded by the ice and left after the glaciers had melted.

Outside of the area now occupied by morainal deposits there is, however, one marked exception where the preglacial drainage has been strongly modified as a direct result of the glacial activity. Ganes Creek, one of the streams on which placer gold is found, is at least twice as long at it was before the glacial period, and its volume of water has greatly increased owing to an enlargement of its drainage basin, which is three or four times greater than formerly. Before the glacial period Ganes Creek was little longer or larger than Ophir Creek is to-day, and its valley was confined to the slate formation that occupies the lower half of its present course. Previous to the development of glaciers on the mountains lying between the upper

valleys of Beaver Creek and Dishna River the area now drained by the upper part of Ganes Creek was part of the Beaver Creek Valley. At the time of glaciation the upper part of the wide Beaver Valley was deeply filled with deposits of morainal material. Moreover, the glaciers themselves, when at their maximum extent, appear to have occupied the whole or at least a large part of this basin, completely covering the previous land surface. When the ice melted it left the upper Beaver basin clogged with a thick filling of morainal dumps. Although the detailed features of this glacial filling and damming of the upper Beaver Valley are not well known, it is very evident that the former drainage channels were so disarranged that a large volume of the water produced by the melting snow and ice could not find an outlet into the Innoko, toward the northwest, by way of the lower Beaver Valley. As a result it backed up and found an outlet across the lowest divide to the northeast, into what was then the head of Ganes Creek. The large supply of water that was thus diverted down Ganes Creek rapidly cut a canyon through the slate bed rock of the former divide. This canyon, which is several hundred feet deep and about 4 miles long, is situated about midway between the present source of the stream and its mouth. The rapidity of the down cutting is shown not only by the typical box-canyon features, but also by the rock-cut bluffs, with bench gravels on top of them, that rise at intervals on either side of the valley below the canyon for a distance of about 8 miles, to the point where the flood plain widens to coalesce with that of the upper Innoko.

KUSKOKWIM MOUNTAINS.

The Innoko drainage basin is divided from that of the Kuskokwim to the southwest by the middle part of a low but distinct range, named the Kuskokwim Mountains by Spurr, which, although not high, form a definite belt that extends in a northeast-southwest direction through the central part of the Kuskokwim region. These mountains are traversed by Kuskokwim River between the mouths of the Chulitna and the Yukwonilnuk. To the southwest they may be considered to be represented by a group of mountains which Spurr named the Kilbuck Range. The Kuskokwim Mountains may therefore be described as extending northeastward from the Kilbuck Range to and across Kuskokwim River above Kolmakof. Thence they continue as the divide between the Innoko and Kuskokwim beyond the southern headwaters of the Innoko, and extend northeast toward the lower Tanana as a low belt of highlands between the drainage of Nowitna River, flowing into the Yukon, and that of the East Fork of the Kuskokwim.

These mountains are higher than the Kaiyuh Mountains, and in contrast to them present more rugged features. The passes across

them are not so low and flat as those through the Kaiyuh Mountains, and from them more or less extensive isolated mountain masses rise to altitudes of more than 4,000 feet above sea level. One area, lying between the heads of Ganes and Beaver creeks and Dishna River, is occupied by a comparatively high, rugged group that has been the center of former extensive local glaciation. This glaciated group presents rugged and serrated peaks and ridges, and stands in marked contrast above the more flat-topped, gently rolling forms presented by the surrounding mountains. It has a thoroughly glaciated appearance, with ample and well-developed cirques and U-shaped valleys within the mountains themselves, extensive deposits of morainal material spread out as broad, lobe-shaped ridges, and piedmont terraces stretching out into the wide valleys at the base of the mountains. Other high isolated groups that may have also been locally glaciated occur to the southwest near the Kuskokwim and to the northeast beyond the headwaters of the Innoko.

KUSKOKWIM VALLEY.

Kuskokwim River, second in size only to the Yukon in Alaska, has its sources on the western flank of the Alaska Range. From the junction of its two main forks, which falls within the area here under discussion (see Pl. I), the Kuskokwim flows westward and southwestward for a distance of about 700 miles to Bering Sea. This part of the river is navigable for stern-wheel steamboats.

FORKS TO THE CHULITNA.

The East, Middle, and South forks of the upper Kuskokwim drain extensive silt-covered flats. The East Fork and the lower parts of the Middle and South forks and of the Takotna are sluggish and meandering, and their banks for many miles are hardly above floodwater level, for fresh driftwood is found on top of banks of ordinary height. Throughout the lower half of the course of the South Fork the banks are not more than 10 feet high, and a perfectly flat country extends in every direction as far as the eye can see. At the junction of the East and South forks there is the same low deposit of silt. A short distance below, however, the river approaches the hills or low mountains which lie to the northwest, between the basins of the Kuskokwim and the Innoko, and ultimately cuts the rocks of which these hills are formed on the right side; on the left side, however, the same perfectly level banks of silt, rarely rising over 10 or 15 feet above the river, are continuous for nearly half of the distance from the junction of the East and South forks to the mouth of the Takotna. These silts are in every respect the exact counterpart of the silts of the Yukon Flats and of the similar deposits of the lower Yukon.

As far down as the mouth of the Takotna the Kuskokwim almost everywhere cuts the right bank, and only here and there the left for a short distance. The current is sluggish and the river wide and placid, forming broad meanders. From the Takotna to the Chulitna the river generally cuts the right bank—rarely the left. On the right side it usually runs close to mountains, and there are some hills on the left side, although for much of the distance there are only wide stretches of a low, flat, silt-covered region. At the junction of the Takotna the hills lie some distance away from the river and have a very smooth, rounded outline. Farther downstream the hills appear to approach gradually on both sides, until the river flows most of the way in a broad, definite valley, between rounded, level-topped low mountains. Here the country bears a striking resemblance in general appearance to the Lower Ramparts of the Yukon, just as the flat country above is similar to the Yukon flats. The tops of the hills present a nearly uniform level, and the sides are distinctly terraced. Some distance north of Chagavenapuk River the mountains on the left side of the valley trend away from the river and finally disappear in the distance, the intervening space being occupied by low silts and gravels.

Between the forks and the Chulitna the only large tributary of the Kuskokwim from the right is Takotna River, a considerable stream that flows into the Kuskokwim from the northwest about 50 miles below the junction of its east and south forks. The Takotna drains most of that part of the drainage basin of the Kuskokwim which lies near the headwaters of the Innoko. Its lower course has a general northwest-southeast direction for about 15 miles above its mouth, where it forks. The larger or southwest fork rises about 75 miles to the southwest in a direct line, but by its winding course this tributary is 150 or more miles in length. The northeast fork of the Takotna is apparently not so large or long. The valleys of these two forks are really one continuous shallow trough-like depression having a northeast-southwest direction with gradual axial grades from either end toward its middle. The lower Takotna flows at right angles to the direction of the upper valleys to the Kuskokwim through a flat, silt-covered country. These shallow valleys of the upper Takotna are separated from the Kuskokwim by a belt of low relief 20 to 30 miles in width, made up of flat-topped ridges and rounded hills, except where it is broken by the wide flat across which the lower Takotna meanders to join the Kuskokwim. There are also several higher isolated mountains, including, near the southwest fork of the Takotna, two of intrusive rock that rise prominently to a height of about 1,500 feet above the general level of the surrounding country.

Most of the drainage of the country lying between the southwest fork of the Takotna and the Kuskokwim flows directly into the main

river by streams from 15 to 25 miles long. This condition places the divide near the Takotna, and in fact some of the streams flowing into the Kuskokwim rise within 2 miles of the main channel of the upper Takotna. As a consequence the upper Takotna receives most of its secondary drainage from the southeastern slopes of the low mountains that separate it from the Innoko, and this drainage into the Takotna heads directly against the headwaters of the Innoko, which drain the slopes lying northwest of the divide formed by the low belt of relief named the Kuskokwim Mountains. Thus the valleys of the two forks of the Takotna occupy a shallow, troughlike depression between and in general parallel to Kuskokwim River and the Kuskokwim Mountains. Whether this land form is caused by or related to geologic structure has not been learned.

In contrast to the comparatively short streams that form most of the tributary drainage from the northwest side of its valley, the central Kuskokwim receives from the southeast side a number of large tributaries of considerable length that drain extensive areas. Most of these tributaries rise in the mountain ranges that flank the northwest face of the southwestern extension of the high Alaska Range. The South Fork of the Kuskokwim, when its relations to the trend of the main Kuskokwim Valley are considered, is really one of these tributaries. From the South Fork down the river the other principal tributaries from the southeast are named Big River, Kalitna, Tusoluksuk, Chagavenapuk, Stony, and Chulitna. The Chulitna is the largest of these rivers, and its valley appears to occupy part of a former broad valley system, occupied chiefly by the uppermost Kuskokwim, the Chulitna, and the Nushagak. The last two rivers head close together at a very low divide and have the same trend, but flow in opposite directions. These valleys appear to be part of what may formerly have been one general master valley system that separated the Kuskokwim Mountains and the Alaska Range.

CENTRAL PART.

From the mouth of the Chulitna nearly to the mouth of the Yukwonilnuk, a distance of about 70 miles, Kuskokwim River cuts across the Kuskokwim Mountains. Here the river flows in a narrow valley, much more confined and distinct than at any other point on its course. The mountains on either side are higher and, although of smooth, rounded outlines, many of them show considerable relief, and certain peaks, isolated from the rest, rise considerably above the surrounding country. On some of them patches of snow remain throughout the summer. Along this part of the river the rock bluffs rise to a general height of 500 or 600 feet, the level of a broad upland plateau which stretches away from the river and above which rise low, rounded summits.

It seems possible that the ancient course and outlet to the sea of Kuskokwim River may have been by way of the present Chulitna and Nushagak valleys, which now head against each other and are separated only by a broad, flat, low divide, and that the delta of the present Kuskokwim marks the former outlet of the Yukon. It is also probable that the present valley through the Kuskokwim Mountains may represent the deeply intrenched ancient valleys of two opposing streams, one of which flowed into the Kuskokwim and the other into the Yukon.

KUSKOKWIM RIVER BELOW KOLMAKOF.

Below the point where the Kuskokwim turns from a northwesterly to a southwesterly course again its valley begins to widen just above the junction of the Yukwonilnuk, and below this stream the mountains become lower and recede from the river. The mountains still rise to the same general plateau level, which is 500 or 600 feet above the river, and show in many places definite, deeply cut benches. Below Kolmakof the river cuts the right or north bank continuously, until at Kaltshak it leaves the mountains entirely. Here on the north the mountains are at no great distance from the stream, but break down and give way to low hills in its immediate vicinity. These low hills have smooth contours, nearly level tops, and deeply cut terraces. In places the stream in meandering trends away from the hills, which become dim in the distance, but another bend will again bring the river against them, and it repeatedly flows for many miles along a high rock bluff on its right bank. On the left or south side a broad, level plain stretches southward to the mountains, which at Kolmakof have already become distant and which within a short distance downstream diverge so far from the river as to fade entirely from sight, so that only a horizontal sky line remains. The left banks of the river, which are 15 or 20 feet above the ordinary water grade, give evidence of being inundated by the spring floods, for their tops bear fresh driftwood and show the evidences of recent overflow, due to ice gorges.

Below Kaltshak the low, flat tundra spreads out between the lower Yukon and the lower Kuskokwim. This vast lowland has the shape of a great coalescent alluvial delta fan in the form of a quadrant with a radius of about 175 miles that extends southwestward to Bering Sea. As far as one can see the country is low and flat on both sides of the river, and the banks are in general not more than 10 feet high. Where exposed in fresh cuts the banks are seen to be made up of silt, with an upper layer consisting of alternating strata of silt and vegetable matter. Abundant driftwood on the tops of the banks shows the extent of the spring inundation. In some places deposits of small, cross-bedded gravel, the bedding dipping downstream, are

seen in the banks, but there are no rock outcrops on this part of the river. At two points between Kaltshak and Bethel the low banks are replaced by higher bluffs of sand, silt, clay, and vegetable matter. Such a bluff, about 50 feet high, occurs about 40 miles above Bethel, on the right or northwest side of the river. In this bluff the vegetable matter is found in layers extending to the very bottom of the bank. Another bluff of considerable height, also on the right bank, is located about 10 miles above Bethel, but here the silt is clean and contains no vegetable matter. At Bethel the banks are hardly more than 10 feet above high water, and tundra, covered profusely with small, swampy lakes, stretches as far as the eye can see. In this low country the river is actively cutting its banks and constantly shifting its channel. The banks which are being cut away generally show in the immediate vicinity of the river considerable groves of small willow, cottonwood, and some spruce, while those which are being formed by the river show no timber, but only young vegetation. The river splits up into various channels that surround many large islands, and is probably in places as much as 8 or 9 miles wide from bank to bank.

From Bethel to the sea the Kuskokwim flows through a treeless tundra. For a long distance above its mouth there is not even tall brush, but the country is a level swamp covered with several feet of peat, below which is mud or clay. Here and there the clay banks rise to heights of 20 feet, but generally they are not more than 2 or 3 feet above the river. From Bethel downstream the tide affects the river, so that the variation of water level at Bethel reaches a maximum of 3 or 4 feet, which increases until at the mouth of the river it is probably 30 feet.

HISTORICAL SKETCH.

NATIVE INHABITANTS AND SETTLEMENTS.

The natives of the Innoko and central Kuskokwim valleys belong to the general type of North American Indians called Athabascans, and have no doubt inhabited this region for a long time, but never in large numbers. There are not more than 100 natives in the Innoko Valley at the present time, and these are congregated in more or less permanent villages on the lower course of the river, this part of the valley being chosen apparently because of the more reliable food supply that may be obtained there by fishing, and also because of its convenience to the small trading posts that have been maintained since Russian times on the lower Yukon at Kaltag, Anvik, and Holy Cross. There are now three settlements occupied, and the ruins of four or five others may still be seen at other places on the banks of the main river. While their fixed villages are on the lower river, the

natives formerly made hunting excursions of several months' duration to the mountains about its headwaters.

On the Kuskokwim the remains of former villages, consisting of a number of houses, are not uncommon, but most of these are now abandoned and only indicate a larger population in the past. At present the Indians in this valley probably do not number more than 200. They are a poor and widely scattered folk, who wander from place to place in small parties of two or three families and live for the most part in small, temporary camps, being governed in their changes of abode by the movements of the scanty amount of game and the seasonal abundance of fish in different parts of the valley.

RUSSIAN EXPLORATION.

In 1832 the Russian Creole Lukeen went with a party of natives from Nushagak up Nushagak River and down the Chulitna to the Kuskokwim. About 50 miles below the mouth of the Chulitna, on the Kuskokwim, Lukeen built a number of log houses and called the settlement Lukeens Fort. Here he remained several years. In 1835 Glasunoff explored the mouth of the Kuskokwim, and after this supplies were brought up the river to the post from its mouth, and the station took the name of a redoubt. In 1836 Kolmakof ascended the lower Kuskokwim in bidarkees. In 1841 the post was partly destroyed by fire at the hands of the natives and Kolmakof, then in charge of Fort Alexander at Nushagak, proceeded up the Kuskokwim and rebuilt the post, which has since borne his name. The Russian garrison, then in charge of Dementoff, was withdrawn in 1866, just before the transfer of Alaska to the United States, and since that time Kolmakof has been only an Indian trading post.

The Russian Lieutenant Zagoskin made explorations on the lower Yukon and Kuskokwim rivers during 1842 to 1844 under a commission from the Russian-American Company. During his travels he visited the lower Innoko and central Kuskokwim valleys. An account of his explorations, accompanied by a map, was published in 1849.[a] Zagoskin's map conveys a good idea of the general geography of the country. The relative positions of the large rivers, especially of the Yukon and Kuskokwim and their principal tributaries, are shown with general correctness. The course of the upper Innoko is approximately indicated, presumably from information gathered from the natives on the lower part of that stream. The Kuskokwim is shown as far up as the mouth of the Takotna, and the location of the settlements on the river at that time are indicated. According to Zagoskin's map, a trading post was then established near the present location of Vinasale and there were about a dozen

[a] Zelanie, S. I., Jour. Russian Geog. Soc., vol. 1, pp. 211–266.

native settlements on the central Kuskokwim, indicating that the native population was far more numerous at that time than at present. This map has been the original source from which have been copied all representations of Innoko River to this date.

DISCOVERY OF GOLD.

Prospectors are known to have passed through the Kuskokwim Valley as early as 1889. In that year Frank Densmore, one of the American pioneers of the interior of Alaska, passed from the Tanana to the Kuskokwim with a party of prospectors and descended the Kuskokwim to the Yukon portage. About the same time another pioneer prospector, Al King, made the same trip. Afterward, Joe Goldsmith crossed the portage from the Yukon below Russian Mission and ascended the Kuskokwim several hundred miles. James Cleghorn and Harry Mellish also crossed this portage and wintered at Kolmakof, and since that time others have occasionally visited that country from year to year, especially since 1898. It is reported that prospectors visited the Innoko in 1898, during the earlier days of the gold excitement in Alaska. But none of these men appear to have been sufficiently encouraged by what they found to remain. However, since the discovery of placer gold in paying quantities on some of the headwaters of Innoko River, in 1906, this field has received more attention from prospectors than any other district in the Yukon basin. During the last three years probably at least 1,500 men have visited the Innoko district and remained there for the whole or part of a season. At present there is a winter population of about 150 at the settlement of Ophir, on the upper Innoko, and many more men are scattered through the Kuskokwim and Innoko valleys.

The actual discovery of placer gold in commercial quantities in this region was made during the summer of 1906 by a party of prospectors consisting of Thomas Gane, F. C. H. Spencer, Mike Roke, and John Maki. These men came into the headwater country of the Innoko Valley from the Kuskokwim and found a few colors of gold on the bars of the main Innoko a short distance below the mouth of its principal headwater tributary, now named Ganes Creek. Later in the season of 1906 they ascended Ganes Creek with the hope of finding the source from which these colors of gold were derived, and during August or September they located Discovery claim, on Ganes Creek, about 10 miles above its mouth. At this time, their provisions having become exhausted, the party returned to the Kuskokwim for a new outfit of supplies, but these they failed to find there, so they again crossed to the headwaters of the Innoko and descended that river to the settlements on the lower Yukon. They returned to Ganes Creek during the winter of 1906–7, hauling supplies with them

on sleds. In the meantime news of the discovery had spread to prospectors who were scattered in various parts of the upper Kuskokwim Valley, so that during February and March, 1907, stampeders from the Kuskokwim arrived on Ganes Creek. The news also reached Nulato, on the Yukon, and others rushed to the Innoko from that place and the settlements near by. By early spring encouraging reports of the discovery had reached Nome and Fairbanks, so that as soon as summer navigation of the rivers was possible a great many people were ready to go to the new placer district. It is estimated that during 1907 about 800 or 900 people went to the Innoko from Fairbanks, and several hundred from Nome.

Up to the time of the 1907 summer arrivals attention had been devoted to locating claims on Ganes Creek. Over 50 claims were located on this stream below Discovery claim and over 80 claims above it. These claims covered all the ground on Ganes Creek from its mouth to its source. Besides the creek claims along the present valley floor, all of the promising bench ground within the valley was located, though more as a last resort by those who had arrived too late to get creek claims than from any particular knowledge as to where the values were to be found. As a matter of fact, most of the locating on Ganes Creek was done before the winter snows had left the ground.

Many of those who flocked into the Innoko district in the summer of 1907, finding Ganes Creek completely located, became discouraged and left the country. Others, however, remained and devoted their energies toward prospecting other streams. As a result of this search prospects were found on Little, Spruce, and Ophir creeks, which drain into the Innoko to the northwest of Ganes Creek. These streams were entirely covered by locations during the summer of 1907, although gold in paying quantities had not been demonstrated to exist on them at that time. In fact, with the exception of a small production of gold on one or two of the bench claims on Ganes Creek, little was done during the summer of 1907 but to locate a great many claims on nearly every water course within the mountainous part of the upper Innoko Valley. As a result, most of those who had come to the region during the summer had by early fall so exhausted their means that they could not remain during the winter, and so left for Fairbanks and Nome.

It is estimated that about 150 men spent the winter of 1907–8 in the district. The greater part of the time of these men was taken up with the task of providing themselves with food from rather distant points on Yukon and Kuskokwim rivers, for entirely inadequate amounts of supplies had been brought to the region during the previous summer. However, some winter prospecting was carried on, notwithstanding the discouraging conditions. Most of

the prospect holes were sunk on Ganes Creek, but a few were put down to bed rock on Little and Ophir creeks. In the latter part of January, 1908, rich auriferous gravels were discovered at several separate localities on Ophir Creek within the same week. As a result of these finds, all but three or four men stampeded from Ganes Creek to Ophir Creek in February, 1908. On the basis of the meager facts at hand, very optimistic surmises were hastily made concerning the width, length, and richness of the pay streak that was presumed to extend along the whole course of Ophir Creek. Without further investigation, enthusiastic reports were at once dispatched to Fairbanks and Nome and had the effect of restoring a keen interest in the district. As a result, half a dozen small stern-wheel river steamboats went from Fairbanks to the Innoko on the opening of river navigation, early in June. These boats carried about 500 persons and several hundred tons of miscellaneous cargo, and landed them at the upper limit of navigation for such boats, on the banks of the Innoko at points from 75 to 100 miles below Ophir Creek.

Another discovery of placer gold is reported to have been made during the winter of 1907–8 on a tributary of the Kuskokwim called the Tuluksak, which enters from the south about 60 miles above Bethel. The gold-bearing gravels are said to occur on some of the headwater tributaries of the Tuluksak about 60 miles above its mouth, and a small production by a few men working with rockers was made during the summer of 1908.

Placer gold has also been found in small quantity in the northeastern part of the Kaiyuh Range, in the Ruby Creek area, on the south bank of the Yukon, opposite Melozitna River. It is reported that prospects of gold may be found in stream gravels of other parts of these mountains on Yukon River, and also on the Kluklaklatna. The Kaiyuh Mountains have not been well prospected, but their accessibility from the Yukon, especially in winter time, should invite a more thorough search for placer-gold deposits than has been given to them up to the present time.

Another placer-gold district in this region was discovered in 1909. It is on the headwaters of a large tributary of the Innoko, called the Haiditarod, or Iditarod. This tributary rises on the northwest side of the Kuskokwim Mountains southwest of the headwaters of Dishna River, and flows into the lower Innoko about 40 miles above Shageluk Slough. In its lower course the Haiditarod meanders sluggishly for many miles across the swampy plains of the lower Innoko Valley, where it is reported to be navigable for a considerable distance by small stern-wheel steamboats. The headwaters of the Haiditarod, on which the gold discoveries have been made, are in a moderately mountainous region similar to that about the source of the Innoko.

The valleys of these tributaries are said to be of considerable length and to be floored with uniform deposits of stream gravels that contain good values in gold. A large number of men will prospect this new district during the winter of 1909–10. The results of their labors must be awaited before the reports as to the richness of this field can be confirmed.

RECORDING PRECINCTS.

When the discovery of gold was made on Ganes Creek, the Innoko Valley was included in a subdivision of the second judicial division of Alaska that embraced practically all of the Koskokwim basin and all of the Innoko basin. This subdivision was named the Kuskokwim precinct, and the commissioner over it had his headquarters at a place called McGrath, on the upper Kuskokwim at the mouth of the Takotna. Some of the claims located on the Innoko were recorded with the commissioner at McGrath, but as most of the locators passed to and from the Innoko by way of the Yukon, many instruments were recorded at Nulato and St. Michael, the offices of contiguous precincts on the north.

On June 25, 1907, the district court for the second judicial division of Alaska established a recording precinct to be known as the "Innoko precinct," and appointed a United States commissioner for it. The precinct was bounded and described as follows:

> Beginning at a point on the eastern bank of the Yukon River about 50 miles above the village of Anvik and opposite the divide between the Innoko and Yukon rivers; thence following the divide northeasterly to the divide between the Innoko and the Nowi rivers; thence in an easterly direction or southeasterly direction following the divide between the Innoko and the Nowi rivers to a point on the divide between the Innoko and Kuskokwim rivers; thence in a southeasterly direction following the divide between the Innoko and Kuskokwim rivers to the western bank of the Yukon River at a point south of Holy Cross, this last-mentioned line being identical with a part of the northern boundary line of the Kuskokwim precinct; thence northerly along the western bank of the Yukon to the place of beginning.

The Innoko precinct covers the northern part of the former Kuskokwim precinct, and in 1908 the Kuskokwim Valley was subdivided into two separate precincts that embrace the upper and lower parts of the valley. The commissioner for the lower precinct has his office at Bethel and the headquarters for the other precinct are on the upper Kuskokwim near the mouth of Big River.

RECENT SETTLEMENTS.

The recording office for the Innoko precinct was established in September, 1907, on Ganes Creek at the mouth of Last Chance Gulch, opposite claim No. 6 above Discovery. It was named Moore City and consisted of about 20 log cabins. This place was the center of settlement at the diggings during the winter of 1907–8.

After the discovery of gold on Ophir Creek a new settlement was established on the upper Innoko at the mouth of that stream. This place is named Ophir and was the objective point for most of those bound for the diggings in 1908. The United States commissioner removed the recording office for the precinct from Moore City to Ophir early in the summer of 1908.

Attempts were made to form settlements at points on the Innoko River between Ophir and Dishkakat, where the various steamboats landed their passengers and freight, but these settlements were maintained for only a short time. The most elaborate attempt of this kind was at the junction of Dishna River with the main Innoko, about 170 miles by the course of the river below the town of Ophir. This location was selected by a number of persons on the supposition that it had geographic advantages with reference to the future development of the region, in that this point would be the usual upstream limit of steamboat navigation in summer; that a large commercial company would establish a central distributing station for the valley at this place; and that a winter sled trail about 55 miles long would be opened to the diggings. A clearing was made in a grove of good spruce timber on a level-topped silt bank about 25 feet above the normal stage of the river, and a number of very substantial log and lumber buildings were erected. A small sawmill was set up for cutting lumber. The settlement was named Innoko City. Several numbers of a local newspaper were printed. The only post-office in the valley was maintained here, and for a couple of months this place enjoyed prosperity, but by September, 1908, it had completely collapsed. Those who had remained, in the forlorn hope that something would turn up to give the town a boom, finally moved down the river about 20 miles to the Indian village named Dishkakat.

Dishkakat has been an Indian settlement for many years. When the first rush of prospectors entered the valley during 1907, those who came up the Innoko by boats or across from Kaltag by winter trail naturally made this place a stopping point, as it afforded the questionable comforts of established habitations such as the Indians maintain, and in winter dried salmon for dog feed and the services of Indians as guides might be procured. Several white traders located here in 1907. In the summer of 1908, after the spring freshet had subsided, during which the first steamboats had ascended the Innoko to points 75 and 100 miles below Ophir, it was found that Dishkakat, 190 miles below Ophir, was the upper limit of navigation for steamboats drawing 22 inches of water, and that even this point could not be reached without difficulty during July and August. Consequently steamboats made this village their up-river landing place and discharged their cargoes there. By the middle of September, 1908, all

the white people who intended to remain on the lower Innoko during the winter had gathered at Dishkakat, which has a population of about 25 whites, and serves as a halfway station between the diggings and the settlements of Anvik and Kaltag, on the lower Yukon. In the gold-producing area at the head of the river, Ophir, with a population of about 150 whites, has become the central settlement from which supplies are distributed to the creeks. These are the only two settlements of a substantial character within the Innoko Valley.

The principal settlement on the Kuskokwim is Bethel, an Eskimo village, where the Moravian Church has maintained a mission for many years and a trading post has been established for several years. Above Bethel there are several smaller trading posts, of a more or less transitory nature, at Kolmakof, Georgetown, Vinasale, McGrath, and Kempton (at the mouth of Big River), on the Kuskokwim, and at Joaquin, on the Takotna, about 90 miles above McGrath. Up to the present time none of these places has been permanently supplied with even the staple provisions.

CLIMATE.

The temperature, precipitation, and seasons of the Innoko-Kuskokwim region are those which prevail throughout the lower Yukon country. The winters are cold, but not so severe as in the upper Yukon. The summers are usually warm during July and August, but vary from year to year as to rainfall and temperature. In some years rainfall is abundant and in others scanty. During wet summers showers may fall nearly every day, and long rains may be frequent during July and August. This condition is not unusual. In wet summers the rivers are high, but during dry years the rainfall may be so scanty that the rivers become very low, thus impeding steamboat navigation, and the tundra may become so dry that fires are numerous and often extensive.

By the first of September the general temperature becomes distinctly cooler than it has been, marking the beginning of the short autumn season. Early in September killing frosts make the grass practically worthless for forage. The streams usually freeze over in October and thaw out in May. Locally, in the narrow valleys and gulches where the drainage is feeble, much of the alluvial material remains permanently frozen, but in the wider bottoms of the larger streams and the main rivers the alluvial deposits probably carry live water in some quantity throughout the year.

In temperate climates the superficial winter freezing temporarily consolidates only a small part of the detrital cover, but in most of Alaska the effects of the longer cold period are such that unfrozen detrital ground, even in summer, is the least common kind. The final result of the annual superficial freezing in Alaska tends to add

to the amount of detrital material that remains permanently consolidated by the frost.

The alluvial covering of the bed-rock floor is in general permanently frozen over most of that part of Alaska lying north of the area that drains into the Pacific Ocean, though there are local variations of this condition. The extent and development of the ground frost depend on the extent, position, thickness, and proportions of the gravel, sand, clay, and humus members that compose the alluvium and the amount of underground and surface water present. Generally the alluvial deposits are permanently frozen where they are not well drained by an abundant supply of surface water and where the circulation of underground water is feeble. There is, however, no uniformity of condition even within small areas, either vertically or horizontally, for often while shafts are being sunk in ground that appears to be solidly frozen, layers charged with live water are encountered and flood the workings in such quantity that the workers are "drowned out."

In general, the climate of Alaska tends to retard the processes of stream erosion and transportation. The almost universal frost binder, together with the widespread humus and muck insulation it fosters, and the consequent arrested condition of the available supply of running water for the greater part of the year, prevents the streams from moving and reworking the otherwise loose-textured detrital deposits and adding new material to them as rapidly as they would if the material were wholly unfrozen and the flow of water continuous. Probably the concentration of the placer gold in this country is a slower process than it would be under the conditions of a more temperate climate, where the alluvium would be moved more frequently, the lighter materials carried farther, and consequently the heavier gold concentrated more rapidly than it is under the conditions of frozen ground that now prevail.

VEGETATION.

The valley floors and mountain slopes of this region are mostly covered by the characteristic blanket-like accumulation of sphagnum mosses that form the ground covering of all northern Alaska. This moss covering, with low bushes, is thickest in the lowlands and gradually becomes thinner as the hillsides are ascended, except in favorably moist places and on cool, sheltered slopes. The highest ridges and the mountains above 2,500 feet are generally well covered by mosses, heathers, stunted bushes, and grasses. The Iceland or reindeer moss and various other edible mosses are especially abundant in this higher belt. The highest mountain tops of this region are the only places where a ground-covering vegetation is sparse or absent.

Several kinds of grasses suitable for summer forage for horses and cattle grow in the rather meager meadow areas in the valleys and in open places, many of them old burnt areas, on the ridges. In the meadows and along the banks of the streams where they are free from brush, a moderate amount of grass may be cut and cured into hay of fair quality if the season is not too rainy and advantage is taken of the sunny days.

The central Kuskokwim Valley is covered with a good growth of spruce of considerable size and birch on the higher flats along the river, while the lower flats near the river bear an abundant growth of cottonwood and willow. Of the trees growing on the river flats spruce is the most abundant, although sandy tracts are covered with cottonwood, willow, and alder, and clumps of birch grow where the land is well drained. In the more boggy places scattered larches are found, and on the rocky hills and river bluffs is the small-leafed poplar or quaking aspen.

In the Innoko Valley timber suitable for fuel grows in moderate abundance throughout the larger valleys, up the gulches, and locally well up the slopes of the lower ridges. On the evenly undulating tops of the ridges timber is usually scarce. White spruce up to 16 inches in diameter is practically the only tree that reaches a size suitable for cabin logs or sluice-box lumber, and even this is not plentiful in desirable sizes except in small clumps along the valleys of the main river and its larger tributaries. The more scrubby black spruce, together with stunted white spruce, grows in scattered clumps on the slopes of the ridges.

In swampy areas in the middle Innoko Valley there are considerable groves of larch or tamarack. In these localities it reaches a diameter of 8 to 10 inches and a height of 30 feet. Smaller larch trees are scattered in the tributary valleys and on their lower slopes.

Birch grows here and there throughout the region and also in thick groves of considerable extent on the drier banks of the lower Innoko, where it has been cut as cord wood for the small river steamboats.

Cottonwood and quaking aspen also grow in a scattered manner along the Innoko; the former in lower levels of the valleys, the latter more commonly on the hillsides. Alders and willows form dense thickets along all the streams and up to the very heads of the gulches.

In general, the abundance of vegetation is most strongly marked in the river bottoms and on the low hills which rise above them. With increasing elevation the vegetation becomes more scanty. At altitudes of about 2,500 feet the spruce and other large timber disappear and there is a belt where alder brush and grass grow thickly without trees; higher up is a belt where the chief vegetation is low, scraggly shrubs, and finally a higher zone covered only with a great variety of mosses and lichens.

The growth of spruce is continuous along Kuskokwim River to a point below Kolmakof. Here there is a remarkably sharp division line, where the thick growth of spruce of the hills along the river abruptly thins out, becomes very straggling, and in the course of a few miles disappears entirely, leaving only low, barren, moss-covered hills, which stretch southward away from the river and merge into the low, swampy, treeless plains known as tundra. From this point downstream for some distance the islands in the river and the flats bordering it carry many groves of cottonwood, some of them of considerable size, but practically no spruce, while the tundra farther away from the river is quite treeless, supporting only low shrubs and an exceptionally profuse growth of moss. It is not easy to understand the reason for the disappearance of the spruce toward the coast, for the climatic and soil conditions appear to be practically unchanged. G. F. Becker[a] has suggested as a cause for the general treelessness of Alaska Peninsula the recency of the late general uplift of the land. It is known from independent sources that all this coastal region was entirely submerged beneath the ocean waters in very recent geologic time, and it has been suggested that the subsequent uplift has been so rapid that the timber has been unable to migrate coastward at a rate equal to the westward retreat of the shore line. This idea appears to offer at least an explanation of a phenomenon which apparently does not depend on climatic conditions.

GAME AND FISH.

The Innoko-Kuskokwim region as a whole is not plentifully supplied with game. On the swampy plains of the lower country ducks, geese, swans, and cranes breed in considerable numbers during the summer. In the spruce timber grouse are sometimes seen, and on the mountain slopes above the timber a few rock ptarmigan may occasionally be found. A few small herds of caribou still survive in the mountains. The moose is very rare except on the upper Kuskokwim. Bears may be encountered here and there.

In the summer several kinds of salmon ascend the Innoko from the Yukon to spawn on the gravel bars of its upper middle course, but in 1908 the run was very small. Likewise on the Kuskokwim the run of salmon was not large in 1908, although in favorable seasons salmon ascend this river and its tributaries in enormous numbers, so that the industrious native has little difficulty in gathering sufficient fish for a year's supply of food, even with the crudest appliances. Whitefish and pickerel are common in the more sluggish waters of the lower valleys. In the shallow ponds and lakes and small sluggish streams the blackfish or ink fish (*Dallia pectoralis*) is abundant.

[a] Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, p. 19.

Grayling and trout abound in the clear streams of the upper parts of the valleys.

ROUTES OF TRAVEL AND TRANSPORTATION.

GENERAL STATEMENT.

The Yukon and its larger tributaries are the chief means of transportation for the vast area of country within its basin. From June to October practically all supplies consumed by the population of the interior of Alaska within the Yukon Valley are taken into that country by water transportation over the routes afforded by the navigable streams and distributed at points where they may be used or obtained for places not located directly on these routes. A number of large stern-wheel river steamboats, together with freight barges, carry the freight to points along the main course of the Yukon and up Tanana River to Fairbanks. Most of this freight is taken up the Yukon from St. Michael, near the river's mouth on Bering Sea, after it is delivered there by ocean steamships from Seattle and San Francisco during the summer, as this part of Bering Sea is closed by ice from November until June. Some supplies, mostly perishable, are brought down the Yukon from the head of navigation on that river at White Horse, in Canadian territory, where connection is made with the White Pass and Yukon Railway. This railway extends for 111 miles across the Coast Range from White Horse to Skagway, on the Pacific coast of Alaska, where ocean navigation is open for the whole year to Seattle and San Francisco. Freight for the Alaska Yukon brought in by this route is bonded through Canadian territory and transferred from Canadian to American carriers at Dawson. Supplies shipped in the spring by this route reach destinations on the Yukon earlier in the summer than if sent by way of St. Michael, as the upper Yukon is open to navigation at an earlier date.

From various points on this trunk route of transportation through the center of the country smaller steamboats extend the distribution of supplies up all the important tributaries of the Yukon for greater or less distances, as occasion may warrant, and when these boats reach the limits of navigation to which they may proceed the supplies are distributed still farther by employing shallow-draft scows of 5 to 10 tons capacity, towed by horses, or light-draft poling boats, that carry from 1 to 2 tons, propelled by men. By a successive combination of these methods supplies can be carried to the headwater districts of the whole Yukon basin region. As a rule, supplies can be conveyed during the summer by some method of boat transportation within comparatively short distances of the places where they are to be used. For the final distribution to the camps on the individual creeks where mining is being conducted it generally becomes necessary to employ

some means of land transportation for distances from 1 to 30 miles, or possibly more. The means of carrying adopted varies according to the magnitude of the operations being conducted. In the summer season the most primitive method is that of men carrying loads on their backs. A stage in advance of this consists of packing on horses. If the country is not too rugged and operations are to be conducted in a larger manner, roads are built so that wagons may be used. In the better-developed districts operations may become sufficiently extensive to justify the construction of railways, supplemented by wagon roads and trails. During the winter hauling supplies on sleds is the universal method. Its efficiency varies with the form of motive power employed, the range being from small sleds drawn by men or teams of dogs to larger ones hauled by one or more horses.

As the primary reason for writing this paper is to give an idea of the present commercial condition of the Innoko-Kuskokwim country from the miner's standpoint, and as the Innoko placer-gold district is now the center of mining development, the account of transportation routes and their possibilities will be given, with special reference to the ways and means of reaching the upper Innoko Valley. This involves a description of the trunk routes by which all other parts of this region may be reached, as the headwater region of the Innoko happens to be its most inaccessible part.

SUMMER ROUTES.

There are two principal summer routes by which the Innoko placer district may be approached. These are determined by the geographic position of the Innoko Valley between the easily navigable portions of the two largest rivers in Alaska—the Yukon and the Kuskokwim.

YUKON RIVER.

By way of Yukon and Innoko rivers it is about 244 miles from Anvik to Dishkakat, and about 190 miles farther upstream to Ophir, or 434 miles by the summer water route from Anvik to the diggings. As already stated, small river steamboats can deliver freight as far up the Innoko as Dishkakat throughout the season of navigation, from June to October. In early June and at other uncertain times of high water these boats can occasionally ascend the main river to points within 55 to 75 miles of Ophir.

As the summer of 1907 was one of much rainfall and a consequent high stage of water in the streams, and that of 1908 was one of very scanty rainfall with a low stage of water, a comparison of the navigation limits reached in these two years probably represents the maximum and minimum availability of the Innoko as a route for transporting supplies into the country with steamboats of the size and type

now employed. In 1907, during a period of high water, a steamboat with a draft of about 22 inches when loaded reached a point on the upper Innoko about 55 miles below the present town of Ophir. A cargo of 50 or 60 tons of freight might be landed at this distance below Ophir under such conditions of high water.

It will probably always be necessary to transport freight from this point to Ophir in small lots of 3 or 4 tons by light-draft, flat-bottomed scows, or in 1 to 2 ton lots by still smaller poling boats. In 1908 conditions were not so favorable. Even at the time of the early summer high water the same steamboat could get only within 70 miles of Ophir, and during July and August this boat found it difficult to ascend the Innoko to the village of Dishkakat and was obliged to discharge its freight there, being unable to go farther upstream.

Most of the freight shipped into the Innoko has been brought from Fairbanks, the largest town in the Yukon Valley, situated on Tanana River, 770 miles above Anvik and about 1,014 miles from Dishkakat by the rivers. The freight charge from Fairbanks to Dishkakat has been $80 a ton. The transportation companies operating large steamboats on the Yukon from St. Michael, where they connect with ocean steamers, have quoted a rate of $38 a ton from Seattle or San Francisco to Anvik or near-by points on the Yukon. One of these companies has also published a through rate of $70 a ton to Dishkakat from Seattle or San Francisco, and a local rate of $35 a ton to Dishkakat from Anvik, but the company did not offer a regular service on Innoko River and reserved the right to operate steamers thereon only when business warranted. These rates expired on September 1, 1908, and were somewhat reduced in 1909. No attempt has yet been made to ship freight direct from the United States to the Innoko. The ocean distance from San Francisco to St. Michael is 2,846 miles, and from Seattle to St. Michael 2,487 miles. If the traffic should amount to much, probably a lower freight charge would be quoted. This route has a further advantage over that by way of Fairbanks in the much lower original cost of supplies in the United States.

A few individual outfits have been purchased at Nome and shipped a distance of 115 miles by ocean vessels to St. Michael, there reshipped on Yukon River boats to Anvik, 405 miles from St. Michael, and there again transferred to the smaller boats which ascend the Innoko. The distance from Nome to Dishkakat by this route is about 764 miles, and it appears that if a reliable line of transportation was established between Nome and Dishkakat by way of the lower Yukon the merchants of Nome, enjoying a comparatively low freight tariff afforded by direct ocean communication with the Pacific ports of the United States, should be able to bid successfully for the Innoko trade in competition with the merchants of Fairbanks. It is doubtful,

however, whether the Innoko route is as good as that by way of Kuskokwim River if an equally reliable line of communication should be established from Nome to Bethel.

KUSKOKWIM RIVER.

The Kuskokwim is the second largest stream in Alaska and is perhaps the best river for steamboating in that country, with the possible exception of the Yukon. Steamboats of large size can ascend the river about 650 miles to the confluence of its two principal headwater branches, the East and South forks, and smaller steamboats have been up the South Fork about 40 miles above this junction and no doubt could also ascend the East Fork for some distance. Boats with a draft of 2 feet have ascended Takotna River, a large tributary of the Kuskokwim that heads against the sources of the Innoko, for a distance of about 60 miles to a point within 25 miles of Ganes Creek, whence supplies may be forwarded 30 miles farther up the Takotna to the mouth of Big Creek, which is only about 12 miles from Ganes Creek.

The Kuskokwim has not been used to any great extent as a route for the transportation of supplies, because the country within its watershed has not been prospected or developed, as has the territory within the Yukon basin. Another reason is that Kuskokwim Bay and the estuary or tidal portion of the river's mouth has been considered a hazardous locality in which to navigate ocean vessels, but this opinion appears to be due more to the fact that this part of the Alaskan coast is mapped only in rough outline, and is not known in a detailed way, even by the very few who have some personal knowledge of these waters, rather than to the presence of any real dangers to navigation other than those caused by lack of acquaintance and proper charts for guidance. When accurate surveys of Kuskokwim Bay and the mouth of the river are made and the channels that run through its extensive shoals are properly marked, ocean vessels with a draft of 12 feet may enter and ascend it to Bethel with safety and dispatch. In fact, even without these aids to navigation, vessels with a greater draft than 12 feet have entered this river and departed from it successfully. The United States Fish Commission steamer *Albatross*, of 636 tons and a draft of 13 feet, ascended the Kuskokwim about 40 miles in 1889. A few years ago another ocean steamer of good size, the *Leelanaw*, of 1,923 tons, went up the river to the second island in the channel 40 miles below Bethel. This point has since been known as Leelanaw Anchorage. In 1908 the *Charles Hanson*, of 192 tons and 12 feet draft, ascended the Kuskokwim with several hundred tons of freight to Bethel. Thus it may be seen that the importance of this river as a route of transportation has not been

fully realized, although it enjoys the advantage of being one of the two rivers in Alaska which can be entered by ocean vessels of commercial size. The other is the Nushagak, emptying into Bristol Bay.

Before the gold excitement of 1898 the only white people within the Kuskokwim Valley were a few missionaries whose headquarters have been maintained for a number of years at Bethel, about 60 miles above the river's mouth. Their supplies have been brought each year from the United States by ocean sailing vessels that have delivered their freight at the mouth of the Kuskokwim, to be taken up to Bethel in small boats. During the last ten years several parties have established Indian trading stations at various points on the river, and within the last five years a few prospectors have gone into that country each year. Several stern-wheel river steamboats have been brought to the river from St. Michael and Nome and used to make irregular trips up the river with small amounts of supplies. Since Nome and St. Michael have become well-supplied places, the traders and prospectors on the Kuskokwim have had most of their supplies brought from those settlements by small craft plying in the coastwise trade on Bering Sea during the summer.

The Kuskokwim route was traveled by many of the people who went to the Innoko from Nome in 1907. The passengers and their supplies were taken across Bering Sea from Nome to the mouth of the Kuskokwim, a distance of 480 miles, by various small unseaworthy craft. Thence they were taken up the river on several steamboats to Takotna River and up the very winding course of that stream to points 12 to 20 miles from Ganes Creek, which was reached by several trails across a low mountain range over which supplies can be packed by men or horses during the summer or hauled on sleds during the winter.

In the spring of 1908 a company with trading interests on Kuskokwim River brought several hundred tons of freight direct from San Francisco to Bethel on a large two-masted ocean schooner equipped with auxiliary gasoline power. During the summer this company sent about 40 tons of supplies up the Kuskokwim and Takotna to Joaquin, at the mouth of Big Creek, about 90 miles above McGrath, which is on the Kuskokwim at the mouth of the Takotna. This freight was taken up the Takotna about 60 miles by a small stern-wheel boat which could go no farther owing to the unusually low water. From this point the goods were taken in scows and poling boats the remaining 30 miles to Joaquin, where a log store has been built. From Joaquin it is about 12½ miles to the settlement called Moore City. on

Ganes Creek, half a mile below Glacier Gulch. A trail that may be used by pack horses in summer and sleds during winter follows Big Creek for 9 miles to its head, with an ascent of about 900 feet, all of which is gradual except in the upper quarter of a mile, where the trail rises more steeply for 200 feet. This trail passes over a saddle divide to the head of Glacier Gulch, down which it goes for 3 miles to Ganes Creek, with an even descent of 600 feet. This route offers no particular difficulties to the construction of a wagon road. If a wagon road or permanent winter trail is to be built from the Kuskokwim drainage area to the Innoko Valley, however, it appears best to select a somewhat longer route which would connect a point on the lower Takotna more directly with the Innoko at the mouth of Ganes Creek, 10 miles below Moore City. This point on the Innoko side is more central to the placer-gold area, as it is now known, and the advantage on the Kuskokwim side lies in the fact that some point on the lower Takotna can be reached at all stages of water by steamboats plying direct from Bethel, where direct connection can be made with ocean vessels from Seattle or San Francisco. By such a route it may be possible to deliver freight at a centrally located distributing point in the mining region with fewer transfers, and consequently a lower transportation charge, than is possible by any other route into the headwater portion of the Innoko Valley. A wagon road, or at least a good winter sled trail, could be built from a point on Takotna River 15 to 25 miles above its confluence with the Kuskokwim to the upper Innoko Valley near the mouth of Ganes Creek, or about 5 miles farther to the town of Ophir. Such a road would not be over 30 or 35 miles long, and the divide to be crossed from the Kuskokwim to the Innoko is not high nor rugged. The road would probably not be as high nor present as steep grades as the Big Creek and Glacier Gulch trail does, and it would lead more directly to a suitable central distributing point for the placer region. In the fall of 1908 an auxiliary gasoline schooner of about 15 tons burden, with a draft of 4 feet, made a continuous trip from Nome to a point on the Takotna 30 miles above its mouth, without any difficulty. This trip shows the advantages of this route, for the same boat could not have proceeded farther than Dishkakat by the Yukon-Innoko route, and even if successful in reaching that place it would still be 55 miles by the winter trail from Ophir. The distance from Nome by way of the Kuskokwim to a point on the Takotna 25 miles above its mouth and within 35 miles of the Innoko diggings is 1,170 miles. The distance over the Yukon-Innoko summer water route from Nome to Dishkakat, 55 miles from Ophir by winter trail, is about 764 miles.

APPROXIMATE DISTANCES.

A comparative table of approximate distances by the various summer water routes is given below:

Approximate distances to Innoko region.

	Miles.
On Pacific Ocean and Bering Sea:	
San Francisco to Nome	2,730
San Francisco to St. Michael	2,800
San Francisco to Goodnews Bay	2,440
Seattle to Nome	2,370
Seattle to St. Michael	2,450
Seattle to Goodnews Bay	2,090
Nome to St.Michael	115
Nome to Goodnews Bay	480
St. Michael to Goodnews Bay	480
On Yukon and Innoko rivers from St. Michael:	
St. Michael to Anvik	405
Anvik to Dishkakat	240
Dishkakat to Ophir, by Innoko River	190
Dishkakat to Ophir, overland, about	55
St. Michael to Ophir, by water route	840
On Kuskokwim River from Goodnews Bay:	
Goodnews Bay to Leelanaw Anchorage	110
Leelanaw Anchorage to Bethel	40
Goodnews Bay to Bethel	150
Bethel to McGrath at the mouth of Takotna River	475
McGrath to forks of the Takotna	15
Forks of Takotna to Ophir, overland, about	35
McGrath to Joaquin on Takotna at Big Creek	90
Joaquin to Ganes Creek, overland	13
Bethel to Joaquin, by water route	575
Nome to Ophir, by way of Yukon-Innoko	955
Nome to Ophir, by way of the Kuskokwim	1,200
Seattle to Ophir, by way of ocean vessel to St. Michael, 2,447 miles; river steamboats on Yukon and Innoko to Dishkakat, 649 miles; and small boats from Dishkakat to Ophir, 190 miles—total distance	3,280
Or by overland winter trail from Dishkakat to Ophir, 55 miles—total distance	3,150
Seattle to Ophir, by way of ocean vessel to Bethel, 2,235 miles; river steamboat on Kuskokwim to forks of the Takotna, 488 miles; and overland trail or road from Takotna to Ophir, 35 miles—total distance	2,760
Difference in favor of Kuskokwim route	390

ADVANTAGES OF KUSKOKWIM ROUTE.

The advantage of the Kuskokwim route lies not only in the shorter distance of its terminus from the diggings, but also in the smaller number of transfers of freight necessary. At St. Michael, which is a shallow, open roadstead rather than a protected harbor, it is necessary to lighter all cargo from ocean vessels to the shore and then reload the freight into the river boats at the docks or warehouses. More-

over, it is often necessary for the river boats to wait several days or even a week, after being loaded, for calm weather on Norton Sound during which to make the passage of 60 miles around the shoal coast to the mouth of the Yukon. This passage is hazardous for the small steamboats that can ascend the Innoko. Consequently, safety will make it advisable to send freight from St. Michael to Anvik on large steamboats and to transfer it again at Anvik to smaller boats for the trip up the Innoko. Thus three transfers are necessary between starting point and destination. By the Kuskokwim route, on the other hand, only one transfer is necessary—that at Bethel—and it can be made directly from the ocean vessel to the river boat in a safe port.

During 1907–8 supplies have been transported to the Innoko gold diggings in a rather unsatisfactory manner by means of small river steamboats to the head of navigation, and thence by small scows towed by horses and poling boats propelled by men to Ophir. This settlement has never been a well-stocked distributing point, however. In fact, many of the necessities have often been entirely lacking, and a shortage of provisions in the whole Innoko Valley has prevailed throughout the last two years. During the winter of 1907–8 it became necessary for many of those who wished to remain in the country to journey over difficult winter trails to Anvik, Kaltag, and Nulato, on the lower Yukon, and haul back with them on hand and dog sleds the bare necessities for existence, thus expending much time in unprofitable labor.

The cost of transporting freight from points on Innoko River where the steamboats may be able to land it to Ophir by means of man-propelled boats varies from 10 to 20 cents a pound, according to the distance it must be carried. At present it costs from $280 to $480 a ton for freight charges alone to have supplies brought to the Innoko diggings from the larger centers of supply on the Yukon. Besides this heavy freight toll, the initial cost of provisions in Fairbanks is much higher than at the ocean ports of Nome or St. Michael. By establishing reliable communication with St. Michael the freight charge from Seattle may probably be reduced to about $70 a ton for goods delivered at Dishkakat, but the difficulty of carrying them from that place to Ophir will still remain. The writer was told that the charge for hauling freight with horses and sleds over the 55 miles of winter trail from Dishkakat to Ophir was about 7 or 8 cents a pound, so that the lowest estimate it is now possible to make with the figures at hand is a freight cost of $210 a ton for delivering supplies at Ophir from Seattle by way of St. Michael and the Yukon. This figure is based on the current freight tariffs, but there appears to be no reason why this cost might not be materially reduced by an organized and well-regulated effort.

There is no doubt that freight can be brought from San Francisco or Seattle to Bethel fully as cheaply as to St. Michael. At Bethel the river boats can be loaded directly from the ocean vessel, only one handling being necessary. The river boats can ascend the Kuskokwim and the Takotna to its forks without any difficulty, and from this vicinity the overland haul of about 35 miles to Ophir can easily be made by summer wagon road or winter sled trail, or by a light railroad if developments should warrant. There appears to be no question that the Kuskokwim route to the Innoko placer camp affords the most expeditious and satisfactory solution of the transportation problem, that even under present conditions there is no reason why supplies from Seattle may not be delivered at Ophir for $100 a ton, and that with good management the actual freight cost over this route may be reduced considerably below that figure.

WINTER ROUTES.

Distances by the winter routes from the lower Yukon to the Innoko are much shorter than by the summer water routes. The wide extent of flat, swampy country of the lower Innoko Valley is then frozen over, so that more direct courses may be followed from one place to another. It is about 57 miles by sled trail from Kaltag to Dishkakat, and about 55 miles from Dishkakat to Ophir, or 112 miles altogether. This trail is for the most part over flat-lying country, but between Dishna and upper Innoko rivers it crosses a low mountain range at an elevation of about 1,300 feet above sea level by way of a low, wide pass, with easy grades approaching it from either side. Kaltag is a military telegraph station and a regular post-office on the winter mail route from Fairbanks to Nome. During the winter of 1907–8 a moderate amount of freight was hauled over this trail by dog teams from Kaltag and Nulato to Ophir for 50 cents a pound. A number of personal outfits were hauled over it by means of hand sleds, and some new arrivals even hauled their provisions from Nome. A herd of reindeer of about 30 head was driven from Unalaklik to the Innoko and sold for the meat.

Another winter route to the Innoko leaves Yukon River at a small trading station called Lewis, which is located on the north bank of the Yukon, about 15 miles below the United States military telegraph station called Melozi. The trail goes south from the Yukon up the valley of Yuko River, crosses the wide, flat pass at its head into the valley of the North Fork of the Innoko, and continues southward down this valley to a point on the Innoko 65 miles below Ophir. The route then follows Innoko River to its headwaters. Several parties traveled over this route during the winter of 1907–8, and a few dog-team loads of freight were hauled over it. The distance is estimated to be about 100 miles, and it is by far the shortest winter route for those who wish to go from Ophir to upper-central Yukon

points such as Tanana, Rampart, or Fairbanks. Under present conditions this route would be the shortest and most direct for a winter mail service to Ophir, as all the winter mail for western Alaska now passes down the Yukon from Fairbanks; but no service to Ophir has yet been established.

During the winter of 1907–8 the Alaska Road Commission sent a party, in charge of one of its engineers, to make a reconnaissance of a winter mail trail from Seward to Nome. Seward is a port on the Pacific coast of Alaska open to ocean navigation throughout the year, and the object of this survey was to traverse the most feasible route under actual winter conditions so as to test its practicability for winter mail service. The party crossed Kenai Peninsula and ascended the valleys of Yentna and Skwentna rivers to Rainy Pass. Thence it descended the South Fork of the Kuskokwim to McGrath, at the mouth of the Takotna; ascended the Takotna to Big Creek; and followed the route up Big Creek and down Glacier Gulch to Moore City, on Ganes Creek. From Ganes Creek it followed the route already described, by way of Ophir and Dishkakat to Kaltag, and from the Yukon the regular mail trail now used from Kaltag to Nome. This route was found to be an entirely satisfactory one for a winter trunk-line mail trail across this part of Alaska, and it is announced that the road commission will open this route. When this is done the Innoko region will be situated about midway on a trunk-line mail trail from Seward to Nome. The distance from Seward to Ophir is about 465 miles, and from Ophir to Nome it is about 424 miles, or about 889 miles from Seward to Nome. At present the winter mail for Nome is carried from Valdez to Fairbanks, 373 miles; thence down Tanana and Yukon rivers to Kaltag, 550 miles; and from Kaltag to Nome across Norton Bay, 312 miles, a total distance of 1,235 miles. Thus, the route from Seward to Nome saves about 346 miles over that now followed from Valdez to Nome by way of Fairbanks and Kaltag, and besides being a much shorter route to Nome it may serve the Innoko Valley directly.

Distances from Seward to Nome.

	Miles.
Seward to end of railway	72
Crow Creek Pass	86
Old Knik	128
New Knik	148
Susitna Station	180
Mouth of Yentna River	183
Mouth of Skwentna River	222
Mouth of Happy River	266
Mouth of Pass Creek	291
Summit of Rainy Pass	298
Mouth of Dalzell Creek	307
Mouth of Rohn River	310
Mouth of Takotna River (McGrath)	418
Mouth of Big Creek (Joaquin)	442

	Miles.
Big Creek summit	451
Moore City on Ganes Creek	454
Ophir	465
Dishkakat	520
Kaltag	577
Unalaklik	667
Seward to Nome	889

MAIL SERVICE TO THE INNOKO.

Up to 1908 the Innoko Valley has not been provided with contract mail service, although there has been a postmaster in the precinct for the preceding two years. Two men have held this appointment and, owing to the unsettled conditions, each has been vested with the authority to maintain a post-office wherever his personal inclination might dictate. The post-office for the valley has been located first at Dishkakat, then at Innoko City, and again at Dishkakat, where it is at latest reports.

EFFECT OF HIGH TRANSPORTATION RATES.

It appears that the transportation of supplies to the Innoko placer district for a reasonable cost has not been accomplished, and that the exorbitant operating expenses in this district are the direct result of poor and inadequate transporation. For this reason the present conditions and possibilities have been described in detail, as the transportation problem is of vital importance and its solution as soon as possible is imperative to the success of the Innoko placer district as a mining community.

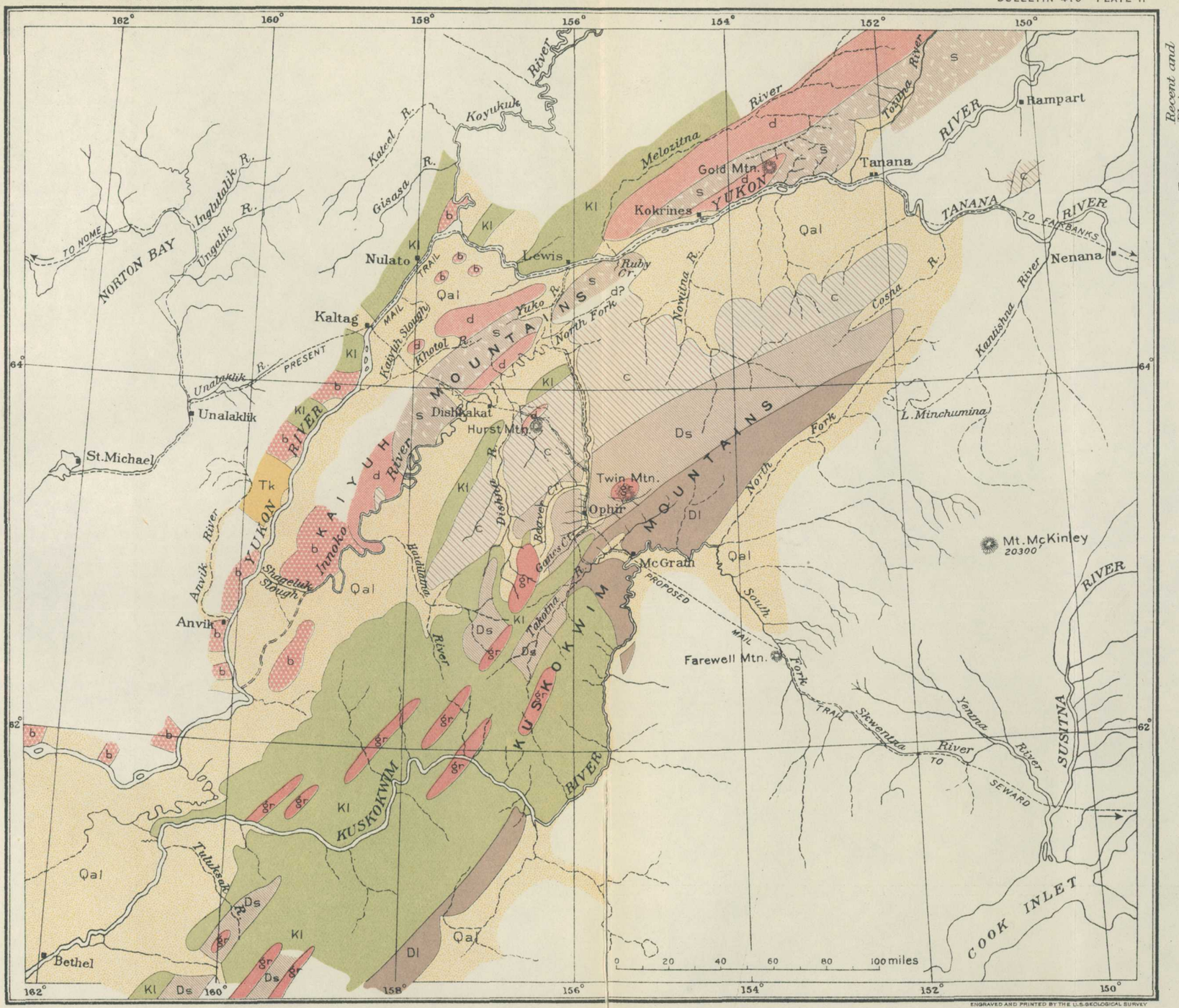
During 1907–8 the prices of staple provisions at Ophir were as follows:

Flour	per pound	$0.30	Bacon	per pound	$0.65
Corn meal	do	.50	Ham	do	.65
Rice	do	.50	Butter	do	1.00
Rolled oats	do	.45	Cheese	do	.75
Beans	do	.50	Dried fruit	do	.55
Coffee	do	1.00	Canned fruit	per can	1.00
Tea	do	1.00	Canned vegetables	do	.75
Sugar	do	.50	Canned milk	do	.50

GEOLOGIC SKETCH OF THE INNOKO-KUSKOKWIM REGION.

INTRODUCTION.

The bed rock of the Innoko-Kuskokwim region is for the most part primarily of sedimentary origin, although the original condition of the older rocks has been greatly changed by metamorphic alteration, so that now they are mostly in the form of schists and slates, with some cherts and crystalline limestones, especially throughout the Kaiyuh Mountains and the Innoko Valley (Pl. II). Associated with these metamorphosed sediments, more particularly with the



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LEGEND

Recent and Pleistocene	Qal	Alluvium	QUATERNARY
Eocene	Tk	Kenai formation (shales, sandstones, and conglomerates)	TERTIARY
	Kl	Limestones, calcareous sandstones, arkoses, with some igneous rocks	CRETACEOUS JURASSIC? — MESOZOIC
	Dl	Thin-bedded limestones and limy shales	MIDDLE DEVONIAN
	Ds	Slates	DEVONIAN? SILURIAN? — PALEOZOIC
	c	Cherts, slates, and diabase	
	d	Diabase and greenstone schist	
	s	Schists, cherts, and crystalline limestones	PRE-ORDOVICIAN
	gr	Acidic laccolithic and dike intrusives, granite porphyries, and diorites	MESOZOIC OR LOWER TERTIARY
	b	Tertiary effusives, lavas, basalt, andesite, and tuffs	UPPER TERTIARY

GEOLOGIC SKETCH MAP OF THE INNOKO, CENTRAL KUSKOKWIM, AND LOWER-CENTRAL YUKON REGIONS

Compiled by A. G. Maddren

1909

slates, and making up considerable areas of the bed rock are large masses of basic volcanic rock, principally diabase, that may be related with part of the slates as one or more extensive original effusive stratigraphic members, or may be, in a stratigraphic sense, distinct from the slates. In addition to this large amount of apparently extrusive igneous rock, in the form of diabase, both the schists and slates contain locally intrusive dikes of more acidic igneous rocks. These dikes may be considerably younger than either the schists or the slates into which they are intruded, and they have no purely stratigraphic relation with those rocks such as the diabases may have with the slates. All the rocks above mentioned, with the possible exception of the acidic igneous intrusives, are considered to be of Paleozoic age because of their lithologic and stratigraphic similarity to the Paleozoic rocks of the upper Yukon Valley.

Lying unconformably above the Paleozoic rocks is a series of unaltered sedimentary formations of Mesozoic age that consist principally of limy sandstones and shales. Along the Kuskokwim Mountains between the southern headwaters of Innoko and Kuskokwim rivers there is a belt that shows past igneous activity of both extrusive and intrusive character. The effusive rocks appear to be lavas, for the most part of basic type, that were poured out over moderate areas during Mesozoic time, for they are interstratified with arkoses, shales, and other sedimentary rocks that show ripple marks with plant remains, giving evidence of formation along a shore. On Kuskokwim River, where it cuts through the low ranges of the Kuskokwim Mountains from Kolmakof to Kaltshak, Spurr [a] noted a number of occurrences of old-appearing volcanic rocks that appear to be flows of lava contemporaneous with the Mesozoic sedimentary rocks which form most of the mountains in this vicinity. Spurr considered these interbedded effusives to be of Cretaceous age, Dikes are also of common occurrence in this range of mountains. In general they are of siliceous varieties and most of them have a porphyritic texture. These dikes are considered to be of Tertiary age because they cut sedimentary rocks thought to be Cretaceous.

With the exception of a very small area of slightly consolidated clays and sands containing some lignite, seen on the lower Innoko, the writer knows of no sedimentary rocks within this area that he considers to be of Tertiary age, although there is little doubt that rocks of this age may occur. Besides the igneous rocks associated with the Paleozoic and Mesozoic formations, there are some fresh, young-looking volcanic rocks of andesitic and rhyolitic types and effusive aspect on the lower Innoko at the southwest end of the Kaiyuh Range. These rocks are probably late Tertiary in age, and may be considered, through similarity and proximity, to be closely

[a] Spurr, J. E., A reconnaissance in southwestern Alaska in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 159–163.

related to the Tertiary volcanic rocks that occur at intervals along the lower Yukon from Nulato to St. Michael.

Thus there appears to be evidence that this region has been the scene of volcanic activity, in the form of lava flows, during three distinct periods—the Paleozoic, Mesozoic, and Tertiary.

The accompanying geologic sketch map (Pl. II) and stratigraphic table convey as comprehensive an idea of the geology of the region as it is possible to give at present. The map shows the general relations of the areas occupied by the various groups of formations that have been recognized.

Generalized table of stratigraphic sequence in the central Kuskokwim, Innoko, and lower-central Yukon region.

	Age.	Character.	Distribution.
	Quaternary.	Clays, silts, sands, and gravels; locally moraines and outwash deposits.	Widely spread throughout all the valleys and lowlands.
	—Unconformity—		
	Tertiary.	Basaltic and andesitic lavas and tuffs.	Lower Yukon and lower Innoko.
		—Unconformity—	
		Fresh-water deposits (Eocene). Light-gray sandstones and clays, slightly consolidated, with lignite beds. Fragmentary plant remains.	Lower Yukon and lower Innoko.
	—Conformity?—		
Mesozoic.		Acidic intrusives (granite porphyries and diorite).	Throughout the Kuskokwim Mountains.
Mesozoic.	Cretaceous.	Conglomerates, arkoses, and shales, with some coal beds on the Yukon. Contains acidic dikes and sills on lower Kuskokwim and also basic volcanic material. Fragmentary plant remains and marine shells. Probably includes both Upper and Lower Cretaceous and is conformable with Jurassic.	Throughout the lower Kuskokwim Mountains, southeast side of the Innoko Valley, northwest side of lower Yukon Valley, lower Koyukuk Valley, and upper part of central Kuskokwim Valley.
Paleozoic.	—Unconformity—		
Paleozoic.	Devonian.	Thin-bedded limestones and limy shales. Middle Devonian fossils.	Upper part of Kuskokwim Valley and possibly in Chulitna Valley.
Paleozoic.	—Unconformity?—		
Paleozoic.	Devonian or Silurian.	Slates intruded by acidic dikes, locally gold bearing.	Upper Innoko basin and Kuskokwim Mountains northeastward.
Paleozoic.		—Unconformity?—	
Paleozoic.		Greenish cherts and dark slates, with diabase tuffs and sills.	Innoko River above North Fork to 10 miles below Ophir.
Paleozoic.		—Unconformity?—	
Paleozoic.		Massive effusive diabases, considerably broken and crushed and recemented by calcite and quartz, but only locally schistose.	Northwest and southeast flanks of Kaiyuh Mountains, north side of Yukon in vicinity of Gold Mountain, and northwest side of Yukon-Melozitna divide.
Paleozoic.		—Unconformity—	
Paleozoic.	Pre-Ordovician.	Quartzite and mica-quartz schists, with closely associated crystalline limestones, garnet schists, and fine-textured slaty schists. (Birch Creek schist).	Axis of the Kaiyuh Mountains and north of Yukon River from vicinity of Kokrines northeastward to Tozitna basin and beyond.

All the older sedimentary formations apparently lie in broad belts that trend in general from northeast to southwest, and the igneous rocks associated with them appear to conform also to this trend.

The oldest group of sedimentary rocks consists of the quartzite and mica-quartz schists, with associated crystalline limestones, garnet schists, and fine-textured slaty schists or phyllites that form a large part of the Kaiyuh Mountains and extend northeastward across the Yukon to the basin of Tozitna River and possibly southwestward to the Haiditarod. Succeeding this belt of schistose sediments is an extensive group of ancient diabasic effusive rocks that appear to be stratigraphically associated with the schistose rocks. These diabasic rocks have not been deformed nearly so intensely as the schistose group. In places they show greenstone schist phases, but for the most part they have not been greatly altered. Their contact relations to the schists are not known in this region. They appear to flank both the northwest and the southeast sides of the schist belt in the Kaiyuh Mountains, where they extend southwestward to the Innoko, and they have an extensive development toward the northeast north of the Yukon, as far as Gold Mountain and beyond, as indicated on the map. No statement as to the thickness of this diabasic group can be made at present.

The upper Innoko Valley is largely occupied by rocks, for the most part of a slaty character, which appear to be divisible into at least two formations, and have been so indicated on the map. The rocks that appear to comprise the older division are closely associated with the diabasic greenstone group just described. They lie in a broad belt along what may be considered the northwestward flank of the Kuskokwim Mountains. On their northwest side they are composed of fine-textured, impure, tuffaceous sediments in which material of basic volcanic origin predominates and in which diabase is also probably intrusive. Farther to the southeast greenish cherts occur. From a point 10 miles northwest of Ophir to the divide between Ganes Creek and the Takotna there are only black slaty rocks, the diabasic volcanic material being absent. Both the cherts and the slates are known to extend southwestward to the Dishna Valley, and it is presumed that they form the largest part of the country rock northeastward toward Tanana River, as has been indicated. Slates are also reported to form large areas of the country rock in the basins of the Tuluksak and Riglugalik rivers to the southwest. These rocks are considered by the writer to be of Silurian-Devonian age.

Along the northwest side of the Kuskokwim Valley, from a point below the mouth of the Takotna northeastward to its forks, and beyond up the northwest side of the valley of the North Fork, there is a belt of Devonian rocks mostly composed of thin-bedded limestones and limy shales. A belt of these rocks is also indicated along the

northwest side of the Chulitna Valley, as limestones are reported from that vicinity and it is presumed that they may be of Devonian age.

From the above statement it may be seen that a wide area of Paleozoic formations similar to those that occur in the Yukon-Tanana region to the northeast extends southwestward throughout the Kaiyuh Mountains to the lower Innoko and through the Kuskokwim Mountains as far as the head of Takotna River. They may also outcrop in other areas from beneath the mantle of younger Mesozoic sediments that largely form the country rock of the central Kuskokwim Valley. At least this is reported to be the case on Tuluksak and Riglugalik rivers.

The schists of the Kaiyuh Mountains are the oldest and most intensely metamorphosed of the Paleozoic rocks of this region. From the Kaiyuh Mountain belt of schists toward the southeast there is a disconnected succession of belts of more or less metamorphosed Paleozoic formations to Kuskokwim River below its main forks, a distance across the strike of about 100 miles. These belts all appear to parallel each other in their general trends, which are from northeast to southwest. The Devonian rocks on the Kuskokwim are considered to be the youngest (Middle Devonian) of these Paleozoic sediments, and they are the least changed by metamorphism, although some of the shaly beds show slaty structure. They are considerably folded, contain numerous small quartz veins, and in general give the impression of considerable age.

Next to the schists of the Kaiyuh Mountains the slates of the Innoko district, which lie along the divide and what may be the principal axis of the Kuskokwim Mountains, appear to be the most highly altered of these old rocks. The cleavage of these slates stands at high angles and is in many places vertical. The chert and slate-greenstone series lying between the slates of the Innoko district and the diabases of the Kaiyuh Mountain does not appear to be so highly altered, for its bedding is in many places at angles of 45° and less. Likewise the series of diabasic rocks that flanks the schists of the Kaiyuh Mountains does not appear to be very highly changed, although locally it presents schistose phases.

The meager facts in hand regarding these Paleozoic rocks, as provisionally expressed in the generalized stratigraphic table above and also on the map (Pl. II), give the impression that there may be a more or less continuous succession of Paleozoic formations, of which the schists of the Kaiyuh Mountains are the oldest. These were followed by effusive diabases of stratigraphic significance, which may gradually merge or intergrade as more or less tuffaceous mixtures with a series of slates or phyllites nearer the occurrences of the diabase, and which are essentially sedimentary deposits laid down con-

tiguously to the slates. The slate series becomes freer of tuffaceous material the farther it is removed from the diabase; and the slate series in the upper Innoko Valley (which does not contain tuffaceous material) is overlain by a marine limestone formation of Devonian age that may have been contemporaneous with the slates as a deeper sea deposit or that may have succeeded them.

Mesozoic sediments occupy the largest part of the central Kuskokwim Valley, and tonguelike extensions to the northeast appear to have been deposited in depressions in the Paleozoic rocks of the Innoko and Takotna valleys. Where observed there is a marked unconformity between the Paleozoic and Mesozoic formations, a heavy conglomerate forming the basal bed of the Mesozoic in many places. In the central part of the lower Yukon Valley there is an extensive development of Cretaceous sediments that extends far to the northeast up the valleys of Melozitna and Koyukuk rivers. Coal beds occur in the Cretaceous sediments on the Yukon, but no coal has been reported from the Mesozoic rocks in the Kuskokwim Valley.

Tertiary sediments are not very extensively developed in this area, so far as known. There is a small patch of lignite-bearing rocks on the lower Innoko, too small in area to show on the map, and a larger area on the lower Yukon, that is indicated. These rocks are apparently entirely of fresh-water origin. There are also considerable areas of lavas and tuffs along the Yukon and lower Innoko that are all considered to be of Tertiary age.

Pleistocene and Recent unconsolidated gravels, sands, silts, and clays are widely distributed throughout the valleys and lowlands of all the larger streams.

DESCRIPTION OF ROCKS.

PALEOZOIC ROCKS.

BIRCH CREEK SCHIST.

The oldest rocks in the Innoko-Kuskokwim region appear to be the schists which are found in the Kaiyuh Mountains. Although observed by the writer only at the northeast end of the range, about Ruby Creek, and along the right bank of Innoko River, from 5 to 25 miles below Dishkakat, where they outcrop at intervals along the southwest flank of the mountains, there seems to be no reason to doubt that a belt of schist rocks extends along the whole length of the Kaiyuh Range. Prospectors report the presence of schists in these mountains about the headwaters of Kluklaklatna and Yuko rivers, and the gravels brought out of this range by the North Fork are mostly rocks of this kind, so it appears that schists are a common type of rock throughout the Kaiyuh Mountains. These rocks are provisionally correlated with the Birch Creek schist.

The bluffs that occur at intervals for 10 miles along the south bank of the Yukon, opposite the mouth of Melozitna River, afford good exposures of these rocks, though as the river section runs nearly parallel to the strike of the beds it is not very satisfactory for showing the structure. At the eastern or up-river end of these bluffs is a massive blue-gray crystalline limestone that forms the river bluff for about 1,000 feet. Its general strike is magnetic north and south and the dip is about 40° W. There are some bands of white marble and small stringer veins of calcite and a few of quartz in this limestone. It is succeeded downstream by a belt of garnet-mica schist about 1,000 feet thick. This member appears to be conformable with the limestones, and its schistosity likewise has the same trend as their strike and dip. Downstream from the schist another crystalline limestone is exposed, but this is not so pure as that farther up the river. It is more banded and shows the effects of metamorphism by the plications of the bands and the segregation of more or less pure lenses and veinlets of calcite along the bedding. The strike and dip of this limestone is about the same as those of the upper belt. From the end of this outcrop down to Flat Creek, 1½ miles below, there are no good exposures of bed rock in place, but the slide material from the hillside slopes indicates a change from the impure limestone into fine-grained dark-colored mica-quartz schistose rocks.

The next exposures down the river are in bluffs just below Flat Creek. Thence down to Ruby Creek, a distance of about 4½ miles, the rocks consist of a fine-grained mica schist or coarse mica slate. In general, these schists appear to have the same structure as the limestones above, except where a large dike has been intruded into them about 1 mile below Flat Creek. Below this dike the dip of the schists is toward the west, the same as that of the limestones, but on the up-river side of the dike the dip is about 45° toward the east, and this attitude prevails for some distance up the river, nearly to Flat Creek. Vein quartz in the form of reticulating stringers and lens-shaped bunches occurs in the schists. Near Flat Creek the results of shearing in these rocks is somewhat pronounced and large quartz lenses and stringers now occupy the openings thus produced. The dike above mentioned is about 200 feet wide. It is a medium-grained dioritic rock intruded vertically across the schists diagonal to their strike. Since its intrusion the dike itself has been sheared, as it is fractured into blocks, and quartz stringers have been deposited along the joints. One of these quartz stringers is 6 inches thick.

Just below Ruby Creek there is a prominent exposure of limestone called Lime Bluff that rises as a sheer wall 100 feet high from the waters of the Yukon, whose main current flows strong and deep along its base. This limestone is about 1,000 feet thick, and it has the same

general strike and dip as the limestones farther up the river. Below Lime Bluff there are mud banks for half a mile, and the bluffs of the ridge beyond are made up of fine-textured mica schists similar to those which occur above Ruby Creek.

South of this part of the Yukon the bed rock is mostly covered by a thick growth of moss, brush, and scrub spruce. A few low bluffs afford exposures along the creeks, and outcrops are generally found on the tops of the low, dome-shaped mountains. These exposures, so far as observed, show that the bed rock is made up largely of quartz-mica schist, with some cherty limestone.

The writer considers the schists described as occurring in the vicinity of Ruby Creek and on the Innoko to extend throughout the Kaiyuh Mountains, where they probably form the predominating bed rock, and to be the stratigraphic equivalents of the schists of the upper Yukon region in the Fairbanks, Birch Creek, and Fortymile districts. These schists, as a whole, are a diverse complex of old rocks, primarily of sedimentary origin, that have been changed from their original form by metamorphism. The most common varieties are schistose quartzites and mica-quartz schist. Crystalline limestones and cherts are closely associated with the schists in some localities, and may be present in the Kaiyuh Mountains, as these kinds of rocks are known in the northeastern part of the range, and as cherts occur on Innoko River about 100 miles below Dishkakat.

These mountains have not been well prospected, but their accessibility from the Yukon, especially in winter, should invite a more thorough search for placer-gold deposits than has been given to them up to the present time. The gold in the placers of the Fairbanks, Birch Creek, and Fortymile districts has been derived from rocks of this kind, and in the Ruby Creek area, at the northeast end of the Kaiyuh Range, placer gold is known to occur under similar conditions. Prospects of placer gold are also reported from other parts of the Kaiyuh region. It is said that the country rock of the recently discovered Haiditarod placer-gold district consists of schistose rocks similar to the above-described formations.

VOLCANIC ROCKS AND SLATES.

The schists of the Kaiyuh Mountains have a general strike corresponding to the structural trend of that range—that is, from southwest to northeast. As Innoko River is ascended from Dishkakat around the southeast flank of the Kaiyuh Range, above the point where the schist belt was observed, the next hard country rocks encountered in place are altered diabases that outcrop on the right (northwest) bank of the river as low, isolated bluffs which form the terminations of ridges from the low, undulating mountains. The

first outcrop of diabase seen going up the Innoko is about 45 miles, by the extremely meandering course of the river, above Dishkakat, and from this outcrop up to a point within 7 miles of the mouth of the North Fork, through a distance of about 45 miles by the river, there are four or five outcropping bluffs of these rocks exposed on the northwest bank of the stream. These outcrops, although widely separated, do not indicate that the rocks observed occupy a very wide belt, for the Innoko in this part flows along the southwest flank of the Kaiyuh Range in a direction parallel to the general structural trend, and a few of the wide meanders of the river run into the low foothills on the right and expose the bluffs noted. It thus appears that these basic igneous rocks, which are presumed to be effusive in origin, lie in a belt along the southeast flank of the schist belt of the Kaiyuh Range. Whether they are in contact with the schists to the northwest, or other formations intervene, is not known. The diabasic rocks appear to be younger than the schists, as no schistose phases were observed within them. They have, however, been considerably distorted and are much broken and crushed into blocks, many of which show slickensided surfaces, and in places the fractures between the fragments have been filled with calcite veinlets. The exposures along this part of the Innoko give the impression that these volcanic rocks may constitute a rather homogeneous stratigraphic member of considerable thickness, which may be quite distinct from and not interbedded with contiguous formations of sedimentary origin. This is mentioned merely as a possibility and not as a certainty, for the exposures observed are widely separated and too little is known of the rocks that occupy the intervening areas to make a definite statement of their relations possible at this time. Enough is known, however, to justify the statement that the diabases make up considerable masses of the bed rock in the localities where they occur. It may be found that this belt of diabases extends northeastward into the basin of the North Fork of the Innoko.

On the lower Innoko, northwest of the schists that outcrop on the river, there is another wide belt of diabases that appears to extend northeastward and flank the schist belt along its northwest side.

Just below the mouth of the North Fork the bars of the Innoko are made up largely of quartz-mica schist pebbles that indicate the presence of considerable areas of schistose rocks in the country to the north drained by that stream.

Above the confluence of the Innoko and its North Fork there is a wide stretch of flat valley country through which the main river meanders for 30 miles after it flows out of the low mountains of its upper province. The first hard rocks encountered as these mountains are approached are some limy sandstones and shales that form long

bluffs on the south bank, but these rocks are considered to belong to a younger formation that will be described later (p. 55). (See Pl. II.)

Farther upstream older rocks appear again at a point about 50 miles below Ophir. Here there are some highly sheared greenish rocks, showing local tendencies toward schistosity, that appear to be made up largely of diabasic material with a mixture of fine-grained shaly sediment. They are probably altered, fine-textured, impure tuffaceous sediments in which material of basic volcanic origin predominates. A few miles farther upstream dark, fine-grained slaty rocks with similar greenish diabasic igneous material interbedded and perhaps also intruded, together with green cherty beds, outcrop along the river and continue to make up its bluffs on the east side to a point within 10 miles of Ophir. These rocks all have a general strike from northeast to southwest, and along this trend several miles southeast of Mount Hurst the ridges show many outcrops of greenish and some brownish-red cherty rocks, indicating that a considerable belt of these rocks is here represented. They may comprise a distinct formation and may eventually be correlated with the group of argillites, in part interbedded with graywacke and associated with cherts found by Brooks along Tonzona River, which flows from the slopes of the Alaska Range into the Kuskokwim near its forks. This group of rocks extends along the inland front of the Alaska Range in both directions from the Tonzona basin. Similar rocks also appear to be represented north of Tanana River between Tolovana flats and Baker Creek and farther northeast in the Rampart district. The writer considers that the rocks of similar appearance observed on the upper Innoko may eventually prove to be a southwesterly extension of the rocks in the Yukon-Tanana region that have been tentatively correlated with the group along Tonzona River, just described.

From a point on Innoko River 10 miles below Ophir upstream to that place and above it to the Ganes Creek valley only black slaty rocks were observed, the diabasic volcanic material apparently being absent. These black slates, with a small amount of coarser-grained sedimentary rocks of rough grain, hackly or jagged fracture, and schistose aspect, form the country rock of the placer-gold area, as it is now known. Good slaty cleavage is not universally present in all these fine-grained black rocks, but in many places a very well developed cleavage is characteristic. On Ganes Creek some typical pencil slates were seen. Taken as a whole, the rocks about the headwaters of the Innoko may be properly called slates. These slates appear to be free from any admixture of volcanic material such as was observed farther north, down the Innoko. Another distinction that may be

drawn between these two contiguous belts of essentially similar sediments is that the slaty structure of the rocks is apparently better developed in the gold-bearing area, and that, besides being highly folded and cleaved, the resultant slates have been strongly disrupted in places and to some extent intruded by dikes up to 15 or 20 feet in width, of a highly siliceous composition.

It therefore appears that the province of the upper Innoko Valley is largely occupied by dark, fine-grained rocks of sedimentary origin that, to the north, lie in a belt in which a considerable amount of basic volcanic material was mixed with the original shales. This volcanic material does not appear to be present in the more altered sediments of similar appearance to the south. The rocks to the south have been subjected to enough metamorphism to produce pronounced slaty cleavage, and later have been intruded by siliceous igneous rocks in the form of dikes that are considered to have caused the formation of the gold.

The slates of the upper Innoko are considered to be of Silurian-Devonian age. The reasons for so placing them are similar to those expressed for the schists of the Kaiyuh Range, namely, their apparent lithologic and stratigraphic resemblance to similar formations found in the upper Yukon placer-gold districts and also the fact that Devonian rocks are known to occur on Kuskokwim River a short distance southeast of Ganes Creek. On this slight basis the gold-bearing formation of the Innoko district may be provisionally considered to belong with the rocks that have been termed the Rampart group in the Yukon-Tanana region.

DEVONIAN ROCKS ON KUSKOKWIM RIVER.

Under the name "Tachatna series," Spurr[a] describes the rocks that outcrop on the north bank of the Kuskokwim from a point a short distance below the junction of the Kuskokwim with the East Fork down to a point about 10 miles below Vinasale. Through this distance the river cuts many rock outcrops, generally on its right bank.

The easternmost outcrop of the "Takotna series" is made up of much-decomposed clayey limestone and slate-carrying quartz veins. Two miles farther down is a heavy-bedded light-gray limestone, which contains many calcite veins and is highly fossiliferous; still farther down is black limy shale interbedded with arkose, which weathers dark red. The same general characters persist as far as the formation extends, the rocks consisting in the main of a limy shale or an impure limestone, much of which contains sedimentary material. The limestone is mostly pure, but in some places is siliceous; elsewhere small areas are occupied by chert. Some of the slates are carbonaceous,

[a] Spurr, J. E., Reconnaissance in southwestern Alaska in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 157–159. "Tachatna" is now spelled Takotna.

others chloritic. The arkose layers are in some places fine, in others coarse; many of the latter are granitic, being made up of quartz, orthoclase, plagioclase, and various ferruginous minerals that are evidently the products of alteration.

At the easternmost outcrop the strike is northeast and southwest and the dip is southeast at a slight angle. This strike and dip persist for a number of miles downstream, and then change to a general northwesterly strike and a southwesterly dip as far as the point where the Kuskokwim turns toward the south. Thence to the western limit of the formation on the river the strike continues northwest (nearly west) and the dip varies, being generally, however, to the north at angles not exceeding 45°. In addition to the usual attitudes of the rocks, as just stated, there is continued folding, so that the dips are locally reversed, and in some places the rocks stand vertically. The folding, however, is generally not close.

Below Vinasale the rocks of the "Takotna series" are cut by some porphyritic dike rocks, all being apparently of nearly the same variety. A specimen of one dike proves to be a granite porphyry. Except in this neighborhood, no dikes were observed in the series as it is exposed along the Kuskokwim. Throughout the series, however, there are many small quartz veins, although nowhere in great abundance; these veins contain pyrite.

Rocks similar to those just described were observed by the writer on the northwest flank of a mountain on the south bank of the Takotna opposite the mouth of Big Creek. The mass of this mountain and another similar to it a few miles to the east appear to be made up of a batholithic intrusion of diorite. Farther to the west, between the two principal headwater forks of Ganes Creek, there is a dome-shaped prominence of cherty limestone called Knob Hill that the writer is inclined to associate with the Devonian rocks on the Kuskokwim.

The rugged mountains in which rise Takotna River, Ganes and Beaver creeks, and the eastern tributaries of the Dishna, appear to consist largely of massive intrusions of porphyry. These seem to have constituted the center of intrusive activity of these rocks, and the dikes on the Kuskokwim and in the Innoko placer area may be apophyses from this center.

At a point on the Kuskokwim about halfway between the forks and the Takotna abundant fossils, which indicate a probable Middle Devonian age, were found in light-gray limestone, and it is on the basis of this one known fossil locality that the rocks associated with these by lithologic similarity and a general appearance of considerable age are placed in this part of the time scale. No doubt closer examination will reveal many other fossil localities and make possible a much more definite and satisfactory classification of the formations that make up the group.

MESOZOIC ROCKS.

The Devonian rocks on Kuskokwim River that have just been described are succeeded downstream by a much younger group of sedimentary formations of Mesozoic age. Spurr[a] considers all the hard sedimentary rocks exposed by the cutting of Kuskokwim River from a point about 10 miles below Vinasale to the last outcrops on the right bank of the river just above Kaltshak to belong to the Mesozoic era. Spurr divided this extensive Mesozoic terrane into two groups, the "Holiknuk series" and the "Kolmakof series," but states that their stratigraphic relations could not be determined and that so far as the evidence goes the two may be provisionally considered as essentially contemporaneous in origin, the only differences being lithologic and caused by variations in local conditions. Spurr's descriptions are here repeated:

HOLIKNUK SERIES.

Distribution.—At a point some 10 miles below Vinasale conglomerates and arkoses, which are taken as the base of the Holiknuk series, outcrop. From this point there are frequent outcrops along the river as far as Kolmakof, at which point the boundary between the Holiknuk series and the Kolmakof series has been chosen. The river here flows for the most part in a definite rock-cut valley, so that the only interruptions in the section are occasional local silt deposits.

Lithology.—As before mentioned, the basal bed of the Holiknuk series consists of conglomerates and arkoses which are quite different from the shaly limestones of the Tachatna [Takotna] series farther up the river, having a comparatively fresh appearance. The pebbles in the conglomerate are sometimes 5 or 6 inches in diameter, and are mostly of black or dark-gray siliceous limestone or limy shale, evidently derived from the Tachatna series. From this point all of the way to the Holiknuk [Chulitna] the rocks are generally uniform in appearance, being composed of granitic arkose and sandstone alternating with carbonaceous shale, the arkose or sandstone often passing into the shale laterally within the limit of a single cliff. Plant remains are common in both shales and arkoses. At the junction of the Kuskokwim with the Holiknuk the rock becomes more limy, with not quite so much arkose, but contains similar plant remains. Below the Holiknuk, rocks of the same character are found, but they grow continually more sandy and contain frequent beds of coarse granitic arkose. On the right bank of the river, for some distance above Kolmakof, the same series of shales, sandy limestones, and arkoses show frequent plant remains, also ripple marks and all other kinds of shore markings.

Folding.—The basal bed of conglomerate has a northwest strike and a dip of about 45° SW. From here about halfway to the Chagavenapuk [Swift River] the general strike is northwest, while the dip varies constantly from northeast to southwest with the folding in the rocks, which is constant, but never close. The folding in general is greatest at the first point where the series is encountered [near the contact with the older rocks below Vinasale] and grows less farther down the river, the folds becoming more and more gentle. At a point about halfway between Vinasale and the Chagavenapuk River the strike changes to true north to south in general, so that the river flows along the strike, while the dip, as before, varies. From the Chagavenapuk to the Holiknuk, where the course of the river changes, the strike of the rocks is also found to change, becoming constantly northeast and parallel with the trend of the

[a] Spurr, J. E., op. cit., pp. 159–163.

river. Along here the general dip is northwest at slight angles. From the Holiknuk to the Yukwonilnuk River the strike of the rocks again changes, in general conforming with the northwest shoot of the Kuskokwim. The series is here, however, more highly folded than higher up the river, so that deviations are numerous; the dip, as before, varies greatly. Where the northwest shoot of the river gives place to a southwest shoot above the Yukwonilnuk the strike of the rocks remains the same, so that the river cuts directly across it, and this seems to be true in general as far as Kolmakof.

Dikes and veins.—The rocks between Vinasale and the Holiknuk are practically free from dikes. Just below the Holiknuk are heavy intrusive bodies of siliceous porphyritic rock, which cut across the bedding of the sedimentaries or run parallel to it in heavy sheets. * * * These dikes weather a brilliant orange color, and owing to concentric weathering the colors are often arranged in curves. From here all the way to Kolmakof the sedimentary rocks are cut frequently by similar siliceous dikes. The Yukwonilnuk River brings down a great variety of igneous rocks, which makes it seem probable that its course lies in mountains which are largely made up of these.

Examined microscopically, it is found that the dike rocks are all members of a decidedly siliceous series. The series runs through many varieties * * *. being always porphyritic and generally having a granular groundmass. * * * In the vicinity of the dikes the sedimentary rocks are hardened for a few feet, so that they are more resistant, and near these contacts are occasionally small veins of quartz or calcite; as a whole, however, the whole series is free from veins.

Definition of Holiknuk series.—The Holiknuk series is a series of alternating beds of sandstone, argillaceous or siliceous limestone, shale, and arkose, which are everywhere bent into open folds. The basal bed of the series is a conglomerate containing pebbles apparently derived from the Tachatna series. Throughout all of the rocks are frequent obscure plant remains, and in many places, especially above Kolmakof, are indisputable evidences of a shore formation in the presence of ripple marks and other shore marks. The series is well separated from the Tachatna series by unconformity, lithology, and generally younger appearance, while the division between it and the succeeding Kolmakof series is based on the presence of volcanic materials in the rocks of the later series.

Relative age of Holiknuk series.—It has been mentioned that the Holiknuk series overlies unconformably the Tachatna series, in which have been found fossils indicating a Middle Devonian age. In the Holiknuk series itself fossil remains, though frequent, are generally too imperfect to admit of identification. At a locality about halfway between the Chagavenapuk and Vinasale a small specimen containing imperfect plant remains was collected, which Dr. F. H. Knowlton pronounced to contain a fragment of a dicotyledonous leaf, indicating an age presumably later than the Jurassic * * *. [About 15 miles below the mouth of Yukwonilnuk River] the limestone contains abundant remains of *Inoceramus*, and the same fossils occur a short distance above Kolmakof associated with the ripple-marked shales and shaly limestones. These fossils * * * probably belong to a Cretaceous species.

KOLMAKOF SERIES.

Distribution.—The Kolmakof series outcrops frequently all along the right [north] bank of the Kuskokwim, between Kolmakof and the beginning of the low silt plain just above the entrance to the Yukon portage route above Kalchagamut [Kaltshak]. For all this distance there are no outcrops on the left [south] side of the river.

Lithology.—The first outcrop below Kolmakof on the right side of the river is nearly black in color and proves to be made up mainly of andesite, although apparently interstratified with some beds of arkose or shale; these latter beds contain abundant plant remains and lumps of carbonized wood. The same general exposure, a few miles farther down the river, changes to green arkoses and soft shales, which sometimes show

cross-bedding and carry plant remains. About 15 miles below the end of this exposure, which is terminated by an expansion of the superficial silts and gravels that form the left bank continuously, the next exposure is composed of various volcanic rocks having an altered and ancient appearance; these vary to coarse and fine tuffs, evidently directly derived from the volcanics. A few miles farther down one of the beds of the same general series proved to be a glauconitic calcareous chert, full of sponge spicules. A number of miles still farther the river again cuts massive basalt on its right bank. This bluff is continuous along the river for a number of miles. After a few miles it begins to have a finely stratified appearance, and when examined was found to have changed into alternating layers of tuff with shaly beds. From this point nearly to Kalchagamut there are no outcrops, although the hills not far from the river on the right seem to be made up mainly of igneous rocks.

The rocks of the Kolmakof series are sometimes evidently volcanic, but again are so dense and fine-grained that they can hardly be distinguished in the field from massive sedimentaries. They have all a general greenish color, such as naturally belongs to ancient and somewhat altered lavas. The microscope is needed to determine their exact nature, and then they are found to comprise dacite, trachyte, andesite, and basalt. The associated tuffs appear to be mainly trachytic, so far as examined. The arkoses are all fine grained.

Folding.—The general strike of the bed rocks below Kolmakof seems to be north to south, while the strata are bent into broad folds having this trend, so that the dip varies from horizontal to vertical and from east to west; the strike also changes considerably, becoming in places * * * east to west.

Dikes and veins.—Both volcanic and sedimentary rocks of the Kolmakof series are cut by many dikes, mostly of a siliceous nature, and in many cases the intrusive rock is nearly equal in amount to the rocks through which it intrudes. As a whole, therefore, it may be said that the intrusive rocks, which are very rare in the Tachatna series and in the Holiknuk series above the Holiknuk [as they are exposed along the immediate banks of the Kuskokwim], become progressively more abundant farther down the river and culminate in the Kolmakof series between Kolmakof and Kalchagamut, which series is also distinguished from the rest by containing within itself such great quantities of bedded volcanic rocks.

When examined microscopically the dike rocks are found to be ordinarily of siliceous varieties, although some are more basic. It is possible that these more basic ones may belong to an earlier period of intrusion and be more connected with the volcanic flows. The most siliceous rock examined was a biotite granite porphyry, and other varieties are bostonite, quartz syenite, hornblende diorite porphyry, diabase porphyry, and basalt.

The rocks of the Kolmakof series do not, in general, contain veins, but in the vicinity of numerous dikes are many small veins and other evidences of alteration. The material of these veins is generally calcite. About 3 miles below Kolmakof a vein of cinnabar, which is evidently one of the features of mineralization connected with the intrusive rocks, has been discovered and worked on a small scale by a trader, but at a loss.

Definition of Kolmakof series.—The Kolmakof series consists of a series of volcanic rocks of various types, which change laterally into or are interbedded with volcanic tuffs, shales, impure limestones, and fine-grained arkoses. The rocks contain frequent plant remains and are characterized by ripple marks and other evidences of shore formation. They are considerably folded and are cut through by great masses of intrusive rock.

Relative age of Kolmakof series.—The rocks of the Kolmakof series, except those of volcanic origin, are essentially like those of the Holiknuk series, being of the same lithologic variety, containing frequent plant remains, and showing the same ripple

marks and other evidences of a shore formation. Just above Kolmakof rocks which have been included in the Holiknuk series carry plant remains and an *Inoceramus*, which has been determined to be probable Cretaceous. Not far below Kolmakof rocks of similar appearance, which have been referred to the Kolmakof series, also carry many imperfect plant remains but no fossil shells.

MESOZOIC ROCKS IN THE INNOKO BASIN.

Mesozoic rocks do not appear to occur to any considerable extent within the Innoko basin. The occurrence of rocks considered to be of Mesozoic age on the south bank of the Innoko, where it leaves the low mountains of its upper province, has been mentioned. These rocks are hard, limy sandstones and shales, exposed as bluffs along the river at intervals for several miles. They are, for the most part, gritty in texture, appear to be tilted at high angles, and have suffered considerable deformation. The heavier beds are much broken into blocks that have been recemented to some extent by calcareous material, and calcite sweat veins are common; the weaker shaly beds are rumpled and rather kneaded in appearance. No fossils were found in these rocks, and no volcanic material was seen in them at this locality.

On the divide between Ganes Creek and Big Creek, which is a tributary of Takotna River, there is apparently an unconformable contact between the slate formation that occupies the Ganes Creek valley and a younger overlying formation that extends southeastward from the divide toward the Takotna. The rocks of the younger formation occupy the valley of Big Creek and extend north and south on the Takotna side of the divide. The contact between these younger rocks and the underlying slates was followed south for several miles along the divide from the saddle where the trail from Ganes Creek to Big Creek crosses. At their base the rocks overlying the slates are coarse, gritty sediments, with some fine-pebble conglomerate beds. The small-pebble beds alternate with thin beds of grits. To the southeast, about halfway down the valley of Big Creek, are hard, fine-textured carbonaceous shales that are fractured into irregular blocks, which weather into roughly spherical shapes by a flaky spalling of the outside.

The above-described sedimentary rocks, together with the similar ones observed on the Innoko, are considered to be of Mesozoic age and to be northeasterly outliers of the extensive Mesozoic formations found by Spurr on Kuskokwim River, from a point 10 miles below Vinasale to Kolmakof, and described by him under the name "Holiknuk series." The basal beds of this series are conglomerates and grits, succeeded by sandstones alternating with carbonaceous shales carrying fragmentary plant remains and some sandy limestones in which shell remains indicate a Cretaceous age.

MESOZOIC VOLCANIC AND INTRUSIVE ROCKS.

No igneous rocks were seen by the writer in the sediments above described, but Spurr found effusive and intrusive igneous rocks so pronouncedly developed on the Kuskokwim, from Kolmakof to Kalchagamut, that he grouped them under the name "Kolmakof series," and it appears that this series may extend northeastward from the Kuskokwim to the vicinity of the headwaters of Dishna River and Ganes Creek, where there are considerable areas of igneous rocks, similar to those observed by Spurr, apparently associated with sedimentary rocks that are thought to be of Mesozoic age. The detailed relations of these rocks were not determined. The intrusion of massive siliceous porphyries has been so extensive that they appear to make up a large part of the mountain group situated between Dishna River and Ganes and Beaver creeks. Some of the rugged peaks of these mountains rise to a height of 4,500 feet. The group has been the seat of heavy local glaciation. The thick moraines that have been deposited on their lower slopes and around the mountains obscure the bed-rock geology very much. The intrusive igneous rocks which largely make up these mountains may be either late Mesozoic or early Tertiary in age, and it may be that they have an extensive development throughout that portion of the Kuskokwim Mountains that extends from the source of Dishna River toward Kolmakof, for Spurr noted that Yukwonilnuk River has brought a large quantity of igneous rocks down to its confluence with the Kuskokwim, which makes it seem probable that the basin of this stream is occupied in large part by igneous rocks.

TERTIARY ROCKS.

SEDIMENTARY FORMATIONS.

Spurr did not find on the portion of the Kuskokwim included in this bulletin any sedimentary formations which he considered to be of Tertiary age. The only sedimentary rocks seen by the writer in Innoko Valley that are thought to be of Tertiary age are on the lower course of the Innoko, about 90 miles below Dishkakat. These rocks are semiconsolidated beds of gray shales and sandstones, with some thin beds of lignite. The beds have been somewhat folded and tilted, but the rocks are not hard and the lignite is not very coaly, but rather woody, in appearance. Fragments of the lignite show plainly the matted texture and surface markings of the original vegetable material of which it is composed. The exposure of these beds extend as low bluffs along the right bank of the Innoko for about a mile, and in this distance no lignite beds of sufficient thickness to be worked for fuel were observed. It is reported that in the hills back of this locality lignite occurs in thicker beds, but it is doubtful if

they will ever have any commercial importance. Probably areas of lignite-bearing sediments of this age may be found in other parts of the Innoko Valley when the region becomes better known.

VOLCANIC ROCKS.

The extreme southwestern part of the Kaiyuh Range is made up almost entirely of volcanic rocks that appear to have been extruded as rather extensive lava flows of andesitic and basaltic types. They outcrop as bluffs along the right bank of the lower river at a number of places for a distance of 30 miles above the point where Shageluk Slough flows into the Innoko. All the outcrops seen consist of lava rock, and their relationship to any older sedimentary rocks is not known. The fresh appearance of these rocks and their general similarity and proximity to other areas of volcanic rocks that occur throughout the lower Yukon Valley from Nulato to St. Michael, associated with lower Tertiary and upper Mesozoic sedimentary formations, is the basis for considering these lavas of probable Tertiary age. However, such an assignment of these lavas and the other extensive flows of similar effusive rocks in the lower Yukon and Kuskokwim regions can only be considered very tentative, because there are strong indications that there has been a transitional period of sedimentation, accompanied by extensive volcanic activity, from upper Mesozoic to lower Tertiary time, which has linked these two periods, in this part of Alaska, in so intimate a manner that only detailed studies will enable satisfactory time distinctions to be drawn.

QUATERNARY DEPOSITS.

GENERAL OUTLINE.

The general character and distribution of the Recent and older unconsolidated formations have been mentioned in the sketch of the geography of the region. The comparatively small areas of unconsolidated deposits that are now known to contain placer gold are typical of most of the alluvium that occupies the upper part of the Innoko Valley and all of the secondary valleys throughout the mountainous part of the region. These deposits are the same in every particular, except for the absence of gold, as the auriferous deposits, which are described under "Mineral resources."

Along the major drainage courses and particularly the large rivers, like the Kuskokwim, the unconsolidated deposits are divisible into two distinct classes, older and younger, which may be distinguished by differences in character and position. The younger deposits form the low banks, which are not more than 20 feet above the rivers and which consist of fine silt alternating with

layers of vegetable matter with numerous buried logs and the upright trunks of trees, and which are in many places covered with fresh mud. The older deposits comprise high banks without vegetable material, and are cut more rarely by the rivers. These vary from 20 to 150 feet in height. Both classes occupy largely the same areas and merge into one another more or less.

There is also a special group of the older deposits that has marked characteristics which are easily recognized. These are the morainal deposits from former glaciers, which are quite distinct and definitely limited in their distribution. The finer materials washed out from the moraines, however, are of much wider distribution and, because of their similarity and closer association with the younger sediments, are not so easily recognized. Generally they are more free from vegetable material, and they occupy more elevated positions than the more recent silts.

OLDER UNCONSOLIDATED DEPOSITS.

The older unconsolidated deposits are characterized by their mode of origin, being the result of a kind of drainage different from that which now prevails. During the Pleistocene period the drainage of the southern headwaters of the Innoko was predominantly glacial in character. The group of mountains between Dishna River and Ganes Creek was occupied by snow and ice fields of considerable local extent. The former glaciers eroded this mountain group strongly and laid down extensive moraines of unassorted angular rock blocks and bowlders about the base of the group and out into the wide surrounding valleys on either side for considerable distances; while the large volumes of water from the melting snow and ice carried considerable quantities of cobbles, gravels, sands, and silts farther down the valleys and deposited them in an assorted arrangement.

The higher silt banks cut by the lower Innoko, some of which stand 25 to 30 feet above the normal stage of water, and upon which the present settlements, such as Dishkakat, are located to avoid the high floods in the spring, are considered to have been formed during the glacial period and therefore to be of Pleistocene age. No doubt a number of areas of similar old silt deposits are present in the wide expanse of flat country throughout the lower province of the Innoko Valley. Nearer the mountains deposits of Pleistocene age appear to be represented here and there by banks of gravel that stand from 20 to 30 feet above the present stream grades, and within the mountains the bench gravels on Ganes Creek are typical of deposits formed partly by Pleistocene drainage.

Along the portion of the Kuskokwim included in this report some high silt banks of the older class are cut by the river. About 20

miles above the Takotna there is a bluff of fine yellow silt 100 or 150 feet high. This material is blue where unoxidized and is horizontally stratified, with local feeble cross-bedding. The top of the bluff is a level plateau, and the face of the bluff trends away from the river nearly at right angles. This is the first high bluff below those on the upper Kuskokwim, many miles away. In the intervening country the silt banks are of the younger class and do not reach more than 20 feet above the river. From the Takotna to the Chulitna there are a few bluffs of the older class that range from 60 to 150 feet in height. About 10 miles below the Takotna such a bluff is cut, and this is one of the few places where the river has high banks on its left side.

From the Chulitna to the northern part of an important bend of the Kuskokwim, 40 miles below, no silts or similar deposits are found. About 12 or 15 miles below that bend, just above the sharp turn to the north, there is a local deposit of silt which rises in banks from 20 to 50 feet above the river. About 10 miles farther downstream, directly west of this locality and on the opposite side of the loop, where the river runs toward the south, are banks of clay and silt 40 to 80 feet high, for a distance of a mile. At two points between Kaltshak and Bethel the low banks of the younger unconsolidated deposits are interrupted by higher bluffs of sand, silt, and clay.

Besides these elevated fluviatile deposits of Pleistocene age along the immediate courses of the present rivers, there are in this region three minor elevated deposits of unconsolidated cobbles, gravels, and sands that present a somewhat peculiar appearance and seem to deserve separate mention. Two of these deposits, one in the Ruby Creek area and the other on the lower Innoko, were seen by the writer; the third, on the upper course of the Kluklaklatna, was described and some of the material shown to him by a reliable prospector. The material at all three localities is the same, practically all of it being quartz in the shape of well-rounded cobbles, gravels, sand, and pure light-colored siliceous clay. This clay has the appearance of being a later residual product of decay in place. There is a marked absence of any vegetable matter in these deposits. Their distinctive features are their moderately elevated positions without any particular relation to the present or any past river channels that can be recognized, and the uniform character of the material. These deposits may be remnants of cleanly washed bars of former swift streams, or of old beaches of late Tertiary or Pleistocene age. There appears to be fairly good evidence that considerable areas of the Yukon Valley and of the other large river valleys of Alaska were occupied by large lakes during late Tertiary or Pleistocene time, and it is surprising that more definite evidences of their shore lines, in the form of beach deposits, are not easily observed.

It is not difficult to conceive that the present or past rivers of this region have deposited bars made up entirely of quartz cobbles, gravels, and sands; and it is equally possible to understand how the wind-driven waters of lakes, by long-continued washing and the constant grinding of shore material upon itself, should wear away and remove all the softer portions, and leave only the harder quartz in the concentrated condition in which these deposits are now found. The writer is inclined to favor the theory of beach-wash rather than river-wash origin for these deposits.

It is interesting to note that colors of gold are reported to be found in this washed-quartz formation in the deposit called Skookum Bar, in the Ruby Creek district, and also at the locality where the formation occurs on Kluklaklatna River.

RECENT UNCONSOLIDATED DEPOSITS.

All the unconsolidated sediments that have not already been mentioned may be grouped in the younger class. The general character of the younger deposits that occur in the upper province of the Innoko Valley will be described under "Mineral resources," so only the recent alluvium of the lower Innoko and central Kuskokwim Valley will be mentioned here.

From the North Fork to the mouth of the Innoko recent alluvial deposits are the most widespread formation in the valley. They form the principal part of the low banks of the river and of the swampy flat lands that stretch away from these banks for miles. From the North Fork downstream to a point about 30 miles below Dishkakat the present bars of the Innoko consist largely of fine gravel and sand, but on the lower river they are all of fine silts and mud. This change in the texture of the alluvium is also noticeable in the banks of the river as it is descended.

The banks of the Innoko average about 10 feet in height from North Fork to Dishkakat, but from that place to Shageluk Slough the height gradually decreases. In places on the lower river the banks are only 3 or 4 feet above the water. Along the 50 miles of its course above Shageluk Slough there are some natural levees about 6 feet high that have been formed through the deposition of silt along the sides of the main river channel by the flood waters that spread far out on either side during the spring freshets.

The recent sediments are for the most part of a darker color than the older unconsolidated sediments, with which they are associated to some extent. This darker color appears to be due to the larger proportion of vegetable matter that is mixed with them. The vegetable matter in the silts is apparently derived in large part from the peat deposits which lie mostly on top of the recent alluvium, but which are also at many places interbedded with the silts. It

appears that the peat derived from the heavy growth of sphagnum mosses over all the swampy lands may be considered the most characteristic and widespread of recent deposits. Peat beds several feet in thickness, interbedded with silts, are exposed repeatedly along the low-cut banks of the Innoko. There are also some lenticular beds of ice exposed along the cut banks, and it is probable that considerable of this "flood-plain" ice is deposited throughout the Innoko flats.

As the general character and distribution of the recent alluvial deposits along the Kuskokwim have been described in connection with the geography of that valley (pp. 15–19), an account of them will not be given here.

MINERAL RESOURCES.

GENERAL STATEMENT.

The only minerals of commercial value known to occur in the Innoko-Kuskokwim region are gold, in placers and possibly in lodes, and a deposit of cinnabar of undetermined value on the Kuskokwim, about 6 miles below Kolmakof. Up to the present time the only production has been from the placers. The best gold lode so far discovered is being actively prospected, however, and its owners hope to prove it to be of commercial value.

KINDS OF PLACERS AND METHODS OF WORKING.

From the standpoint of the miner the placer-gold deposits of Alaska may be classed as shallow or deep. Each of these classes may be subdivided into those in a solidly frozen, partly frozen and thawed, or unfrozen state. The unfrozen deposits may be still further subdivided into those that are unfrozen throughout the year and those that are only superficially thawed during the summer. A permanently frozen condition is normal for most of these deposits throughout the northern half of Alaska.

No particular limit can be arbitrarily set to the depth of shallow placer ground. In a broad, general way such ground may be defined as that which can be most economically worked for its gold content by some kind of surface opening and the removal of all the unconsolidated deposits lying on the bed-rock floor. The methods of moving the unconsolidated material may be various—hand shoveling, ground sluicing, hydraulicking, horse or steam scraping, steam shoveling, derricking, and dredging, singly or in various combinations. Placer deposits 40 feet or less in depth may perhaps be called shallow, because this depth may be considered the average limit for dredging operations.

Deep placers may be considered to be those in which the valuable strata are so deeply buried under barren material that they can not be mined successfully by any kind of open surface works. The universal

method of mining deep placers is by shafts and drifts, with or without thawing and timbering. In Alaska such works have been extended to depths of 200 to 300 feet.

The Innoko-Kuskokwim region affords no exception to the conditions found elsewhere throughout the interior of Alaska. All the gold-bearing deposits now known there are comparatively shallow, being not more than 35 feet in depth. They occur in mixed and interbedded deposits of humus, muck, clay, sand, and gravel in the various characteristic conditions as to frost already named. On their depth and condition depend the methods of working that should be practiced. Most of the work that has been done in the region so far may be classed as that of merely prospecting the ground. This has included both the sinking of shafts to bed rock and the digging of open cuts, the methods usually employed in a new camp, by pick and shovel labor, aided by the use of a few small steam boilers for thawing frozen ground. The sinking and drifting method may be carried on throughout the year, provided the ground does not contain too much live water. Open-cut work is confined to the summer season.

WORKING SEASONS.

The climate of Alaska is such that it divides the year, both for transportation and for mining operations, into two working seasons—summer and winter. The summer season is the period of surface flowing water, and this directly governs cheap transportation (by water routes) and cheap mining (by hydraulic methods). During the winter season, from October to early May, practically all the streams are frozen over. So far as mining operations are concerned, the effects of the summer and winter seasons are not marked except where the gold-bearing gravels are of the class that can be worked only to the best advantage by open-cut or hydraulic methods. Many gold placers in Alaska can be mined throughout the year, but the local conditions vary in the different districts, and in some places may be so different on two adjacent creeks, or even at two localities on the same creek, that entirely different methods of working are used.

The average season during which hydraulicking operations may be conducted, provided there is a sufficient supply of water available for this method of working the gravels, extends from about the first of June to the middle of September. As a rule, sluicing may be commenced by the middle of May and continued two or three weeks later than hydraulicking, because it does not require so large a quantity of water.

PLACER-GOLD LOCALITIES.

At present gold is being mined in three widely separated localities and prospects of placer gold are reported to occur at other places in the Innoko-Kuskokwim country. From the little that is now known of the bed-rock geology of the region shown by the map, it does not appear improbable that the older metamorphosed sedimentary formations may be found to be gold-bearing in other areas and that the metamorphosed formations are more commonly exposed and of wider extent than has been thought. At present the best known of these gold-mining localities is in the upper Innoko Valley; the second in importance is on the headwaters of the Haiditarod, a large tributary of the lower Innoko; another is on the upper part of Tuluksak River, a tributary of the lower Kuskokwim that enters from the south about 60 miles above Bethel. Ruby Creek, on the south bank of the Yukon, at the northeast end of the Kaiyuh Mountains, is a locality of minor importance where gold is known to occur; and the Gold Hill district, on the north side of the Yukon, about 25 miles below the mouth of Tanana River, is being more thoroughly prospected. Little information about the Tuluksak is available except that during the summer of 1908 a few men mined several hundred ounces of gold there by very crude methods.

Reports from the Kuskokwim Valley for 1909 indicate that the region has been considerably prospected this season; it is estimated that there are 75 miners on the river and its tributaries. The Tuluksak has been the scene of a little placer mining on its upper course and on Bear Creek, which flows into it. Bed rock is found at a depth of 2 to 8 feet. The production will amount to about $6,000 or $8,000. Supplies are said to be scarce.

Little is known about the more recently discovered placer-gold area on the headwaters of the Haiditarod except that it is attracting a large number of men, possibly a thousand, who will prospect that district during the winter of 1909–10. No member of the Geological Survey has visited the Haiditarod, and the little information here presented is merely gleaned from current reports and has not been verified. The principal stream on which prospecting has been done is called Otter Creek and is said to be about 30 miles long. Where prospected the gravel deposits are about 12 feet deep and are frozen. The pay streak is said to be about 4 feet thick and 50 to 60 feet wide and to average from 7 to 10 cents to the pan. The gold is fairly fine, of a uniform size, and evenly distributed. In these characteristics it appears to differ from the gold mined on Ganes and Ophir creeks on the upper Innoko.

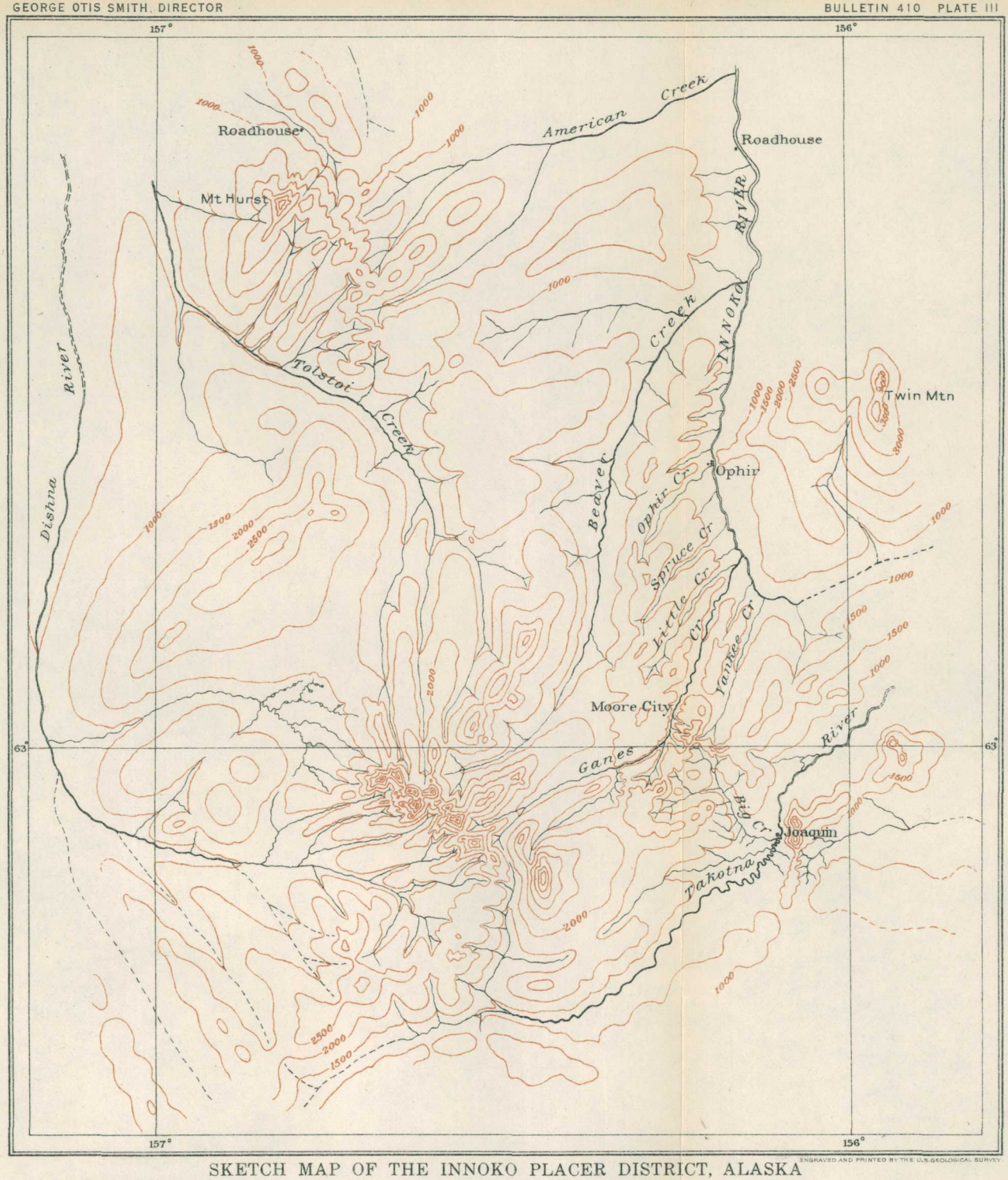
The Innoko, Ruby Creek, and Gold Hill placers were visited by the writer during 1908 and are described below.

DISTRIBUTION OF GOLD AND ITS BED-ROCK DERIVATION ON THE INNOKO.

The area of known economic importance lies near the headwaters of the Innoko, in a region of low mountains. (See map, Pl. III.) It extends from a point about 5 miles north of Ophir up the Innoko to the divide between Ganes Creek and Takotna River, and is about 20 miles long (north and south) by about 10 miles wide (east and west). It embraces that part of the slate formation which has been most intensely altered and in addition intruded to a moderate extent by siliceous dike rocks. Some of these siliceous dikes are altered and mineralized with pyrite. Secondary quartz deposited along the walls of one of these dikes is known to carry free gold. This locality is well up on the southeast side of the Ganes Creek Valley, at the head of Carter Gulch, near the divide on the trail that runs from Ganes Creek to the Takotna. The residual quartz found on the surface along the outcrop of the dike carries values in free gold. A shaft sunk for 30 feet on the dike did not reach below the zone of surface weathering and disintegration, and down to this depth the lode is not very well exposed. At the time of visit the lower 10 feet of this shaft was filled with ice, so that little could be seen. The association of free gold in quartz with this siliceous dike is a good indication of the probable original source of the placer gold of the district, for rough flaky particles of gold were obtained by panning some earthy residual material scooped out of crevices in the disintegrated bed rock along one of the exposures of a dike in this vicinity.

How far these slates extend to the northeast of the Innoko is not known. The writer did not visit that part of the valley, and few prospectors have been far in that direction. To the southwest the slates extend up Ganes Creek for about 10 miles, or throughout the lower half of its valley. The entire drainage basins of Little, Spruce, and Ophir creeks, which each average about 7 miles in length, are within the slate bed-rock formation. Similar slaty rocks intruded by similar siliceous dikes were observed in the upper part of the valley of Tolstoi Creek, about 15 miles northwest of the known productive area, on the southern flanks of the group of low mountains between Beaver Creek and Dishna River of which Mount Hurst is the highest. This locality, however, is not known to have received the attention of prospectors up to the present time, and it can only be suggested that its general appearance might warrant examination.

Paying quantities of placer gold have so far been found only on Ganes, Little, and Ophir creeks. This gold occurs in the present stream gravels and in bench gravels.



SKETCH MAP OF THE INNOKO PLACER DISTRICT, ALASKA

By A. G. Maddren

0 10 Miles

Contour interval 500 feet

1909

ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

TOPOGRAPHIC AND DRAINAGE CONDITIONS.

GENERAL OUTLINE.

The topographic conditions of the placer-gold area and its immediate vicinity are those of relatively even-topped mountain ridges, whose highest parts stand at an elevation of about 1,200 feet above the Innoko Valley floor. These ridges occupy all the major interstream areas and appear to express the former existence of an old land surface that had a much less pronounced relief than the surface of to-day. The present drainage system appears to be directly inherited from a former one in which the streams occupied the same relative horizontal positions as they now occupy. There has merely been a change in vertical position with reference to the ancient surface, brought about by a gradual downcutting into the older, more shallow valleys to a depth of at least several hundred feet, followed, during Quaternary time, by a much more rapid downcutting by Ganes Creek and Innoko River of at least 75 feet.

The first, longer, and more gradual downcutting period of erosion was largely preglacial in age. It is apparently indicated by the level tops of the major interstream ridges and divides and by the moderately sloping upper sides of the larger valleys where they descend from the divides. These slopes continue down on the secondary ridges and spurs between the minor gulches, to break off abruptly into the present valley troughs as bluffs of bed rock from 50 to 100 feet in height. Many of the present streams are now cutting along the bases of these bluffs.

The second period of stream erosion, in which the downcutting has been more rapid, has taken place since the glacial activity that has been already described (p. 58). It is expressed on Ganes Creek and Innoko River by canyons and rock-cut bluffs, and on the secondary streams by gulch topography. These secondary gulches are deeply eroded well back toward the major divides. During this period the erosion has been so rapid that on the larger streams considerable areas of the preglacial valley-floor filling of gravels have been left perched on the present valley sides as bench deposits. In places these bench gravels occupy positions 100 feet or more above the present streams, but on the gold-producing creeks the benches are on an average about 60 feet above the water level. About the mouths of Little, Spruce, and Ophir creeks, where they merge with the much wider valley of the main Innoko, there are also some elevated bench deposits. These are not creek benches, but benches of the Innoko Valley.

The three producing creeks now known fall into two classes as a result of the topographic development of the country they drain. Ganes Creek is a large stream with an extensive drainage area,

carries a good volume of water, and is in a class by itself when compared with the other streams of the district. Its topography is in strong contrast to that of the other two gold-producing creeks—Little and Ophir—for these are relatively small streams, whose valleys are small in area and whose water supply is scanty. Little, Spruce, and Ophir creeks do not show any canyon topography due to a large and sudden increase in their water supply with its attendant rapid downcutting. Their valleys are deeply eroded for their size and length, but are of the form that indicates a long period of more uniform erosion.

STREAM GRADES AND WATER SUPPLY.

The valleys of Little, Spruce, and Ophir creeks have an average cross section of the broad, open V form, and although the streams are not large and their grades are not steep, they appear to have had sufficient transporting power throughout their history to carry the detrital materials produced by their erosion out into the wide Innoko Valley without any marked clogging or accumulation of material within their own valleys. As a result, these valleys are comparatively clean.

On the other hand, the volume of water in Ganes Creek is large and the stream has cut the bottom of its valley down to a rather low grade, especially below the canyon. This condition of low stream grade on the gold-producing part of Ganes Creek appears to be shown by the wide, uniformly flat bed-rock cross section of the valley from the canyon to the mouth. The plan of this cross section is that of a wide, shallow rectangular trench cut down into an older, broadly V-shaped bed-rock valley. From the canyon down to the Innoko the present floor of Ganes Creek is covered throughout its width and length by alluvium, over which the stream meanders with a current of irregular velocity. At one place the stream is obstructed by a large beaver dam which causes a riffle, and there are other irregularities that accelerate the current for short distances and give it a velocity in some places of 4 or 5 miles an hour. In other places the stream runs more slowly, at a rate of only 2 miles an hour. Probably its average velocity is 3 miles an hour.

To sum up the situation so far as stream grades and water supply are concerned, it appears that on Ganes Creek there is ample water with enough head for hydraulicking if the supply is obtained at the upper end of the canyon and brought around to its lower end, but that the grade of the bed rock below the canyon, upon which lie the deposits that are supposed to carry paying quantities of gold, is not sufficient to afford a good dumping ground for hydraulic tailings, which would have to be elevated or disposed of by some other mechanical means that would add to the cost of operation. On Little and

Ophir creeks the valley grades are not quite so flat and appear to be sufficient to afford dumping ground for the tailings, but the water supply that may be obtained within these valleys themselves does not appear to be adequate for conducting hydraulicking operations on an efficient scale. There may also be doubt as to the presence of enough rich gravel within these valleys to justify bringing water for hydraulicking from a considerable distance. In 1908, which was a dry year, the amount of water in Little and Ophir creeks did not appear to be more than enough for sluicing purposes.

Of course, final statements on a subject of this kind can not be made without thoroughly prospecting the gravels by determining their quantity and average value, actually measuring the average water supply, and carefully investigating the whole problem from an engineer's standpoint.

PRODUCING PLACER STREAMS OF THE INNOKO.

GANES CREEK.

GENERAL DESCRIPTION.

Ganes Creek may be considered the head of Innoko River (see Pl. III), although it shares this distinction about equally with the unnamed headwater fork that is generally spoken of as the upper Innoko, which flows from the northeast and joins Ganes Creek to form the main river. The volumes of water in these streams are about equal. Each can be ascended 10 miles or more in light poling boats.

Ganes Creek, which is about 20 miles long, heads in a large, strongly glaciated basin that is surrounded by sharply irregular mountains 4,500 feet above sea level. It flows for about 3 miles in this mountain basin over and through a mass of large glacial bowlders composed of the hard igneous rocks that make up the mountains. A large percentage of these bowlders are varieties of porphyritic igneous rocks. Near the lower end of this cirque Ganes Creek is joined by a stream called Idaho Creek, of about the same size and character and flowing from a similar basin.

From the mountains Ganes Creek flows for about 5 miles in a northeasterly direction out across a wide basin that is now largely filled by morainal bowlders. Topographically this basin appears to have been a part of the head of Beaver Creek valley before glacial time. About 1 mile southeast of this part of Ganes Creek is another large stream parallel to it, called Last Chance Creek. This stream is of about the same length and volume as upper Ganes Creek, heads in the same mountains in a similar basin farther south, and flows across the basin in the same manner. Ganes and Last Chance creeks are separated by a ridge which appears to have been a medial moraine

during the period of maximum glaciation. This ridge, on its surface at least, is formed of morainal deposits, except near the middle of its length, where a large dome-shaped mass of cherty limestone bed rock outcrops. This dome is called Knob Hill. Last Chance and Ganes creeks join at the northeast side of the basin, at the head of the canyon that has already been described as occupying the middle course of Ganes Creek valley. Throughout the basin both of these creeks flow over deposits of morainal bowlders which, like those in the cirques, consist mostly of igneous rocks derived from the glaciated mountains. From a point near the source of Ganes Creek to the head of Ganes Canyon, a distance of about 8 miles, the descent of the stream is about 500 feet.

In its middle course Ganes Creek now runs for about 4 miles in a box canyon across a low range of mountains, made up of slate, which forms the divide between the Beaver and Innoko valleys. This canyon is not much wider than the present stream, which here flows on bed rock.

Below the canyon the stream has cut a wide, shallow trench of rectangular cross section with rock-cut bluff walls in the slate formation. This rock-cut trench is about one-eighth of a mile wide at the lower end of the canyon and broadens out to a width of about a mile at the point where the Ganes Valley joins the Innoko Valley, 8 miles below. The perpendicular rock-bluff sides of this trench rise nearly 100 feet above its rock floor at the mouth of the canyon, and these bluffs bound the valley for considerable distances at intervals below the canyon. The heights of the bluffs decrease gradually from the canyon downstream, their average height being probably about 60 feet. Their continuity as a rock wall is interrupted by the numerous short tributaries that come in through steep side gulches, most of which are cut down to the level of the main valley. The presence on the tops of these rock bluffs of remnants of the old stream-gravel filling of the former valley shows that the latest period of downcutting was rapid. It is evident that to produce this wide, trenchlike valley Ganes Creek has performed considerable lateral cutting, while the grade of the stream has remained at practically the same level. The rock floor is covered to a depth of 5 to 30 feet with stream deposits of fine to medium-sized gravels, which are made up chiefly of slate, with some clay and a few bowlders 1 to 2 feet in diameter. The larger cobbles and bowlders consist of igneous rock derived from dikes in the slates to some extent, but mostly from the morainal wash from the area above the canyon. Nearly everywhere the gravel deposits are covered by humus muck 10 to 20 feet thick, upon which is a thick growth of willows, alders, and other brush, with here and there a clump of spruce trees of fair size. Probably most of these valley-floor deposits are frozen, but the large percentage of porous gravel

beds and the good water supply cause a considerable amount of live water to be present. This tends to keep a considerable proportion of the material in an unfrozen condition, at least for part of the year. The deposits have not been prospected thoroughly enough to determine the distribution either of the ground frost or of the gold values.

STREAM DEPOSITS.

Locally the present stream deposits are loosely divided into "creek claims" and "creek-flat bench claims." The creek claims embrace the lowest ground; the creek-flat bench claims lie a few feet higher and are mostly situated along the bases of the low-rock bluffs. The creek-flat bench claims are essentially of the same character as the rest of the valley-floor detrital covering, but to some extent they may contain more of the detrital material that has sloughed down from the higher benches lying on top of the rock bluffs.

All the ground along Ganes Creek, from the morainal rock piles in the cirque at its source to the alluvial flats at its mouth, has been located as placer-mining ground. In the wider part of the valley, from the canyon to its mouth, the valley bottom on either side that is not embraced within the claims immediately along the creek is located as far back as the bluffs on the right and left. These side claims are the "creek-flat bench claims."

The numbers that designate these claims run from about 58 below Discovery claim, which is 7 miles above the stream's mouth, to about 83 above Discovery. The ground along all the tributaries of Ganes Creek has been located, on most of them for their entire length. From claim "No. 40 above," on Ganes Creek, which is just above the head of the canyon, to the head of the creek, the ground located embraces nothing but glacial deposits. These upper claims were located in the winter, when covered by snow, under the supposition that the placer gold on the lower part of the stream had been brought down from its headwaters.

No work has been performed above claim "No. 40 above," on which several holes have been started. These holes are in coarse morainal material and, as might be expected, have yielded no encouragement. From this claim down through the canyon to claim "No. 13 above" no work of any consequence has been done. It is reported that on claim "No. 37 above" the bench-rim gravel is about 10 feet thick and that it contains coarse gold. There is not much gravel at this place, however. From "No. 13 above" down to "No. 29 below" prospecting along the creek has been carried on in a desultory way at different places. During the summer of 1908 there were only a few men working in the Ganes Creek bottom, and they were engaged in prospecting and in doing assessment work. Prospects of gold are

reported at irregularly distributed localities from "No. 13 above," which is at the mouth of Spaulding Creek, a short distance below the lower end of the canyon, to "No. 2 below." Some open-cut pick and shovel work has been done on "No. 11 above," but no profitable returns are reported. On "No. 10 above," or on a fraction between Nos. 9 and 10, a shaft has been put down from which values are reported. During the winter of 1907–8 26 holes were sunk on the boundary line between "No. 20 below" and "No. 21 below," 16 holes on "No. 21 below," and 9 holes on "No. 29 below," all with no results. "Nos. 22 and 23 below" have also been prospected unsuccessfully. The holes sunk in the creek deposits are from 18 to 30 feet deep, and the alluvium is found to be made up of 15 to 22 feet of humus muck on top of 3 to 8 feet of gravel.

A little work was done on several of the tributaries of Ganes Creek during 1908. Glacier Gulch, which is 2 miles long and is staked from its mouth to its source, comes into Ganes Creek about half a mile above Moore City, on the east side of the valley. A little open-cut work has been done on the lower end of claim No. 1, at the mouth of the gulch. Here the deposit is coarse washed gravel about 4 feet deep, in which a little gold was found. Above, on claim No. 2, an open cut was started, and here the alluvium is much deeper than at the mouth of the gulch. This cut penetrated about 20 feet of muck and sandy clay with a little gravel, but did not reach bed rock.

Carter Gulch is the next tributary to Ganes Creek on the east side below Glacier Gulch. On this stream, just above its mouth, in August, 1908, one man was ground sluicing a trench down to bed rock with the aid of an automatic dam. The cut was put down to a depth of 23 feet, in ground composed mostly of tenacious clay, without exposing gravel, bed rock, or a pay streak.

On Last Chance Gulch, the next tributary below on the same side of Ganes Creek, another man was making an open-cut trench with the aid of an automatic dam similar to that used on Carter Gulch. This trench reached a depth of about 10 feet, mostly in tenacious clay, and a few colors of gold were found. Work was done on these three gulches because they were thought to be favorably situated for the presence of gold. The reason for this supposition is that these gulches all head on the divide southeast of the Ganes Valley, in an area of slates that have been intruded by mineralized dikes with which quartz carrying free gold is associated.

BENCH DEPOSITS.

The occurrence of bench deposits of stream-worn gravel upon the tops of the rock-cut bluffs of the Ganes Valley appears to show that before Ganes Creek acquired its large increase in length and drainage area as a result of the glaciation above its canyon it was a stream of the same character as Little, Spruce, and Ophir creeks are to-day.

The preglacial valley of Ganes Creek was then wholly within the slate belt, which extends to the head of its present canyon, and there was a divide across the site of this canyon that separated the drainage of the Ganes Valley from that of the basin above, now glaciated. Apparently the gravels now found in the benches are what is left of the preglacial alluvial deposits that occupied the Ganes Valley before the invasion of the glacial waters. When the waters that had accumulated above the canyon first burst across the divide and flowed rapidly down Ganes Creek, they no doubt rewashed most of the preglacial valley gravels now found on top of the bluffs, and thus introduced some bowlders and cobbles of the igneous rocks from the glaciated mountains. But this condition did not last long, for the enlarged stream of water that came down the valley soon cut a trench valley below the grade of the older deposits and with its rapidly lowering level carried the largest part of them downstream, so that they now make up a considerable portion of the present stream deposits. It does not appear that any large amount of the glacial wash was transported through the canyon from the basin above, and therefore most of the present valley filling is made up of detrital material that has originated within the slate belt.

The placer gold in the present valley gravels of Ganes Creek is no doubt derived from that which may have been contained in the gravels of its preglacial valley, but this gold is probably not concentrated to the degree it was in the older valley gravels, because the new stream, having a very much larger volume of water, has performed more erosion and transported a large amount of loose material out into the Innoko Valley. The power of the present Ganes Creek is shown by the deep canyon it has cut down through the slates and also by the fact that only very small remnants of the preglacial valley floor now exist. These remnants consist of disconnected strips along the valley that have an average height of about 60 feet above the present stream and extend back from the edges of the bluffs for a few hundred feet. They are cut in the slate, and this rock makes up the valley sides above them.

The alluvial deposits on top of these rock benches are essentially the same in composition as the present valley deposits. They extend along the right side of the valley from a point near Spaulding Creek, opposite claim "No. 13 above," down to about "No. 5 below" discovery. On the left side of the valley some bench ground is found on "No. 16 below" and again on "Nos. 19 and 20 below." Thus it is evident that the high bench ground is very meager in extent. However, the production of placer gold on Ganes Creek in commercial quantities is practically confined to several of these bench claims. The Pelky and Discovery bench claims have given the largest production. Under present conditions it is hard to work

these bench claims because of a scarcity of water. Barely enough water for sluicing can be obtained from the small streams that flow in the short gulches which have been cut down through the bench deposits at intervals. Two ditches were being dug in 1908 to bring water upon some of the bench claims, but neither had been used at the time of the writer's visit. One was to take water from Last Chance Gulch to the bench opposite "No. 6 above." The other was intended to bring water from Yankee Creek over a divide into Mica Gulch and upon bench claim "No. 3 above." The Pelky bench claim is on the east side of Ganes Creek opposite creek claim "No. 4 above." Here there is 6 feet of gravel covered by 10 feet of muck at a distance of 72 feet back from the edge of the bluffs. All of the muck and gravel is frozen. Three laymen worked this claim on a 40 per cent basis during the summer of 1908. They worked an area of 7 cuts 20 feet wide and 6 sluice-box lengths, from 60 to 80 feet back from the edge of the bluff; in all about 11,200 square feet of bed-rock surface was uncovered. The tailings were dumped over the bluff. The gold is coarse and not flattened and has considerable quartz attached to it. The largest nugget weighed 16 ounces 7 pennyweights and 8 grains. Discovery bench claim was worked during 1908 by four laymen on a 50 per cent basis, but the production was not as large as in 1907.

LITTLE, SPRUCE, AND OPHIR CREEKS.

Little Creek (see Pl. III) is a comparatively small stream about 7 miles long. It lies to the northwest of and in a general way parallel to lower Ganes Creek, into which it flows about one-half mile from the Innoko in the river valley flat. All of the alluvial ground in the valley of Little Creek, from its mouth to its source, was located for placer-mining purposes in 1907. The claims next above and below Discovery claim are located in the form of association groups of 160 acres each, and are the equivalents in area of eight ordinary single placer claims. Work was being carried on by means of shafts and drifts on the Fathergill association group, below Discovery, and about eight men were employed on open-cut pick-and-shovel operations at the lower end of the Gold Run association group, where it joins Discovery claim. In August there was hardly enough water in Little Creek for sluicing. Both of these association groups had a gold output during 1908. Several other camps of prospectors were located at intervals on this creek above the Gold Run association tract, and prospects are reported to have been found at several separated localities up as far as claim "No. 14 above."

Spruce Creek is the next stream northwest of Little Creek. It is of about the same character and length as Little and Ophir creeks, and all of its alluvial ground has been located. Little work has been

done within its basin, and it has not produced gold in commercial quantity.

To the northwest of Spruce Creek is Ophir Creek, which is about 7 miles long and empties into the Innoko about 5 miles below the mouth of Ganes Creek. Like every other stream in the region, Ophir Creek has been completely staked from its mouth to its source. There are two discovery claims on this creek, a lower and an upper. Eight claims are located below Lower Discovery claim, and they extend upstream to "No. 12 above Lower Discovery." "No. 12 above" is the same as Upper Discovery, and upstream from this claim the numbers begin again with 1 and extend up to No. 23 above Upper Discovery. Thus there are 43 claims staked along the course of Ophir Creek. Besides the creek claims there are also some side or low bench claims, but no work has been done on ground of this class. From claim "No. 8 below" up to "No. 2 above Lower Discovery, no substantial development had taken place in 1908, only the assessment work having been performed. From "No. 2 above Lower Discovery" up to "No. 3 above Upper Discovery," a length of 14 claims along the creek, more or less work has been done upon every claim. On "No. 4 above Lower Discovery" 5,000 buckets of dirt are said to have been raised. The largest production of gold, however, is reported from "Nos. 8 and 9 above Lower Discovery."

During 1909 mining operations have been extended into previously unprospected ground on this stream, and a good production of gold is reported.

Ophir, Spruce, and Little creeks are all of about the same length. They are parallel to one another and to Ganes Creek in a general way. Their valleys are of about the same depth and grade, and are separated by ridges of about the same width and height. The whole area drained by them is made up of the same slaty bed rock. They all flow into the Innoko from the southwest and have their sources on a low mountain ridge about 1,200 feet above the Innoko. This ridge extends in a north-south direction from the canyon of Ganes Creek to the lower course of Beaver Creek, a distance of about 10 miles, and lies between the upper Innoko Valley and the glaciated basin of Beaver Creek to the west.

The alluvial deposits in the valleys of Little and Ophir creeks are all of the same general character and are not very thick or wide. The depth to bed rock is from 15 to 24 feet, the lower 4 to 7 feet being gravel and the upper part silt and muck. The width of 600 feet that is embraced by an ordinary placer claim includes the larger part of the alluvial deposits along these creeks, although in many places so-called bench claims have been located to cover the more gently sloping portions of the valley sides. Practically no work was done on these side locations in the summer of 1908, and little is

known of their real character. All of the alluvial ground is covered by a heavy accumulation of moss. There is also a thick overgrowth of brush and considerable scrub spruce in the valleys.

The gold from Little and Ophir creeks is, like that from Ganes Creek, coarse and rounded, with a good many nuggets.

Yankee Creek is a stream similar in size and length to Ophir, situated southeast of Ganes Creek. During the winter of 1908–9 prospecting on Yankee Creek is reported to have given good encouragement, and it is thought that the gravels on this stream will pay to mine.

SUMMARY.

The creek deposits of the Innoko are all shallow and are composed of muck, clay, and gravel, which are for the most part frozen. The gravel and gold lie mostly on bed rock, and so far as experience indicates there are no well-defined pay streaks—that is, the distribution of the values is irregular both horizontally and vertically.

The opportunities for profitable drift mining on these creeks do not appear to be so favorable as the possibilities for a comprehensive scheme of hydraulic mining, by which all of the alluvial material may be worked in a systematic manner and all the values in the whole body of gold-bearing material may be recovered, regardless of its condition of distribution. Such a method of working means an entirely different community of interests from that which now exists, and probably there is at present little hope of bringing this about. To work these deposits with the greatest possible profit would involve the thorough prospecting of all the gold-bearing ground under expert supervision, the bringing of water from a considerable distance, and the consolidating of all property interests.

AMOUNT OF GROUND LOCATED IN THE INNOKO PRECINCT.

About 1,600 filings have been recorded in the official books of the Innoko precinct. About 1,200 of these cover placer-mining claims, which are located on nearly every water course within the Innoko Valley, many of them being on streams far removed from the known gold-bearing area. In other words, there has been a maximum of locating and a minimum of prospecting done by those who have visited the region. Of all the ground located only that on Ganes, Little, and Ophir creeks may be considered to have been prospected.

GOLD PRODUCTION OF THE INNOKO PLACERS.

On Ganes, Little, and Ophir creeks about 25 claims have produced placer gold. In 1908 the production of about four claims exceeded $10,000 each, but none of the claims had reached a production of $20,000.

In 1909, however, a better acquaintance with the local distribution of the deposits, especially on Ophir and Little creeks, has resulted in a much larger production of gold.

An estimate of the total production for the Innoko precinct for 1907–8, based on the most reliable information the writer has been able to obtain, gives a total of $85,200, of which the season of 1907 is credited with $13,100 and that of 1908 with $72,100. The production for 1909 is estimated to amount to about $200,000.

The placer gold thus far found in the Innoko country is very pure, its fineness being about 0.915. The average refined value is about $18.50 an ounce, and at Ophir the unrefined gold passes in commercial exchange at $17 an ounce.

SOURCE OF THE GOLD OF THE INNOKO PLACERS.

The chief source of the placer gold is probably in the belt of slates that have been strongly metamorphosed and intruded to some extent by siliceous dikes. The slates occupy the lower half of the Ganes Valley and all of the area drained by Little, Spruce, and Ophir creeks. It is thought that all the gold comes from points within the slate area. The writer saw dikes cutting the slates in the Ganes Valley and on Little Creek, and other dikes are reported to occur within the basins of Spruce and Ophir creeks. Some of these dikes are known to be mineralized with pyrite, and it is presumed that more of them may be so mineralized. Vein quartz is found along the walls of some of the dikes, and some of this quartz is known to carry free gold. Thus it appears from the evidence in hand that the placer gold now found in the stream gravels of Ganes, Little, and Ophir valleys has originated from the mineralizing activities brought about by the siliceous dikes that are known to cut the slates.

The placer gold appears to have been formed by slow concentration as a result of the long period of erosion to which this mineralized slate belt has been subjected by the streams that drain its area. The gold now found in the bench deposits of Ganes Creek was probably all formed before the canyon was cut across the former divide by glacial water, and the placer gold in the present stream gravels on Ganes Creek is undoubtedly derived from the former valley filling of which the benches are small remnants. Probably almost all of the placer gold in this district is of pre-Pleistocene age.

RUBY CREEK AREA.

GEOGRAPHIC SKETCH.

LOCATION.

The area known as the Ruby Creek district (see map, Pl. IV), from the name of the small stream on which gold was first discovered in it, is situated along the south bank of Yukon River, directly south of and

opposite the mouth of Melozitna River, about 175 miles below the town of Tanana or 110 miles above Nulato, the two nearest large settlements on the Yukon.

The district is within the St. Michael recording precinct, as it is now defined by the court for the second judicial division of Alaska. The nearest points where supplies may be obtained are at the village of Kokrines, 24 miles up the Yukon, and at Lewis's store, 23 miles down the Yukon. The United States military telegraph station called Melozi is on the north bank of the Yukon 8 miles below Ruby Creek. The region is easily reached throughout the year by way of Yukon River.

RELIEF.

For a distance of 10 miles along the south bank of the Yukon the Ruby Creek area presents rolling hills from 400 to 500 feet high that overlook the river with rock bluffs 200 to 300 feet high. These hills may be considered to form the northeast end of the Kaiyuh Mountains, which extend for about 175 miles toward the southwest to lower Innoko River. The Ruby Creek hill country is noteworthy as being the only place along the south side of Yukon River between Tanana River and Bering Sea, a distance of over 800 miles, where highlands of the older rocks and bluffs of consolidated bed rock form the immediate bank of the Yukon. The south bank of the Yukon throughout all the rest of this distance is made up of low bluffs of unconsolidated alluvial silt, which covers the older hard-rock formations for distances of 5 to 20 miles or more back from the river. Ten miles south from Ruby Creek the rolling hills near the Yukon gradually rise to low, dome-shaped mountains 1,200 to 1,500 feet in height, and these low mountains continue southward and southeastward to the Innoko Valley.

DRAINAGE.

The drainage of this area is of the kind that may be expected to characterize a low, rolling region. None of the streams carry much water and their grades are not steep. Nowitna River discharges into the Yukon from the south about 36 miles above Ruby Creek, after meandering across wide flats that extend southward from the Yukon for 20 miles or more. Along the valleys of the larger tributaries of the Nowitna broad strips of flat bottom land extend far back into the hills, and the Ruby Creek hills descend eastward to these flat lands of the lower part of the Nowitna Valley. A large western tributary of the Nowitna, called the Solatna, rises southeast of the northeast end of the Kaiyuh Range, which is formed by the low-domed mountains south of the Ruby Hills. The largest streams whose sources are in the Ruby Creek district flow toward the east into the Nowitna Flats. These streams, named in order from north to south, are Big, Inde-

ENGRAVED AND PRINTED BY THE U.S.GEOLOGICAL SURVEY

MAP OF THE RUBY CREEK DISTRICT, ALASKA

Based on surveys by Alaska Road Commission and traverses by A. G. Maddren

0 1 2 3 4 5 10 Miles

Contour interval 200 feet.

Datum is mean sea level.

1909

pendence, and Eureka creeks and the headwater tributaries of the Solatna—Wolf, Joe, New York, Beaver, and Dome creeks. There are also several large creeks that rise in the Ruby Hills and drain toward the west, across the wide flats that are occupied by sloughs, small lakes, and the meandering lower course of Yuko River, which discharges into the Yukon about 23 miles below Ruby Creek. Only two of these streams have been named—Ora and Main creeks; both empty into a slough that leaves the Yukon just below the bluffs along the main river.

Big and Ora creeks run east and west, respectively, 3 or 4 miles south of the Yukon and somewhat parallel to it. The divide that separates these creeks from the Yukon is the southern boundary of the strip of hilly country, from 2 to 3 miles wide and about 10 miles long, that extends along the south bank of the Yukon, with the bluffs already mentioned overlooking the river. The bluffs are separated by small valleys, at right angles to the Yukon, that are occupied by creeks from 1 to 3 miles in length. Named from east to west, these streams, which drain directly into Yukon River, are as follows: Flat, Center, Melozi, Ruby, Short, and Hannah creeks. They are all small streams with a very scanty supply of water. Thus the Ruby Creek hills and the low, dome-shaped mountains that rise to the southwest of them form a divide between waters that flow eastward into the Nowitna and westward to the Yuko Flats, and thence into Yukon River.

GEOLOGIC SKETCH.

The bed rock of the hills and low mountains of the Ruby Creek district comprises a variety of old, altered sedimentary rocks—crystalline limestones, garnet-mica schists, and mica-quartz schists with so fine a grain that they may well be called coarse slates. These rocks occur in the bluffs along the Yukon. The bluff exposures show local zones of shearing, with quartz stringers deposited along the fractures. Near Flat Creek the results of shearing in the schists are somewhat pronounced, and large quartz lenses and stringers occupy the openings thus produced. On the surface these quartz deposits are of the lens or bunch type, with no particular uniform trend or thickness for any considerable distance. Two principal exposures of quartz were seen, one about 100 yards below the mouth of Flat Creek that shows a maximum thickness of 4 or 5 feet on its face, and another about 100 feet downstream that is several feet in thickness but of no marked linear extent. Assays of samples of quartz from these exposures are said to have shown good values in gold. In 1906 a tunnel, now caved in, was run in on the largest of these quartz deposits, it is said, for a distance of 150 feet, with the object of following the quartz that shows on the surface of the bluff. After the work

had progressed for a short distance, it was found impracticable to follow the irregularities of the quartz stringers with a straight tunnel, and most of the tunnel was run through the slaty schist country rock, as is shown by the material on the dumps. In brief, the bodies of quartz were found to be too irregular and uncertain in extent to be mined by tunnels, and what has been demonstrated at this place will probably be found to be true of any other quartz deposits in this district.

Farther south from the Yukon quartzite schists, mica-quartz schists, cherty limestone, and cherts make up the low mountains. All these rocks have been considerably changed from their original form by metamorphism, but not to a degree that noticeably obliterates their sedimentary origin and arrangement. They are similar to and are presumably to be correlated with formations that occupy large areas of the mineral belt between Yukon and Tanana rivers, 200 miles to the east. There also appears to be no reason for doubting that these formations extend to the southwest throughout the length of the Kaiyuh Mountains and make up the largest part of their mass.

The rocks of the district have been intruded to some extent by dikes of igneous rock. These dikes are of diabasic and granitic types.

The alluvial deposits that fill the bottoms of the valleys are moderate in amount and thickness, and appear to be the gradual accumulations produced by a meager drainage such as now prevails. The rounded forms of the hills and mountains suggest that the present aspect of the country is the result of a long period of uniform erosion.

PLACER-GOLD PROSPECTS.

Late in the summer of 1907 a report was circulated that prospects of placer gold had been discovered on Ruby Creek. The discovery was made at the mouth of the creek in some fine gravel at the level of the spring high-water mark of the Yukon. As this locality is very accessible, especially from the settlements of Tanana, Rampart, and Fairbanks, a good many men went to Ruby Creek during the latter part of 1907 and, following the usual practice adopted when a new placer district first attracts attention, located practically all of the alluvial bottom lands along the streams of this district as placer-mining ground. These locations comprised both association placer groups containing 160 acres and single 20-acre tracts. Large areas of the valley slopes were also located as so-called "bench claims."

During the winter of 1907–8 about 30 men prospected for placer gold in the alluvial deposits of the creeks by sinking a number of shafts to bed rock, largely with the aid of three small steam boilers, and although colors of placer gold are reported to have been found

in the alluvial deposits of nearly all the streams that rise in the Ruby Creek district, no rich gold-bearing gravels have yet been found. By July, 1908, most of the men had left the district, and Discovery claim on Ruby Creek was the only property that was being actively worked.

Most of this winter work was done on Ruby and Big creeks, but a few holes were sunk on Boston Creek and two of its headwater tributaries, Logger and Boston gulches. Some prospecting was also done on the headwaters of the Solatna—Beaver and Dome creeks. One hole that did not reach bed rock was sunk on Melozi Gulch.

On Big Creek about 15 holes from 15 to 60 feet deep were dug to bed rock. The deeper holes are on the upper part of the creek. Farther downstream the unconsolidated deposits are not so thick. Washed gravel of schist rocks lies on bed rock in a layer from 1 to 7 feet thick and is overlain by sandy clay and muck. Bowlders of igneous rocks and quartz up to 1 foot in diameter are also present. It is reported that colors of gold were found in all the holes on Big Creek. A good deal of iron pyrite is included in the gravel, both as washed grains and inclosed or attached to the larger fragments of slaty bed-rock material.

The unconsolidated valley deposits on Ruby Creek probably average about 15 feet in depth. They are composed of muck, loamy sands, patchy layers of flat schist and slate pebbles, and a good many water-rounded bowlders of igneous rock. The bed rock is schist, slate, and limestone in the form of rectangular blocks and slabs.

The results that had been obtained by the close of the winter prospecting season do not appear to have been of sufficient promise to encourage the prosecution of summer work, except at the mouth of Ruby Creek. In July, 1908, two men were carrying an open-cut work on Discovery claim, the first from the Yukon. They were working about one-eighth of a mile back from the river on the east side of Ruby Creek in a bank of muck, silt, gravel, and bowlders. A small ditch had been built with an intake about 400 yards above to bring a sluice head of water to the open cut. The bed rock in this cut is a blocky, impure, banded crystalline limestone similar to that exposed on the Yukon in the "lime bluff" just below the mouth of Ruby Creek. It is in the shape of sharp-cornered rectangular blocks and brick-like slabs that have not been rounded by erosion. It is all in a shattered condition.

The material handled in working consists of this loose, blocky limestone, flat pieces of coarse mica slate similar to that seen above and below Ruby Creek on the Yukon, close-grained cobbles of diabase, and large heavy bowlders of medium-grained diorite similar to that seen in a large dike on the Yukon. These bowlders are from

12 to 18 inches in diameter and are well rounded. The large, heavy bowlders do not lie on bed rock, as might be expected, but for the most part several feet above it, in the muck. The finer wash is below the muck on bed rock and is made up mostly of flattish slate pebbles mixed with loamy sand. This sand also fills the spaces between the blocky limestone fragments of the bed rock. Mixed with the sand and in patchy layers within it and on top of the blocky limestone are finer waterworn gravels consisting of slate pebbles mostly flat. These layers of fine washed material do not appear to be continuous for any great extent, nor are they very thick. They carry most of the placer gold, which is in the form of fine, flakey, light particles not as large as bird shot. Owing to this fineness, it is hard to save all of the gold in the sluice boxes.

Up to July, 1908, about $1,000 worth of this fine gold had been produced from the open cut on Discovery claim on Ruby Creek.

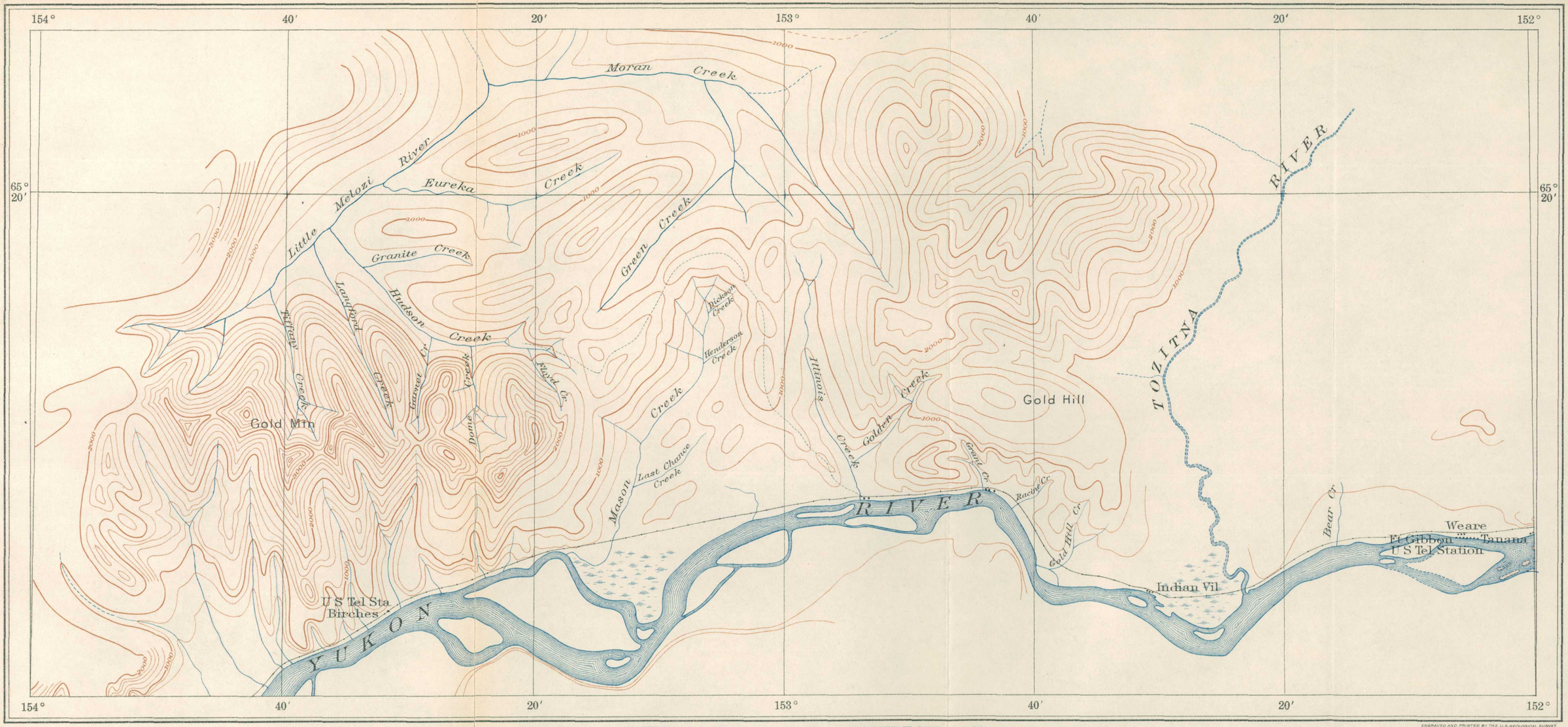
PLACERS OF THE GOLD HILL DISTRICT.

INTRODUCTION.

In 1907 deposits of placer gold were found on several small streams that flow into the Yukon from the north about 25 miles below the town of Tanana. Further prospecting showed that placer gold occurs also in streams that lie across the divide and flow northward into the upper course of Melozitna River. This district may be easily reached by way of Yukon River, and as soon as the news spread that placer gold had been found on these creeks, all of the alluvial ground on them was located for placer-mining purposes. Most of the locations were made by association groups, covering 160 acres each, a plan which enables a few persons present on the ground, provided with the powers of attorney of a number of absent persons, to tie up completely many thousands of acres of alluvial gold-bearing deposits. As the healthy growth of the placer-mining industry depends largely on individual effort, there has not been as much prospecting in the Gold Hill district as its accessible situation and other favorable conditions appear to warrant. About 25 men spent the winter of 1907–8 in this locality prospecting on the various creeks. The writer made a hasty examination of the district from June 25 to July 4, 1908.

GEOGRAPHIC SKETCH.

The name Gold Hill district (see Pl. V) is loosely applied to an area in the central Yukon Valley, about 25 miles below the mouth of Tanana River, that lies along the north side of the Yukon and extends westward from the western slopes of the valley of Tozitna River to the higher mountains north of the United States military telegraph station called Birches. The Yukon forms the southern boundary of



Based on surveys by
Alaska Road Commission

MAP OF THE GOLD HILL DISTRICT, ALASKA

Scale $\frac{1}{250000}$

5 0 5 10 15 Miles

Contour interval 200 feet.

Datum is mean sea level assuming an elevation of 810 feet at Eagle.

1909

ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

this district, and its northern boundary is defined in a general way by the headwater drainage of Melozitna River. Roughly, the district embraces an area extending 30 miles east and west and 20 miles north and south, covering about 600 square miles. Most of this area consists of mountains that form a divide extending east and west about midway between the main courses of the Yukon and the headwaters of the Melozitna.

This divide separates the region into two areas that are drained to the north and south by creeks of moderate length and volume. The principal southward-flowing streams on which placer locations have been made, named from east to west as they join the Yukon, are Grant, Illinois, and Mason creeks and their tributaries; those flowing northward into the Melozitna, named in the same order, are Moran, Eureka, Hudson, Langford, and Tiffany creeks and their tributaries. All these streams are of moderate length and volume. The topography is one of comparatively low, rolling mountains with wide, moderately sloping valleys that appear to be the result of a long period of rather uniform downcutting and wearing away of the country rock by a drainage system similar to that of the present day. With the exception of the silts along the immediate banks of the Yukon, there are no detrital deposits that occupy elevated positions with reference to the present drainage in the sense in which this distinction is usually made; that is, all the alluvial deposits of the streams now lie in the bottoms of the valleys and may be properly classed as stream deposits or creek gravels, none of them being sufficiently above the present stream grades to place them in the class usually called bench gravels.

The mountains of the district have an average altitude of about 3,000 feet above sea level. For the most part they form wide undulating ridges, but a few of the mountains rise to heights of 4,000 feet and have more rugged forms. Yukon River cuts into the southern slopes of these mountains and exposes bed-rock bluffs where the ridges between the creeks come down to the main river. The tributary valley spaces between the ridges show low banks of recent alluvium about 10 feet high and also a few benches of the older silt deposits that stand in places from 20 to 50 feet above the river level.

The Yukon has an elevation of about 300 feet above the sea at Gold Hill. Owing to this low level the tributary valleys along the south side of these mountains have been eroded more deeply than those on the north side, and they all have considerable grades, especially in their upper portions. These valleys are in the form of wide basins extending from 5 to 10 miles back into the mountains and opening out into the Yukon Valley with widths of one-half mile to 3 miles.

The valleys on the north side of the mountains lie from 600 to 1,000 feet above the level of the Yukon, and for this reason the headwater streams corresponding in length to those flowing into the Yukon have lower grades and their valleys have not been eroded so deeply into the country rock as those on the south side of the divide.

GEOLOGIC SKETCH.

The low, rolling mountains of the Gold Hill district appear to be made up entirely of a typical development of an assemblage of metamorphic rocks that have been given the general name "Birch Creek schist." The name was first used by Spurr for the bed-rock formations in the Birch Creek gold-placer district, and he considered the rocks of Gold Hill to belong to the same group because of their similarity. These schist rocks made up a general group of formations that have been recognized as a characteristic part of the bed rock in all the better-known placer-mining districts of the Yukon Valley. In the Gold Hill area the predominating rocks are quartzite schists and micaceous quartz schists. More or less vein quartz occurs in the schists, mostly in the form of small and nonpersistent stringers and lens-shaped bodies. Many of these quartz fillings appear to have been shredded and faulted by movements in the rocks that have occurred since most of the quartz was deposited, so that they can not be traced very far. Much of the quartz is recemented by iron mineral matter, and some of it is known to carry gold.

ECONOMIC DEVELOPMENTS.

Probably the first attempt to open a lode mine in the interior of Alaska was made about 1890 at the locality since known as "Gold Hill." The prospect on which work was done is situated on the river slope of a ridge that comes down to the north bank of the Yukon 20 miles below Tanana. A tunnel 110 feet long was run in on a vein of sheared and broken rusty quartz that outcrops on the surface with a width of 2 or 3 feet. The tunnel is now abandoned and caved. It is said that the vein became more and more broken away from the surface and that at the breast only a few streaks of it remained in a decomposed schist, between talcose schist walls, in a country rock of micaceous quartz schist. The quartz taken from this tunnel is known to be gold bearing, but the prospect has not been developed into a mine. This occurrence of gold-bearing quartz is similar to that seen in the Ruby Creek district.

Placer gold is reported to occur in the creek gravels of all the streams that have been named, but, although many thousands of acres of ground have been located, only a very small amount of

prospecting work has been done, because there have not been many men in the district.

About 20 holes were dug in the stream deposits during the winter of 1907–8. All of this work was done with the aid of wood fires for thawing the frozen ground, as there were no steam prospecting plants in the district. Some of these holes reached bed rock and showed prospects of gold; others tapped live water in thawed ground and did not reach bed rock.

Open-cut ground-sluicing operations have been begun at several localities in the Gold Hill district, but owing to the scarcity of water, due to the unusual dryness of the summer of 1908, very little gold was then produced. It is reported that $700 was taken out in 1908 on Mason Creek near the mouth of Last Chance. Work has been continued during 1909 on several of the streams, but especially on Grant Creek, where 12 outfits are reported to have worked and found pay ground the dimensions of which are yet to be determined, though it is said that the gravels are 5 to 7 feet deep and contain values for a width of more than 100 feet. Sluicing operations were continued on Mason Creek also, and a yield of $27 to the shovel is reported for some of the work.

It is expected that both Mason and Grant creeks will be productive during the winter season of 1909–10. This district, however, may be considered to be still in the prospecting stage of development.

The Grant Creek gold is made up of small nuggets and medium-fine gold. One $17 nugget has been found. Some gold found near the head of Mason Creek is mostly in the form of small rounded pellets about the size of bird shot. The Mason and Grant Creek gold has a value of $18.60 an ounce.

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