RECONNAISSANCE IN THE MATANUSKA AND TALKEETNA BASINS, WITH NOTES ON THE PLACERS OF THE ADJACENT REGION.

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INTRODUCTION.

In the following pages are presented the salient features of the geography and geology of a roughly quadrangular area lying adjacent to and northeast of Cook Inlet. The features of direct economic interest will be emphasized here, but the more complete discussion of the geology will be reserved for a fuller report now in preparation. The detailed report will contain a topographic map on a scale of 4 miles to the inch. This same province has been the subject of investigation by Mendenhall,[a] who explored the Matanuska Valley in 1898, and by Eldridge,[b] who explored the Susitna Valley in the same year. In 1905 Martin[c] made a brief study of the Matanuska coal field, which contains the most important of the mineral resources of the province thus far developed. Appended to the present report is a brief account of the more important developments in the placer districts of the adjoining regions.

GEOGRAPHY.

The area studied (see fig. 2) lies partly within the Talkeetna Mountains and partly within the valley of Matanuska River. The Talkeetna Mountains are separated from the main Chugach Range, of which they may be considered a part, by the Matanuska Valley. The Chugach Range trends westward from Mount St. Elias, turns southward at the Matanuska, and forms the eastern mass of Kenai Peninsula. Within the region of the Talkeetna Mountains the peaks rise to a general elevation of 5,000 to 6,000 feet, though altitudes of 8,000 to 9,000 feet are reached in the center of the range.

[a] Mendenhall, W. C., A reconnaissance from Resurrection Bay to Tanana River, Alaska, in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 265-340.

[b] Eldridge, G. H., A reconnaissance in the Sushitna basin and adjacent territory, Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 1-29.

[c] Martin, G. C., A reconnaissance of the Matanuska coal field, Alaska: Bull. U. S. Geol. Survey No. 289, 1906, 34 pp.

Matanuska River rises on the western margin of the Copper River plateau, flows westward and southwestward between the Talkeetna Mountains and the Chugach Mountains, and enters Knik Arm at its eastern end.

The Talkeetna Mountains are roughly divided into two sections by the drainage of Chickaloon Creek and Talkeetna River. The former heads in a glacier and flows southward for about 30 miles, entering the Matanuska about midway in its course. Talkeetna River rises on the northern side of the Chickaloon Creek divide and flows northwestward and southwestward to Susitna River.

The western portion of the region delimited by this division is characterized by a radial drainage, the great majority of the streams therein flowing away from the center of the area. In the eastern portion the drainage is divided between Matanuska and Copper rivers by a northwestward-trending watershed. The recent drainage has incised many steep-walled canyons, and progress, except along the larger river systems, is exceedingly difficult.

GENERAL GEOLOGY.

STRATIGRAPHY.

The rocks of the area investigated display considerable variety, both of age and of character, ranging from highly crystalline mica schists of unknown age to unconsolidated Pleistocene stream and glacial gravels. The following section shows, provisionally, the stratigraphy of this area:

Provisional statement of stratigraphy of Matanuska and Talkeetna basins.

Age.	Character.	Thickness.
		Feet.
Pleistocene	Stream and glacial gravels	300+
Unconformity.		
Post Eocene	Basaltic lavas, breccias, and tuffs	1,000+
Unconformity.		
Upper Eocene (Kenai)	Coal-bearing shales, sandstones, and conglomerates	3,000±
Unconformity.		
Lower Cretaceous	Limestone	300
Upper Jurassic and upper middle Jurassic.	Shales, sandstones, conglomerate, tuff, and arkose	2,000±
Unconformity.		
Lower middle Jurassic	Graywacke, shales, sandstones, and conglomerate	1,000±
	Greenstones, tuffs, agglomerates, and breccias	1,000+
(?)		
Upper Paleozoic(?). (Sunrise series)	Graywackes, slates, arkose, and greenstones	(?)
Upper Paleozoic(?). (Susitna slates)	Slates and graywacke slates	(?)
(?)		
Pre-Silurian(?)	Garnetiferous mica schists, albite-zoisite schists	(?)

The distribution of the above rocks has been indicated in a broad way on the accompanying map (fig. 2). On account of its small scale a condensation of the stratigraphic column was found necessary. An effort has been made, however, to bring out with greater clearness the facts of possible economic importance. The rocks have been grouped as follows:

1. *Granitic rocks, chiefly quartz diorites.*—These are probably intrusive in rocks as high up in the stratigraphic column as the lower middle Jurassic. They apparently make up the main mass of the Talkeetna Mountains, and occur as isolated bosses on the south side

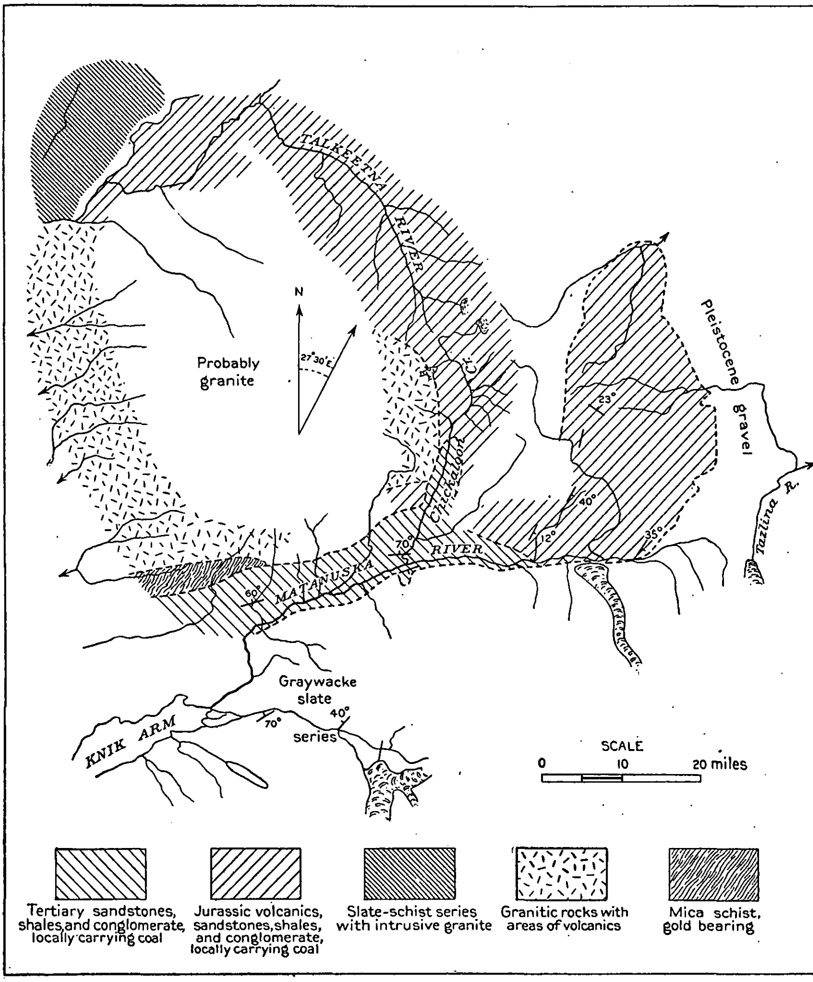

FIG. 2.—Geologic sketch map of region northeast of Cook Inlet.

of Knik Arm. The importance of these granitic rocks lies in the possible mineralization which they may have induced in adjacent formations as a result of "eruptive after-effects." Such a causal relation between intrusion and mineralization has been recognized by Spencer[a] in the case of the Coast Range granites of southeastern Alaska and by Lindgren[b] in California.

[a] Spencer, A. C., Magmatic origin of vein-forming waters in southeastern Alaska: Trans. Am. Inst. Min. Eng., vol. 36, 1906, p. 364.

[b] Lindgren, W., Characteristics of the gold-quartz veins in Victoria: Eng. and Min. Jour., 1905, p. 460.

2. *Mica schists.*—A narrow belt of these rocks borders the granites on their southern side. On account of their strongly foliated and thoroughly metamorphosed character they are regarded as representing the oldest rocks of the region. They possess considerable economic interest from the fact that locally they yield gold-bearing gravels, in places rich enough to be of commercial value.

3. *Slates and graywacke slates.*—These rocks occupy an area near the mouth of Talkeetna River and probably extend up Susitna River. They are known to be more or less gold bearing and have yielded some creek and bar diggings. On account of the lack of fossil evidence the age of these rocks is not known. They show some similarity to the series to be described next.

4. *Graywacke-slate series, including some greenstones.*—These rocks occur on the south side of Knik Arm, and are found striking into the Chugach Mountains on the south side of Matanuska River. They are a continuation of the rocks exposed in the Sunrise district on Turnagain Arm. No fossils have yet been found in them, so that their age is in doubt. They strongly resemble the rocks of Prince William Sound and are regarded by Mendenhall and Moffit as of probable upper Paleozoic age. The slates and graywackes are partially schistose and have been closely folded, uniformly presenting isoclinal dips. They are cut by a great multitude of small quartz stringers, and it is possible that these rocks may yet be found the source of gold placers.

5. *Jurassic.*—All the rocks of Jurassic age have been grouped together on the map. With them is included the lower Cretaceous limestone, whose distribution is limited to the headwater region of Matanuska and Nelchina rivers. These beds contain thin seams of low-grade bituminous coal. This is in marked contrast to certain localities in the Tertiary (Kenai) rocks, where strong seams of high-grade bituminous coal occur, a reversal of the usual state of affairs, in which the older rocks ordinarily carry coal of a higher grade than the younger rocks. In general the Jurassic rocks show only folding of an open character, but minor faulting is of widespread occurrence.

6. *Upper Eocene (Kenai).*—Strata of this age comprise a series of sandstones, shales, and conglomerates, carrying workable seams of bituminous coal, chiefly developed within the lower Matanuska Valley. These beds represent a period of fresh-water sedimentation of upper Eocene age, as shown by the fossil plants contained in them. The rocks are well indurated, and, as first noted by Mendenhall, resemble the Paleozoic coal measures of the Appalachian region. Since they were laid down they have been subjected to sharp folding and now stand in vertical attitude in portions of the area. They are affected by a great number of faults of small throw.

The Kenai rocks of the Matanuska Valley differ markedly from those of the type section of the Kenai as exposed at Kachemak Bay, on Cook Inlet. In this latter locality the sandstones are soft and incoherent, the shales are plastic when wet, and the lignite seams form the resistant members. The beds lie at low angles in undisturbed attitudes. With this lesser degree of alteration and folding may apparently be correlated the fact that the coal of Kachemak Bay is of much lower grade than that of the Matanuska Valley.

The inferior character of the Jurassic coal of the Matanuska region compared to that of some of the Tertiary coal of the same province has already been mentioned. The Tertiary rocks have, as a general rule, been more highly folded than the strata of older age to the north, and it is a fact of some interest that certain *Aucella*-bearing sandstones of upper Jurassic age show a lesser degree of consolidation than the sandstones of the Tertiary.

7. *Pleistocene stream and glacial gravels.*—The larger part of this formation is made up of the glacial and fluvio-glacial gravels which underlie the Copper River plateau to a depth of several hundred feet, as exposed in the gorge of upper Matanuska River. They are probably not of economic importance. These gravels should not be confused with the gravels formed in the present streams.

8. *Dikes.*—In addition to the bedded volcanics of Jurassic and Tertiary ages, dikes and sills of diabase are widely prevalent. They reach their greatest development in the region east of Chickaloon Creek and along Anthracite Ridge between Boulder and Hicks creeks, where they attain a thickness as great as 500 feet. Their texture varies from finely granular to coarse ophitic. They cut all the rocks of the area, and thick sills of diabase are included between strata of Kenai age. It is probable that these sills are the subterranean accompaniments of the great outpouring of Tertiary basalts.

The Tertiary lavas have not been indicated on the map on account of the unnecessary detail which they would introduce. They are widely distributed and cap the older formations, forming many of the peaks and summits of the region.

STRUCTURE.

As Martin has indicated, the general structure of the Tertiary coal-bearing rocks trends northeast and southwest, parallel with the trend of the valley. Open folding parallel with this direction and accompanied by faulting with northeast trend is characteristic. Minor folds with axes in varying directions are present, that at the coal openings on Chickaloon Creek being an example. Here the axis of an anticline and an adjacent syncline trends southeast and northwest.

Along the northern boundary of the field, between Little Susitna River and Eska Creek, the sandstone beds forming the ridge dip steeply to the south. There is physiographic evidence of faulting at the base of this ridge, as well as of block faulting within the lower hills of the valley. A fault occurs near the base of the mountains on Eska Creek. Another may be observed on Chickaloon Creek, near the northern edge of the valley. The trend of these faults and their occurrence in rough linear arrangement along the northern boundary suggest structural rather than erosive origin of the Matanuska Valley.

East of Hicks Creek the older rocks of Jurassic age do not present the same structural features. The sediments of the upper Jurassic trend northwestward, whereas those of the lower middle Jurassic strike in a northeasterly direction. Block faulting and open folding are present in both of these formations also. More data must be collected before the nature of the relations of the older rocks to those of Tertiary age can be clearly understood.

ECONOMIC GEOLOGY.

COAL.

AREAL DISTRIBUTION.

So far as known, the Tertiary coal-bearing rocks occurring in the Matanuska basin cover an area of about 380 square miles. Coal-bearing rocks of Mesozoic age developed in the upper Matanuska basin cover approximately 500 square miles. The areal extent of these divisions is shown on the map (fig. 2, p. 106) and the character of the beds has been described above. The mapping of the coal-bearing rocks must in no sense be taken to mean that areas so mapped are underlain by workable coal seams. So far as known, the actual area underlain by coal from Tsadaka Creek to Hicks Creek, inclusive, approximates 70 square miles. Localities where coal of commercial importance has been observed will be described.

There are three kinds of coal within the region—anthracite coal, confined to a small area in the Mesozoic rocks; high-grade bituminous coals, occurring in the eastern portion of the Tertiary field; and high-grade lignite, found in the western division of the Tertiary field and in certain localities in the upper Matanuska Valley associated with Mesozoic rocks.

Coal outcrops have been observed on Tsadaka, Eska, Kings and its tributaries, Chickaloon, and Coal creeks; on the small streams heading in the Talkeetna Mountains between Boulder and Hicks creeks; on Hicks and Billy creeks; and on the banks of Matanuska River about 3 miles above the mouth of Chickaloon Creek. They have also been reported from Boulder and Caribou creeks, from a creek on the south side of the Matanuska 9 miles above Coal Creek, and from Little Susitna River.

Last season's work extended the known area of Tertiary coal-bearing rocks approximately 18 miles up Chickaloon Creek, though no outcrops of coal were observed. The discovery of an area of Mesozoic rocks in the upper Matanuska Valley also extends the field in that direction, as indicated on the map, though all the outcrops of coal north of Anthracite Ridge, which lies between Hicks and Boulder creeks, are of a lignitic nature.

The following paragraphs contain a brief description of the several localities where coal has been observed:

ANTHRACITE.

Anthracite occurs along the flanks of the Talkeetna Mountains, between Boulder and Hicks creeks. It has the ordinary physical characteristics of most good coal of this kind, being heavy, firm, hard, and not much fractured. It has a high luster. The seams are not much broken by small partings of shale and bone. Two sections were measured by Martin. One, on the south side of Purinton Creek

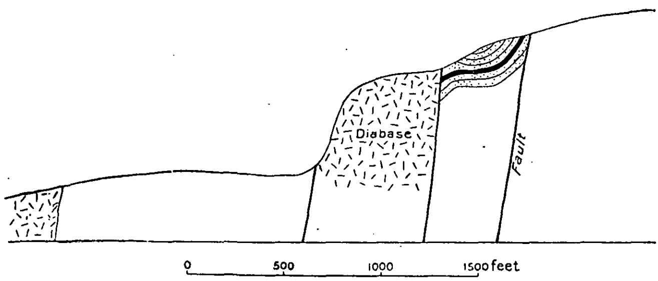

FIG. 3.—Cross section showing relation of anthracite to intrusive diabase near Purinton Creek.

at an elevation of 3,410 feet, showed 38 feet of clean coal with both roof and floor concealed. At this point the rocks strike N. 40° E. (magnetic) and dip 10° NW. into the mountain. The rocks in the vicinity are chiefly graywacke and sandstone and show considerable variation of strike and dip. A mass of diabase occupying the axis of an anticline which is in other places broken by a fault occurs a short distance below the coal.

Martin [a] states that "the anthracite is probably restricted to a zone along the face of and in the mountains which is cut off from the valley plateau by a fault following the base of the mountains."

About a mile northeast of this locality, at an elevation of 3,460 feet, the second section measured by Martin showed four seams of coal aggregating a thickness of 21 feet. The strike is N. 60° E. and the dip 55° SE.

Two sections measured during the last season, farther east on the ridge, showed in one place 7 feet of coal more or less mixed with shale,

[a] Op. cit., p. 18.

and in the other an aggregate thickness of 11 feet 6 inches of coal, though no seam exceeded 2 feet 6 inches in thickness. At the first locality the strike is N. 70° W. (magnetic) and the dip 40° S.; at the second the strike is N. 80° E. (magnetic) and the dip 34° S.

In a small creek west of Purinton Creek is exposed a synclinal of coal, 3 feet thick, cut off by a heavy diabase dike, as shown in fig. 3.

It is believed that the anthracite of this region covers only a small area. The rocks are closely folded, and the seams are cut off by thick diabase dikes. Though it is not certain that the intrusion of diabase dikes is the cause of the anthracitic nature of the coal in this vicinity, its presence at least suggests the possibility of such an influence. At other localities in areas of Tertiary rocks diabase dikes are found in immediate contact with bituminous coals, which in some places have been altered to a dense coke. None of these latter coals can be classed as anthracite. However, in the vicinity of the anthracite, diabase is present in greater mass than elsewhere observed near the coal, and it is reasonable to suppose that the heat derived from its presence was at least a supplemental agency in causing the formation of anthracite.

BITUMINOUS.

The bituminous coal field of the lower Matanuska Valley may be divided into two districts—the eastern and western. Under the first may be included the coals of Kings and Chickaloon creeks and those on both sides of the Matanuska in the vicinity of Chickaloon Creek; under the second, the coals of Tsadaka and Eska creeks.

EASTERN DISTRICT.

Martin [a] states in regard to the coal of the eastern district:

> The coal in this area all possesses about the same physical characteristics, and, as will be seen by the analyses, the variation in chemical composition is not great and supports this grouping. It has the ordinary properties of most bituminous coal. It is soft and fragile, but often without any well-defined planes of fracture. It burns with a short flame and a small amount of smoke and possesses distinct caking properties. The seams generally contain a large amount of impurities, both in the form of thick partings of shale and as thin bands of shale and bone. Many of these can not be separated in mining. The coal is soft and friable, and much of it will not stand severe handling without crushing. Pyrite is present both as balls and as scales, but not abundant. The friable character of the coal is not a great detriment when it is considered that much of it will probably have to be crushed and washed (especially for coke making) and that the coal when used for steam or heating will cake as soon as put in the furnace, so that there will consequently be little or no loss through the grates.

On the south bank of Matanuska River, 3 miles above the mouth of Chickaloon Creek, three coal seams have been found. The upper seam, 7 feet thick, is separated from the middle seam by 43 feet of shale and a 6-inch stringer of coal. The lowest seam, 5 feet 8 inches thick, is separated from the middle seam by 13 feet of shale, which

[a] Op. cit., p. 19.

includes an 8-inch and a 6-inch seam of coal. The strike at this locality is N. 36° E. (magnetic) and the dip 44° SE.

On Coal Creek, which enters the Matanuska from the south a short distance above Chickaloon Creek, coal occurs at three localities. At the first, at an elevation of 1,010 feet, three benches of coal, 2 feet, 1 foot 5 inches, and 1 foot thick, are separated by sandstone and shale partings. The strike is N. 64° E. and the dip 70° SE. About 500 feet farther upstream coal seams are seen intruded by sills of igneous rock. Here 5 feet 5 inches of coke occurs under an intrusive sill 12 feet thick, mixed with coke and overlying a second intrusive sheet 14 feet thick. Ten feet below this second sheet 6 feet 3 inches of coal, followed by two small seams 6 inches and 9 inches thick, may be seen. The strike and dip are as above. Half a mile above the first coal described a 6-foot seam may be observed striking N. 60° E. and dipping 55° NW. It may be seen from this northwestward dip that a possible syncline exists between this upper coal and the two localities

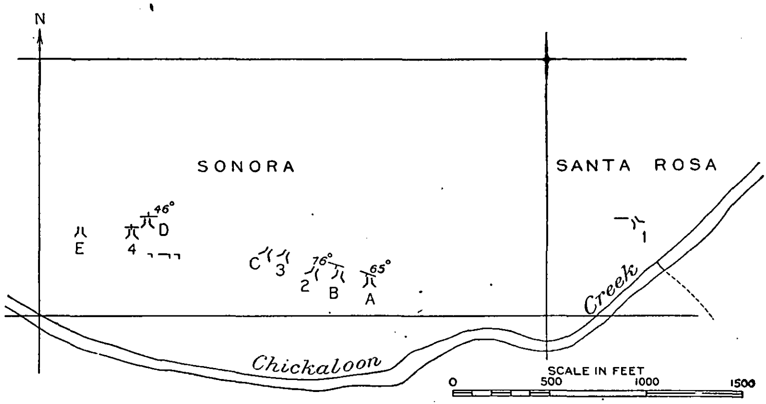

FIG. 4.—Sketch showing location of Chickaloon tunnels.

previously described. As the mouth of Coal Creek is approached a flattening in the dip may be observed, and on crossing the Matanuska and ascending Chickaloon Creek a quarter of a mile an anticline with axis striking N. 50° E. is found crossing the creek. The limbs of this anticline dip at an angle of 30°. Coal was observed in it, but measurements could not be made.

At a point on Chickaloon Creek 1¾ miles above its mouth, but only half a mile in a straight line from the Matanuska, the most important coal openings of this region have been made. Nine tunnels have been driven, crosscutting a number of coal seams cropping in a steep bluff on the north bank of Chickaloon Creek. (See fig. 4.)

Only the thickness of the coal measured in the several tunnels will be given here, the more complete section being reserved for a detailed report. The change of direction of dip which is evident between tunnel D and those farther east (C, 3, 2, B, and A) may possibly be explained by the presence of an anticlinal axis passing westward from the anticlinal fold at tunnel No. 1, or possibly by irregularities in beds representing the south side of such an anticline. It has been found difficult to correlate the several beds within these tunnels, because of striking irregularities in their thickness. In tunnel A three seams were seen. The first at the face measured 16 feet 7 inches, in which is included a 9-inch layer of bone and coal 1 foot 2 inches from the bottom. The second seam is small, containing but two narrow 8-inch layers separated by 5 inches of bone and shale. The third seam is 3 feet thick and occurs 77 feet from the mouth of the tunnel.

In tunnel B as many as six distinct seams were measured. Several of these, however, contain intervals of shale. Near the face of the tunnel a 2-foot 1-inch seam occurs in which is included 4 inches of bone. On passing outward a thickness of 5 feet 9 inches of sandstone brings the section to a 17-foot 3-inch seam. As in tunnel A, a 1-foot interval of bone is seen near its floor. This seam is undoubtedly to be correlated with the thick seam of tunnel A. Toward the mouth of the tunnel the following coal occurs: A 6-foot seam of bony coal in which is included a foot of sandstone; a 2-foot 4-inch seam of coal; a 7-foot 6-inch seam, at the top of which is 1 foot of bone. Two feet below this seam is 3 feet 7 inches of coal, 7 inches of which is bone.

In tunnel No. 2 a thick bony seam that occurs in B was measured, but shows 12 feet 11 inches. It is in this tunnel very bony and includes 1 foot 6 inches of shale near its middle. A drift has been run from B to No. 2, so that there is no doubt of the correlation. A second seam, separated from this one by 18 feet of shale, measures 4 feet, 7 inches of which is bony.

Tunnel No. 3 reveals the thick seam at the face. Its total width could not be seen, but 7 feet 10 inches may be measured, including a 2-foot interval of shale which probably corresponds to the 1 foot 6 inches of shale in the same seam in tunnel No. 2. The second seam of tunnel No. 2 has in No. 3, 2 feet 5 inches of very bony coal in its center. Its total width is 16 feet 2 inches. About 20 feet from the mouth of tunnel No. 3 a third seam measures 4 feet 1 inch. Small streaks of bone occur in it.

In tunnel C but one small seam was measured. It was 4 feet thick, 2 feet of which was coal with shale.

In tunnel D two seams of crushed coal, each 2 feet 6 inches thick and separated by 49 feet of sandstones and shale, were seen.

In tunnel E 10 feet 11 inches of coal containing several 6-inch streaks of bone and 2 feet of crushed shale mixed with coal was seen.

At the face of tunnel No. 4 a thickness of 5 feet of crushed coal was exposed

Considerable variation in the thickness and in some places unexpected interruptions of the seams are disclosed in these tunnels. Whether faulting or pinching out of the coal be the explanation, further work must show. The rocks in the near vicinity are closely folded, and faulting, with the added difficulties of mining which it incurs, should be expected.

On Kings Creek, 7½ miles above its junction with the Matanuska, coal seams are cut by the creek, on both sides of which they were measured. A seam of impure coal 6 feet 6 inches thick, overlain by 5 feet 5 inches of dense impure coke, is seen on the east bank. On the west bank coal occupying a stratigraphic position approximately 6 feet lower than this seam measures 10 feet in thickness. In it are several streaks of bone 4 to 8 inches in width. The strike is N. 42° W. (magnetic) and the dip 42° NE. A short distance upstream from the exposure on the east side the sandstone beds are considerably disturbed. Folding or faulting, or possibly both, has occurred.

On Young Creek, a tributary of Kings Creek from the west, 1 foot 1 inch of coal was seen by Martin, and below it a 6-inch seam was found. Workable seams are reported on this creek. The strike of the beds at this locality is N. 15° E. (magnetic) and the dip 20° NW.

WESTERN DISTRICT.

The coal of what has been termed the western district—i. e., that occurring on Tsadaka and Eska creeks—is a bituminous coal of low grade. Its physical properties are much the same as those of the coals farther east. Most of it is bright and hard, though dull shaly bands are numerous. On Eska Creek, at an elevation of 875 feet, 7 feet 8 inches of coal in which are included four shale streaks and some bony coal was measured. The strike is N. 30° E. (magnetic) and the dip 44° NW.

About 300 feet farther upstream 7 feet of coal is exposed, 15 inches of it being made up by the shale streaks. This coal dips to the northwest.

About 600 feet above the section first cited 2 feet 6 inches of clean coal and 1 foot or more of dirty coal may be seen dipping 32° SE.

On the west bank of the creek, at an elevation of 1,030 feet, a steep bluff made by stream erosion reveals a number of seams of coal. A marked fault cuts this bluff. The strata above it, in which the coal was measured, strike N. 40° W. (magnetic) and dip 40° SW. Below the fault the beds strike northeastward and dip to the southeast. At the top of this section are three seams, none of which exceeds 2 feet 3 inches in thickness. They are separated by small intervals of shale. About 12 feet lower in the bluff follow coal and shale bands aggregating 12 feet in thickness, but containing no solid coal thicker than 2 feet 1 inch. Two 1-inch seams separated by 2 feet of shale occur 12 feet lower.

On Moose Creek about 11 feet of good coal is exposed 100 yards below the upper cabin. The seam strikes N. 80° E. and dips 45° N. A strike fault dipping 80° S. can be seen crossing the bed, with a throw of about 5 feet. An eighth of a mile downstream from this exposure a sharp syncline crosses the creek, with axis striking about S. 70° E. and dipping steeply to the west.

A short distance farther downstream coal beds are exposed striking N. 70° E. and dipping 60° N. This direction does not accord exactly with the synclinal axis. In these beds the thickest seam measured 3 feet 6 inches of clean coal. Higher in the section were found two seams, each 1 foot 7 inches thick, but consisting partly of bone.

On passing up Moose Creek and following the ridge on its southern side sandstones may be observed dipping to the southeast, which is the opposite direction from that of the beds just described. Still farther east conglomerate beds dip to the southwest. There is undoubtedly block faulting within this area, and should the coal beds be followed eastward it would probably be encountered.

It will be noted that at nearly all the localities above described faulting or folding is present. Such a condition will surely place the cost of mining higher than it would be if the beds were less disturbed.

LIGNITIC COALS.

At various points in the region north of Matanuska River thin seams of coal were found in rocks of Jurassic age. None exceed 3 feet in thickness. In the vicinity of Billy and upper Caribou creeks the highly shattered condition of the strata is unfavorable to the presence of workable deposits of coal.

On Billy Creek is exposed an interesting section showing very clearly the complex history through which the coal has gone since its formation. The coal-bearing strata have been folded into a closely appressed anticline. Subsequently they have been cut by basaltic dikes, coking the coal at the contacts. The dikes have been faulted, with a displacement of 5 feet, and the coal has been crushed and sheared, and finally small stringers of quartz, 2 to 3 inches thick, have been formed, accompanied by veinlets of calcite in the coal.

GOLD.

DISTRIBUTION OF GOLD-BEARING ROCKS.

Gold-bearing rocks are found over considerable areas in the region adjacent to Cook Inlet. A graywacke and slate series cut by small quartz stringers occupies the eastern part of Kenai Peninsula, extends across Turnagain Arm, and may be seen in the valley of Knik River still farther north. The search for placer gold in rocks of this type is warranted and discoveries of commercial quantities may be expected where they appear.

North of Matanuska River, on the southern margin of a granite mass, occurs a band of highly crystalline mica schist. It is closely folded and infiltrated with fine quartz stringers, and streams cutting it yield gold placers. It is noteworthy that the igneous rocks, granitic and volcanic, to which this schist gives way on the north and east have so far proved barren of workable placers.

To the northwest, near the mouth of Talkeetna River, a slate-schist series, folded, intruded by granite, and containing abundant quartz stringers, represents the gold-bearing rocks. Eldridge[a] reports the occurrence of similar rocks north of the Susitna-Tanana divide. Some gold has been found in the past on streams heading within this formation. The gold-bearing gravels of the new Yentna district are reported to have a slate bed rock, indicating the presence of the same formation.

Though there is yet some question as to the relative ages of these several series of rocks, there is little doubt that their economic importance is due to the mineralization accompanying local infiltration of quartz stringers. In the subsequent wearing away of the rocks the gold content therein has been concentrated in the form of placers.

Though placers have not been found within the areas of older volcanic rocks, some mineralization has occurred. West of Hicks Creek a large cropping of gossan was found. This gossan is due to the oxidation of finely divided pyrite disseminated through a quartz porphyry. A sample selected for assay showed a trace of gold and no silver.

The whole southern flank of Sheep Mountain, at the head of Matanuska River, is colored a strong red from the oxidation of pyrite in the greenstones. At some points the sulphuric acid formed during the oxidation of the pyrite has bleached the greenstones entirely white, and this bright color, contrasting vividly with the red, produces a marked scenic effect. Certain streams emerging from the range are so highly charged with iron salts as to coat their gravels red with oxide. The mineralization of the greenstones, which are here roughly schistose, is extensive but diffuse. An assay showed the presence of a trace of gold, but no silver.

DESCRIPTION OF LOCALITIES.

WILLOW CREEK.

Placer gold is being mined in commercial quantities only at one locality within the area covered during the season—on Grubstake Gulch, a southern tributary of Willow Creek, which enters Susitna River about 30 miles above its mouth. Willow Creek proper was staked by M. J. Morris and L. Herndon in 1898, and it is reported that

[a] Eldridge, G. H., A reconnaissance in the Susitna basin and adjacent territory, Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 15–16.

they extracted about $4,000. In 1899 A. Gilbert staked Grubstake Gulch and in 1900 sold his interest to O. G. Herning, who manages the property for the Klondike Boston Mining Company, of Boston, Mass.

The valleys of Willow Creek and of the small tributary gulches show clearly the results of ice action, the side streams occupying hanging valleys, with steep gradients or falls where the smaller streams join the main watercourses. Grubstake Gulch is an example of such conditions. Near its mouth a rim of bed rock crosses the stream and is cut through by the present stream, which falls precipitously about 150 feet in a very short distance and enters Willow Creek at a low gradient. An excellent dump for hydraulicking is thus afforded. The bed rock is a mica schist, penetrated by minute veinlets and augen of quartz. The schistosity at this point is S. 60° W., with a steep dip (40°) to the north. The fact that the direction of the schistosity is across the stream with the dip downstream is especially favorable for the collection of any gold that might be concentrated from the rocks in the process of erosion which the valley has undergone.

In the last three years, during which time hydraulic methods have been in use, 900 feet of the creek has been worked out. Pay averages 200 feet in width, with a depth of 2½ to 3 feet. The gold is coarse and rough and at the mint assays $16.58. Very little black sand is found. The greater part of the gold occurs close to or in crevices of the bed rock, but it is not deemed necessary to clean up by hand, the hydraulic giant being relied on entirely to sweep all gold into the boxes. The wash, which is practically all confined to the gulch bed, there being no well-defined bench, is coarse, ill sorted, and not greatly waterworn. Many large bowlders make it necessary to employ at least two men in breaking up and removing oversize, which adds materially to the cost of extraction. Three Hendy giants are installed on the property, two No. 2 and one No. 1. Only one is used at a time, however. Seven hundred inches of water at a pressure of 180 feet is brought three-fourths of a mile down the gulch. A 24-inch pipe at the intake dam is reduced to 9 inches at the giant, to which is fitted a 3-inch nozzle. The 900 feet of sluice boxes used are built entirely of whipsawed lumber. The bottom boards are 1½ inches thick and the side boards 1 inch thick; the frames are 3-inch square timbers. The flume is 27 inches wide and 30 inches deep, inside measurements. Block riffles are used. A grade of 5¼ inches to 12½ feet is maintained. The gravel is piped downstream into the boxes. Very little gold is caught below the fourth box, the greater part being retained in the second. Mercury is placed in the third, fourth, and fifth boxes.

The origin of the gold may be with certainty accorded to the quartz stringers abundant in the mica schists. The coarseness and roughness of the grains suggest a near source of supply. It is very probable that the discovery of placer gold in commercial quantities in this region will be in the areas where mica schist is the dominant formation or where streams have cut rocks of that type. The fact that placer gold has not been found in paying quantities where streams have headed in granitic or other crystalline rocks bears out this statement.

Recent prospecting has developed the fact that a well-defined bench occurring about 75 feet above the bed of Willow Creek carries gold in commercial quantities. It is planned to install during the coming winter a hydraulic plant for their exploitation near the mouth of Wet Gulch, 2 miles below Grubstake Gulch, on the south side. The location, with excellent facilities for dump and a catchment area at least as large as that of Grubstake Gulch supplying water under sufficient pressure, suggests a commercial proposition well worth investigation. The possession of the creek claims as dumping ground will be necessary. Such bench claims lend themselves particularly to exploitation by hydraulic methods and may be worked at far lower cost than gravels situated at the level of present stream drainage.

NELCHINA RIVER.

Two prospectors from Copper Center were met in the headwater country of Nelchina and Tyone rivers. Gold was reported present in all the stream gravels, but in very small quantities. The gold obtained on the Tyone is almost exclusively in the form of small round plates, worth about a cent a piece. Occasionally small shotty nuggets are found, not exceeding 5 or 10 cents in value.

Panning of the hard conglomerate interstratified with Jurassic shales and sandstones failed to yield colors. Yet, in view of the unaltered and unmineralized character of the prevailing sandstones and shales and the comparative coarseness of the gold, it is nevertheless probable that the meager gold content of the present stream channels has been derived by a concentration of the ancient conglomerates.

KNIK RIVER.

It is reported that prospectors discovered gold on Metal Creek, a tributary of Knik River, $7 or $8 a day to the shovel being claimed.

YENTNA DISTRICT.

The following data are compiled from various sources: The placer gold diggings of the New Yentna district are located approximately 75 miles northwest of the mouth of Susitna River where it enters Cook Inlet. They occupy in the main the headwaters of Kahiltna River, a northern tributary of the Yentna, 25 miles above the latter's confluence with the Susitna. The Yentna heads in the Alaska Range and enters the Susitna 20 miles above its mouth.

Except the diggings of Lake Creek, a tributary to Yentna River from the north about 10 miles above the Kahiltna, the workable ground may all be classed as shallow, varying in depth from bare bed rock to 5 feet. On Lake Creek the surface gravels only are washed, bed rock never having been reached. It is reported that the pay is from 2 to 5 feet deep and varies in width from 10 to 30 feet.

The gold, with which much black sand occurs, is fine, and at Susitna station (at the junction of Yentna and Susitna rivers) brings $15.75.

About 35 miles above its mouth Kahiltna River forks, its eastern branch being called Peters Creek. Near the head of the latter are Willow and Poorman creeks, both fair producers during the last season. Poorman Creek is tributary to Willow Creek, which in turn enters Cottonwood Creek, a tributary of Peters Creek, between the upper and lower canyons.

The remaining creeks of first importance are all western tributaries of Cache Creek, which enters the western branch of Kahiltna River from the northeast about 20 miles above the mouth of Peters Creek. They are, in order, proceeding upstream, Dollar, Falls and its tributary Treasure, Thunder, and Nugget creeks. They are all located above timber and are characterized by shallow ground and coarse gold. An ounce to the shovel was generally obtained. The bed rock on all these creeks is reported to be slate.

During the open season the steamer *Caswell* and several gasoline launches run from Tyonek, on Cook Inlet, to Lake Creek. A trail to the diggings from Youngstown, on the Yentna, 40 miles above Lake Creek, is also used.

It is probable that $35,000 is very close to the actual production of the district.

SUNRISE DISTRICT.

The following notes on the status of mining in the Sunrise district were gathered at the end of the field season while en route to Seward. The greater part of the mining done last season was confined to Resurrection Creek and its tributaries, Crow Creek, Sixmile Creek, East Fork, Canyon Creek, and Mills Creek. A small amount of work was probably done on a number of other streams, but the quantity of gold produced could not have been great.

Mining has been in progress for a number of years[a] on all the above-named creeks. The richer and more easily accessible portion of the gold content has been removed. Present mining is confined largely to the working of high benches, which, though containing less gold, lend themselves by their position to more economical methods of mining than can be pursued in the creek bottoms. The utilization of

[a] Moffit, F. H., Mineral resources of Kenai Peninsula, Alaska: Bull. U. S. Geol. Survey No. 277, 1906, pp. 33-43.

water under pressure brought by ditches or pipe lines to hydraulic giants is the method most generally employed.

Little mining was done on Resurrection Creek during the season of 1906. A dredge installed in 1905 did not prove a success. The shallowness of the ground and the presence of bowlders of such size as to effectually prevent successful operation appear to have led to this result.

A hydraulic plant on Rainbow Creek, which enters Turnagain Arm on the north opposite Resurrection Creek, was not working during the past season.

Developments on a large scale were made on Crow Creek, a northwest tributary of Glacier Creek, which enters Turnagain Arm on its northern shore 8½ miles east of the town of Sunrise. The Crow Creek Consolidated Mining Company began operations June 6, a large hydraulic plant having been installed under exceptional difficulties at a point a short distance above the junction of Crow and Glacier creeks.

The deposit being mined, aside from its economic value, is of considerable interest in a study of the development of the adjacent region. The following points are to be noted: First, a rock gorge of considerable depth cut in bed rock; second, the gorge, as well as a considerable extent of territory on each side, filled or overlain by a notable thickness of water-laid sands, silts, and gravels; third, recent stream action, superimposed upon these gravels, cutting through them, and forming the present gorge, now far below the older one.

It seems reasonable that the cutting of the first gorge may be referred to preglacial stream action. The glacial striæ and rounded surfaces on the exposed bed rock below the pit at the old level of erosion are excellent evidence of the former presence of the ice. The encroachment of the ice down the main valley of Glacier Creek and the accompanying occupancy of Crow Creek by a glacier would account for a cessation of the cutting of the old gorge. It is assumed that either the mass of the trunk glacier acted as a barrier while the side gulch was already clear of ice, or lateral morainal deposits from the trunk glacier were sufficient to dam the valley of Crow Creek, offering an opportunity for the filling of the old valley of that stream by a process of intermittent flood and low-water deposition. The character of the sediments exposed in the upper pit would strongly suggest such an origin for them. Moreover, the cemented condition of the old gravels lying immediately next the old bed-rock surface is evidence of a quiescent stage in their history such as might occur were they buried in a lake deposit. The erosion of a new channel through this thickness of gravels, sands, and silts, with the consequent formation of the present gorge, was the final step in the history of this creek.

The following is a description of the lant: Water is supplied by a ditch 5,700 feet in length, 6 feet wide at the top and 4 feet at the bottom, and 4 feet deep. To the ditch is added a pipe line 3,000 feet long, reduced from 24 inches in diameter at the ditch intake to 15 inches at the giant. An abundance of water was obtained until September 8, when the supply fell below 2,000 miner's inches, a quantity insufficient to work to the best advantage a plant of this size. Operations may begin as early as May 15. Two No. 7 giants, with 15-inch intakes, were installed. The pressure varied between 280 and 330 feet, depending on the position in the pit.

Up to September 21 200,000 yards had been moved. The gold-saving apparatus consisted of a string of sluice boxes 200 feet in length occupying a bed-rock cut at a grade of 8 inches in 12 feet. Ample dump space is afforded by a rather peculiar topographic feature. The pay gravel occupies an old stream channel cut in a steep gorge of bed rock. Cutting through this old bed is the present more recent creek course, which has lowered its level many feet below the old channel. As a result, there is excellent opportunity for the disposal of tailings. The sluice boxes are 5 feet 3 inches wide inside the lining boards. Twelve-inch cube hemlock block riffles are used. Their life is about three months. It is found that hemlock from this region is tougher and wears longer than the fir of the western United States. Attached to the end of the tail sluice is an undercurrent. It is divided into three tables, each 6 by 30 feet, fitted with 6 by 2 by 2 inch block riffles nailed to a cross strip. The first 4 feet of each table, however, is fitted with rock riffles, which, though they offer a slight disadvantage in the difficulty of setting up and removal, can be commended because of their durability and efficiency. The presence of numerous large bowlders required the installation of a tram from the pit to the tailings pile. Bowlders less than a foot in diameter which the hydraulic giant is unable to move are trammed out. Those greater than a foot in diameter are blasted and then treated in the same manner. It was found that in the lower heavy ground a duty of only 1 cubic yard per miner's inch was obtained, whereas in the top ground, where the wash is regular and bowlders not abundant, a duty of 3 cubic yards per inch could be expected. The gold is for the most part fine and assays $14.90 per ounce.

A second pit worked a short distance below the one just described differs in the character of its bed rock. An area about 350 feet long by 100 feet wide was piped down through an average depth of about 10 feet, where a clay and cement-gravel bed rock retained the pay. Hand cleaning was necessary, though the taking up of the bed rock was not deemed profitable.

About 2 miles above the plant just described, at the mouth of Milk Gulch, a small tributary of Crow Creek from the northeast, mining was in progress by hydraulic methods the greater part of the season.

In all, about 50,000 yards of gravel were washed from two pits, with reported satisfactory results. The deposit worked lies in a basin formed by the damming of Crow Creek by a terminal moraine, left after the retreat of the glacier which formerly occupied its valley. A cut through this moraine had been run at considerable expense to tap the bedded deposits lying above it. At the upper pit a giant using 200 inches of water under a pressure of 240 feet had moved 15,000 yards. The flume from this pit was 3 feet 9 inches deep by 50 inches wide and floored with 8-inch square blocks. The posts and sills were 4 by 6 inch timber, and the lining boards were 3 inches thick. The side and bottom boards were made of 1½-inch lumber. A grade of 7 inches in 14 feet was maintained, and the tailings were dumped in Crow Creek. A 5-ton derrick, reported to move 1½ yards a minute, was used in removing rock too large to put through the flume. Thirty inches of water under a pressure of 200 inches was sufficient to run the derrick. In the lower pit 25,000 yards was moved in ten days by two giants equipped with 5-foot nozzles and supplied each with 250 inches of water under a head of 250 feet. Above the upper pit, jutting out from the mountain side on the northeast, may be seen what appears to be a remnant of the valley filling consequent on the damming of Crow Creek by a glacial moraine. It consists of a ridge of ill-sorted angular material, cemented by a fine rock-flour silt, a condition to be expected where deposition was as rapid as would occur near the head of a gulch of extremely steep gradient. It is reported that a drift run into the deposit disclosed prospects of sufficient value to warrant mining by hydraulic methods, and it is planned to begin active work next season.

Mining on Sixmile Creek, which enters Turnagain Arm at the town of Sunrise, was not carried on with any great activity during 1906, but the high benches along its course were worked by individuals with small outfits at several localities. Work in the stream gravels proper amounted to little. At the forks of Canyon Creek an attempt was made to reach bed rock by means of a hydraulic elevator. What success attended the work was not evident at the time of visit, as work had ceased.

Bench claims on Gulch Creek, a tributary of East Fork a short distance above its junction with Sixmile Creek, produced a small amount.

On Canyon Creek the most important work was that by S. W. Wible. About 50,000 cubic yards were moved during the season by hydraulic methods from a bench claim on the east side of the creek. Water, which during the height of the season amounts to 1,000 or 1,500 inches, is brought through a ditch 4 miles in length. The ditch measures 6 feet at the top, 3 feet at the bottom, and is 3 feet deep.

It was built at a cost of about 60 cents per cubic yard. Owing to the usual inadequate water supply during the last third of the season, it is planned to build 12 miles of ditch to Summit Lake at the head of Canyon Creek. This ditch, which is now partially built, is 5 feet wide at the top, 3 feet at the bottom, and 2 feet deep. A contract price of $2.50 per rod has been made, which is 10 cents cheaper than the old ditch. Two giants fitted with 4-inch nozzles are used when an abundant supply of water is available. As the water falls, the size of the nozzle is reduced. A yardage of 1,000 cubic yards per day can be maintained at a reported working cost of 4 cents per yard. This figure is exceptionally low, and probably can not be realized without most careful management. The gold-saving apparatus, which is adapted to the precipitous bluff upon which the bench is mined, is a combination of sluice boxes, grizzles, and undercurrents combined in an ingenious manner. A main sluice of four box lengths, with 11-inch grade and fitted with riffles, is terminated by a steeply inclined grizzly over which large rocks pass to the dump. The grade of the grizzly is 5 feet in 16 feet, and the bars are 4½ inches apart. Fitted beside the main sluice are two undercurrents fed by material passing through grizzly bars 3½ feet long and 2½ inches apart. The undercurrents have a grade of 8 inches to 12 feet, are each 6 feet long by 3 feet wide, and are fitted with slot riffles. The material from the undercurrents passes by a small sluice to meet the material which falls through the large grizzly at the end of the main sluice, and with it runs down a second large sluice at right angles to the first. Undercurrents from the second sluice are arranged in a similar way to those above described. A third turn in the arrangement of the boxes brings the wash, now thoroughly cleaned, back to a point nearly beneath the large grizzly at the end of the first sluice. The arrangement is said to be very satisfactory.

On Mills Creek, a tributary of Canyon Creek from the southeast, a small amount was produced. At one point drifting was carried on with reported success.

On Cooper Creek, a tributary of Kenai River 2 miles below its source, benches carrying gold in commercial quantities are reported.

Though no gold was produced the last season on Lynx Creek, a tributary of East Fork 8 miles above its junction with Sixmile Creek, development work of importance was completed. It is planned to work the gravels near the mouth of this creek by hydraulic methods. To reach bed rock and to avoid the thick deposit of coarse wash at the mouth of the creek, upon which sufficient grade for a dump could not possibly be secured, a 600-foot tunnel has been run through a sharp ridge, reaching a point where the valley of East Fork is lower than the bed-rock floor of Lynx Creek. The tunnel is 6 feet high by 5 feet wide and cost $10 per running foot. By extending a tailrace across this flat, as débris collects, a practically unlimited dump may be obtained. A flume 3 feet wide and 2 feet high, fitted with block riffles, will be used. Lumber, either whipsawed or brought in, costs about $100 per thousand. It is reported that abundant water to work two No. 1 hydraulic giants under a head of 400 feet can be secured by a 1,000-foot pipe line 8 inches in diameter. The gravel bank, of which the greater part may be piped to the sluice, is 25 feet deep and is reported to run 50 cents to the yard. The gold is coarse, nuggets up to $20 and $60 having been found.

COPPER.

KNIK RIVER.

In August, 1906, prospectors reported the discovery of copper in the high mountains between Knik and Matanuska rivers, but this locality was not visited. The ore is chalcopyrite (sulphide of copper and iron) and is associated with pyrrhotite (magnetic iron pyrites). The ledge is reported to be nearly vertical and has been traced through four claims. No actual development work has been done. The ore body is said to be 3 feet thick, consisting of 18 inches of solid chalcopyrite and 18 inches of quartz irregularly cut by stringers of ore. Graphitic gouge matter occurs near the ledge. From the foregoing description it appears probable that the deposit occupies a mineralized shear zone similar to those found in the Prince William Sound region, both in its manner of occurrence and in the bed rock with which it is associated. The mountains between Knik and Matanuska rivers, though difficult of access, are thought worthy of prospecting.

KASHWITNA RIVER.

During the summer of 1906 assessment work was done on copper claims near the head of the north fork of Kashwitna River, a tributary of the Susitna from the east. Samples of bornite said to occur in a granite were seen. The claims are about 120 miles from Knik and 10 miles from timber.

SUNRISE DISTRICT.

A copper prospect located on the west side of Lynx Creek, a southern tributary of East Fork, near the summit of the divide near its head, is being developed by the Ready Bullion Copper Company, of Boston, Mass. The country rock at this locality is a part of the graywacke-slate series composing the central and northern mass of the Kenai Mountains. The dominant cleavage at this point is N. 10° E., a direction nearly parallel with the ridge in which the copper deposit to be described occurs.

At an elevation approximating 3,000 feet a tunnel has been run 350 feet S. 80° W. into the mountain, a direction nearly at right angles to its trend. A drift from a point near the end of the tunnel was driven 150 feet to the south and 90 feet to the north, along a zone characterized by intense slickensiding or shearing in a nearly vertical direction. A short distance beyond this zone a fault dipping 35° W. was observed. Such a dip would not interfere with the continuation of the ore in depth.

Chalcopyrite ore accompanied by pyrrhotite and pyrite with much quartz has been deposited along the zone of shearing disclosed by the drifts. Irregular masses as thick as 2 feet were observed, but their horizontal linear extension was short, the vein fluctuating between 6 inches and 2 feet in thickness. At the south end of the drift the vein was narrow, and at the north end the face did not disclose ore. It was reported that gulches cutting the mountain north and south of the tunnel showed no signs of copper. Stripping, however, had not been done.

A thousand feet below the entrance of the upper tunnel an adit is being driven to catch the ore in depth. A length of 800 feet has now been completed. A rough estimate shows that with continued vertical dip the shear zone would be reached within a distance of 2,000 feet from the mouth of the adit.