THE KOYUKUK-CHANDALAR GOLD REGION.

By A. G. MADDREN.

INTRODUCTION.

LOCATION AND EXTENT.

The placer-gold districts of the Koyukuk and Chandalar valleys are situated toward the heads of those valleys, between 67° and 68° north latitude and 147° and 152° west longitude, from 50 to 75 miles north of the Arctic Circle. They lie well within the southern ranges of the mountain system that forms the Yukon-Arctic divide across northern Alaska, and are noteworthy as constituting one of the most northerly gold-mining regions in the world. (See Pl. VII.)

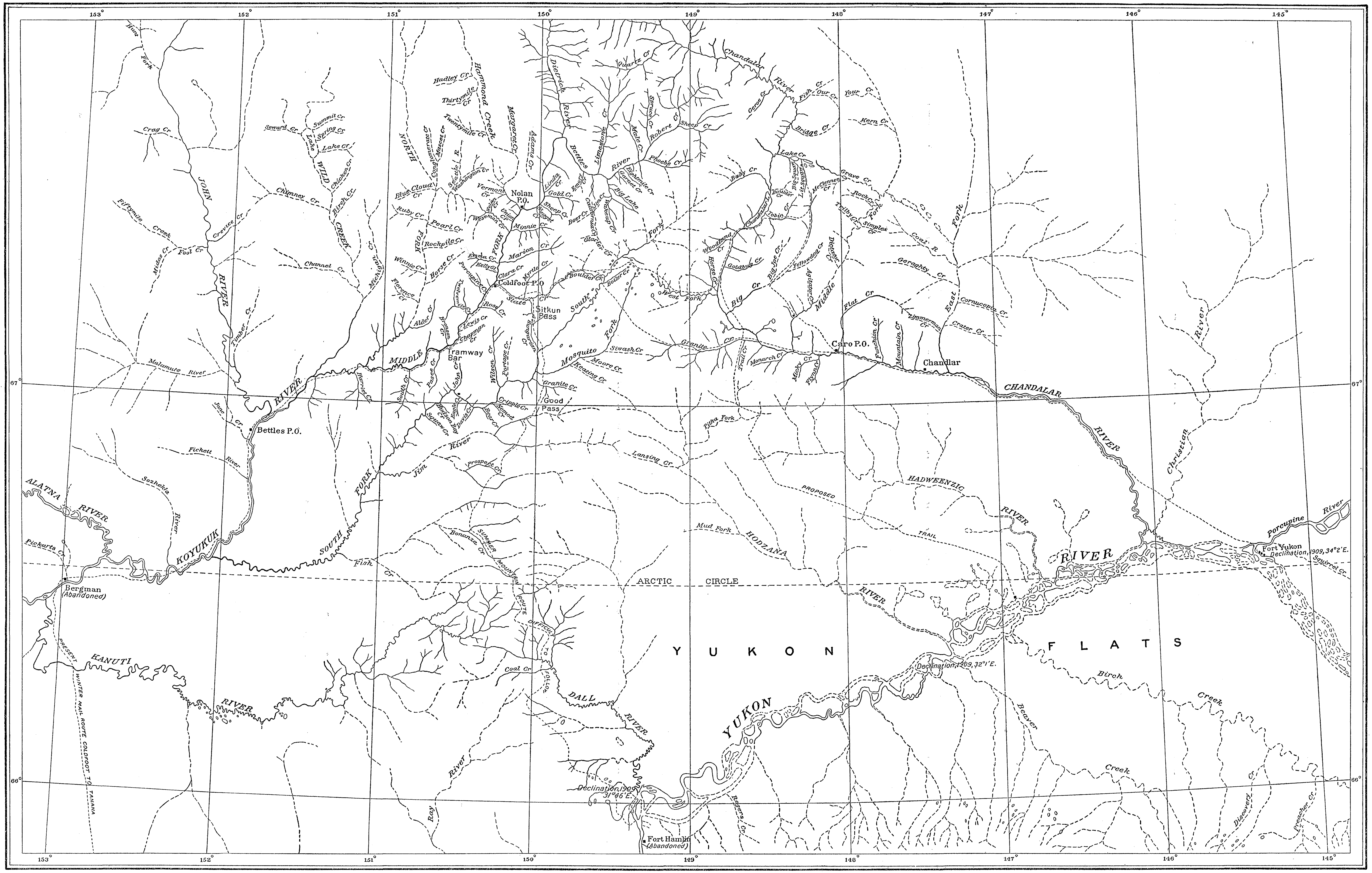
The same formations occur in both valleys in the sections where gold has been found. The kinds of rocks and their relations are similar in a general way throughout the region. Schrader [a] noted this general geologic similarity in a report on an expedition he made through this region in 1899.

The writer visited this region during the summer of 1909. He spent a month in gathering information about the occurrence, distribution, and general development of the gold placers of the Koyukuk district, and in the first week of September made a hasty examination of the Chandalar district.

RELIEF AND DRAINAGE.

The general features of relief are similar in every way throughout both these districts. The surface of the region is predominantly one of bold mountainous character, whose principal features are rugged ranges, with general structural trends from northeast to southwest, and deep but comparatively narrow, steep-sided valleys cut through the mountains by the larger rivers from north to south. The bottoms of the larger valleys are from 1,500 to 2,000 feet above sea level and from one-fourth mile to 1 or 2 miles in width. The mountains rise boldly and in many places abruptly from the valley bottoms to rugged heights from 2,000 to 5,000 feet above the valleys, or from 3,000 to 6,000 feet above sea level; indeed, along the major divides some peaks rise to elevations of nearly 7,000 feet.

[a] Schrader, F. C., Preliminary report on a reconnaissance along Chandalar and Koyukuk rivers: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 441-486.



Scale $\frac{1}{750,000}$

10 0 10 20 30 40 50 Miles

MAP OF KOYUKUK-CHANDALAR REGION.

The most marked features of the drainage are a north-south system of narrow, parallel major valleys deeply incised into the mountainous land mass and an immaturely developed lateral drainage on the flanks of the mountain divides that separate the larger rivers. The downcutting along the larger valleys has been so rapid during the comparatively recent geologic history of this region that most of the drainage of secondary magnitude lateral to the rivers has not been able to extend the areas of the tributary valleys or wear them down to the lower level of the principal valleys, the result being that most of the creeks on which placer mining is done are rather swift in flow and consequently have steep gulch valleys and in many places box canyons along their courses, especially in their lower parts, just before they join the larger valleys. Much of the placer gold mined has been taken from the comparatively narrow and shallow gravel deposits along the bottoms of these gulch-shaped tributary valleys.

The general attitude of the Koyukuk-Chandalar drainage system and the forms of the mountains appear to show that before the region was eroded into its present form it presented a very different kind of relief from that of to-day. Remnants of an older land surface of much more gentle character, with wide valleys and low ridges gently sloping up to moderate mountains, are indicated, but these older features have been largely obliterated by a profound regional glacial erosion that extended over a large part of the Endicott Mountains and deeply impressed an entirely new relief upon the region. A comprehensive description of these changes of land form can not be given at this time because most of the region is still unexplored. However, the development of the drainage system that has formed the dominant features of the present relief throughout the Koyukuk-Chandalar region and the widespread deposits the streams of this system have laid down are so intimately associated with some of the gold placers that it seems necessary to give an introductory description of their principal characteristics in order to explain the relations of some of the placer deposits.

The main valleys appear to owe their present size and forms chiefly to the former presence of large, long glaciers that had their sources on the Arctic divide to the north and extended at least to the southern flanks of the Endicott Mountains. The large ice streams appear to have deepened the main valleys somewhat and steepened their side slopes considerably to the forms they have to-day, characterized by flat bottoms and abruptly rising sides, which are especially pronounced where formed by the truncated ends of the intertributary mountain spurs that are lateral to the main divides. In places these steeply truncated sides of the main valleys extend across the mouths of the tributary valleys, thus making them of the hanging-valley type.

In most such places the streams in the discordant side valleys have partly cut their immediate channels down below the old floor levels of the hanging valleys and now enter the main valleys through gorges or canyons. Other side valleys, however, enter the main valleys by wide mouths at accordant levels.

When the large glaciers disappeared by melting, they left behind considerable quantities of unconsolidated material in the form of bowlders, cobbles, gravels, and silts, which now largely cover the floors of the valleys throughout their length and width. Very little of this material is now found in the form of unassorted drift. Most of it belongs to the class of glacial deposits that have been subjected to the vigorous wearing and assorting action of swiftly running water after the glaciers retreated. Along the flat lower parts of the valleys these deposits have been well graded and now occur in the form of partly sorted cobble beds, regularly arranged gravels, coarse cross-bedded sands, and fine silts and clays. They occur not only along the floors of the large valleys, but also as terraces along their sides and back into the tributary valleys that open out from the mountains. In the middle part of the Tobin Creek valley and on lower Big Creek there are thick deposits of silt and clay which appear to have been deposited in small lakes that were formed along the borders of the glaciers in the lower parts of these side valleys at a time when the main valley glaciers dammed up their mouths with high barriers of ice. Most of the silts and clays of the dammed valley deposits appear to have been derived from muddy glacial waters, but no doubt some of the silts may have come from the upper parts of the side valleys above the areas formerly occupied by the lakes, and also from the slopes that were above the levels of the lakes along their sides. Wiseman Creek, on the Koyukuk, occupies one of the best examples of these glacier-dammed and silt-filled valleys, where the silts and clays have buried older gold-bearing stream gravels and where the later drainage has not been able to remove the glacial silt and clay filling. Tobin Creek is an example of a filled valley where the present drainage has been vigorous enough to remove a large part of the clays and is now rapidly carrying away what remains. This is shown by the turbid silt-laden water of this stream from the "mud banks" to its mouth. The lake that formerly occupied the basin of Wiseman Valley was apparently drained by several comparatively sudden drops to lower levels, with longer periods of rest between the different drops. During the stationary periods bench deposits, or narrow beaches, were formed on the valley slopes at the positions of the different shore lines of the lake and the gold now found in these benches along the valley sides was no doubt concentrated in them at the mouths of gulches. The gold appears to have come from the bed rock of the mountain slopes above the lakes, and no doubt much of the gold now

found in the benches at the lower levels is from similar benches at higher levels where gold was concentrated previously.

On Tobin and Big creeks, in the Chandalar Valley, the old shore lines of the former lakes have not been traced or prospected and it is not known whether they occur at more than one level. On Wiseman Creek, in the Koyukuk Valley, the former glacial-lake shore lines are known to lie at several different levels. These have been prospected to a slight extent and the two lowest have been mined at several places along the east side of Nolan Creek. Placer gold is reported to occur on Tobin Creek, both below and above the locality where the stream is now washing away the clay deposits of the former glacial lake that occupied the lower half of its basin, but paying quantities have not yet been developed.

The foregoing examples show that the erosion and deposition accomplished during the period of glacial drainage that preceded the development of the present drainage system have exerted considerable influence on the distribution and character of the placer-gold deposits in the localities that have been mentioned. At other places, however, glacial drainage does not appear to have caused much change and the processes of erosion and concentration of the gold appear to be such as are normal to any mountain region. The influence of glacial drainage appears to be largely or wholly absent in the part of the Chandalar district where the most mining development has been carried on, and also on some of the streams in the Koyukuk district, such as the upper parts of Myrtle, Vermont, and Gold creeks.

CLIMATE AND VEGETATION.

The winters in this region are long and severe, the temperature being below zero much of the time, and occasionally getting as low as 70° below zero.

The short summers, because of the long days, are generally warm enough to allow hardy vegetables to be grown to a good state of maturity in properly prepared gardens in the bottoms of the larger valleys, but killing frosts may occasionally occur in midsummer, even in the most favorable situations.

Spruce is the only tree that grows here to a sufficient size for cabin logs, and this tree of suitable size for sluice-box lumber is found only in scattered localities in the larger valleys. Up the mountain slopes it becomes more scrubby and does not extend beyond an elevation of 3,000 feet above sea level.

At present the principal supply of water in this region is derived from snow, but a moderate rainfall during the summer also adds a variable and uncertain amount to the total stream flow. The snowfall over this region is not great in average amount, and it is only the great length of the winter season, from October to April, that enables an

average depth of 3 to 4 feet of it to accumulate. Most of the snow melts and passes away during May, and then the streams are at their maximum flood stage. The larger streams continue to flow strongly during most of June, after which there is a subsidence with spasmodic increases until colder weather in September changes the precipitation into snow, freezes the higher mountain slopes, and lessens the flow. Early in October the rivers become frozen over and although there is still some flow of water in all the larger valleys, as is made manifest by frequent outbursts from under the ice, these rarely do more than form temporary local accumulations of ice, which disappear the following May. Sometimes, however, these overflows of water from beneath the ice continue throughout the winter and form considerable masses of flood-plain ice, called "glaciers" by the miners, which are not entirely removed during the following short summer, and become somewhat permanent features.

The rugged topography of this region presents many high, cold sheltered slopes and mountain-surrounded basins in which a considerable part of the snowfall does not melt rapidly, so there is generally a reserve flow of water in all the larger streams throughout the summer; but on the smaller creeks water sometimes becomes too scanty for the effective handling of the gold-bearing gravels, and the miners look forward to the uncertain rainfalls, especially during August.

POPULATION AND SETTLEMENTS.

The population of the Koyukuk region during the eleven years in which it has been occupied by whites has not been large. In the Klondike rush 1,000 or more inexperienced gold seekers entered the Koyukuk Valley in the fall of 1898, but nearly all of them departed during the early summer of 1899 and only about 100 of the more hardy ones remained. Although a revival of interest was caused in 1900 by the discovery of gold on Myrtle Creek and the reports of rich finds on Hammond Creek, and the population again reached 1,000 or more, by 1901–2 it had dwindled to about 200. About 350 are reported to have been there in 1903–4, and since then the average population of the district has been about 200 persons.

Since mining was established in 1900 the principal settlement in the Koyukuk region has been the town of Coldfoot, located on Koyukuk River, about 586 miles from the Yukon, at the mouth of Slate Creek. Here the postal and recording offices are established; but within the last two years a new settlement has been formed about 16 miles farther up the Koyukuk at the mouth of Wiseman Creek, and this place is now the largest town in the district.

A small group of cabins on the north bank of Chandalar River near the mouth of Flat Creek is named Caro. This place is about 110 miles from Fort Yukon and 35 miles from the placer diggings about

the head of Big Creek. During 1907–8 it had a small population of whites and the postal and recording offices for the district were located there. At present only a few natives live there, and the mining population of the district consists of some twenty white men who reside near their claims about the head of Big Creek.

TRANSPORTATION AND TRAILS.

There is only one natural highway for approaching this part of Alaska—that by way of Koyukuk River. From the middle of June until early in September the main Koyukuk may be ascended by medium-sized stern-wheel steamboats having a draft of about 2 feet. By this means all the supplies for the region are now transported up the river to the vicinity of a warehouse station named Bettles, a few miles below the mouth of John River and about 60 miles below Coldfoot. During some seasons of low water it has been found impracticable to reach Bettles, and at certain periods of high water it is possible for steamboats to ascend a short distance above that place. The general practice is to take all supplies from Bettles, or near by, upstream to Coldfoot or the mouth of Wiseman Creek during the summer by shallow-draft scows that carry from 8 to 12 tons, towed by horses, or by poling boats that carry about 1 ton, propelled by men. Both of these methods are tedious and expensive. From June 15 to September 15 may be considered the boating season on the Koyukuk.

The freight charges during the last three years have been from Seattle or San Francisco to Bettles by ocean and river steamboats, 4 to 6 cents a pound; from Bettles to the mouth of Wiseman Creek by horse-towed scows, 6 to 8 cents a pound. Thus it costs from 10 to 14 cents a pound, or from $200 to $280 a ton, for freight charges alone from Seattle or San Francisco to the mouth of Wiseman Creek.

Winter sledding of freight from Coldfoot to Nolan Creek is done for 4 cents a pound and horse packing in summer from the mouth of Wiseman Creek to Nolan Creek for 6 cents a pound.

To reach this district during the winter or closed season it is necessary to travel with dog-drawn sleds. A monthly winter mail service of this kind is maintained and a few persons occasionally travel in this manner.

COSTS AND WAGES.

It is impossible to give a detailed analysis of the commercial mining status of the Koyukuk district, because direct evidence in the form of actual figures from books is not available, but from general information the principal features may be outlined.

All the goods consumed by the population of this district, with the exception of a very small amount of game and fish procured locally,

are brought from the United States, and the freight charges alone, for delivery at the mining localities, cost the consumer from 10 to 20 cents a pound.

Prices in 1909 were considerably below the average for the last ten years, as a result of recent competition in the commercial enterprise of the district. Likewise, the present scale of wages is considerably less than it has been during the past, and no doubt, if accurate figures could be obtained, they would show that the high retail prices of goods have directly controlled the scale of wages. The amount of supplies available has had considerable influence on prices. On a number of occasions during the last ten years a shortage of some articles has occurred, in spite of the high prices asked, and 1909 is the first year in the history of the district in which there has been a satisfactory amount of provisions in stock at the mining settlements at the close of summer transportation on Koyukuk River.

Very few miners in this district keep good records of operation costs and it is difficult to obtain accurate statements of the yield of gold, so both have to be approximately estimated in order to make comparisons.

The annual cost of proper food and clothing for the average prospector or miner is about $1,000. Ordinary manual labor at present is paid from $4 to $6 a day, with food. The cost of food per man varies from $3 to $5 a day, according to the cost of transporting provisions from the settlements to the places where mining is being done. Before underground mining was developed on Nolan Creek, four years ago, there was little demand for day labor, and when men were employed for a period of time the usual wage was $1 an hour, without board; but a large part of the mining, especially the shallow shoveling kind, and considerable of the deep mining, is done by groups of men who enter into partnerships and work on shares.

Under present commercial conditions only the richest placers of this district yield returns that are considered an adequate reward. A few of the most profitable operations are stated to have been conducted with a profit of 70 per cent of the gross yield of gold, or at a cost of 30 per cent of the production. These results, however, have been obtained only in a few localities of the richest deep ground on Nolan Creek and in the most easily worked shallow unfrozen ground, notably on Mascot Creek. Most of such opportunities have been short lived, and a large part of the mining has been done with a relatively low percentage of profit, so low in many instances as to furnish no more than a bare living under the harsh conditions of climate and isolation that characterize this region, where only the optimism that is the predominant characteristic of the gold-seeker's temperament serves to stimulate many of these men to continued effort from year to year.

GENERAL PROGRESS OF MINING.

Since placer gold was found in 1899 on Myrtle Creek, a tributary of Slate Creek, successive discoveries have been made on other tributaries of the Koyukuk, with the general result that the yearly production has steadily increased during the last ten years (see p. 292), the newer finds more than compensating for the decreasing yield of the older placers.

The production of placer gold in the Koyukuk, though not so large in amount as that of the Nome and Fairbanks districts, has been noteworthy when its difficulty of access and small population are considered, and has probably averaged higher per capita than that of any other district in Alaska. Since the discovery of the district its development has been practically accomplished with only its inherent mineral resources to aid mining enterprise, there having been, with one exception, no exploitation by capital from without the district. In other words, the Koyukuk stands as an entirely self-supporting mining community.

PRODUCTION.

Schrader [a] has published a table of production of gold for the Koyukuk district for the period from 1900 to 1903, based on the most reliable information he could obtain. The writer has endeavored to extend this table to the close of 1909 (p. 292). Schrader's table gives a total of $667,500. To this he added $40,000 as the approximate output of sundry smaller diggings not given in the list for 1901; $6,000 as the output in 1899, derived mostly from Myrtle and Slate creeks and various places on South Fork; and $3,000 to $4,000 from Tramway Bar bench and river bars in previous years, all of which gave an aggregate yield for the district to that date of about $717,000. The revised and enlarged table presented here gives an approximate total production of $2,200,600 for the ten years 1900–1909. Up to 1909 the output of the year 1903 appears to have been the largest. This is easily accounted for by the facts that the shallow diggings were then at their best and that the very easily mined gravels on Mascot Creek yielded about $100,000 during that summer. After 1903 there were several years of gradual decline in production, which appears to have reached its lowest point in 1906. The low yield for that year is partly explained by the rush to the new Chandalar placer district, about 75 miles east of Coldfoot, in August of that year, which took a number of men from productive work in the Koyukuk a month before the summer mining season had closed. From 1906 to the present time there has been an increase of produc-

[a] Schrader, F. C., Reconnaissance in northern Alaska: Prof. Paper U. S. Geol. Survey No. 20, 1904, p. 102.

tion each year which has been derived largely from the deep placers on Nolan Creek. There is some uncertainty in assigning the figures of production since 1906 to separate calendar years, because the underground mining operations extend from one year into the next and the figures given for a particular claim cover parts of two years. In the table the production of Nolan Creek for 1908 and 1909, which has been the largest factor during these two years, has been arbitrarily divided; but it is thought that if the statements obtained as to the yield are reliable the totals are good approximate estimates, and that the table as a whole is as fair a summary as it is possible to present from the information at hand.

Estimated production of placer gold in the Koyukuk district from 1900 to 1909, by localities and years.

Localities.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.	1909.	Total.
Middle Fork:											
Tramway Bar	$5,000	.....	.....	.....	.....	.....	.....	.....	$300	.....	$8,000
Twelvemile Creek	1,000	$1,500	.....	.....	.....	.....	.....	.....	.....	.....	5,000
Porcupine Creek	500	1,000	.....	.....	.....	.....	.....	.....	.....	.....	2,000
Slate Creek	1,000	.....	.....	.....	.....	.....	.....	.....	.....	.....	3,000
Myrtle Creek	40,000	7,000	$50,000	$30,000	$15,000	$15,000	$5,000	$5,000	5,000	$10,000	182,000
Clara Gulch	1,000	2,000	.....	.....	.....	.....	.....	.....	.....	.....	3,000
Kelly Gulch	.....	500	.....	.....	.....	.....	.....	.....	.....	.....	500
Marion Creek	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1,000
Emma Creek	27,000	40,000	13,000	15,000	10,000	15,000	5,000	5,000	5,000	5,000	160,000
Nolan Creek	.....	.....	.....	.....	14,000	40,000	90,000	125,000	208,000	288,000	765,000
Smith Gulch	.....	.....	.....	25,000	30,000	50,000	10,000	5,000	5,000	83,000	208,000
Archibald Gulch	.....	.....	.....	.....	2,000	2,000	.....	.....	.....	.....	6,000
Fay Gulch	.....	.....	.....	3,000	20,000	.....	3,000	.....	.....	2,500	30,000
Minnie Creek	.....	.....	.....	.....	500	.....	400	.....	.....	.....	1,000
Union Gulch	.....	1,500	30,000	.....	.....	.....	.....	.....	.....	2,000	35,000
Hammond Creek	2,000	2,000	10,000	2,000	2,000	2,000	.....	.....	.....	.....	20,000
Goldbottom Gulch	.....	.....	6,000	2,000	2,000	.....	.....	.....	.....	.....	10,000
Swift Gulch	.....	.....	3,000	2,000	1,000	.....	.....	.....	.....	1,200	7,200
Buckeye Gulch	.....	.....	.....	.....	1,000	200	.....	.....	.....	.....	1,200
Vermont Creek	.....	5,000	30,000	25,000	22,000	20,000	20,000	20,000	10,000	20,000	172,000
Sheep Creek	.....	.....	.....	.....	.....	.....	.....	500	1,000	500	2,000
Gold Creek	2,000	50,000	30,000	70,000	45,000	24,000	3,000	3,000	2,200	3,000	232,200
Linda Creek	.....	.....	8,000	10,000	.....	.....	.....	400	300	.....	20,000
Bettles River:											
Emory Creek	.....	.....	.....	.....	.....	.....	.....	.....	.....	1,000	10,000
Garnet Creek	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1,000
Mule Creek	.....	.....	.....	.....	.....	.....	300	.....	.....	.....	1,000
South Fork:											
Gold Bench	25,000	60,000	20,000	15,000	5,000	.....	.....	.....	.....	.....	125,000
Ironside Bench	500	.....	.....	.....	.....	.....	.....	.....	.....	.....	2,000
Grubstake Bar	1,500	1,500	.....	.....	.....	.....	.....	.....	.....	.....	4,000
Eaglecliff Bench	500	.....	.....	.....	.....	.....	.....	.....	.....	.....	1,000
Davis Creek	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5,000
California Creek	.....	1,000	.....	.....	.....	.....	.....	.....	.....	.....	3,000
Jim Gulch	.....	500	.....	.....	.....	.....	.....	.....	1,000	1,000	3,000
North Fork:											
Mascot Creek	.....	.....	.....	100,000	25,000	20,000	.....	.....	.....	.....	145,000
Washington Creek	.....	.....	.....	2,000	2,000	1,000	.....	.....	.....	.....	5,000
Wild River:											
Birch Creek	.....	.....	.....	.....	.....	5,000	5,000	.....	.....	.....	10,000
Lake Creek	.....	.....	.....	.....	1,000	1,000	.....	.....	.....	.....	2,000
Spring Creek	.....	.....	.....	.....	.....	.....	.....	5,000	1,000	1,000	7,000
John River: Crevice Creek	.....	.....	.....	.....	2,500	.....	.....	.....	.....	.....	2,500
	107,000	173,500	200,000	301,000	200,000	195,200	141,700	168,900	238,800	418,200	2,200,600

The results of mining as summarized in the table have been accomplished by an average of 100 men per year who have actually worked at mining. Some men have left the district each year, but others

have come to replace them. If the average cost of production is placed at about 50 per cent of the total yield, about $1,000,000 may be considered the amount of wealth that has been taken away from the Koyukuk district during the last ten years by those who have become satisfied with their gains and have departed from Alaska for "the outside with a homestake," as it is called in that country.

The Koyukuk placer gold is of a high grade. Its refined value varies from $18 to over $19 an ounce. The unrefined gold has passed in commercial exchange at $17 an ounce until 1909, when it was allowed a value of $18 an ounce.

GEOLOGIC SKETCH.

The country rock of the Koyukuk region is made up of many different kinds of metamorphic rocks, which are similar to and probably the same as the old formations that are known to form the bed rock over large areas through the interior of Alaska, both north and south of the Yukon and westward into the Kobuk Valley and Seward Peninsula. These old formations may be assembled into several indefinite groups that in general show similar characters, the most important of which is that the placer gold is associated with and largely derived from one or more of their members.

The oldest of these formations make up a diverse complex of more or less schistose sediments, in some places associated with igneous rocks of various types and relations. Many different phases of the schists have been recognized, but because of the changing character of the rocks from place to place enough evidence to warrant their definite subdivision, correlation, and classification has not yet been gathered, more particularly in the region north of the Yukon. South of the Yukon, between that river and the Tanana, the general sequence of the rocks, from the oldest upward, appears to comprise quartzite schists, carbonaceous and graphitic schists, quartz-mica schists, garnetiferous schists, crystalline limestones, and altered igneous rocks largely granitic and locally gneissoid intruded into the sediments. These rocks are called the Birch Creek schist and are considered to be of early Paleozoic age. North of the Yukon rocks that are considered to belong to the Birch Creek schist occupy a wide belt from the upper part of the Dall River basin northward to the headwaters of Jim River. In this area the rocks are similar in every particular to those of the Yukon-Tanana region and they contain a considerable amount of igneous intrusive rocks, mostly granite porphyries, both unaltered and metamorphosed. The Birch Creek schist appears to extend as a more or less continuous belt southwestward along the divide between Kanuti and Yukon rivers, and probably connects with the schists that occur in the Gold Hill district, on the north bank of the Yukon about 25 miles below the mouth of

Tanana River. It is also reported to extend northeastward from upper Dall River to the upper basins of Hodzana and Hadweenzic rivers.

North of Jim River the Dall River belt of Birch Creek schist is interrupted by a belt of younger formations that extends from the South Fork of the Koyukuk to the West Fork of the Chandalar, but north of these younger rocks the Birch Creek schist reappears in the valley of Slate Creek and occurs throughout the gold-producing part of the Koyukuk Valley. On Slate Creek and generally throughout the Koyukuk placer district a carbonaceous schist, phyllite, and slate phase of the Birch Creek schist is commonly developed. To the northeast, in the vicinity of Chandalar Lake and along Chandalar River to Horse Creek, the rocks are more quartzose and micaceous, but also contain graphitic phases; to the southwest the lower part of the John River valley is crossed by a belt of schistose rocks, largely of sedimentary origin, which are locally graphitic and contain much secondary quartz like the carbonaceous schists of the Slate Creek valley. In the Koyukuk area these do not appear to contain the large amounts of igneous intrusive rocks that are characteristic of the areas between the Tanana and the Yukon or between Dall and Jim rivers.

In a general way this northernmost belt of Birch Creek schist may be considered to extend for a width of 10 to 20 miles from the Chandalar Lake region across the Koyukuk Valley between Slate and Gold creeks and southwestward across the lower John River valley. Its distribution eastward from the Chandalar Lake region is not known, but to the west and southwest it extends to the Kobuk Valley and Seward Peninsula, where part of it forms the gold-bearing rocks of the Nome, Candle, and other districts.

Northwest of the Chandalar-Koyukuk-John River belt of Birch Creek schist, throughout the southern part of the Endicott Mountains, there is a considerable thickness of massive, heavily bedded crystalline limestones with numerous layers that grade into micaceous schist. These limestones occupy a belt from 15 to 20 miles wide and form rugged mountains from 5,000 to 6,000 feet above sea level. They are much jointed and some of the fractures have been filled by veins and veinlets of calcite and some quartz, a few of which contain a little galena or iron and copper pyrites, but these limestones and associated schists are not believed to be gold bearing. Schrader named them the Bettles and Skagit formations and believed them to be of Silurian age.

In the vicinity of Tramway Bar, on the Middle Fork of the Koyukuk about 16 miles below Coldfoot, there is a formation which contains coal. The rocks with which this coal is associated are much younger than the rocks previously described. Eastward from the

Middle Fork of the Koyukuk rocks believed to belong to this younger group were observed on the mountains just south of the mouth of Mosquito Fork, and they may extend still farther eastward to the Chandalar Valley but are not now definitely known to occur there. These rocks are probably of Cretaceous age.

SOURCE OF THE PLACER GOLD.

It has already been noted that the Birch Creek schist of the Koyukuk district contains a carbonaceous schist or phyllite that has been well silicified. The quartz is rather finely and uniformly disseminated throughout much of the rock, but in some places it occurs largely in the form of gashed and laced stringers, and is segregated as more or less lenticular or knotty bodies that have a general tendency to swell and wedge out and follow the curves and crenulations of the schistose structure. In other localities more intense metamorphism appears to have altered the carbonaceous rock with its quartz content into a micaceous quartz schist. That is, this rock apparently varies horizontally from a carbonaceous phyllite, locally having slaty cleavage, to a carbonaceous schist with more or less secondary quartz, at some places finely disseminated, at others more or less segregated; at other localities it has been further altered into a more typical schist of the micaceous quartz variety, some of which shows graphitic phases.

The form in which the secondary quartz occurs at different localities has undoubtedly been largely influenced by the physical character of the various phases of the rock. The more rigid quartzitic phases and the igneous rocks have been fractured or shattered into fragments and blocks, affording opportunity for quartz to be deposited in gashed and laced veinlets, while the members of finer-grained texture appear to have been kneaded like putty rather than broken, and as a consequence the quartz now contained in them is more finely and evenly disseminated throughout and is not so conspicuously segregated as in the harder rocks.

The disseminated and segregated quartz content of these rocks may be an original constituent or it may have been introduced by migrating solutions from other rocks during the progress of metamorphic changes, or it may very probably have been derived from both sources. Where the rock is fine textured and is a more typical phyllite the quartz is more finely disseminated, and locally, at least, this phase also contains a considerable amount of gold-bearing pyrite distributed through the rock as well-formed, sharp individual crystals. The rock at such localities might be called a pyritized phyllite or schist. A selected sample of fresh sharp crystals of this pyrite from Nolan Creek assays $1.24 in gold to the ton. Where the quartz content of

the rock occurs more in the form of knotty segregations and veinlets the pyrite is present in both the country rock and the quartz, though most of the quartz appears to be quite barren. But some weathered pieces of this quartz show oxidized pyrite, cubical cavities from which pyrite has evidently been removed, and occasionally small flakes and particles of free gold. Assays of samples from the quartz segregations and veinlets that occur in the micaceous quartz schist phase of these rocks show that gold occurs sparingly in it also.

The evidence outlined above appears to be sufficient to warrant the conclusion that the placer gold of the Koyukuk district has its chief source in the carbonaceous phyllite and micaceous quartz schist phases of the Birch Creek schist, because the pyrite it contains is known to be gold bearing and the quartz veinlets and lenses characteristic of parts of it are known to contain free gold. No doubt the form and condition of the gold as it now occurs in the bed rock is the result of one or more cycles of complicated changes and segregations, and no doubt the coarser placer gold as it now occurs in the gravels represents gradual accumulations from the erosion of a great amount of this mineralized country rock. Whether this gold-bearing pyrite mineralization is confined to any particular rocks, and if such is the case what its distribution within the rocks may be, can not now be definitely stated. Only a detailed study will show what the real relationships are and how they have come about.

MINERAL RESOURCES.

GENERAL STATEMENT.

The only mineral of present commercial value in the Koyukuk district is placer gold, so far as known to the writer. No gold lodes carrying values have been found. On the other hand, probably the most promise for the future in the Chandalar district lies in its quartz-lode gold deposits, for the placers so far found appear to be rather local alluvial concentrations of gold derived from the quartz veins near by, some of which are now known and located. That these quartz lodes carry more or less free gold is indicated by the specimens that may be gathered near the surface of the outcrops, which give encouraging assays. None of the quartz veins in the Chandalar district have been prospected to a sufficient depth below the surface zone of weathering and probable zone of secondary enrichment to determine whether the veins extend in depth or if the values they show at the surface may hold good at deeper levels. Pieces of galena are occasionally found associated with placer gold, and this mineral is reported to occur in places at several localities in the limestone belt that lies northwest of the belt of gold-bearing schist. One of these localities is in the upper valley of Wild River and another on

Bettles River. Native copper and silver are reported to have been found in small amounts on a northern tributary of Bettles River, associated with placer gold.

On the Middle Fork, just above Tramway Bar, in the southern part of the Koyukuk district, there is at least one coal bed of workable thickness. It is about 12 feet thick, of which the middle 9 or 10 feet is good fuel of a low-grade subbituminous quality, but no development of it has been undertaken up to the present time, though it should prove to be serviceable for local use.

Placer gold was first found in this region in the river bars of the Koyukuk sometime between 1885 and 1890, when it was visited by a few of the first prospectors who came to the lower Yukon Valley. John Bremner, who was killed by an Indian in 1888 on Hogatza River, was one of these pioneers.

Previous to 1898 Tramway Bar bench and two other localities, named Hughes and Florence bars, appear to have been the best-known occurrences of placer gold in the Koyukuk Valley, and it is estimated that about $4,000 worth of gold was mined from them.

Since 1898 prospectors have searched for gold within the valleys of all the headwater branches of Koyukuk River, with the result that placer gold has been found in greater or less amounts in the gravels of some of the tributaries of John and Wild rivers and the North, Middle, and South forks of the Koyukuk. This search has been best rewarded on the tributaries of the Middle Fork, so the deposits and operations within this drainage basin will be considered first. At present placer gold is known to occur in many of the creeks and gulches tributary to the Middle Fork, from Chapman Creek and Tramway Bar on the south to the head of Bettles River, but it is only from five or six of these streams that gold may be mined profitably under present conditions, and in many places work has been carried on from year to year with considerable uncertainty as to the result of the enterprise. This uncertainty is due in part to the nature of the gravel deposits, but largely to the high cost of all supplies and to the primitive methods of mining, which in turn may be attributed to the general remoteness of the region.

PRINCIPAL PLACER-GOLD LOCALITIES ON MIDDLE FORK.

The name Middle Fork is here used to designate that branch of the Koyukuk which, after being formed by the confluence of Dietrich and Bettles rivers, flows southward and westward about 75 miles to the point where it is joined by the North Fork, 37 miles below Coldfoot. (See Pl. VII.) The most important creek, gulch, and bench gold-bearing deposits of the Middle Fork will be considered in upstream order from south to north.

SLATE AND MYRTLE CREEKS.

Slate Creek is the largest eastern tributary of Middle Fork. The settlement of Coldfoot is situated on its south side at its mouth, approximately 1,450 feet above sea level. About 8 miles above its mouth its principal tributary, Myrtle Creek, enters from the mountains on the north, and its main branch heads in the same mountains about 12 miles farther northeast. Most of its valley floor is covered by deposits of washed gravels from 10 to 40 feet thick. The present drainage has intrenched itself in these gravels in the upper third of the valley, but has not reached bed rock, while along the lower two-thirds of the valley the main stream and the lower 2 miles of Myrtle Creek have cut through the gravels and further intrenched their channels into the underlying bed rock, so that rock bluffs from 10 to 20 feet high overlain by gravels from 15 to 30 feet thick are exposed along their banks. In several places these rock-walled cuts are narrow enough to be called canyons. Over the surface of the gravel benches, along the valley, are depressions, some of which are occupied by lakes and ponds, that have the position and arrangement of one or more old stream courses that apparently flowed on top of the gravels during a former period.

The bed rock of the Slate Creek valley is principally a carbonaceous phyllite that shows in places slaty cleavage and a micaceous quartz schist, both of which contain considerable segregated quartz in the form of veinlets, leaflets, and knotty lenses. There are also several dikes of altered dioritic intrusive rock, which has a speckled greenish-gray color and a medium grain. The gravels throughout the valley are the residual débris of the above-named kinds of rocks. The dike rock is the hardest and forms the largest bowlders, a few of which are as much as 6 feet in diameter. Most of the gravels are derived from the schistose rocks, and because of this they show a strong tendency to form flat, slabby shingle, the coarser pieces of which average 6 inches in longest dimension. The whole deposit of gravel is very cleanly washed, there being very little sand, silt, or sediment mixed with it. As a result of this, water seeps through it readily, and it does not pack closely, but lies loosely in the bars, which are consequently not easy to walk over.

Placer gold was discovered on Myrtle Creek in March, 1899, in the present stream-bed gravels, which are from 2 to 4 feet deep and from 100 to 300 feet wide. These gravels have been worked more or less from a point near the mouth of the creek up to claim No. 20, but have not proved profitable above claim No. 15. The seven creek claims from No. 9 to No. 15 have been the most productive. Considered in a general way, the gold has been found well scattered across the width

of the present bed of the stream and mining has yielded an average of $5 to $15 a day to the man. All the work along the creek has been done with shovel, pick, and sluice box, the loose shingle gravels from 2 to 4 feet thick being favorable for this kind of mining. This work has been carried on more or less actively during each summer for the last ten years. Nearly all of this shallow ground is now worked out. The largest yield of gold has been mined from claim No. 11, and claims No. 12 and No. 9 have been the second and third best producers, respectively. These three claims are on that part of the creek from 2 to 3 miles above its present confluence with Slate Creek, just below the point where it leaves its mountain valley. Below these claims Myrtle Creek flows through the bench gravels of the Slate Creek valley, and these compose its banks. Above claim No. 12 the bed-rock slopes of the mountains that bound the real Myrtle Valley come down near the stream on both sides, and here and there it cuts rock bluffs at the bases of these slopes. Thus the richest concentration of gold appears to be just beyond the mountains, in that part of the creek that was its mouth when the main drainage along the Slate Valley may have occupied a more northerly position or when Myrtle Creek was at a higher level and dumped its gold-bearing gravels out upon the gravels of Slate Valley, to be mixed with the bench deposits. The gold of this locality is probably all derived from the wearing down of the bed rock of the mountains from which the valley of Myrtle Creek has been eroded.

The bench gravels along the sides of the lower 2 or 3 miles of Myrtle Creek carry some gold and are now being mined by a small hydraulic plant situated on the east side bench of claim No. 6. These bench gravels are largely of Slate Creek channel wash. As exposed by the cut of Myrtle Creek along its lower 2 miles they are from 10 to 30 feet thick and rest on a bench of bed rock from 10 to 15 feet above the present stream level. The gold in the gravel benches along lower Myrtle Creek has probably been largely introduced into them by that stream. However, the bench gravels of Slate Valley have been found to contain gold at other localities, especially above Myrtle Creek, and it may be proved that these gravels are more generally gold bearing than the prospecting that has been done has disclosed.

The future of mining on Myrtle and Slate creeks apparently depends on the application of hydraulic methods. The only hydraulic plant in the Koyukuk district is now installed on the east side of Myrtle Creek about 1½ miles above its mouth.

The Myrtle Creek gold is of the size that the miners call shot and wheat gold. It is coarse, clean, and hammered flat to some extent. Some of it is of the size and shape of melon seeds, and nuggets up to $20 in value are occasionally found. It rests principally near the

bottom of the gravels and in the crevices of the slabby schistose bed rock, which stands on edge and is loosened with picks and shoveled into the sluice boxes after the upper part of the loose gravel has been moved aside.

EMMA CREEK.

Emma Creek is on the west side of the Middle Fork about 7 miles above Coldfoot. Its basin is bounded from south through west to north by a high semicircular divide that rises from 3,000 to 4,500 feet above the Middle Fork in the short distance of 5 to 7 miles, thus giving this basin very steep grades, the average fall being more than 500 feet to the mile, with the result that all the streams within the basin are swift.

At the mouth of its basin the main stream, the confined accumulation of a considerable drainage area, has cut a canyon about 100 feet deep and half a mile long through crystalline limestone and schist into the bottom of an older, wider valley, The Emma Creek valley appears to have been a hanging valley that has been partly dissected, but not enough to altogether obliterate its older configuration.

Some gold has been found in scattered patches of older stream gravels on top of the rock walls of this canyon, but most of the placer gold has been concentrated in the gravels that have choked into the wider funnel-like expansion of the valley at the upper end of the canyon, in the narrow gorge of the canyon, and in the upper part of the gravel fan at the lower end of the canyon, where the swift stream has dumped its gravel load into the valley of the Middle Fork. The funnel entrance at the upper end of the canyon and the bottom of the canyon also are clogged by numerous large bowlders from 3 to 10 feet in diameter. Thus the canyon is a great natural sluice box, with bowlder riffle blocks, through which a tremendous quantity of gold-bearing gravels from the upper Emma Creek basin has been sluiced during a long period of rapid erosion. Without doubt this is the reason why the richest diggings have been found just above the canyon, in it, and just below it. The richest claim has been that at the mouth of the canyon, and the formation of the richest placer deposits in the gravels just above, through, and immediately below the canyon is a good example of natural hydraulic washing and concentration.

The rich placers of Emma Creek were first worked in 1900 and the largest production was attained in that and the two following years. Since then the locality has not been worked so extensively but has produced some gold each summer. The number and large size of the bowlders prevent it from being ideal ground for pick and shovel work.

WISEMAN CREEK.

Wiseman Creek is a west side tributary that flows into Middle Fork about 16 miles by the course of the river above Coldfoot. It is

a comparatively small stream, occupying a large, broad valley, bounded by mountains that rise over 2,000 feet above it on both sides. The bottom of this valley is filled over a width of half a mile by deposits of gravel, sand, and silt from 200 to 300 feet thick. These unconsolidated deposits extend more than 6 miles from the mouth of the stream to a point near its head and also for more than 2 miles up Nolan Creek, its principal north side tributary.

Although Wiseman Valley has been located for placer-mining purposes throughout its length and width and even far up on the high sloping benches along its mountain sides, there has been no mining development of this ground. All the locations were made without any discovery of gold on the land. This was done on the assumption that because gold was known to occur in Nolan Creek, one of its tributaries, it might be expected to be present in the deep deposits of the main valley. Only one prospect shaft has been put down to bed rock in Wiseman Valley. This work was done during the winter of 1908–9 about a mile below the mouth of Nolan Creek. The shaft is 260 feet deep. In going down it passes through 40 feet of vegetable muck, 180 feet of tough blue clay that had to be chopped with an ax, 30 feet of stream-washed gravels, and 10 feet of ground-up country rock mixed with some gravel. The bed rock is a black phyllite or slate. The shaft is dry. Colors of gold are found on bed rock and all through the 30 feet of washed gravels above bed rock, but are not considered to be present in large enough quantity to make the ground at present profitable for drift mining.

NOLAN CREEK AND ITS TRIBUTARIES.

Description.—Nolan Creek, a north-side tributary of Wiseman Creek, is about 4 miles long. Above Discovery claim its valley is of the mountain-gulch type, but for the most part cut to bed rock. This steep-sided V-shaped bed-rock valley continues down nearly to its mouth, but this would not be apparent if it were not for the information disclosed by mining operations. For 2 miles above its mouth the valley is deeply filled with unconsolidated glacial-silt deposits, the surface of which presents a gradually widening flood plain that slopes gently downstream to join the still wider flood plain of Wiseman Valley.

Nolan Creek and its east-side gulches—Smith, Archibald, and Fay—are the important creeks of the district at present because it is along them that the rich gold-bearing gravels have been found and actively mined. The placers within the Nolan Creek basin are of three classes—bench gravels, shallow gulch gravels, and deeply buried frozen gravels.

Bench gravels.—The character of the bench deposits along Nolan Creek Valley suggests that they may be remnants of narrow, crudely

washed beaches along the mountain sides that were formed when Nolan Valley was an arm of a glacier-dammed lake which occupied Wiseman Valley. They appear to mark periods of rest occupied by the lake at different stages. Those that have been found to contain gold in paying quantities are situated from 50 to 200 feet above the present valley floor between Smith and Fay gulches, through a distance of about 1½ miles. They have been prospected and mined to a moderate extent, but are difficult to work to advantage because of an inadequate supply of water for cheaply ground-sluicing away the frozen clay and vegetable muck containing accumulations of ice that cover the washed gravels.

Shallow gulch gravels.—There is not much shallow gold-bearing gravel in the valley of Nolan Creek. What there is appears to be confined to the tributary gulches. The discovery of gold in shallow gravels on Fay Gulch in 1901 a short distance above the point where it joins Nolan Creek first aroused interest in the search for gold within this drainage basin and caused its unconsolidated deposits to be located for placer ground, but actual mining was not actively begun until 1903, when the small amount of shallow ground on Fay, Archibald, and Smith gulches was worked. The lack of boilers and the necessary equipment for steam thawing delayed the investigation of the deep placers for several years. Some work of this kind was attempted with wood fires, however, that resulted in 1903 in the mining of ground from 15 to 25 feet deep on Smith Gulch and on Discovery claim on Nolan Creek at the mouth of Fay Gulch. Smith Gulch was a good producer from 1903 to 1905, Discovery claim on Nolan Creek yielded considerable gold during this period, and claims Nos. 1 and 2 on Fay Gulch were also productive; but not until 1905–6 were the deeper gravels in the bed of Nolan Valley itself demonstrated to be rich.

Deep frozen gravels.—By far the largest bodies of gold-bearing gravels in Nolan Valley are deeply buried beneath frozen silts and clays. By 1906 several boilers and some steam thawing equipment had been brought to Nolan Creek, and in this year the first successful prospect shaft was sunk 135 feet to bed rock in the valley on the lower end line of claim No. 3 below Discovery. Rich gold-bearing gravels were found at the bottom of this shaft, and since that time placer drift mining in the deep frozen deposits of this valley has been actively conducted by about 100 men.

Up to the present time the most productive ground on Nolan Creek has been found to extend from Discovery claim to claim "No. 6 below," a distance of about 1¾ miles. The creek extends to claim "No. 8 below," one-half mile farther, where it joins Wiseman Creek. There are also six claims above Discovery, but little gold has been mined above Fay Gulch, which joins Nolan Creek on Discovery

claim. The depth of the unconsolidated deposits increases downstream from 20 or 25 feet on Discovery to 180 feet at the mouth of the creek on claim "No. 8 below." This increase is gradual, the depth being from 40 to 70 feet on claims Nos. 1 and 2, 135 feet on No. 3, 155 feet on No. 5, 165 feet on No. 6, 170 feet on No. 7, and 180 feet on No. 8 below Discovery. However, the general configuration of the bed rock is not so regular as these figures indicate, for underground drifting shows that there are considerable irregularities, called "drop-offs" by the miners, especially across the bed of the valley. Besides these irregularities of the bed-rock surface of Nolan Valley, it carries numerous bowlders in many places, some of them of large size, between which the gold-bearing gravels have lodged. Here and there these bowlders separate the gravels into patches of greater or less extent and, together with the "drop-offs," make the work of drifting along the bed rock more uncertain than if the gravels were of uniform size and more evenly distributed, as they are in the Fairbanks district.

Source of the gold.—The country rock of Nolan Valley is largely carbonaceous phyllite schist strongly mineralized with gold-bearing pyrite. This formation extends northward through the mountains to Vermont Creek. The country rock is well jointed and quartz occurs in the form of veinlets along these joint cracks. Several of these veinlets are known to carry sulphides and some free gold. No doubt there are many more of these joint-crack veinlets that are concealed, and probably a great amount of country rock similarly mineralized has been worn away by erosion, and in this manner a large part of the placer gold has been concentrated from the stream gravels. The quartz mineralization along these joint cracks probably comes from the country rock, and as the sulphides in the country rock are known to be gold bearing, the gold in the quartz veinlets may be derived from the gold-bearing sulphides disseminated through the carbonaceous phyllites.

Character of gold.—The placer gold from Fay Gulch and the upper part of Smith Gulch, where it appears to be near its bed-rock source and probably has not been carried far, is mostly in the form of rough, angular grains. That in Fay Gulch has about as much quartz attached to it as there is gold, the proportion being about half gold and half attached quartz. On Smith Gulch the gold is in more rounded and heavier pieces the farther downstream it lies. Some of the gold in Smith Gulch has a coating of white mineral matter, which the writer has not had opportunity to test, which is said to be lime but may be some other mineral substance. This coated gold is most common toward the head of the gulch. Either it does not occur on the gold farther downstream or the coating has been worn off of it by travel. The gold from Smith Gulch is of very high grade,

its assay value being said to be more than $20 an ounce, which would make it some of the highest-grade placer gold known.

The gold in the deep gravels along Nolan Creek is mostly in the form of rounded, smooth, heavy, chunky pieces. Large nuggets are rare; one of the largest, having a value of about $300, was found on claim "No. 1 below," and another nugget with a value of about $120 was taken from claim "No. 3 below."

UNION GULCH.

On the west side of Middle Fork, between Wiseman Creek and Hammond Creek, two gulch valleys drain the east side of the mineralized mountain mass that lies between Middle Fork and Nolan Creek. These gulches are named Union and Confederate. The gravels in both contain gold, but the southern, Union Gulch, which is situated about 2 miles above Wiseman Creek, is the more important. Although the deposits on Union Gulch are limited to about one claim in extent, about $30,000 worth of coarse gold has been mined from them. Gold was discovered on Union Gulch in 1901. The largest production was attained in 1902, but work is still being carried on there. Prospects of coarse gold have been found on Confederate Gulch, but no mining has been attempted.

HAMMOND CREEK.

Hammond Creek flows into Middle Fork from the northwest about 20 miles, by the course of the main river, above Coldfoot. It is the largest tributary of Middle Fork, being at least 45 miles long and discharging a volume of water equal to about one-fourth of the flow of the main river above their confluence. The Hammond Valley shows strong evidences of having passed through the same stages of drainage development as the smaller tributaries to the south. In modified forms it has bench and deep gravel deposits and canyon features somewhat similar to those that have been already outlined for Emma and Wiseman valleys.

While the Hammond Valley has been prospected more or less throughout its lower 25 miles, gold has been mined only along its lower course, more particularly in several short gulch valleys tributary to it from the south within 5 miles of its mouth.

Little systematic or continuous mining has been done on the stream gravels of Hammond Creek, because the large flow of water and the presence of numerous cobbles and small bowlders make pick and shovel labor unprofitable. In 1902 a wing dam was built on claim "No. 6 above" early in the spring at a time of low water, to divert the river so that the gravels in its bed might be mined.

Although the summer's work produced considerable gold, the expense of the operation is said to have made the venture unprofitable. Spasmodic work from year to year along the banks of the river, chiefly on Discovery claim, has yielded from $8,000 to $10,000 worth of gold. Most of this gold has been of the coarse nugget variety, some pieces being of large size. One nugget of a value of $849 was found on claim "No. 6 above," another worth $842 was found on Discovery claim, and one worth $1,000 and another worth about $1,100 have been mined in this valley.

GOLD-BEARING STREAMS TRIBUTARY TO HAMMOND CREEK.

Along the south side of Hammond Creek, between the Middle Fork and Vermont Creek, are several gulches that drain the north face of the mineralized mountain mass that has been already referred to in describing the placers of Nolan Valley and Union Gulch, and will be mentioned later in the discussion of Vermont Creek. The profitable ground on these gulches is near their mouths, where they have accumulated considerable washed waste from the mountain slopes to the south, more or less mixed with bench-gravel remnants of river deposits along the south side of Hammond Creek. The principal gulches are Goldbottom, Swift, and Buckeye. A small amount of mining has been done on them at different times.

VERMONT CREEK.

Vermont Creek is a small stream flowing into Hammond Creek from the south about 5 miles from the Middle Fork. It is formed by two branches, an east or left one, about 2 miles long, and a west or right one, about 3 miles long, which flow through deep gulch valleys that join about a mile from Hammond Creek. These gulch valleys head against similar gulches that are tributary to upper Nolan Creek and drain southward.

The bed rock in Vermont Creek is the same as that already described as occurring in Nolan Valley. This carbonaceous phyllite formation extends northward through the mountains from Nolan Creek to Hammond Creek and is well exposed on the east or left fork of Vermont Creek and to the east of it for some distance. It also outcrops along the south banks of Hammond Creek for some distance downstream from the mouth of Vermont Creek, where much of it shows slaty cleavage. On the upper part of the east fork of Vermont Creek, where unweathered exposures may be observed, it is found to be mineralized with pyrite in the same manner as on Nolan Creek, and it is here that quartz veinlets along joint cracks may be easily observed. One of these joint-crack veinlets about 1 inch thick was

observed to be mineralized by sulphides and free gold in flakes and specks. No doubt there are other veinlets so mineralized.

Placer gold was discovered on Vermont Creek August 25, 1901, and has been profitably mined there ever since. Discovery claim is located on the main lower part of the creek just below the forks. Two claims, covering about half a mile, on the east fork have been good shallow mining ground, and Discovery claim and the two claims below Discovery contain good values. Thus the rich gravels extend over five claims for a distance of about 1¼ miles, of which three-fourths of a mile is below the forks and half a mile along the east fork. On the west fork of Vermont Creek gold has not been found in paying quantities. The gravels on the east fork average about 3 feet in depth and are not very wide, as the bottom of this gulch is narrow. On Discovery claim the valley bottom broadens and the gravels are from 200 to 300 feet wide. On claim "No. 1 below" their width increases to about 400 feet. The gravels become somewhat deeper on the lower end of claim No. 1 below Discovery and decidedly deeper on claim No. 2 below Discovery. In fact, the lower half mile of Vermont Creek is flowing over deep frozen deposits that may be more properly considered, at least in large part, bench deposits of Hammond Valley, for these deposits are not in the form of shallow gravels, largely unfrozen, lying on the bed-rock floor of a narrow rock-cut valley such as extends above claim No. 2 below Discovery, but are deep frozen accumulations of gravel, sand, and clay that are directly related to similar extensive bench deposits which occur along the sides of Hammond Valley. Although the largest part of the unconsolidated stream deposit on this claim belongs to the sediments of Hammond Valley, there appears to be little doubt that most of the gold in this deep ground has been derived from Vermont Creek.

About the center of claim No. 2, below Discovery, on Vermont Creek, a sinking and drifting operation in these deep frozen deposits has proved very successful. This work was begun during the winter of 1908–9. The shaft is about 90 feet deep. At a depth of about 50 feet a bed of cemented sediment 11 feet thick was encountered which is termed a "false bed rock." Below this hard bed there is from 7 to 8 feet of washed gravel. In August, 1909, a drift about 200 feet long had been driven in a direction up Vermont Creek and another drift about 100 feet long across the direction of Vermont Creek. A report received in February, 1910, states that a rich pay streak 40 feet wide has been found on this claim and that the gravels panned in two days have yielded $2,400 worth of gold.

The Vermont Creek gold is mostly coarse and rounded. Several nuggets worth more than $200 have been found.

GOLD CREEK.

The present form of the valley of Gold Creek apparently shows that it has passed through a series of drainage changes somewhat similar, but of modified form, to those that have taken place in the development of the basin of Emma Creek, but as it is impossible to describe these changes clearly without illustrating its features by a detailed topographic map, only an outline will be given here.

The most marked feature this valley now presents is a canyon section 1½ miles long in its lower part which is cut at right angles across a sloping bench of bed rock on the east side of the valley of Middle Fork. One mile above the mouth of Gold Creek this narrow canyon is 50 feet deep and its depth increases upstream for about half a mile, reaching 200 to 250 feet. In its upper part, where deepest, it appears to have cut down through a spur that slopes from the mountain mass which lies on the south between Gold Creek and Sheep Gulch. On the north wall of the canyon, in line with this mountain spur, there is a small but prominent bed-rock knoll that appears to be a remnant of the mountain spur on the south side of the canyon. Just above or northeast of this knoll, in the bed rock of the north wall, there is a depression about 50 feet deep and 300 feet wide, the bottom of which is about 200 feet above the present bottom of the canyon. This depression is filled with stream-washed channel gravels which in their present position are resting on top of the canyon wall. These washed gravels appear to occupy a part of a former channel of Gold Creek when it flowed at a level 200 feet higher than it does now. The significance and probable course of this old high channel will be discussed later in connection with the gold placers that occur on Linda Creek, with which it appears to be closely related.

The fall of Gold Creek from the head of its canyon to its mouth is about 200 feet in a distance of less than 2 miles. Above this canyon the valley widens out somewhat and has a deep V-shaped cross section whose slopes rise steeply to a height of about 1,000 feet above the creek. At this elevation, which is about 3,000 feet above sea level, the steep lower slopes form a shoulder, with more gently inclined slopes on the higher parts of the mountains; that is, the present valley of Gold Creek shows strong evidence of having been rather abruptly cut down into an older land surface which had a moderately rolling mountain relief that was much less rugged than the topographic form of this region to-day.

This deep V-shaped portion of the valley extends upstream from the head of the canyon for about 3 miles, and in this distance the fall of the creek is about 400 feet. At about midway of this stretch and also at the upper end of it there are two more contractions in the

valley, where the creek runs through short, low-walled, narrow gorges or small canyons. The halfway gorge appears to be caused by the presence of a hard dike of intrusive diabase which outcrops on the north slope of the valley and whose greater resistance to erosion over that of the softer schists on both sides of it has offered a barrier to the cutting of the stream. The uppermost gorge, about a mile farther upstream, is cut through a low ridge of schists that are harder than the surrounding schists. This barrier rises about 60 feet above the present creek bed. Thus the lower half (4 or 5 miles) of Gold Creek valley has three contracted features, the first and deepest of which is a canyon, the second and third gorges. Between these three contracted features there are two wider V-shaped portions of the valley and it is in these portions that the richest gold-bearing gravels have been found and mined.

Above the upper gorge the upper half of the Gold Creek valley is wider and has a form entirely different from its lower half, as there are no canyon-like contractions, and instead of a sharp deep V-shaped cross section it has more open and gradually sloping sides. This form continues throughout 3 or 4 miles to its headwater gulches.

The country rocks of the Gold Creek valley are practically all schists. The outcrops in the lower half of the creek are mostly of the carbonaceous phyllite schist that has been already noted in the basins of Wiseman Creek and Hammond Creek; in the upper half of the valley the bed rock is mostly of the micaceous quartz schist variety that occurs to the south in the Myrtle Creek basin.

Placer gold was discovered on Gold Creek in 1900 and has been mined more or less throughout 6 miles of its length, from claim No. 4 below Discovery, at the head of the canyon, to claim "No. 19 above," on its headwaters. The most profitable diggings have been the shallow stream gravels that occur in the two sections of the valley situated between the canyon and the middle gorge and between the middle and upper gorges.

Most of the gold placers on Gold Creek are shallow stream gravels without any large amount of overburden. For this reason it has been one of the best valleys for pick and shovel mining in the district. Some of the gold on claim "No. 19 above" and in the gulches near by is in rough, light pieces that appear not to have been transported far from their bed-rock source, but most of the gold has the form of rounded shotlike pieces and small smooth nuggets.

LINDA CREEK.

Linda Creek is a small stream about 4 miles long that drains the southern half of a gravel-filled depression on the east side of the Middle Fork about a mile north of Gold Creek. The part of this wide depression occupied by Linda Creek is the southwesterly arm

of a semicircular bend around or to the east of a mountain 3,000 feet high, which stands isolated from the main mountain ridges that bound the valley of Middle Fork. Linda Creek heads in a large pond in the elbow of this bend, where, with several other smaller ponds, it occupies a flat gravel and silt covered watershed between Linda Creek and another small creek of about the same length, which drains the northwesterly arm of this depression and flows into Middle Fork about 6 miles above the mouth of Linda Creek. A covering of water-worn gravels and silts is spread over the broad bottom of this depression throughout its extent, over which the creeks that drain its arms flow for the most of their lengths, but about the middle of their courses these creeks have washed through the unconsolidated deposits and cut shallow channels into the underlying bed rock. Linda Creek, however, has done practically no bed-rock cutting and does not occupy a valley of its own making, and it appears evident that any placer gold now occurring in the gravels of its channel must have been introduced there by some agency other than the present stream.

The most probable source for the placer gold that has been found on Linda Creek is Gold Creek. In the description of lower Gold Creek the significance of the stream-washed deposit of gravel that occupies an elevated position about 200 feet above that stream on the north wall of its canyon was referred to as having a possible intimate connection with the placer gold that has been found on Linda Creek. The gravels on top of the canyon wall occupy a depression in the bed rock about 300 feet wide and 50 feet deep, and as exposed have every appearance of being a cross section of an old high channel of Gold Creek before that stream was diverted down its present canyon. If the rock knoll that forms the west side of this depression in the north wall of the canyon is, as it appears to be, a remnant of a former continuation of the mountain spur opposite to it on the south wall of the canyon, then the most natural course for Gold Creek to have followed when at this higher level would have been to the north toward Linda Creek, across the sloping bench that now intervenes. The direct distance across this bench between the high gravels in Gold Creek canyon and the locality where placer gold occurs on Linda Creek is a little more than a mile and the fall of the surface is about 300 feet. The indications that a stream flowed between these two points are not particularly marked. There is no strong surface evidence of a former channel unless a slight depression or sag of the surface from 300 to 600 feet wide, which is indicated by a timberless strip overgrown with moss and willows, is considered to mark a frozen channel, that is too cold to foster a good stand of timber such as now grows along both sides of it. This barren strip of land seems to connect the high gravels on the canyon wall with the

placer-gold locality on Linda Creek, but whether it is the course of an old channel can be proved only by prospecting, and even if this is proved it may not be found to contain gold, especially throughout its length.

Gold is said to have been first found on Linda Creek in 1901. The only ground that has been mined is on Discovery claim, situated about half a mile above its mouth, and only the lower half of this ground has proved very productive. The gold is similar to that of Gold Creek.

BETTLES RIVER.

Bettles River is the large eastern headwater branch of the Middle Fork of the Koyukuk. Its basin extends over 30 miles from east to west, and 25 miles from north to south, in a region of rugged mountains between the Middle Fork and upper Chandalar River. Its longest and largest tributaries flow from the north out of mountains largely composed of the crystalline limestone formation that overlies the gold-bearing schist formations. Its southern tributaries are shorter and flow almost wholly over the same schist formations that extend to the south from Gold to Slate creeks. This valley was not visited by the writer. The information given here is taken from notes gathered from prospectors who have worked on the creeks in this basin at various times during the last ten years.

Prospects of placer gold have been found on a number of creeks tributary to Bettles River, namely, Emory, Garnet, Mule, Eightmile, Phoebe, Spruce, Sheep, and branches of Robert Creek. The gold is found on the lower courses of these creeks where they have cut down into the schists beneath the massive limestones. Except on Emory Creek, which is said to have produced about $10,000, only prospect work has been performed on the tributaries to Bettles River that have been mentioned and they have not yielded much gold.

SOUTH FORK OF THE KOYUKUK.

GENERAL DESCRIPTION.

The South Fork of the Koyukuk is one of the largest and longest branches of that river. It rises about 10 miles west of Chandalar Lake, just south of the headwaters of Bettles River, and flows southwestward for about 175 miles. Its general course is parallel to that of the Middle Fork throughout its length. At no place are the main channels of these two rivers more than 25 miles apart, and at one place a few miles below Tramway Bar their main channels approach within 7 miles of each other.

The three large tributaries to the South Fork, Fish Creek, Jim River, and Mosquito Fork, all flow from the east, where they have

their sources in mountains from 4,000 to 5,000 feet above sea level. These mountains are made up of the schistose formations that compose the wide belt of metamorphic rocks between Dall and Jim rivers. These three streams head against the headwaters of Dall and Hodzana rivers and of West Fork and Crooked Creek, west-side tributaries of the Chandalar. Some prospecting for placer gold has been carried on within the valleys of these streams at different times during the last ten years, more particularly in the basin of the Hodzana, but though prospects of gold are reported to be widely distributed throughout this region no mining operations have been undertaken up to the present time.

In 1909 the Geological Survey party panned the gravels on the upper part of the south branch of Jim River and found colors of gold. The stream on which these colors were found has been named Prospect Creek. (See Pl. VII.)

The best known placer-gold locality in the valley of the South Fork is named Gold Bench. It is a deposit of high stream gravels situated on the northwest side of South Fork about 10 miles south of the Tramway Bar bench on Middle Fork, and apparently belongs to this same class of deposits. It is usually reached by a trail about 8 miles long that leaves the Middle Fork near the halfway road house, 28 miles below Coldfoot or 32 miles above Bettles.

The gold-bearing gravels lie on top of a sloping bench of thick unconsolidated wash deposits in a semicircular bend of the river. The surface deposits in which most of the gold has been found consists chiefly of fine washed stream gravels, largely composed of schist pebbles, a considerable amount of quartz pebbles, some of flint, and a few bowlders and cobbles of igneous rocks. The best gold-bearing gravels mined were from 18 to 24 inches thick, distributed over an area about three placer claims (60 acres) in extent. Most of the gold rested on a "false bed rock" of reddish sand from 2 to 12 inches thick and the richest yield was obtained from an area 150 to 200 feet wide and about a quarter of a mile long. Some of this shallow ground was so rich and so easily handled that from $80 to $90 a day to the man was mined with rockers, and in 1900–1901 an extensive shovel and sluice-box operation is reported to have yielded $85,000 worth of gold. The gold is in the form of fine, flaky, light, and very much flattened pieces, the largest of which had a value of $3.50.

The bed-rock source of the gold is not known. It may have been washed from the direction of Tramway Bar bench, as there is a low valley-like depression from that direction filled with channel-washed gravels, but it appears more probable that the gold may have come from the mountains that border the south side of the river opposite and for some distance above Gold Bench. These mountains are apparently formed of igneous rocks, largely diabases, which may

have intruded the schist formations with which they are associated, and it may be that these igneous rocks have an intimate relation with the origin of the placer gold. On the south branch of Jim River, where colors of gold were found on Prospect Creek, the mountains that form the north side of the valley appear to be largely made up of the same diabasic rocks.

One of the best reasons for believing that the Gold Bench gold may be derived from the mountains that lie between the South Fork and Jim River is that placer gold is known to occur on some of the streams that drain from this group of mountains and also in other bench-gravel deposits on the South Fork above Gold Bench. Three of these bench deposits are named Ironside and Grubstake bars and Eagle Cliff.

DAVIS AND OTHER CREEKS.

Davis Creek is a stream about 5 miles long flowing from the mountains about 4,000 feet high that lie to the southeast between South Fork and Jim rivers. It joins South Fork about 8 miles above Gold Bench and is one of the first known placer-gold streams in this valley. The bars at its mouth are usually dry, as the stream apparently sinks into unfrozen gravels, but there is a good flow of water above its mouth, where it has cut into thick washed-gravel deposits. A small amount of gold occurs in these gravels and they have been mined to a small extent at intervals for the last ten years. It is reported that above Davis Creek there are prospects but no good paying quantities of gold in several creeks flowing from the same mountains, and also on Wilson Creek, a north-side tributary to South Fork, about 21 miles above Gold Bench. It is also reported that loosely scattered colors of gold may be found in the gravels along South Fork as far up as Bowlder Creek, which rises opposite the upper basin of Slate Creek; but no mining has been done along this part of the river.

HEADWATERS OF GLACIER CREEK.

Glacier Creek is a large north-side tributary of the upper South Fork, about 10 miles long, that heads against Gold Creek and two south-side tributaries of Bettles River. Gold was discovered in 1901 on its principal headwater branch, California Creek, and two of its tributaries, Jim and Boer gulches. Shovel and sluice-box mining operations have been carried on in a small way by several men each summer since 1901, but this work has never yielded much more than the equivalent of the current wages of the district, and hence has not proved very attractive to the miners.

NORTH FORK OF THE KOYUKUK.

GENERAL DESCRIPTION.

The North Fork of the Koyukuk is a large stream that rises on the south side of the Arctic divide west of the head of Hammond Creek and drains a north-south valley over 60 miles long and from 10 to 15 miles wide that lies west of and parallel to the Middle Fork Valley. The upper part of the North Fork valley is in mountains of the same limestone formation that occupies a wide belt north of Bettles River, extends westward across Dietrich River, and crosses Hammond Valley about 25 miles above its mouth. The southern half of the North Fork valley lies in the schist formations that underlie the massive limestones to the north. About halfway up the valley, some 35 miles above its mouth, are several small creeks that carry shallow gold-bearing gravels. The first discovery of gold in this valley was made on Washington Creek in August, 1902; in September of the same year gold was found on Mascot Creek, a short distance farther west.

Washington Creek, which heads against several of the lower west-side tributaries of Hammond Creek, has not so far yielded enough gold to encourage serious mining operations, although some coarse smooth gold is found in its gravels.

MASCOT CREEK.

Mascot Creek is the only stream in the North Fork Basin that has been extensively mined. Its bed rock is a micaceous quartz schist and its gravels are shallow, being nowhere more than 3 feet and in some places but a few inches deep. While the gravels were not considered to be very rich by the miners, the ease with which they could be handled made the work very profitable, it being little more than equivalent to what is termed "cleaning bed rock" in an ordinary hydraulic operation. The gold rested mostly upon bed rock or in the lowest layers of gravel and to some extent in the soft decayed bed rock, which in places was removed to a depth of a foot. The gold mined was coarse, large nuggets, some worth $100, being found. The ease with which these deposits could be handled made it possible to carry on mining with a profit of about 70 per cent of the yield, and when the extremely high costs of that time are considered the operations on Mascot Creek may be said to be the most profitable that have ever been performed in the Koyukuk district.

WILD RIVER.

Wild River enters the Koyukuk from the north about 13 miles below the mouth of North Fork. Its valley lies between that of North Fork on the east and that of John River on the west, but it

is not so long or large as either of these streams and is probably not over 50 miles long in a direct north-south direction. The upper part of the valley crosses the gold-bearing schist belt from 30 to 40 miles north of Koyukuk River, and small amounts of gold have been mined from three creeks lying in this schist belt. To take these creeks in upstream order, the first one is Birch Creek, an east-side tributary, from which about $10,000 worth of gold was mined during 1905–6.

About 10 miles above Birch Creek the river flows from a lake, and on two small creeks that flow into this lake from the east some gold has been mined. The southern of these streams is named Lake Creek. In 1903–4 gold to the amount of $2,000 was mined from a claim on one of its headwater gulches. The gold was coarse, some of the nuggets ranging in value from $90 to $150.

Spring Creek is the next stream above on the same side of the lake. The claim that has been mined is located about a mile from the lake and made a good yield in 1907, but the summer of 1908 was so dry that there was not enough water available for advantageous work.

JOHN RIVER.

John River is one of the largest northern tributaries of the Koyukuk, which it joins about 2 miles above Bettles. It is about 120 miles long and occupies a deep valley across the Endicott Mountains that has its head in a pass across the arctic divide at an elevation of about 2,500 feet above sea level.

From 40 to 60 miles above its mouth this river crosses the southwesterly extension of the Koyukuk belt of gold-bearing schist. North of this belt is the same massive limestone formation that is found overlying the schists on North Fork, Hammond Creek, and Dietrich and Bettles rivers to the northeast. Schrader has noted a zone of sulphide mineralization in this belt of schistose rocks and the localities where prospects of gold have been found, and small amounts mined are located in this belt. No gold-bearing deposits have been found north of this schist belt.

Crevice Creek, which lies in these rocks on the east side of the river, and Fool Creek and its tributaries, on the west side, are the only localities where encouraging prospects have been found up to this time. About $1,800 worth of gold was mined on Crevice Creek in 1904 and good prospects were found on Midas Creek, a tributary of Fool Creek, in 1905, but these discoveries have not led to further development.

CHANDALAR RIVER.

At present mining operations in the Chandalar Valley are confined to a rather small area whose central part is situated about 6 miles east of the upper end of Chandalar Lake. On the west this area

is bounded by the north-south portion of the Chandalar Valley, on the north by a wide east-west valley feature now drained by Lake and Grave creeks, on the east by the headwaters of McClennan and Big creeks, and on the south by Tobin Creek. As thus limited the area is about 10 miles in extent from north to south and the same from east to west and embraces about 100 square miles. The mountains within it are from 5,000 to 6,000 feet above sea level and from them the placer streams flow in various directions. These streams are Big Creek and its tributary headwater gulch (St. Marys), Tobin Creek, Bowlder Creek, Big and Little Squaw creeks, and Big and Little McClennan creeks.

The largest production of placer gold to date in this district has been from the head of Big Creek and St. Marys Gulch. The gold so far mined appears to be rather local alluvial concentrations derived from quartz veins near by that are now known and located. It is estimated that about $50,000 worth of placer gold has been produced since 1906.

Probably the most promise for the future of the area defined above is in its quartz lodes, but it requires a much larger initial investment of capital to develop lode deposits than placers, especially in a region so remote as this, where even rich shallow placers that require very little capital or machinery do not always yield adequate returns under present commercial conditions. A more detailed account of this district will be presented in a report now in preparation.