# MINERAL RESOURCES OF THE BONNIFIELD REGION.

By STEPHEN R. CAPPS.

## INTRODUCTION.

The region covered by this report lies on the north slope of the Alaska Range between Nenana and Delta rivers, and in a general way is limited on the south by the crest of the range and on the north by the Tanana Flats. It therefore forms a belt about 30 miles wide and 110 miles long, extending from Nenana River eastward to the Delta. That portion between Nenana and Little Delta rivers has been widely known as the Bonnifield region, which is here considered to extend eastward to Delta River. Since the establishment of Fairbanks as an important mining camp the area south of the Tanana has been visited by large numbers of prospectors, and although no strikes of exceptional richness have been made placer gold is widely distributed and has been found in paying quantities on a number of creeks. Further attention has been attracted to this region by the extensive fields of lignite, by reports of large bodies of low-grade gold-bearing ore, and by the possibilities of profitably developing some of the great gravel benches which carry a low content of placer gold.

The western border of this area was visited in 1902 by Alfred H. Brooks [1] and L. M. Prindle, the results of their work being embodied in a report now in press. In 1906 Prindle again visited that part of the area lying between Nenana and Wood rivers, and a brief account of his work has been published.[2] The notes, traverses, and manuscript of both of these investigators have been freely drawn upon by the present writer, who has also been greatly aided by them in personal conferences in the office. The organization of the field party and its itinerary are discussed on page 11 of this volume.

## GENERAL DESCRIPTION OF THE REGION.

### GEOGRAPHIC FEATURES.

The region bounded by Nenana, Tanana, and Delta rivers may be divided into three distinct east-west belts of different topographic character. On the north the Tanana Flats extend from Tanana River to the foothills. As Tanana River makes a broad loop north-

[1] Brooks, A. H., and Prindle, L. M., The Mount McKinley region, Alaska: Prof. Paper U. S. Geol. Survey No. 70, 1911.

[2] Prindle, L. M., Bull. U. S. Geol. Survey No. 314, 1907, pp. 205–226.

ward between the mouths of Nenana and Delta rivers, this flat is of varying width, being about 30 miles wide along the Nenana, 50 miles south of Fairbanks, and 20 miles on the west side of Delta River. This great lowland area is of slight relief, broken only by a few isolated hills which rise above the general level of the plain. Most of it is heavily timbered with spruce, and the drainage is so poorly developed that numerous lakes and marshes make summer travel over the greater portion of it impossible. Along its southern edge the Tanana lowland ends abruptly, giving place to a belt of foothills which stretch southward from 15 to 20 miles beyond the flats. These hills form minor east-west ranges parallel to the higher mountains to the south and have for the most part rounded summits and long connecting ridges of smooth outlines, ranging in elevation from 2,500 to 3,500 feet, although here and there hills with somewhat sharper peaks rise to heights of 4,000 or 5,000 feet. Between the ranges of hills there are in places broad structural valleys. The third belt comprises the rugged mountains of the Alaska Range, which here trends nearly east and west, and though not so high as that part west of the Nenana its loftier peaks are snow covered and support vigorous glaciers. The highest peak in this region, Mount Hayes, with an altitude of 13,800 feet, is a conspicuous landmark through much of the Tanana country. (See Pl. X.)

The drainage throughout the region is tributary to the Tanana. The larger streams rising in the higher ranges and flowing southward cut transversely across the foothill ranges, in many places with deep, narrow canyons, but many of the streams from the foothills follow the east-west transverse valleys to join the larger north-south streams. The most important streams of the area, from west to east, are Nenana River, Totatlanika and Tatlanika creeks, Wood and Little Delta rivers, Delta Creek, and Delta River. Only those streams of considerable volume maintain definite channels to the Tanana, the smaller creeks being absorbed by the flats, which are drained by irregular swampy streams.

As supplies can be transported to the hills much more cheaply by sledding in the winter than by trail in summer, few trails have been built in this region. An old Indian trail from the Tanana up the Nenana has been cut out and widened, but numerous forest fires during the summer of 1910 were followed by the falling of the timber, and much of this trail is now obliterated. A trail from the mouth of Wood River to the diggings on Tatlanika and Gold King creeks is passable during the summer months, and a good winter road from Gold King Creek to Fairbanks has been chopped out. Another feasible route to Dry Creek and Wood River follows the military winter road from Washburn across the flats and then swings southwest over the bare ridges. A fourth route, but little used, leaves the

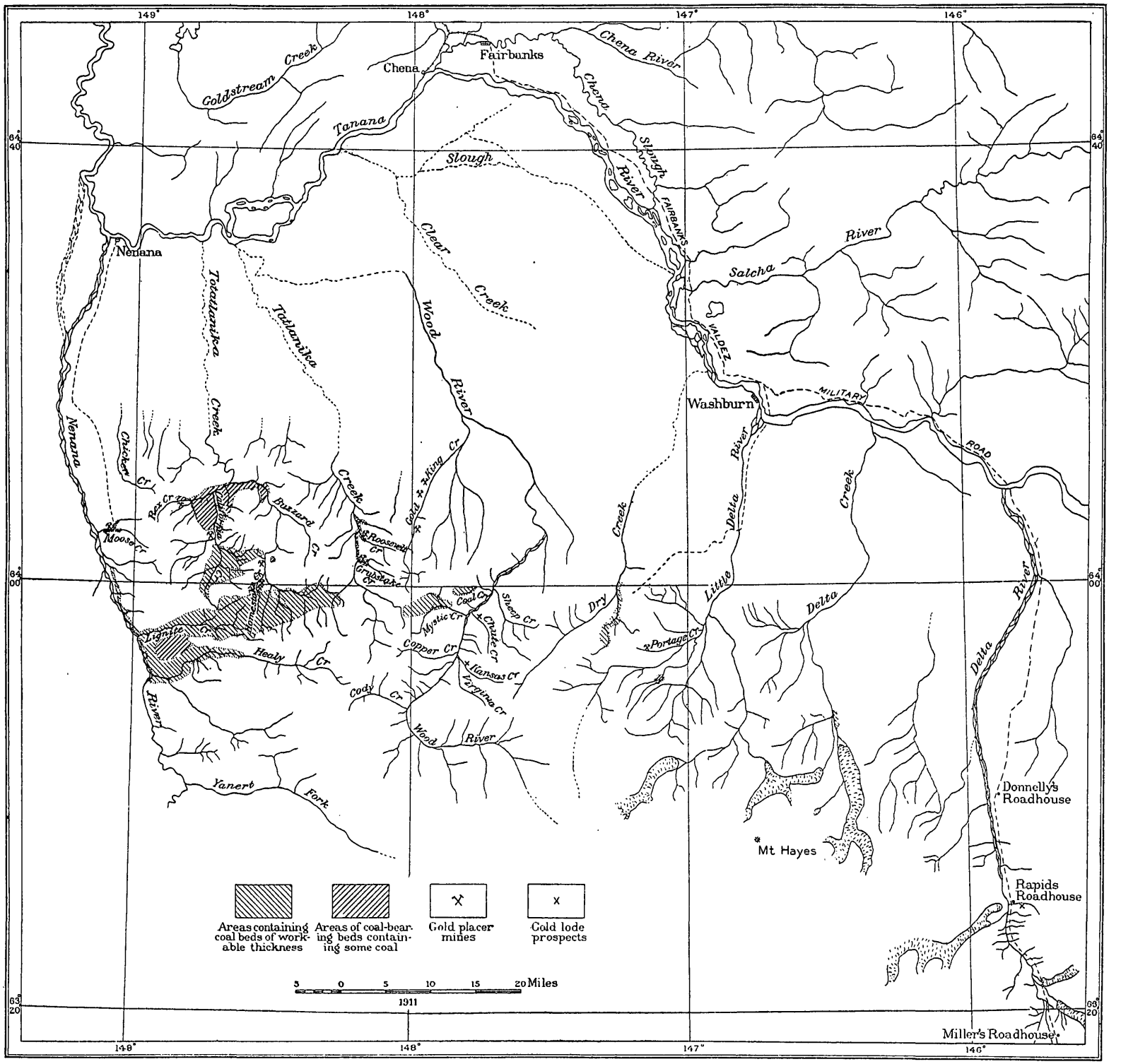
Valdez-Fairbanks road near Donnelly's and follows the low hills westward. Fairbanks and Tanana River points form the base of supplies for the region, and the greater part of the expense of freighting is usually incurred between the river and the creeks.

Horse feed is found nearly everywhere in the summer months, either along the stream valleys or in the heads of the small draws above timber, which commonly grows to an elevation of 2,000 to 2,500 feet.

## GENERAL GEOLOGY.

The geologic formations represented in the region include an old schist series composed of metamorphosed sedimentary rocks and another schist series of metamorphic igneous rocks, both having been cut by large bodies of intrusives; much younger deposits of loosely cemented and somewhat folded beds; high bench gravels but little deformed; and more recent glacial and alluvial deposits. The old schists formed from metamorphosed sediments compose the greater part of the main range of mountains. They consist for the most part of quartz-mica schists with quartzites, cherts, and carbonaceous schists. Large bodies of granitic rocks have in places been intruded into these schists, and other varieties of igneous intrusives have been injected into and metamorphosed with the sediments in an intricate way. This series has been called the Birch Creek schist. The second schist series of altered igneous rocks forms the more important of the foothill ranges. It contains some sedimentary material, however, so that the two schist series in places show such intergradations that the boundaries are difficult to establish. Quartz-feldspar schists are the prevailing type, the rock being porphyritic over considerable areas, the feldspars occurring as conspicuous crystals with characteristic boundaries. These feldspars in places are over 2 inches in diameter, and many slopes are covered with crystals which have weathered out of the matrix.

Unconformably overlying the schists and occupying shallow warped basins between schist ridges are areas of Tertiary sediments consisting of slightly cemented sands and clays and beds of lignitic coal. The coal-bearing series when first deposited doubtless covered a much wider area than it does now. It probably covered all or nearly all of the foothill belt and may even now underlie large areas of the Tanana Flats. The beds vary in attitude from a nearly horizontal position to dips approaching the vertical, but in general occupy basins in the schists, the coal series dipping away from the bordering schists toward the centers of the basins. Overlying the coal series is a thick deposit of gravels, which is evidently of considerably later age than the coal series but which locally seems to be structurally continuous with it. The gravels have a total thickness of at least 1,500 feet and are in general less folded and tilted than the




SKETCH MAP OF BONNIFIELD REGION.

coal beds. They, too, were formerly much more widespread than now, as is shown by the remnants of the beds and by scattered gravels over the tops of many of the foothill ranges. Still later in age than the high gravels are the glacial moraines and terraces and, latest of all, the extensive gravel deposits of the present streams.

## MINERAL RESOURCES.

### GOLD PLACERS.

#### GENERAL DESCRIPTION.

The locations in which placer gold in paying quantities has been found all lie in the foothill belt between the Tanana Flats and the high schist range to the south. (See Pl. X.) Furthermore, the placers all occur in the valleys of the smaller streams which were either north of the area invaded by ice at the time of the maximum glaciation or which were themselves not occupied by glaciers. It may be that formerly there was a concentration of gold in the valleys of the main range, but if so this gold was removed by the ice and scattered throughout the moraine deposits, and postglacial erosion has been insufficient to reconcentrate it or to form new placers in its stead. Colors can be found in almost all the streams of the foothills, but gold in paying quantities has so far not been found between Little Delta and Delta rivers. The streams between Wood and Nenana rivers are peculiar in that in their northward course from the high mountains to the Tanana Flats they cross one or two, and one of them four, hard-rock ridges into which they have cut deep canyons with steep rock walls. Between the canyons the valleys widen out and have developed broad gravel floors. Wide areas in the foothill belt are occupied by high bench gravels, and scattered gravels on the crests of many of the schist ridges give strong evidence that the high gravels formerly covered all of this area north of the main range. All the workable placers have been found in the streams which have cut their valleys into these gravels or which drain areas formerly gravel covered. The high gravels have in many places been shown to carry a small amount of placer gold, and doubtless most of the present placer deposits have been derived from a reconcentration of the gold from these high gravels, although some gold may have been contained in the Tertiary beds and upon their erosion may have been reconcentrated along with that from the high gravels, and some may have been derived directly from the weathering of the schists.

With the exception of Moose Creek, a tributary of the Nenana, on which pay was first found in 1909, the list of producing creeks is much the same as it was when visited by Prindle in 1906, and the total number of men engaged in mining or prospecting is smaller than at that time. The creeks which were producing during the last season

are Moose, Totatlanika and its tributaries (Homestake, California, and Rex), two tributaries to Tatlanika from the east (Grubstake and Roosevelt), Gold King, and Portage creeks.

### MOOSE CREEK.

Moose Creek is a small tributary of the Nenana from the east, joining that river about 10 miles above the Tanana Flats. It heads in a rounded schist ridge which was once capped by high gravels, and some remnants of these gravels still remain. The stream in its upper course occupies a valley cut in the schists, then cuts through beds of the coal-bearing series, below which it emerges upon the gravelly flats of the Nenana. The first production of consequence from this creek was in 1909, when it was reported that 100 ounces of gold was recovered during the last three weeks of the season, the pay being taken from a gravel bench with schist bedrock. It seems probable that the gold is a reconcentration from the high gravels which once covered the schist but most of which have now been removed by erosion. Seven men are reported to have been mining on this creek during 1910.

### TOTATLANIKA BASIN.

*Totatlanika Creek.*—Totatlanika Creek is a stream of considerable size which enters the Tanana Flats about 16 miles east of the Nenana. It drains a basin in the hills about 275 square miles in area. It is formed by the confluence of a number of creeks which head in the high schist ridge north of Healy Fork. Below their confluence the stream flows through a succession of rock canyons and broad, open areas, the floor being narrow and difficult to travel in the canyons on account of the swift current of the stream, the steep rocky walls against which the stream cuts on one side or the other, and the accumulations of large bowlders and coarse blocky talus from the walls above. In the more open spaces between the canyons the valley floor widens, having a breadth of several hundred feet in places, and is composed of cobbles, fine gravels, and sands. The more important tributaries which join the main stream are Homestake, Buzzard, and California creeks below its junction with Rex Creek.

During the last six years a large number of men, encouraged by colors which can be found in almost all parts of the valley, have prospected along this stream from its head to the mouth of the lower canyon, and most of it has been staked during this period. Especially in the canyons where the gravels are shallowest are to be seen numerous old prospect pits and cuts. During 1910 all attempts to work ground on this stream had been abandoned except on a single claim, 2 miles below the mouth of Homestake Creek, where five men were engaged in mining. It is reported that the ground worked was yielding considerably more than wages.

There is abundant water for mining throughout this valley. In fact, the labor required in building wing dams and bedrock drains makes prospecting expensive even in periods of moderate run-off, and in times of high water the control of the stream is a serious problem to the prospector.

*Homestake Creek.*—Homestake Creek is a small tributary of the Totatlanika from the southwest and joins that stream in its upper canyon. Owing to the custom common among prospectors of giving different names to different parts of the same stream, the lower portion of this tributary is called Homestake and the upper portion Platt Creek. It heads in a broad, rolling depression bordered by schist ridges which extends between the Nenana and the head of Tatlanika Creek. This basin is underlain by unconsolidated beds of sands, clay, gravel, and lignite. Two miles below its source it leaves the open country to enter a narrow, steep-walled canyon through andesite mountains, broadening again somewhat before it joins the Totatlanika.

This valley has been prospected throughout its length, but workable placers have been found only in the canyon and in the open part of the valley just above it. Here mining has been in progress since 1906. The gravels are about 6 feet deep and lie on a decayed schist bedrock. The values occur in a well-defined pay streak 30 to 60 feet wide carrying reported values of about $3 to the cubic yard, the gold being found either on bedrock or in thin beds of oxidized yellowish gravels and sands. The ground being worked at the time of the writer's visit evidently received its gold from a small tributary which enters at that point. The gold is somewhat rusty and rather coarse, numerous pieces valued at $3 to $5 having been found. The greatest drawback to mining this ground is the scant water supply, less than a sluice head being available through the summer, so that it is necessary to hold the water with a dam until enough has accumulated to give a good volume for groundsluicing and to supply the sluice boxes.

In the canyon of Homestake Creek, below the mouth of a small tributary called Ptarmigan Creek, three men were engaged in mining, having been at work on this ground since 1906 with the exception of the season of 1908. Here the gravels average about 6 feet deep and lie on either a schist or an andesite bedrock. The values occur in a pay streak about 25 feet wide, and the gravels are reported to yield from $3 to $9 per square yard of bedrock. A sluice head or more of water is available for a season of about 80 days.

From the character of the gold and its distribution it seems probable that it has been derived from deposits of high gravels, most of which have now been removed by erosion.

It is estimated that the total production of Homestake and Platt creeks from 1906 to 1909, inclusive, has been about $50,000.

*California Creek.*—California Creek, which joins the Totatlanika at the head of its lower canyon, drains a considerable area in the vicinity of Jumbo Dome and has developed two canyons at points where it crosses schist ridges. Most of its course, however, is through a broad open country of rounded hills of gravels, sands, and lignite beds. Colors can be found in many parts of the basin of this stream, although no information was obtained of gold having been produced in commercial quantities. During the season of 1910 work was being done in but a single locality at the head of a canyon some 5 miles above the junction of California Creek with Rex Creek. Here two men had constructed a bedrock drain, in gravels about 6 feet deep lying upon a schist bedrock. At the time of visit the gold content of the gravels had not yet been determined, though panning tests seemed to show fair values.

*Rex Creek.*—Prospecting on Rex Creek has been carried on intermittently since 1905 by a number of men with but indifferent success. The creek, a tributary of the Totatlanika, heads in schist hills, some of which still have a portion of their ancient gravel capping. Some of its tributaries have sharp V-shaped valleys cut into the schist, but the valley of the main stream is broad and open and in its lower reaches lies in beds of sands, clay, and white quartz gravel, with some beds of lignite which are thought to correspond with the base of the Tertiary as exposed in Healy Creek.

Both the gravels of the main stream and the low bordering bench gravels carry gold which is in places sufficiently concentrated to yield good pay. The values, however, are unevenly distributed, especially on the benches, and no well-defined continuous pay streak has been found on them. In the main stream the difficulties of securing proper drainage have prevented thorough prospecting. The water supply on upper Rex Creek is too small for extensive workings, between one and two sluice heads being available during the summer.

The ground worked ranges up to 6 or 8 feet in depth, the pay all being found close to bedrock, which consists of decayed schist and into which the gold has penetrated to a depth of about a foot. The gold is bright and fairly coarse, and the gravels contain no bowlders too large to handle.

### TATLANIKA BASIN.

*Tatlanika Creek.*—Tatlanika Creek drains an area east of the basin of the Totatlanika, the streams being 8½ miles apart where they reach the Tanana Flats. It is formed by the union of Sheep and Last Chance creeks, both of which head well back in the high mountains. These streams on emerging from the main range cross areas of much

slighter relief, then enter gorges cut through quartz-feldspar schists, and below their junction enter a broad open basin in unconsolidated sands, clays, gravels, and some lignite, through which the stream has developed a gravel floor many hundreds of feet in width. The coal-bearing series at this place is thought to be much younger than that occurring on California Creek. Through this broad basin the stream continues for more than 10 miles, abruptly entering another rock canyon from which it enters the gravel plain of the Tanana. In the basin above the lower canyon the Tatlanika receives tributaries from both the east and the west, those from the east being somewhat larger and having more deeply incised valleys. Three of the eastern tributaries, Grubstake, Roosevelt, and Hearst creeks, have yielded placer gold.

*Grubstake Creek.*—Mining has been carried on more or less continuously on Grubstake Creek since 1905, though only a few men have been employed there at any one time. The valley of the creek lies along the line where the high gravels join the schist ridge to the south and the basin includes portions of both the schist and the high gravel areas. Workable placers have been found only for a mile or two above the mouth of the stream, which has here cut a valley 200 to 300 feet deep through a wide gravel terrace into the beds of the underlying coal series. Where the stream gravels are worked they lie on a soft bedrock of clay, sand, or coal, the pay being found in the lower foot or two of the gravels or on the bedrock. The pay streak varies from 25 to 75 feet in width, and the gold is flat, well worn, and rather fine, containing few coarse pieces. Though the gravels contain some bowlders of a large variety of rocks, derived both from the high gravels and from the schist, most of the material is small enough to be easily handled. About one sluice head only of water is available throughout the season, so that operations are restricted to open-cut workings. It is reported that in 1910 two men were mining on this creek in ground which yielded a satisfactory return.

*Roosevelt Creek.*—Roosevelt Creek joins the Tatlanika about 3 miles below the mouth of Grubstake Creek. It heads in a high ridge composed of unconsolidated gravels, sands, and clays and has no hard bedrock within its basin. The workable placer ground lies in the lower 2 or 3 miles of the valley, which is here comparatively shallow and open, without high bordering ridges. The placer deposits occur in stream gravels supplied by erosion of the high gravel covering of the ridge in which the stream heads, and the placer gold is doubtless the product of the reconcentration of gold from the same high gravel beds. In the absence of hard bedrock the gold is concentrated on a soft bedrock, consisting of clayey or sandy layers of the coal-bearing series into which the stream has cut its channel.

The ground worked is shallow and the values are obtained from a pay streak 20 to 60 feet wide. The gold is flat and fine, and its worn appearance indicates that it has traveled far from its original source. An insufficient water supply has retarded development on this creek, and the production for the last few years has been unimportant. Mining was in progress at one place on a small scale during the season of 1910.

*Hearst Creek.*—Hearst Creek enters the Tatlanika from the east, a little more than a mile below the mouth of Roosevelt Creek, and also heads in the unconsolidated deposits, with the lower part of its valley cut into the sands and gravels of the coal-bearing series. In the absence of hard bedrock the gold has been concentrated upon the more favorable of the unconsolidated beds. Since 1905 a few thousand dollars' worth of gold has been recovered from this valley, but no information could be obtained of mining there during 1910.

### GOLD KING CREEK.

Gold King Creek is the first stream of importance east of the Tatlanika and flows through the foothill belt with a course somewhat east of north to the Tanana Flats, in which it joins Wood River. It heads in a high ridge of quartz-feldspar schists through which it has cut a deep notch. From the schists it passes out into the area of high gravels, and its valley 10 miles below its head is incised 1,200 to 1,500 feet below the surface of the ridges to the east and west. These ridges were originally part of a gently sloping plain built up of gravels from the mountains to the north, and in many places portions of the original surface of this plain are still preserved. The materials are for the most part well-washed gravels of moderate size, with some sandy and clayey beds, but some portions of the deposit contain bowlders as much as 2 feet or more in diameter. The bowlders and pebbles are all of rocks which can be recognized as having come from the ridges to the north. The stream was nowhere observed to have cut down into the coal-bearing series which probably underlies the gravels.

Mining has been carried on in the stream gravels of Gold King Creek since 1903. The ground worked has ranged in depth from 2 to 8 feet, the principal drawback being the presence of many large bowlders, derived both from the rocks at the head of the valley and from the high gravels. The natural tendency for a stream cutting through gravel beds is to concentrate the large bowlders as well as the heavy metallic contents in the stream channel, the finer and lighter material being carried away. Water is usually sufficient for small mining operations, three or more sluice heads being available even in periods of low water, and in wet seasons the flow of the stream is large. The gold is said to assay $17.82 an ounce and is flat, well

worn, and rather fine. It is found either in the stream gravels or on a soft clayey bedrock. In 1910 mining operations were conducted on two claims, Nos. 19 and 21 below Discovery, and the yield at both places was reported to be satisfactory.

In the valley of Gold King Creek, as well as at a number of points in adjacent creeks, large areas of ground have been staked by those who intend to mine the extensive deposits of high bench gravels into which the stream valleys are cut and which cover a wide area all along the foothill belt in this region. These gravels in the valley of Gold Creek are more than 1,000 feet in thickness and no facts are known as to their depth in the valley bottom. For a number of years these high gravels have been known to be gold bearing, and from them many of the producing placers have been derived by stream concentration. Reports of men who have prospected in different parts of the high-gravel area show their gold content to range from fine colors to 3, 5, and even 15 or 20 cents to the cubic yard. The lower returns are usually from the gravels near the tops of the ridges, and the higher values have been found along the lower slopes. This fact is significant and probably indicates that the values in the richer ground have come from a concentration by erosion from the gravels above rather than that the actual gold content of the gravels increases as the deeper-lying beds are reached. Further evidence of the low average content of the high gravels can be obtained by comparing the amount of material eroded in those valleys which lie wholly within the area occupied by these gravels and the richness of the placers in these valleys. Although some of the gold derived from the high gravels might well be expected to have moved on down these streams, yet if the original gravels carried any considerable values it would be expected that the present stream gravels would be much richer than developments have so far proved them to be. Great care should therefore be exercised when prospecting the high gravels to drive tunnels far enough into the deposits to reach undisturbed beds which have certainly not been enriched by gold from above. Only by careful sampling in this way can the actual gold content of the beds be determined.

By far the largest project under way in the Bonnifield region, and one which may have a most important influence upon its future development, is that of the Berry & Hamil Co., which is making preparations to mine on a large scale the high gravels in which the basins of Gold King and Bonnifield creeks have been eroded. The company controls a large acreage of land in these two valleys. No mining has so far been done, but during the last summer 45 men were employed in building ditches and roads, erecting buildings, etc. It was expected that the ditches would be completed during the summer so that active work might be commenced early

in the spring of 1911. The ditches include one 2½ miles long and one 2 miles long, to take water from the heads of Mystic and Moose creeks, respectively, and drop it into the upper end of the Gold King drainage basin; another, 6½ miles long, to take the water from upper Gold King Creek to the cut on claim No. 5 below Discovery; and a fourth, a little more than a mile long, from Gold King to the cut. The long ditch, which is to supply water under pressure for the hydraulic giants, will carry 3,000 miner's inches of water and will give a head of 700 feet at the cut. This is more pressure than will be needed, but the ditch has been so laid out that its continuation will cross the ridge into the Bonnifield basin and will furnish sufficient water for operations on both streams. The giants, with 4-inch nozzles, have been set, and the cut opened so that sluicing may be begun without delay. The timber for flumes, sluice boxes, building, etc., is sawed at the company's mill located some miles below the mine workings. Most of the upper portion of the valley is timberless. So far as could be learned on the ground it appears that the deposit to be worked has not been extensively prospected, and its gold content can be accurately known only when some considerable body of it has been sluiced. Conditions should be favorable here for the handling of ground at a very low cost per cubic yard, as a very high gravel face will be had when the cut is run back into the hill a few hundred feet. Furthermore, although some large bowlders occur in the gravels, most of the material is fine enough to be readily handled with the giants, and with the high pressure available it is largely a question of water supply. If the ground proves to be rich enough to warrant it mining will be established on a permanent basis in this region, as the gravels are practically inexhaustible and are so widely distributed that the water from a large number of streams could be used in their exploitation.

### DRY CREEK (LITTLE DELTA DRAINAGE).

Dry Creek heads in the high schist mountains and flows north to the Tanana Flats, draining a basin which lies just east of that of Wood River. In the foothills the stream has a large volume of water, but much of its water is said to sink into the gravels and disappear soon after reaching the flats. Above the mouth of Newman Creek, its largest tributary from the east, the valley is cut into schists. Below Newman Creek, for a distance of 5 miles, the stream flows through a wide valley cut through high gravels into the coal-bearing formation, then enters a schist canyon through which it flows for about 5 miles, emerging into the broad, flat valley of the Tanana.

The stream gravels of Dry Creek are known to carry gold, and the valley floor has been staked for a few miles above the mouth of Newman Creek and considerable prospecting done. The gravels are from

4 to 8 feet deep and lie upon schist bedrock. Pay as high as $3.50 per square yard of bedrock has been found, but large bowlders are numerous and the ground proved too wet to work without establishing a bedrock drain, an undertaking which has so far discouraged the owners.

Caribou Creek, a tributary of Dry Creek from the west about 7 miles below the mouth of Newman Creek, flows through a valley which is in high gravels at its head but in schist in its lower portion. In 1909 two men made fair wages by working the stream gravels, but the ground appears not to have been rich enough to encourage them to return, and no work was done on this stream during 1910.

Newman Creek drains a basin which includes schists, the coal-bearing series, and high gravels. The stream gravels carry some gold, and the high gravel hills are also auriferous, reported prospects from the upper beds of the high gravels showing a yield of 3 or 4 cents a cubic yard, with values increasing somewhat in the lower beds. At the base of the high gravels, which are similar to those already described for Gold King Creek (pp. 226–228), there is a bed of clean rounded white quartz pebbles, locally known as the "white channel," on which there seems to be some concentration of gold. Newman Creek has so far not produced gold in commercial quantities, but a project is under way to exploit the high gravels on a large scale. One party has staked 125 association claims of 120 acres each in the basins of Newman Creek and West Fork of Little Delta River, water for hydraulicking to be taken from the latter stream. It was expected that the ditch would be surveyed during September, 1910, and active construction started in the spring of 1911.

Portage Creek is a small tributary of West Fork of Little Delta River and has a basin in the high gravels east of the head of Newman Creek. Placer mining of the stream gravels has been carried on continuously for the last five years by one outfit, the pay being concentrated on a clay bedrock. No hard bedrock occurs in this gulch. The total production of the creek to date is estimated at $10,000.

### LODE MINING.

The wide distribution of placer gold in the Bonnifield region has attracted the attention of many prospectors to the search for placer mines, yet comparatively few men have been seriously engaged in the search for the lodes that must have furnished the gold to the gravels. Both the geologic and the physiographic evidence at hand point to the high schist mountains of the Alaska Range as having been the ultimate source of the gold, and these mountains hold forth considerable promise to the hard-rock prospector. Associated with the schists of the main range which have been correlated with the Birch Creek schist of the Fairbanks region, and also cutting the quartz-feldspar

schists to the north, are many intrusive granitic rocks, and there is some reason to believe that the mineralization of the schists may be due to these intrusions. The schists in the neighborhood of such granite and diorite masses are therefore the most promising fields for the search for mineral-bearing lodes. Lode prospecting has so far been confined largely to the basin of Wood River.

### CHUTE CREEK.

Chute Creek is a tributary of Wood River from the east. It is 5 or 6 miles long and flows in a deep narrow-bottomed gorge through a complex series of schists cut by intrusives. In 1908 a certain zone of the schist series was discovered by J. C. Rogers, a prospector, to be considerably mineralized with iron pyrite and to carry gold values. The lode is an altered igneous rock which weathers to conspicuous red and yellow colors and is filled with extremely small cubes of finely disseminated pyrite. The mineralization was observed to occur in a zone which has a width of over 100 feet, striking nearly north and south, and which has a high dip, so that a large body of pyritized rock is exposed. The same rock, or a very similar one, occurs in the valleys of Sheep Creek to the south and of Dry Creek to the east. In 1909 a 3-stamp mill was installed on Chute Creek and operated for about a month. In August of that year the mill was washed out by a freshet and it has since been removed to another part of the country. A 30-foot tunnel driven this year into the ore body shows no changes in the rock other than those due to protection from surface weathering.

The owners report that assays show a yield of $5 in free gold and $4 in concentrates.[1] The rock milled is also reported to have carried values of about $9 a ton. Assays of similar rocks from Chute, Sheep, and Dry creeks all showed traces of gold, though no attempt was made to sample any ore body. If further tests prove the average gold content of this mineralized zone to be anywhere nearly equal to the values reported, there is here an opportunity to develop mines in which the large supply of ore and the favorable conditions for mining should allow a liberal margin of profit over the cost of production. A rather good grade of lignite coal could be procured for power within 5 miles of the ore croppings.

### KANSAS CREEK.

Kansas Creek is one of the larger tributaries of Wood River from the east. In its basin, as well as in that of Copper Creek, which enters opposite Kansas Creek from the west, bodies of a black quartzitic rock which are reported to carry gold values are associated with the schists. The only development work which has been done in these

[1] Brooks, A. H., Mineral resources of Alaska—Report on progress of investigations in 1909: Bull. U. S. Geol. Survey No. 442, 1910, p. 36.

bodies is on Kansas Creek, where, it is reported, a 90-foot tunnel has been driven into such a black quartzitic bed, which shows disseminated pyrite. No report of the assay value of this rock was obtained.

## COAL DEPOSITS.

### GENERAL DESCRIPTION.

The coal-bearing rocks referred to frequently in the preceding pages occupy a large area in the foothills north of the main range. They have their greatest known development and offer the best exposures on the western edge of the area under discussion and were visited as far eastward as Wood River and their approximate distribution mapped by L. M. Prindle in 1906. During the summer of 1910 further information was obtained regarding the areal extent of this important series, and numerous exposures were found which extend the limits of the formation eastward to the neighborhood of Delta River. Reports from prospectors also show that coal, probably of the same age, occurs both east of the Delta and west of the Nenana, so that further investigation may extend this field both east and west much beyond its limits as now known. It also seems highly probable that the coal series underlies parts of the areas of high gravels and of the Tanana Flats. From the facts now known no estimates can be made of the possible coal resources in the region where the formation is completely covered by later deposits, as the coal beds may there lie too far below the surface to be economically available, and the large supply of more easily accessible coal will certainly be used before an attempt is made to use that which is more deeply buried.

The coal-bearing beds, where best known, lie in low troughlike areas between the east-west ridges of schists which form the foothills. The series consists of sands, clays, gravels, and coal, the beds being in general but slightly cemented. The base of the series is composed of beds of pebbles and angular or partly rounded bits of quartz in a matrix of white sandy clay, or of kaolinic material, which where exposed is conspicuous for its whiteness. This is succeeded by alternating sands, clays, and coal, the coal beds being in general thicker toward the base of the series and becoming thinner toward its top. One section shows an aggregate of 230 feet of coal, of which over 200 feet is in beds 4 feet or more thick, and in other less complete exposures the total thickness of coal measured was in many places from 50 to 130 feet, single beds reaching thicknesses of 20, 30, or even 40 feet. In many places, too, certain of the coal beds have been burned out, leaving the adjacent beds burned to a bright tile-red. Where this has occurred, the beds just above are in places brecciated and much disturbed by caving down to fill the void left when the coal burned out. The red baked beds are much harder than the associated uncon-

solidated deposits and have retained the imprints of fossil leaves which show the coal series to be of Tertiary age.

The coal or more properly lignite beds of the Kenai formation vary considerably in character, being firm and compact and commonly very thick lignite beds near the base of the section but becoming thinner and more woody as the upper beds are reached. No openings were seen which would give an opportunity to collect fresh unweathered samples for analysis, but the surface croppings of the lower beds furnish a fuel which has had some small local use and which is said to burn freely and without much ash. Though probably of too low a grade to ever compete with the better coals of the coast for export, it would find a ready market for use in the interior of the Territory. It also offers exceptional opportunities for the development of power in the coal fields for electrical transmission to points in the Tanana Valley. Fairbanks is less than 60 miles from the nearest of these fields and well within the zone of economical transmission.

A heavy series of gravel beds overlies the Kenai formation at many points and was probably once continuous over much of the foothill area, but erosion has now removed the gravels in many places where their former presence is shown only by small patches or by scattered pebbles. The exact stratigraphic position of this gravel series is still in doubt and can be determined only by more detailed investigation. No determinable fossils have so far been found in it. It seems to be distinctly older than the glacial deposits and occurs at elevations above those reached by the ice at its greatest development, being folded and tilted more than the Pleistocene deposits. Near the Nenana it seems to be structurally conformable and continuous with the top of the coal-bearing beds and was thought by Prindle to be a continuation of the Kenai formation. At points farther east, however, it seems to overlie the Kenai unconformably, and the writer is disposed to think that an erosion interval elapsed after the Kenai before the high gravels were laid down. It is possible, however, that different conditions existed in different localities and that the gravels may be continuous and conformable with the coal-bearing beds in some places and unconformable in others.

### LOCAL DESCRIPTIONS.

*Healy Creek.*—The valley of Healy Creek is occupied by the coal formation for about 10 miles above its mouth. In a general way these beds form a synclinal trough with its axis parallel to the valley. The stream follows the trough of the syncline in its upper end, but lower down it crosses some of the beds. The deposits lie in a basin in the schists, upon which they rest unconformably on both limbs of the basin, the dips of the coal beds ranging from vertical in a few places to horizontal at the bottom of the trough. Near the east end

of the coal basin Healy Creek flows for more than a mile in the trough of a coal bed which forms the banks of the stream on both sides. The folded coal beds have suffered vigorous erosion both by streams and by glacial ice and in upper Healy Creek much of the series has been removed. A measured section about 6 miles above the mouth of the stream shows a thickness of about 1,500 feet of these beds, and here the upper part of the series is missing. Near the mouth of the stream a carefully measured section gave over 1,900 feet of the coal series, with about 2,000 feet of the overlying gravels. The coal series may or may not be complete at this point. At the two places where measurements could best be made the total thickness of coal found was, in the section near the mouth of the creek, 230 feet in 23 beds, of which seven beds contain 174 feet of coal. A section 6 miles east of the above showed 130 feet of coal, of which four beds contain 80 feet. As some beds of coal have been burned out in almost all sections examined, the above measurements probably fall short of the original thickness.

*Lignite Creek.*—The Lignite Creek coal basin is separated from that of upper Healy Creek by a high schist ridge, but the two fields are probably continuous at these lower ends. It extends eastward beyond the head of Lignite Creek and includes areas at the headwaters of Totatlanika and Tatlanika creeks. In its eastern end exposures are few and poor, as the streams have made only shallow cuts into the beds, but sufficient outcrops of coal were seen to place most of the basin among the known coal-bearing areas. By far the best exposures are to be found in the valley of Lignite Creek and its tributaries, which have cut sharp, steep-sided valleys as much as 1,000 feet into the coal-bearing beds, without, however, anywhere exposing the underlying schist in the center of the valley, so that the lower part of the series is not shown. The beds, like those in Healy Creek valley, lie in a basin bordered by schist ridges and old intrusive rocks, the beds dipping away from either border toward the center of the valley. Although at some points along the borders the dips are high, being as much as 45° on the south side of Jumbo Dome, in general the coals of Lignite Creek lie much flatter than those of Healy Creek, and through most of the valley they appear to the eye to be horizontal. The beds consist of cross-bedded sands, soft blue shales, some fine, loosely cemented conglomerates and gravel beds, and coal. In the deeper exposures the coal is hard and dense and the beds are heavy, but toward the upper beds the coals become woody and fibrous, with much shaly material, and the beds become successively thinner. As the coal series of lower Healy and Lignite creeks is overlain by a thick deposit of gravels, its actual areal distribution is much greater than is shown by a map of its surface occurrence.

A section of the coal series measured by L. M. Prindle, about 6 miles above the mouth of Lignite Creek, gives 129 feet of coal in a total thickness of 726 feet of beds. Of this more than 100 feet occurs in beds 8 feet or more thick. Another, about 2 miles farther upstream, shows 48 feet of coal in a section 170 feet high. These two exposures show only part of the whole series, and the total thickness of coal in the complete section is doubtless much greater than that of either.

*California Creek.*—California Creek heads on the south side of Jumbo Dome, in the Lignite Creek coal field. North of this dome it flows through another area underlain by the coal-bearing series, which crops at the surface over about 15 square miles. The beds here have the same structural relations as elsewhere, lying in a basin bordered by schist ridges and dipping toward the center of the basin. The dips, however, are gentle, and through much of the field the beds are nearly horizontal or lie in gentle wavelike swells. The streams have nowhere made deep cuts through the coal series, and the thickness seen is probably much less than the actual thickness, as there may be many coal beds below, no surface outcrops of which were seen. The extent of the field is also greater than the surface distribution, for along its western edge the coal beds are overlain by a heavy deposit of gravels. They are composed of sands, shales, and white kaolinic materials containing quartz fragments and pebbles, and beds of lignitic coal. Along the main stream for several miles a heavy coal bed 12 feet thick shows in the stream bluffs, in places dipping below the stream bars but in general lying nearly flat. Other croppings of the same or a similar bed show in tributary valleys to the east, so that it is probable that the field contains at least 12 feet, and probably more, of coal throughout its area.

In the basin at the lower end of California and Rex creeks the beds of the coal series cover an area of about 20 square miles. In character they are similar to those on upper California Creek and are conspicuous for the prominent white bluffs exposed along Rex Creek and for a bright-red color in many places where the coal has burned out and baked the adjacent beds. Some woody coal was seen on a small tributary south of Rex Creek, but no workable coal beds are known in this basin.

*Tatlanika basin.*—On the east side of the Tatlanika Valley, in lower Grubstake Creek and between Roosevelt and Hearst creeks, the clays, sands, and coal beds of the coal series outcrop, and it is reported that similar beds occur as far north as the head of the lower canyon of the Tatlanika. Little is known of the amount of coal present, although a bed 12 or 15 feet thick is said to outcrop at the surface, dipping at a low angle to the east. No development of the coal has been attempted here, but its occurrence is of interest,

as it affords strong additional evidence that the area of high gravels is underlain by coal between Tatlanika and Wood rivers.

*Wood River basin.*—In the valley of Mystic Creek and westward to that of Moose Creek the coal-bearing beds have an area of about 7 square miles. One section shows 30 feet of coal in two beds, and at another point the upper 10 feet of a coal bed outcrops. The coal has here been used for cooking and heating in a camp of 25 men, with very satisfactory results. The total thickness of the series and of the contained coal beds is nowhere exposed.

At the head of Coal Creek, which joins Wood River 4 miles below the mouth of Mystic Creek, the coal series is exposed, dipping steeply from the schist ridge to pass beneath the high gravels north of Coal Creek. No opportunity was had to study this section closely, but some 16 coal beds were seen, the aggregate thickness of which will reach more than 100 feet. In the uplift and crumpling of the beds the coals may have been given a greater thickness here than they possess farther to the north, but unquestionably there is a valuable coal field beneath the high gravels, concerning the extent of which we know little.

*Dry Creek basin.*—In the valley of Dry Creek, at the mouth of Newman Creek, 140 feet of the coal series is exposed beneath the high gravels. Coal beds at this place have been on fire for at least five years and are still burning. Prospect holes and coal croppings, while giving little information in regard to the thickness of the coal beds, show that the series with workable coal beds lies beneath the high gravels on Dry Creek.

Isolated coal croppings in the basins of Little Delta River and Delta Creek also indicate that the coal is widely distributed and may underlie large areas of the high gravels as far east as Delta River.