GOLD LODES AND PLACERS OF THE WILLOW CREEK DISTRICT.

By S. R. Capps.

INTRODUCTION.

The term Willow Creek district is commonly used to designate a rather indefinite area in the southwestern portion of the Talkeetna Mountains. The name has gradually come to be applied not only to the basin of Willow Creek, which drains most of the western portion of the area, but also to all the mountainous portion of the basin of Little Susitna River, and it is in this more general sense that the term is used in this report. The area considered lies between latitude 61° 40′ and 61° 52′ and longitude 149° 7′ and 149° 30′. Both topographic and geologic maps of the region have already been published, but these are on a relatively small scale. The base map used for the present investigation will be published on a scale of 1 to 62,500, or approximately 1 mile to 1 inch. This map and a geologic map of the same area are now in preparation and will be published later with a more complete report on the geology and mineral resources of the district.

In 1898 G. H. Eldridge and Robert Muldrow,[1] of the United States Geological Survey, ascended Susitna River and crossed the divide to the head of Nenana River. In 1905 G. C. Martin[2] spent three weeks in a study of the lower Matanuska Valley coal field. His geologic map included a portion of the Little Susitna basin. During the same year W. C. Mendenhall,[3] while attached to a War Department expedition in charge of Capt. F. W. Glenn, had ascended Matanuska River to its head and crossed the broad basin to the northeast as far as Delta River. The next geologic expedition to the Talkeetna Mountains was undertaken in 1906, when T. G. Gerdine and R. H. Sargent carried a reconnaissance survey around this mountain

[1] Eldridge, G. H., A reconnaissance in the Sushitna basin and adjacent territory, Alaska, in 1898: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 1-29, 1900.

[2] Martin, G. C., A reconnaissance of the Matanuska coal field, Alaska, in 1905: U. S. Geol. Survey Bull. 289, 1906.

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

mass, and Sidney Paige and Adolph Knopf[1] mapped the geology of the area surveyed. Their geologic map covered the Willow Creek district, but the small scale of the map and the hasty manner in which the field work was necessarily done imposed sharp limitations upon the amount of detail which could be presented. Paige spent only a few days in the Willow Creek district, but in that time he succeeded in dividing the rocks into the three main groups, which are still recognized. In 1910 F. J. Katz and Theodore Chapin, after having spent the summer in the Matanuska coal field, made a four days' trip into the Willow Creek district. In Katz's report[2] on the geology and mineral resources of the area he described the economic development which had taken place up to that time and made some corrections to the geologic map of Paige and Knopf.

GEOGRAPHY.

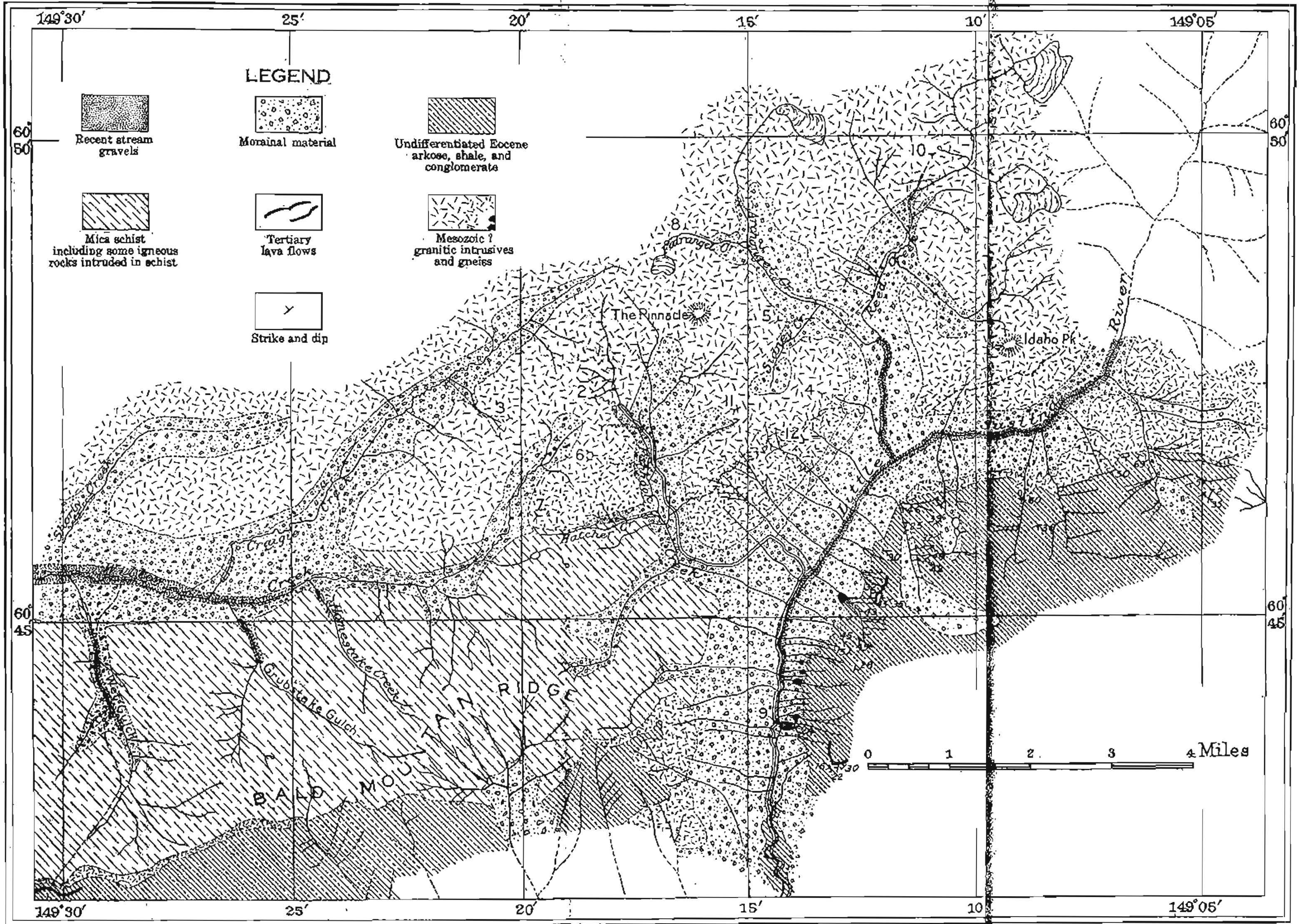
SURFACE FEATURES.

The Willow Creek district includes the southwest corner of the Talkeetna Mountains. It is bordered on the south by the rolling, lake-dotted lowland which lies between Knik Arm and the mountains, and on the east by the broad Susitna Valley. The accompanying map (Pl. X) does not extend far enough westward to embrace all the area commonly included in the district, but it shows that portion in which valuable discoveries of minerals have been made. The district is limited on the east and north by the basins of Little Susitna River and Willow Creek and their headward tributaries. The mountains rise to heights of about 4,000 feet at the western edge of the area mapped, but increase in elevation to the east and north, the highest peaks in the district, near the head of Little Susitna River, reaching elevations of almost 6,000 feet. West of a north-south line through the mouth of Craigie Creek the mountain tops are smooth and rounded. East of that line they are generally ragged and contain many narrow ridges and sharp peaks. The valleys in general are widely U-shaped and head in cirques.

Except for the south front of the mountains, Willow Creek drains the western half of the district, flowing nearly due west to empty into Susitna River. Little Susitna River is much the largest stream in the area. Its bed is filled with large bowlders, and although its course in the mountains is only 15 miles long, it drains several small glaciers and before emerging from the mountains has so greatly increased in volume that during the summer season it can be forded with difficulty and only at a few places. In the winter all the streams freeze over and their flow is greatly reduced.

[1] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: U. S. Geol. Survey Bull. 327, 1907.

[2] Katz, F. J., A reconnaissance of the Willow Creek gold region: U. S. Geol. Survey Bull. 480, pp. 139-152, 1911.



GEOLOGIC SKETCH MAP OF WILLOW CREEK DISTRICT.

GLACIATION.

The present surface forms of this district are in large measure due to the erosive action of the great glaciers which once occupied all the valleys. Four glaciers still exist in the district (see Pl. X), but these are all small and are only the disappearing remnants of vastly greater ice tongues. At a time geologically not long ago all the larger valleys in the Talkeetna Mountains were occupied by ice tongues which pushed down from the valley heads and extended beyond the mountain borders. The Susitna Valley was then occupied by a great ice field, extending at least as far south as the Forelands, and the Matanuska Valley contributed a great ice stream to this glacier.

ROUTES OF TRAVEL.

The village of Knik, on the northwest shore of Knik Arm, is the center of supplies for the Willow Creek district. Knik is above the head of navigation for ocean-going vessels and can be reached by launch only at high tide. At low tide the tidal flats off the town are bare. The upper part of Cook Inlet is closed to navigation during half of the year on account of the formation of ice. During the open season of 1913 one steamship, plying from Seattle through southeastern Alaska to ports on the Gulf of Alaska and Cook Inlet, made trips at intervals of three weeks to Knik Anchorage, at the mouth of Ship Creek, about 18 miles below Knik. From the anchorage all freight is lightered in scows to Knik, and passengers are transferred by launch. Steamships of another line call weekly at Seldovia, in lower Cook Inlet, and some freight and passengers are brought to Knik from that point in small steamers or launches. In the winter the mail is brought by dog sled overland from Seward to Turnagain Arm, and thence across the divide at the head of Crow Creek and around the head of Knik Arm to Knik, but this service is slow and irregular.

From Knik to the mines of the Willow Creek district two summer trails were formerly in general use. One headed north from Cottonwood, crossed the Bald Mountain ridge to Wet Gulch, and thence followed up Willow Creek to the camps. This trail is still used occasionally. The other route was the old Carle wagon road from Knik, leading in a northeast direction to Little Susitna River below the canyon and thence up that stream and Fishhook Creek. In the spring of 1913 a new wagon road, following in a general way the route of the Carle road, was completed by the Alaska Road Commission to upper Fishhook Creek. This road is well graded, is furnished with good bridges, and is now used for practically all the summer travel to the mines and also for winter travel to the Fishhook and Little Susitna basins. The winter road for sledding to upper Willow Creek heads north from Knik, skirts the west end of Bald Mountain Ridge, and proceeds up Willow Creek.

The summer freight rates by wagon to upper Fishhook Creek are 4 to 5 cents a pound. To Willow Creek supplies must be transported by pack horse from Fishhook Creek, at a considerable additional expense. In winter freight may be sledded to the camps by either the new wagon road or the Willow Creek winter road at about half the cost of summer haulage.

VEGETATION.

All the mines and nearly all the prospects in this district are located above timber line, and the problem of obtaining wood for lumber and for fuel is a serious one. The prospector for his camp purposes uses alder almost exclusively, as it may be obtained at much greater elevations than the more desirable spruce, but even the alder must in many places be brought for a distance of 2 or 3 miles. In Little Susitna Valley some good spruce formerly grew as far north as the mouth of Fishhook Creek, but the demand for this timber has already caused the cutting of practically all the good trees above the canyon, and it is now necessary to haul logs a distance of about 7 miles to the mines on Fishhook Creek. Timber for the mine on Craigie Creek is obtained at a distance of about 4 miles, the upper limit of spruce being at about the mouth of Craigie Creek. Spruce trees 2 feet in diameter at the base are not uncommon and furnish a very fair grade of lumber for mining uses. Spruce is also generally preferred for firewood. Some cottonwood grows in the valleys, and birch is common in the lowlands and grows locally up to elevations of about 1,500 feet. Alders grow profusely in the timber and just above timber line, and patches of them may be found up to elevations of 2,500 feet. Small willow bushes extend even farther up the valleys.

Forage for stock is everywhere abundant from the middle of May until early in September, when the first heavy freeze of autumn usually occurs. The commonest grass is the redtop, which grows in great luxuriance, both in the timber and above it to elevations of about 2,500 feet. After frost comes this grass withers and loses its nutritive value and stock must be fed on grain and hay.

GEOLOGY.

The general distribution of the rock types represented in this district is shown on Plate X. This map differs in some details from the previously published geologic maps of the area, but the main subdivisions shown are the same as those made out by Paige and by Katz. No determinable fossils were found during the present investigations, and the age of one of the rock groups is not known, while that of two other groups can be inferred only by comparison with rocks in adjacent areas in which more definite evidence could be obtained.

The oldest rocks of the district lie for the most part between the crest of Bald Mountain Ridge and Willow Creek. These are highly fissile, thoroughly foliated mica schists and are very uniform in appearance throughout their extent. On the north they are cut off by the intrusive quartz diorite; on the south they are in part overlain by gneisses and in part by the Tertiary sediments. The schists are described by Paige and Knopf [1] as garnetiferous mica schists and chlorite-albite schists. They have been intruded by some dikes, which have themselves suffered metamorphism along with the schists. As will be shown later, the schists are probably the source of some of the placer gold of the district, but although they are cut by numerous quartz veins, including some of considerable size, no encouraging gold-lode prospects have been found in the schist area.

The rocks next younger than the schists are the granitic rocks and associated gneisses. A large part of the Talkeetna Mountains is formed by a great intrusive body of granitic texture, which is often spoken of as granite, but most of which is more properly termed quartz diorite. This rock cuts the older schist and is thus younger. Near the southern edge of the quartz diorite mass, especially near Fishhook Creek and eastward to the border of this district, the rock shows a decidedly banded gneissic structure and includes considerable masses of basic crystalline rocks and some large bodies of nearly pure hornblende. In many places the unaltered diorite seems to merge gradually into the gneiss, but east and southeast of Government Peak the gneissic character is particularly well developed; the banding is very pronounced, and it appears likely that some metamorphosed sediments are included in the gneiss. From a study of this locality a suspicion arises that the gneisses are older than the unaltered granitic rocks, but in the present investigation it was not found to be practicable to separate the gneisses from the unaltered quartz diorites, and they have been mapped as a unit. The granitic rocks of the Talkeetna Mountains were assigned by Paige and Knopf [2] to the Middle Jurassic.

The youngest indurated rocks of the district constitute a thick series composed of arkoses, shales, sandstones, and conglomerates. These were deposited upon an old erosion surface and lie upon both the gneisses and the schist. They cover the south slope of Bald Mountain Ridge and form the southeast rim of the portion of the Little Susitna basin included in this investigation. The beds contain abundant fragments of leaves and plants, but none were found that were sufficiently well preserved to be identifiable. In the eastward continuation of this formation, however, Paige and Knopf and Martin and Katz [3] found plant remains which have shown the beds to be of Eocene age.

[1] Page, Sidney, and Knopf, Adolph, op. cit., pp. 10-11.
[2] Paige, Sidney, and Knopf, Adolph, op. cit., pp. 14-15.
[3] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 500, 1912.

The deposits left by glaciers and streams are largely confined to the valleys. The glacial deposits consist for the most part of clayey materials in which bowlders, gravels, and angular pieces of rock are embedded. In Little Susitna Valley, at the mouth of Fishhook Creek, the valley sides are covered by this material for over 1,000 feet above the river, and bedrock crops out in the valley bottom at only a few places between the canyon and the cirques in which the river and its tributaries head. Lower Willow Creek has also extensive deposits of glacial materials. The present stream gravels are of remarkably small development in this district. The larger streams for most of their length occupy valleys trenched into the glacial material. As a result the streams have been employed since the retreat of the glaciers in deepening rather than widening their valleys, and the stream beds are consequently narrow and are filled with large bowlders. In the area shown on Plate X, Little Susitna River and its tributaries have developed no considerable flood plains, and the gravels occupy too small an area to be shown on a map of this scale. Willow Creek below the mouth of Grubstake Gulch has a gravel flat which in places reaches a width of several hundred feet.

MINERAL RESOURCES.

GENERAL FEATURES.

The mineral resources of the Willow Creek district that have been sufficient to encourage mining and prospecting are the gold-quartz lodes and gold placers. The gold placers as developed in 1906 have been described by Paige and Knopf.[1]

By 1909 reports of the discovery of gold lodes in the district had begun to attract attention, and Brooks[2] published a brief account based on reports of prospectors and others. F. J. Katz and Theodore Chapin were the first members of the United States Geological Survey to study the gold lodes, and the results of their four days' visit to the district were published in 1911.[3] Short accounts of the developments in this mining district in 1911 and 1912 were given by Brooks,[4] who visited the eastern part of the district in 1912.

GOLD PLACERS.

GRUBSTAKE GULCH.

Practically all the placer gold that has been recovered from this district has been mined on Grubstake Gulch and on Willow Creek near the mouth of Grubstake. According to O. G. Herning, the first

[1] Paige, Sidney, and Knopf, Adolph, Reconnaissance in the Matanuska and Talkeetna basins, with notes on the placers of the adjacent region: U. S. Geol. Survey Bull. 314, pp. 116-118, 1907; Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: U. S. Geol. Survey Bull. 327, pp. 65-67, 1907.

[2] Brooks, A. H., The mining industry in 1909: U. S. Geol. Survey Bull. 442, pp. 35-36, 1910.

[3] Katz, F. J., A reconnaissance of the Willow Creek gold region: U. S. Geol. Survey Bull. 480, pp. 139-152, 1911.

[4] Brooks, A. H., The mining industry in 1911: U. S. Geol. Survey Bull. 520, pp. 28-29, 1911; The mining industry in 1912: U. S. Geol. Survey Bull. 542, p. 39, 1912.

two claims were staked in 1897 by M. J. Morris and L. H. Herndon on Willow Creek at the mouth of Grubstake. In 1899 A. Gilbert staked two claims on lower Grubstake Gulch. In 1900 the Klondike & Boston Co. bought up the claims on Grubstake Gulch and a number on Willow Creek and attempted to operate them for several years. Over 6,000 feet of steel pipe, ranging from 9 to 24 inches in diameter, was placed on the ground, and hydraulic methods were used. The most productive years for this company were 1904 and 1905. The company later became involved in financial difficulties and failed, and in 1908 its ground was relocated by O. G. Herning, who now holds 33 claims on Grubstake and Willow creeks.

Grubstake Gulch, which enters Willow Creek from the southeast, is a hanging valley, glacial erosion having lowered the Willow Creek valley below the level of this tributary. A lateral moraine of the Willow Creek glacier was built across the mouth of Grubstake Gulch, and the stream has now cut through this material and developed a steep, narrow canyon in bedrock beneath it. From the forks of the stream to the canyon, a distance of about half a mile, the stream falls about 200 feet. Through the canyon it drops about 150 feet in a short distance. Below the canyon an alluvial fan has been built out upon the Willow Creek flat, and the stream is now somewhat intrenched into this fan.

The placer ground that has been worked includes part of the bars of Willow Creek below the mouth of Grubstake Gulch, a portion of the Grubstake alluvial fan, the bed of the canyon, and the bars of Grubstake Gulch for some distance above the canyon. The bedrock is mica schist, and the schistosity strikes across the creek and dips at moderately steep angles, thus affording a rough bedrock surface admirably adapted to retain placer gold. The schist is cut in all directions by tiny stringers of quartz, and quartz veins reaching a width of 3 or 4 feet were seen at several places within the schist area.

The first placer production was made in 1898, the gold being recovered from the claims on Willow Creek at the mouth of Grubstake Gulch. It is reported that about $4,000 was taken out. In 1899 about $3,000 was recovered above the canyon on Grubstake Gulch and a small production was made from Willow Creek. During the next four years little active mining was done, but in 1904 and 1905, when the hydraulic plant had been installed, the production reached its maximum. For the last few years mining has been carried on in a desultory fashion and the production has been small. From what could be learned at the time of visit, the largest area of ground mined lies immediately above the canyon, where throughout the length of one claim ground averaging about 200 feet wide has been worked out. The gravels averaged from 2½ to 9 feet in depth, and on the lower half of the claim the gold was recovered from the surface of a bed of clay about 1 foot above bedrock, while on the upper half of the claim the gold lay on the steeply dipping schist bedrock. About 1,200 feet of sluice boxes, 27 inches wide and 30 inches deep, built on 1 and 1½ inch lumber, with 3-inch square frames, were set on a grade of 6 inches to the box length, the average grade of the bedrock. Water for hydraulic sluicing is brought from a dam at the forks of the creek through a ditch and steel pipe. The pipe is 24 inches in diameter at the intake but is reduced to 9 inches at the giant, and 3 and 4 inch nozzles are used. The head of water decreased as mining progressed upstream but was 180 feet at a distance of three-fourths of a mile below the dam. It is reported that the creek bed has been worked as far upstream as the dam. The gold is fairly coarse and the largest nugget had a value of $14; a number of $5 nuggets were found and pieces worth 50 cents to $1 were numerous. The gold is said to assay about $16.60 an ounce.

At the time of visit, late in August, 1913, assessment work on these claims had just begun. A giant was set about 1,300 feet above the canyon, and a cut was started to prospect the thick deposit of gravels on the east side of the creek. The gravels were there from 8 to 15 feet deep, thickening to the east, as the bedrock surface seems to dip in that direction. Few large bowlders were encountered, and scarcely any rocks were uncovered which two men could not handle. The rocks were for the most part flat, somewhat rounded slabs of schist which did not move freely before the giant, and it was frequently necessary to remove them by hand, the larger ones being first broken with a hammer. Boxes 20 inches wide were in use, and two men were mining. It is reported that a good pay streak was discovered east of the present channel of the creek. The total placer production from Grubstake and Willow creeks is said to have been about $25,000.

The task of determining the bedrock source from which the Grubstake Creek placers have been derived presents some difficulties. Veins rich in free gold cut the quartz diorite on Craigie and upper Willow creeks, and at once suggest themselves as an adequate source for the placer gold along Willow Creek. Upper Grubstake Gulch, however, lies entirely within an area of mica schist, and the richest placers are localized in this basin. It is therefore apparent that the placer gold above the Grubstake Canyon must have come from the schists, probably from the veins and veinlets of quartz which are known to carry some gold. Below the mouth of Grubstake Gulch some gold from this gulch is unquestionably included in the gravels of Willow Creek. Placer prospects have been found on Willow Creek above Grubstake Gulch, and their gold was probably derived in part from veins both in the quartz diorite and in the schist. The absence of placers immediately below the outcroppings of the rich gold-quartz veins in the quartz diorite is to be explained by the severe erosion of glacial ice, which removed any accumulation of gravel and the included gold and incorporated it in the glacial materials deposited farther downstream. The present placers are the result of postglacial concentration of gold from the glacial deposits and from the postglacial erosion of bedrock.

WILLOW CREEK.

Prospecting has been carried on at various places along Willow Creek since the first placer discoveries in 1897, but so far the only ground mined on this stream has been that just below the mouth of Grubstake Gulch, already mentioned. The Alaska Hoosier Co. holds 32 claims on Willow Creek below the mouth of Wet Gulch, extending 2 miles downstream, but only assessment work has been done on them. Some years ago a ditch was built from Wet Gulch down the south side of Willow Creek valley for the purpose of hydraulicking some terrace gravels, but no considerable amount of mining was done. The ground has been prospected by pits and by means of a spring-pole drill. Holes have been sunk to a depth of 22 feet, but in the valley floor none have reached bedrock.

FISHHOOK CREEK.

In 1906 some prospecting for placer ground was done on lower Fishhook Creek. Encouraging prospects could be found in many places, and the creek was diverted into Little Susitna River. A 12-foot pit sunk into the channel showed fair values but no ground sufficiently rich to pay. The best prospects were found in the creek bed and the values decreased with depth. Bedrock was not reached. A 12-cent nugget was the largest found, and all the gold was fairly coarse, but large bowlders were so abundant that mining costs would be prohibitive. The placer gold along Fishhook Creek and Little Susitna River is doubtless a postglacial concentration of gold scattered through the morainal deposits, but the large number of great bowlders along these streams make it improbable that placer mining on them would pay.

GOLD LODES.

GENERAL CONDITIONS OF OCCURRENCE.

The principal gold-lode mines and prospects of this district are described in the following pages, but a statement of the general conditions under which the lodes occur seems desirable. All the producing mines and the more promising prospects lie in the area of quartz diorite bordered on the south by Willow Creek, the east-west portion of Fishhook Creek, and upper Little Susitna River. Most of them are included in an area 6 miles long from east to west and 5 miles wide from north to south. Within the narrow limits of this productive area the quartz diorite is for the most part massive and unaltered, though a few prospects along the southern edge lie within a somewhat gneissic phase of the granitic intrusive. Without exception the gold-bearing lodes are quartz veins cutting the quartz diorite. In many places they are banded, and most of them contain some clayey gouge along one or both walls, showing that the period of vein filling was accompanied by movement along the fractures. Although the banding shows that the vein filling was continued throughout a considerable period of time, evidence of only one general period of vein filling has so far been obtained. The veins, while showing considerable variation in strike and dip, for the most part belong to a set which strike in a general northwesterly direction and dip from a few degrees to 45° SW. In places two or three veins in the same mountain are found to be parallel to one another and also parallel to a prominent set of joints. Almost every well-defined vein that was studied is paralleled by a strong set of joints. It appears, therefore, that the gold quartz veins are fillings of joint cracks. The fact that certain joints of a set have a quartz filling while other equally prominent joints of the same set contain no vein material indicates that only a part of the joints had been formed by the end of the period of vein deposition and that after the circulation of the mineralized quartz-bearing solutions had ceased other joints parallel to the earlier ones were formed.

The veins of the district are practically all fillings of fractures parallel to the jointing, with well-defined, generally regular walls. The quartz usually breaks free from the walls, from which it is commonly found to be separated by clayey gouge. Some veins show brecciated wall rock cemented by quartz, and horses of country rock surrounded by quartz are not uncommon. The surface croppings of one vein indicate that it is continuous horizontally for about 1,500 feet, and other veins, while not so well exposed, will probably be proved to be at least equally continuous. Underground workings are not yet extensive, but one adit tunnel 386 feet long and another 240 feet long have been driven on fairly continuous veins. The veins vary in thickness from place to place and are characterized by pinches and swells. The quartz is white to bluish gray in color and in many places is banded. Near the surface it is usually oxidized, and the visible minerals accompanying it consist chiefly of native gold and limonite. The oxidized ore is commonly full of cavities formed by the leaching out of sulphides. A short distance below the croppings the ore is unoxidized, and sulphides, particularly pyrite, are common. The gold occurs for the most part as free gold in the quartz, but some gold is entangled in the pyrite. Reports of tellurides have been common, and chemical tests of a number of these ores were made. The particles of tellurides in the ore examined were too small to enable the identification of the mineral. Besides free gold, the following metallic minerals were identified in the district: Pyrite, arsenopyrite, stibnite, chalcopyrite, bornite, chalcocite (?), malachite, galena, molybdenite, cinnabar, and an unidentified telluride. Details of the several veins are given in the following descriptions of the mines and prospects.

MINE OF ALASKA FREE GOLD MINING CO.

The property of the Alaska Free Gold Mining Co. comprises a group of 13 claims lying on the bold mountain ridge which forms the west wall of the Fishhook Creek valley, north of Hatcher Creek. The claims, covering practically all of the east slope of this ridge and including a part of the west slope, near the summit, have been surveyed for patent, as has also a mill site on Fishhook Creek. The company is organized as a stock company but is now operated under an eight-year lease, beginning in 1912. It was on this property that the first discovery of gold quartz in this district was made, the first claim being staked on September 16, 1906. Since that time development work and mining have been carried on each summer. The improvements at the mine consisted at the time of visit of a mill and blacksmith shop on Fishhook Creek, and adjoining bunk and mess tents to accommodate about 30 men; two main tramways and a branch tram connecting the mill with the ore bodies; two inclined tunnels 50 and 85 feet long on the lower vein, connected by drifts and stopes; a 95-foot adit tunnel on the main upper vein, and numerous short tunnels, open cuts, and pits on the vein croppings on the several claims.

The mill, operated by a Pelton wheel working under a 35-foot head of water, is a Lane slow-speed Chilean mill, designed to turn about 7 revolutions a minute, and to crush to 40 to 60 mesh. It was first put into service about August 1, 1912. Its maximum capacity is about 25 tons in 24 hours, the ore being passed through a rock crusher before entering the mill. The water supply is adequate to operate the mill only during a portion of the open season, and a 16-horsepower gasoline engine has been installed to furnish power during periods of low water. From the mill the crushed ore passes to two sets of amalgamating tables and thence is fed to two Bartlett concentrating tables, operated by a small overshot water wheel. From 1 to 2 per cent of the ore crushed is saved as concentrates. From 70 to 75 per cent of the gold saved is said to be amalgamated in the mill, and the remainder is caught on the plates. At present the concentrates and tailings are not treated but are being stored until a cyanide plant is installed.

Two principal ore bodies have been opened on this property, although there are openings at a number of places on veins which may or may not be continuations of these two main veins. The lower of the two has been opened at the head of the south tramway, at an elevation of about 4,300 feet, 900 feet above the mill. It will here be called the Homestake vein, as the principal workings are near the boundary between the claims known as the South Homestake and North Homestake. This vein crops out at about the same elevation and has the same general strike and dip as the Granite Mountain vein of the Alaska Gold Quartz Mining Co., 1,500 feet to the north, and it appears likely that the vein is more or less continuous between these two properties, although it has not yet been directly traced throughout the intervening distance. At the head of the tramway the vein is opened by two inclined tunnels 50 feet apart, one 85 and the other 50 feet long, connected at 50 feet from the surface by a drift. The ore was brought to the surface in a car tram operated by a windlass. Most of the ground between these tunnels is stoped out for 25 feet below the outcrop. The average strike of the vein is here about N. 13° W., and the dip varies from 30° at the surface to 42° at the tunnel face. The vein filling, lying between quartz diorite walls, was from 6 to 24 inches thick and was associated with some gouge and clayey matter. The vein cropping has been exposed for several hundred feet along the surface. To the north it has been traced as far as the north tramway, and to the south it was followed to the edge of a large talus slide. It is said that to the south it pinches out to a thin edge. A large part of the ore milled at this mine in 1912 is said to have been taken from this vein.

The upper main vein on this property, known as the Skyscraper vein, is opened by a tunnel at an elevation of about 4,600 feet on the north slope of Skyscraper Mountain, near its top. These workings are at the head of an 850-foot branch aerial tram, which runs in a northeast direction and discharges at the head of the main north tram, 2,500 feet from the mill. At the time of visit the adit tunnel, which is equipped with a car tram, was 95 feet long, and work was in progress in the breast. At 40 feet from the portal a raise reaches the surface 36 feet above. As opened by this tunnel, the vein ranges in thickness from 18 inches to 8 feet of solid quartz, associated with some gouge. The vein matter is generally free from the walls, and there is evidence that considerable movement has taken place along the walls. The vein pinches and swells, but the strike and dip are fairly uniform. The average strike is about N. 15° W. and the dip 40°–45° W.

A short distance southeast of the tunnel and above it, on the outcrop of the same vein, is a large open cut which supplied about two-thirds of the ore milled in 1913. In this cut the vein is split into two parts by a large horse of diorite measuring 15 feet in greatest thickness. Above the horse there is said to be about 5 feet of milling ore, and below it from 4 to 10 feet of ore. At a point 380 feet southeast of the tunnel mouth is another open cut on the same vein, showing about 9 inches of quartz. The tunnel is being driven for this point.

The quartz of the Skyscraper vein is in general massive, though locally showing a banded structure. In the open cuts it is rusty from iron oxide and full of cavities formed by the leaching out of the sulphides. A short distance from the surface, however, oxidation of the sulphides has taken place only along cracks in the vein, and the massive quartz has a light to dark blue-gray color. It contains, besides native gold, rather abundant pale pyrite and some chalcopyrite. A little galena is reported. The native gold occurs both as particles in the quartz not immediately associated with pyrite and as intergrowths in the pyrite, as can be seen from the delicate crystals projecting into the cubical cavities from which the pyrite has been leached. The production in 1913 was diminished by the scant supply of water, as the mill was operated to capacity for only a part of the short open season.

A third vein of proved economic importance crops out on the Eldorado claim, about 3,000 feet south of Skyscraper Mountain. This vein has been developed by several large open cuts and by a 30-foot inclined tunnel, at an elevation of about 4,270 feet. The country rock is a much-decayed quartz diorite. The vein ranges in thickness from 1 inch to 18 inches of solid quartz, associated with some clayey gouge. It strikes N. 24° W. and dips about 36° W. and is therefore nearly parallel with the other veins on Skyscraper and Granite mountains to the north. The quartz is oxidized and rusty, as is also the country rock, even at a distance of 30 feet from the surface. It is reported that in 1912 about 100 tons of ore from this vein was dragged down a trail to a point from which it could be trammed to the mill.

A number of other open cuts and short tunnels on this property expose quartz veins of varying size and gold content, but none of them has yielded ore in commercial quantity.

In 1911 a few tons of ore from this property was milled in the mill of the Alaska Gold Quartz Mining Co., and this was the first gold produced from this mine. In the spring of 1912 the Chilean mill was installed, and about 525 tons of ore was milled that summer. In 1913 the mill was run to as great capacity as the water supply permitted and about 25 men were employed continuously during the working season.

MINE OF ALASKA GOLD QUARTZ MINING CO.

The property of the Alaska Gold Quartz Mining Co. lies for the most part in the upper portion of the valley of Fishhook Creek, on the east slope of Granite Mountain. It comprises a group of five claims and a mill site, all of which have been surveyed for patent. The claims form an irregular tier extending from Fishhook Creek up the mountain to the west and include a portion of the divide between Fishhook Creek and Willow Creek. The claims were located in 1907, and development work and mining have been carried on each year since. The improvements consist of a 4-stamp mill, located on Fishhook Creek, two aerial tramways extending from the ore bodies to the mill, a group of tents in the valley, a blacksmith shop and car tram at the main tunnel, several hundred feet of adit tunnels and stopes, and a number of open cuts on the croppings of the ore bodies. The mill is operated by a small Pelton wheel, which works under a 120-foot head and develops about 15 horsepower. The mill equipment first installed consisted of a prospecting mill of three 500-pound stamps, manufactured by the Mine & Smelter Supply Co. Later a 1,250-pound Neissen stamp was added. The capacity of the four stamps was about $8\frac{1}{2}$ tons in 24 hours, with the small stamps dropping 98 times a minute and the large stamp 90 times. The ore is crushed to 40 mesh and passes from the stamps over amalgamating plates and thence over a Wilfley concentrating table. The concentrates are said to bear a proportion of about 1.80 in the more or less oxidized portions of the vein and of about 1.40 in the unoxidized ore about 400 feet from the surface. The concentrates and tailings have been saved for future treatment, but up to the present time all the values recovered have been in free gold by amalgamation in the mortars and on the plates. When the mill is running to capacity the plates are cleaned every 24 hours and the mortars once a week. Two 2-bucket aerial trams equipped with $\frac{5}{8}$-inch cable lead from the ore bodies to the mill. The lower of the two, heading at the mouth of the main tunnel, is about 1,700 feet long and is supported by one tower near the mill. The other tram is 2,460 feet long in a single span and has a vertical distance of about 1,100 feet between the ends.

Two principal ore bodies crop out on this property. The main tunnel on the lower or Granite Mountain vein, which has furnished most of the production, and which crops out on the walls of a small cirque, is at an elevation of 4,150 feet, or 500 feet above the mill. The upper or Independent vein lies high on the mountain, 620 feet vertically above the Granite Mountain vein, and has so far been prospected only by shallow openings. The country rock is everywhere the quartz diorite which forms all the northern part of this district.

The Granite Mountain vein is developed by a main adit tunnel 386 feet long, another adit tunnel 80 feet long, several short tunnels and open cuts, and several stopes, some of which connect the two larger tunnels with each other and with the surface. In general the vein strikes N. 14°–20° W., the strike varying somewhat in different parts of the vein. The dip also is rather irregular, varying from 10° to 42° SW., but averages about 20° SW. At the portal of the main tunnel the vein cropping shows only 1 or 2 inches of quartz, but in the tunnel the quartz vein matter varies in thickness from 2 inches to 4 feet, rarely pinching to less than 8 inches and averaging about 22 inches. The vein pinches and swells abruptly and contains some horses of country rock but is continuous throughout the tunnel. In one place a dip fault has displaced the vein about 4 feet.

The vein walls are distinct and smooth, are generally slickensided, and are in most places separated from the vein by a layer of gouge matter of varying thickness. The quartz is characteristically massive, though it is banded in places. It is of a light-gray to dark blue-gray color and where unoxidized shows, besides native gold, rather abundant pale pyrite, some chalcopyrite, and specks of some unidentified dark sulphide. The vein matter has been somewhat shattered and slickensided. Very near the surface the ore is rusty and most of the sulphides have been removed by oxidation. Farther underground iron oxide occurs along certain cracks in the ore, but most of the sulphides are unaltered a short distance from the surface. The better ore from this vein occurs in chutes, four of which were encountered in a distance of 386 feet along the strike of the vein.

The upper vein on this property is known as the Independence vein and is connected with the mill by an aerial tram at an elevation of 4,770 feet, 1,120 feet above the mill. The vein strikes N. 12° W., or approximately parallel to the Granite Mountain vein, and its average dip is about 42° W. Although its southward continuation has not been directly proved, it is without much doubt on the same plane as the main upper vein on the property of the Alaska Free Gold Mining Co., and future developments are likely to show that the vein is continuous between these two properties. The developments at the time of visit consisted of an open cut about 100 feet long and a 15-foot tunnel at the head of the tramway, and other open cuts on the vein both to the north and to the south. The vein, as seen at the several openings, is from 2 inches to 2 feet in thickness, averaging about 12 inches, and is accompanied by considerable sheared matter and gouge. The walls consist of blue-gray diorite, somewhat sheared near the vein. The vein near the tramway is forked, a portion of it cropping out about 30 feet below the tunnel. The vein quartz is less massive than that of the Granite Mountain vein, is generally banded, and consists of interlocking crystals of quartz containing free gold, a little pyrite, and small quantities of some other sulphides. Only a small quantity of ore from this vein had been mined up to the fall of 1913, but it was planned to build a cabin near the outcrop and run a tunnel on the vein that fall. It was reported that on September 3, 1913, this tunnel had been driven 34 feet on the vein, and that approximately 4 feet of good ore showed in the tunnel face.

In 1913 difficulties were encountered in keeping the mill in operation, numerous breakdowns causing a serious curtailment in the output, although enough ore was available to supply the mill, and the water supply was sufficient to furnish power throughout most of the summer. Plans were being made to install a new mill that winter.

MINE OF GOLD BULLION MINING CO.

The Gold Bullion Mining Co.'s property is situated on the southeast wall of the Craigie Creek valley, about 4 miles above the mouth of the creek. The first claims were staked in 1907 by William Bartholf, and the group now includes five full claims and a fractional claim, which have been surveyed for patent. The improvements consist of a group of buildings and a 7-stamp mill located in the valley, two branch aerial trams supplying a main aerial tram to the mill, a short aerial tram and a car tram at the upper workings, which are provided with a stone mess house, blacksmith shop, and bunk tents, several hundred feet of tunnels and stopes, and numerous open cuts and strippings. The main workings are connected with one another and with the mill by trails. Power for the mill is provided by a 12-inch Pelton wheel operated under a 28-foot head, about 25 horsepower being developed. Some power is also needed to run the main tramway. Two 1,000-pound Hendy stamps were installed in 1909, and in 1911 five 1,000-pound Halladie stamps were added. The ore is first passed through a coarse crusher and then fed to the stamps, which are regulated to drop from 100 to 103 times a minute, crush to 40 mesh, and discharge over two sets of amalgamating plates and thence over a Wilfley concentrator. The capacity of the stamps is about 21 tons of ore in three shifts of eight hours each, and the ore concentrates in about the ratio of 1 to 200. In 1909 the two stamps then installed were supplied with ore brought to the mill on pack horses, but the next year a cable tram was installed. The main tramway which now supplies the mill is a 2-bucket aerial tram, equipped with $\frac{7}{8}$-inch cable, and is 3,253 feet long, with a rise of 850 feet. It is supported on a number of towers. The buckets have a capacity of 400 pounds, and the tram is of sufficient capacity to keep the mill well supplied with ore. At the head of the main tram there are ore bunkers supplied by two trams, one about 1,600 feet long from tunnel No. 5, and one 1,450 feet long from tunnel No. 2, each equipped with $\frac{3}{4}$-inch cable and two buckets. These trams both consist of single spans unsupported by towers. From the mouth of tunnel No. 2 a car tram 945 feet long follows the mountain slope to the northeast and is fed by an aerial tram 635 feet long, which heads at Discovery, on the Gold Dust claim.

The vein croppings on the Gold Bullion property occur near the summit of the ridge which separates the upper valleys of Craigie and

Willow creeks. The workings are at elevations of 4,400 to 4,600 feet, and the mill in the valley bottom is at 3,050 feet, or about 1,500 feet below the ore bodies. The discovery of the veins on this property in the high, craggy ridge top is no doubt due to the good exposures of bedrock which occur there. Below the workings most of the bedrock is so concealed beneath a covering of talus and of glacial deposits that prospecting is difficult.

The ore milled in 1909, which yielded the first gold recovered from this property, is said to have been obtained from the talus and from open cuts on the Gold Dust claim, the place of the original discovery. During the years from 1910 to 1912 the ore milled was taken from tunnels Nos. 3, 4, and 5, No. 5 furnishing most of the production. In 1913 the production was obtained largely from open cuts and from tunnel No. 1 on the Gold Dust claim, from the same locality that was first mined.

At the time of visit access could be had to the many open cuts on the property, and to adit tunnels Nos. 1, 2, and 4. Tunnels Nos. 3 and 5 had caved in at the portals and were inaccessible. Active mining was being carried on in open cuts near tunnel No. 1 and in that tunnel itself, which was 30 feet long, and a prospecting tunnel, No. 2, was being driven along the vein and had penetrated several hundred feet into the mountain. Between these two tunnels numerous open cuts and strippings have exposed the vein, and although the exposures are not continuous, it is most likely that both tunnels, and No. 3 as well, are all on the same vein. Tunnels Nos. 4 and 5, while somewhat higher on the mountain than the projected dip of the vein from No. 2 would indicate, are in ground that has been somewhat faulted and disturbed, and it is not improbable that the veins on which they were driven are parts of the same ore body exposed in the other workings. The vein may, however, be somewhat displaced by faulting, or it may even prove to be a distinct ore body.

At tunnel No. 1 the vein strikes about N. 28° E. and dips 15° W. Open cuts show its continuation on the opposite side of the ridge to the south. At the time of visit the tunnel was 30 feet long, but it is reported that by October 15, 1913, it had been driven to a length of 184 feet. As exposed in the tunnel the vein is from 3 to 7 feet thick and is composed largely of white or bluish quartz, rusty along the fractures. Sheared matter and gouge occur both above and below the vein, which cuts the quartz diorite. Visible particles of free gold could be seen in many pieces of the ore, as well as small amounts of pyrite and chalcopyrite. Particles of some other finely disseminated sulphides are also present, and copper carbonate stains are common. Although both the country rock and the vein are much fractured, many of the fractures being filled with ice, the ore at even so short a distance as 30 feet from the portal of the tunnel is not greatly oxidized, except along fractures, and many of the sulphides are unaltered. The open cuts at this place have disclosed a large amount of oxidized and broken vein quartz mixed with the surface detritus, and this loose surface material supplied a considerable proportion of the ore milled in 1913. The surface portion of the veins seems to yield somewhat higher returns than the fresher material from the underground workings, probably as a result of the freeing of some gold by the oxidation of the sulphides. At present the only gold recovered is free gold, obtained by amalgamation. *Adit tunnel No. 2 has yielded* a little milling ore, but most of it has been driven in the hope of opening an ore body. The tunnel is on the Golden Wonder claim, and the vein, which ranges in thickness from 5 feet to the vanishing point and averages about 2 feet, strikes approximately N. 30° E. and dips about 14° W. In the breast of the tunnel the vein had thinned out to a small stringer. It is reported that on October 15, 1913, the tunnel had been driven to a length of 240 feet and the vein had widened out, giving a width of 3½ feet of paying ore.

Tunnel No. 3, about 400 feet west of No. 2 and presumably on the same vein, is now caved in but is reported to have yielded considerable good ore.

Adit tunnel No. 4 is said to be 300 feet long, and the vein ranges from 2 feet in thickness down to a small stringer. No work was being done on this tunnel in 1913.

Tunnel No. 5, which is now caved in and abandoned, furnished most of the ore milled in 1912. The vein is said to have had a maximum thickness of 14 feet, though averaging much less than that. In 1913 a small quantity of ore was recovered from the outcroppings of the vein near the site of the old tunnel entrance.

In the mill practice at this mine the only metal which has been recovered so far has been the free gold caught by amalgamation in the stamp mortar boxes and on the plates. In 1913, during the time when the mill was running 24 hours a day, the plates were cleaned up at the end of each 8-hour shift and the mortars were cleaned every 48 hours. The concentrates from the Wilfley table have been stored separately and all the tailings have been impounded. About 4,000 tons of tailings are now stored ready for treatment, and plans are being made to install a 30-ton cyanide plant in 1914. In 1913 the mill was run three 8-hour shifts a day, and two shifts were worked in the mines. About 30 men were employed continuously during the summer. In the fall the number of stamps in operation was reduced as the water supply diminished. The 5-stamp mill ran during the season for a total of 59 days, and the 2-stamp mill for 72 days. It was planned to continue underground mining all winter.

MABEL MINE.

The Mabel mine is situated on the west wall of the Little Susitna Valley, 3 miles above the mouth of Fishhook Creek. The workings, at an elevation of 3,700 feet, are in a small gulch tributary to Little Susitna River, and the camp is near the same gulch, about 800 feet below the workings. The property comprises a block of 12 claims staked to cover the known outcroppings of the veins. The claims were staked in the fall of 1911, and a moderate amount of development work has been done since that time. In 1912 an open cut was made on the vein and an inclined tunnel driven down the vein for some distance, but water in this tunnel became bothersome and it was decided to drive an adit tunnel below to crosscut the vein. At the time of visit the open cut and inclined tunnel were badly caved and little could be seen, but in places a slip zone, said to be on the vein and containing about 8 inches of gouge and a little quartz, was observed to cut through the quartz diorite country rock. This zone strikes in a general northerly direction and dips about 45° W. The vein, as opened in the inclined tunnel, is said to range from 2 to 18 inches in thickness. Ore taken from it showed a decided banding of white quartz with visible interlocking crystals and dark blue-gray fine-grained quartz. Several tons of quartz were obtained from the workings in 1912, and 6 tons was shipped to Tacoma for smelting.

In 1913 an adit tunnel was started 20 feet below the earlier workings and when visited had been driven 51 feet under cover. It was expected that the vein would be struck within a short distance. Near the mouth of this adit tunnel is another quartz vein cutting quartz diorite. This vein strikes N. 52° W. and dips 55° SW. It is from 6 to 8 inches thick and consists of massive rusty and oxidized quartz which breaks free from the walls and contains some horses of country rock. The sulphides have for the most part been removed by oxidation in this surficial portion of the vein, though some pyrite remains. It is probable that the amount of sulphides will be found to increase at no great distance from the surface. Visible free gold could be seen in many specimens of the quartz, and small pieces mortared and panned gave many colors of free gold.

A good horse trail has been built from the wagon road to the camp and also to the tunnel mouth. Plans were under consideration to construct an aerial tram from the tunnel to a mill site on Little Susitna River in 1914.

ARCH PROSPECT.

The Arch prospect is situated on the south side of Archangel Creek, about 1½ miles above the mouth of that stream, at an elevation of 3,200 feet, 550 feet above the valley bottom. This property, which consists of a group of four claims called the Arch group, has been generally known as the Fern, Taulman & Goodall prospect but changed hands in the summer of 1913. At the time of visit there was no one on the ground, and the main tunnel was caved and partly filled with water, so that little could be seen. A good stone house and blacksmith shop have been built near the prospect, and a good trail extends from the cabin to the main trail in Little Susitna Valley.

The vein, which cuts quartz diorite, has been developed by a number of open cuts and by an inclined tunnel said to be 80 feet long. The tunnel follows down the vein, which in the somewhat disturbed ground through which the outer portion of the tunnel is driven strikes N. 33° E. and dips 21° NW. In the accessible portion of the tunnel the vein was from 10 to 40 inches wide and the filling was mostly a clayey gouge, with little quartz. It is said that farther in the tunnel a maximum of 12 inches of quartz was obtained. The quartz, as seen on the dump, is banded and consists of interlocking quartz crystals surrounding pieces of altered country rock. Sulphides are present only in small amounts.

Under the new management a new adit tunnel to crosscut the vein 180 feet below the old incline was started in the fall of 1913, and two other drifts are reported to have cut the vein, showing from 12 to 20 inches of gold-bearing quartz. It is planned to install two small Lane mills on Archangel Creek in the summer of 1914, water for power being obtained from the tributary which joins the creek from the south near the mill site.

BARTHOLF-ISAACS PROSPECT.

The four claims of the Bartholf-Isaacs prospect are located in the upper basin of Archangel Creek, about a quarter of a mile above its mouth. They were staked in June, 1912, and only assessment work has been done on them. No one was working on these claims at the time the area was surveyed, and they were not visited by the writer. It is reported that five open cuts have been made which show the vein at its greatest size to cut quartz diorite and to contain 2 feet of quartz and 5 feet of gangue.

PROSPECT OF BROOKLYN DEVELOPMENT CO.

The Brooklyn Development Co.'s property consists of five mining claims and a mill site in the basin at the head of Willow Creek. The claims are said to have been located in 1909, and have been surveyed for patent. The developments consist of two buildings in the valley bottom, a large number of open cuts and trenches, and two adit tunnels, 40 and 180 feet long. The upper adit tunnel, at an elevation of 4,400 feet, is driven through quartz diorite. It was started on a quartz vein 6 to 8 inches thick, striking approximately east and dipping 15° S. A short distance from the entrance the vein was cut off by a fault, and the remaining portion of the adit shows no continuous vein, although the diorite is seamed and fractured and a little clayey material appears along some of the fractures. The quartz from the vein near the entrance is rusty and much fractured and shows some banding. The vein is now for the most part concealed, but the few bits of quartz obtainable showed little mineralization. Nothing was learned of the gold content of this vein.

The main adit, about 60 feet below the shorter one, is a somewhat crooked tunnel 180 feet long, and there are three 10-foot crosscuts extending from it to the south. On the surface there is said to have been a vein cropping of about 7 inches of quartz, but the tunnel follows a seam in the quartz diorite, containing some clayey material but almost no quartz. In the breast of the tunnel there are a few small quartz stringers, and one crosscut shows 2 inches of clayey gouge with a little quartz. No ore body has been developed in this tunnel. The numerous open cuts and trenches on the property are caved in, and little could be seen in them.

A stamp mill for this property was purchased several years ago and freighted in to a point on Willow Creek 7 miles below the cabins but never delivered at the site upon which it was to be installed.

GRIMES PROSPECT.

The Grimes prospect comprises a group of eight claims, known as the Dolores group, situated on the north side of the ridge which divides the Fishhook Creek drainage basin from that of Archangel Creek. The ground was staked in 1912. The developments consist of a number of open cuts distributed throughout a vertical range of 300 feet and supposed to be on the same vein. The line of cuts strikes a little east of north, but little could be seen of the vein in place, as the sides of the cuts have caved in. The lowest cut, at an elevation of about 3,600 feet, shows on the dump pieces of quartz from a vein at least 10 inches thick. The quartz shows some banding and contains bits of altered country rock but is for the most part rather massive white quartz, somewhat oxidized. The country rock is quartz diorite, cut by a prominent set of joints striking N. 15° W. and dipping 43° SW., and the vein is probably a filling of a joint of this set. Another cut, at an elevation of about 3,200 feet, has on the dump considerable rusty banded quartz stained with malachite. The vein is evidently at least 6 inches thick. Another open cut above the two already described is said to expose 14 inches of quartz which carries sulphides and free gold.

HATCHER PROSPECT.

The Hatcher prospect comprises three claims known as the Little Gem group, in the upper basin of Archangel Creek, about a mile above the mouth. The claims were staked in August, 1913, and were not visited by the Survey party, as no development work had been done at the time that portion of the area was mapped. It was reported in September that an adit tunnel 15 feet long had been driven on this property, disclosing a quartz vein from 1 to 10 inches thick, cutting the quartz diorite country rock. This vein is said to be traceable for 1,500 feet along the surface and to carry considerable gold. A large specimen from this vein showed abundant free gold in coarse specks. It is planned to install an aerial tramway and a 3-stamp prospecting mill on this property in 1914.

McCOY PROSPECT.

The McCoy prospect includes a group of 19 claims on the east slope of the mountain which lies west of the lower Reed Creek valley. The claims were located on June 28, 1913, and prospecting during the year was confined to digging open cuts to uncover the vein croppings. At the time the property was visited no one was working on the claims. About 20 open cuts were examined. None of these are large, and only a part of them reached undisturbed bedrock. Several of the cuts had a small amount of quartz on the dumps, and one showed 4 inches of clayey gouge in place, containing a little quartz. The country rock on this mountain is all coarse quartz diorite, with some inclusions or segregations of a gray sugary porphyritic rock. It is reported that the best showing of quartz on the property is north of the cuts visited. There are said to be three veins, the largest reaching a maximum known thickness of 7 feet. The veins are reported to strike in a northwest direction and to dip to the southwest.

MAMMOTH PROSPECT.

A group of four claims, known as the Mammoth group, is located in the Willow Creek valley on the mountain which lies north of the pass between Fishhook and Willow creeks. The main workings lie at an elevation of 3,800 feet, or 450 feet above Willow Creek. Active development work was carried on during the winter of 1912–13, a 200-foot adit tunnel, with 73 feet of crosscuts and a 12-foot raise, being driven. The vein at the tunnel entrance shows a large body of quartz 28 to 30 feet wide, striking approximately east and dipping 68° N. About 30 feet from the tunnel entrance a fault has cut off the vein abruptly, and the remaining 170 feet of tunnel on this level was driven on a slip zone full of clayey gouge, but the vein was not again encountered. The country rock is a somewhat gneissic quartz diorite which has been broken by slips in several directions. The walls of the slip zone on which the tunnel was driven are well defined, and although they show some rolls, the direction of the zone is fairly constant. The walls are smooth and in many places show slickensides, and the rock has been much altered. In the breast there is about 3 feet of clayey gouge and sheared, altered diorite, with good walls of solid rock on either side. A 35-foot crosscut to the north leaves the main adit 100 feet from the portal, and one or two other short crosscuts have been made, in none of which was the vein encountered. About 70 feet from the portal a 15-foot raise on a slip zone entered a body of quartz, but a 28-foot crosscut from the raise cut through the quartz body, which proved to be an irregular portion of the vein surrounded on all sides by faults. The faulted-off portion of the main vein has not been found in the underground workings.

The quartz is for the most part massive white vitreous quartz, mottled with patches of a bluish-gray color. It shows scattered specks of pyrite and chalcopyrite with stains of copper carbonates. The assays that have been made show the vein to be ore which is of low grade for this district. The vein is, however, the largest seen in the region, and if its underground continuation is established and the tenor holds, there is here the possibility of a mine from which much gold might be recovered.

MINE OF MATANUSKA GOLD MINING CO.

The property of the Matanuska Gold Mining Co. is situated on the north side of a cirque in which Fairangel Creek has its head. At the time of visit there was no one on this ground, on which only assessment work has been done for the last two years, as the property is now involved in litigation. The four claims of this group were staked in 1909, and considerable development work was done in 1910 and 1911. A good trail was built from the Little Susitna Valley to the workings, many open cuts were made, and adit tunnels aggregating over 200 feet in length were driven. The camp, consisting of several tents, is near the creek at an elevation of about 3,500 feet. The country rock in this vicinity is a coarse gray quartz diorite with many inclusions of a gray sugary porphyritic rock. The diorite is cut, near the vein croppings, by small aplite dikes, locally called "quartzite." The dikes are older than the vein fillings, for in places the quartz veins cut the dikes, and cracks in the dikes are quartz filled.

The working nearest camp, at an elevation of 3,680 feet, is a 20-foot tunnel in diorite. No veins show in this tunnel, which was evidently driven to crosscut a vein that crops out on the slope 50 feet above. At the cropping a 22-foot adit shows two quartz veins in the breast, one from 1 to 3 inches thick striking N. 22° W. and dipping 42° NE. and the other from 3 to 8 inches thick striking N. 47° E. and dipping

71° NW. Above the tunnel the smaller vein has been exposed by stripping for a vertical distance of about 50 feet. At a point about 75 feet west of this exposure an adit tunnel, which is said to be 85 feet long, has been driven to intersect the larger of these veins. A cave-in has closed this tunnel about 60 feet from the portal, but it is reported that the position of the vein is believed to be about 10 feet beyond the breast of the tunnel. The tunnel is driven on a slip zone, from 12 to 18 inches wide, which contains much gouge and a little quartz and which strikes N. 44° W. and dips 72° NW., or approximately parallel to the vein in the tunnel. The vein matter, as seen in the tunnels and on the dumps, is from 3 to 12 inches thick and consists of banded white and blue-gray quartz. The quartz contains some visible particles of free gold and considerable sulphides, mostly pyrite. Near the surface it is somewhat rusty and shows small cubical cavities containing iron oxide, the result of the leaching of the pyrite.

At an elevation of about 3,930 feet, or approximately 250 feet above the vein just described, is another quartz vein closely associated with an aplite dike. The vein is younger than the dike, the quartz cutting across the dike and filling fractures in it. An adit tunnel has been driven for 84 feet along the vein, which strikes N. 33° E. and dips 45° W. The vein is distinct on the hanging wall, there being in places 12 to 15 inches of solid quartz. Below this hanging-wall quartz there is a stockwork of reticulated quartz veins inclosing fragments of diorite and containing some gouge. At many places the walls and the ore show slickensides. The same vein is exposed a short distance above the tunnel by strippings and by an open cut. Here the dike and the vein come together. The dike, which along its outcrop varies in thickness from 1 to 6 feet, is at the cut about 6 feet thick and has quartz lying parallel to it both above and below. The vein pinches and swells but in places showed 30 inches of vein matter, mostly quartz, with small inclusions of altered diorite. Some caving has taken place in this cut, and the relations have thereby been partly obscured. The vein walls, the quartz filling, and the diorite fragments inclosed in the quartz all show fine specks of sulphides, mostly pyrite.

Another 24-foot adit tunnel on this property was driven on an aplite dike. The dike rock shows disseminated pyrite.

MILLER PROSPECT.

The Miller prospect is on the east side of Little Susitna River, 1 mile below the mouth of Fishhook Creek and about 60 feet above the river. The developments consist of two cabins on the west side of the river, a footbridge across the river, and a 30-foot adit tunnel driven from the bottom of a steep, narrow gulch. The tunnel follows a thick band of siliceous rock which has been locally called a vein but which proves from study in this section to be an altered igneous rock. The "ore" is white to greenish gray in color and in places contains considerable quantities of sulphides. The so-called "vein" is ill defined in outline and but little of it is exposed. The associated rock is coarsely crystalline and belongs to the gneiss series. Only assessment work has lately been done on this property. Nothing definite was learned of the value of the ore, as assays are said to have given conflicting returns.

MOGUL PROSPECT.

The Mogul prospect comprises two claims situated on a high rock bench in the upper Reed Creek valley, 2½ miles above the mouth of that stream, at an elevation of about 4,000 feet. The claims were staked in September, 1912, and have been developed by three open cuts about 15 feet from one another along the croppings of a quartz vein that cuts quartz diorite. The southernmost cut, about 10 feet long on the bottom, shows about 6 inches of clayey gouge with 2 inches of quartz. The middle cut shows 18 inches of clayey vein matter with 1 to 4 inches of quartz. The north cut shows 4 inches of quartz and gouge above, separated by 18 inches of altered diorite from a lower 12-inch vein of quartz. The vein quartz is very drusy, and small, slender quartz prisms project into the cavities. Much iron oxide is present, and some sulphides. The vein is reported to have given high assays in gold.

RAE PROSPECT.

The Rae prospect consists of four claims called the Jennings group, situated on the divide between Fishhook Creek and Little Susitna River, 1 mile north of the east-west portion of Fishhook Creek. The claims lie in an area of more or less gneissic quartz diorite, which is cut by a considerable fault or shear zone. Two open cuts on the Fishhook Creek side of this property were examined. The larger of these cuts was dug from the bottom of a steep gulch, at an elevation of about 4,000 feet, or 1,100 feet above the valley floor, and extended 15 feet into the mountain side. The country rock is deeply oxidized and decayed gneissic diorite, and the cut was driven on a layer of sticky yellowish clay or gouge from 8 to 18 inches in thickness, striking in a general northeast direction and dipping 43° NW. Some quartz occurs in the clayey material and contains free gold, chalcopyrite, pyrite, galena, and copper carbonates.

A second open cut, 20 feet above the first, shows the same altered country rock, with thin rusty seams. The slight amount of work done on these claims is insufficient to either prove or disprove the presence there of ore bodies of economic importance.

ROSENTHAL PROSPECT.

The Rosenthal prospect comprises the Sun, Moon, Morning Star, and Evening Star claims, all located on the high ridge which borders the Fishhook Creek basin on the northeast. The claims were located in 1907 and have since that time been owned by several different persons. The developments consist of a fair trail from the valley of Fishhook Creek, a crude blacksmith shop, and two adit tunnels. The larger tunnel is on the west side of the ridge, is about 95 feet long, and is driven along a vein which cuts the quartz diorite country rock. The vein consists of white, somewhat banded quartz, strikes N. 40° W., and dips 10° SW. It ranges from 1 to 3 feet in thickness and carries some visible specks of free gold and finely disseminated pyrite. This flat-lying vein is close to the mountain top, and the amount of ore in it, even if it is continuous in all directions, is necessarily small, as the projected plane of the vein comes to the surface everywhere within a few hundred feet of the main tunnel. On the east side of the mountain a 30-foot tunnel, driven on the same vein, is not now accessible. The ore is reported to be "spotted," rich ore being closely succeeded by almost barren quartz. No work was being done on this property at the time of visit.

SAN JUAN PROSPECT.

The San Juan group of two claims is on the crest of the high mountain ridge which forms the west valley wall of Little Susitna River just north of Fishhook Creek. The open cuts on these claims were not seen by the writer, but it is reported that a gold-bearing quartz vein 9 feet wide has been exposed. Pieces of ore said to have been taken from the property appear to be pegmatitic in character, with large quartz and feldspar crystals. If this rock proves to be workable ore it is of different character from the other proved ore bodies of the district.

SHOUGH PROSPECT.

The Shough prospect is located on the Oregon group of claims, on the west side of the Little Susitna Valley 2 miles north of Fishhook Creek. The camp and workings are at an elevation of 3,550 feet, or 1,800 feet above Little Susitna River. Development work on these claims was begun in the spring of 1913, and the improvements consist of tents, a blacksmith shop, a horse trail built from the main valley trail to the workings, an adit tunnel which at the time of visit was 35 feet long, a shallow shaft, and several open cuts.

The shaft was sunk on "vein No. 1," a quartz vein which strikes N. 13° E. and dips 62° W. It is reported that the vein, which cuts a pinkish decayed diorite country rock, reached a maximum thickness of 15 inches. On the mountain slope below the shaft an adit tunnel was driven for the purpose of intersecting the No. 1 vein. In this adit another quartz vein with a greatest thickness of 12 inches was encountered and followed. The vein strikes in general about N. 36° W. and dips 45° E., but both strike and dip vary greatly within short distances. The country rock near the tunnel breast is a dark blue-gray diorite, and the quartz is considerably shattered and much stained with copper carbonate.

A third vein, imperfectly exposed in open cuts, is said to reach a width of 3 feet. Its general strike is east and its dip 68° N.

Notwithstanding the high assays reported from these veins, the vein matter shows little or no free gold and yields unsatisfactory returns when mortared and panned. The principal visible metallic minerals present are azurite, what appears to be chalcocite, iron oxide, and some galena. In the shallow depths reached, however, the quartz is more or less oxidized, and the iron oxide probably represents original pyrite. Insufficient work had been done at the time the property was visited to determine the permanency of the veins or to learn the average gold content in any considerable quantity of ore.

The Shough prospects lie just east of the line of a fault zone cutting the diorite. This fault has been traced for a distance of over 2 miles in a northeast direction, and several prospects have been located near it. The relation of this fault to the veins near it has not yet been determined, as only a small amount of development work has been done along it and the surface exposures are unsatisfactory. It may be, however, that the fault has offered a passage through which mineralizing solutions have circulated, and that the veins near it have a close genetic relation to the fault.

SUMMARY.

Lode mining began in the Willow Creek district in 1908, and since then some $300,000 worth of gold has been recovered. The actual recovery from the ore that has been milled is $42 a ton in gold with some silver. This does not include the values contained in the concentrates or in several thousand tons of tailings which have been stored for future treatment. It is probable that the actual gold content of the ore crushed averages at least $50 a ton. These figures are borne out by the assay returns kindly furnished by various operators.

The veins already shown are in general parallel to pronounced systems of jointing. Though not yet mined to any great depth, individual veins have been traced to considerable distances on the surface. There is no reason to believe that the veins will not be persistent at increased depth. Below the zone of oxidation, which does not exceed a few feet in thickness, they should show no greater variation in value than within the present limit of mining.

The occurrence of this zone of mineralization along the contact of intrusive granodiorite is similar to that of some of the gold deposits of southeastern Alaska and elsewhere in the Territory. The geologic evidence at hand is all in favor of the presence of commercial ore bodies in this district.

The present operating costs are high, owing to the facts that transportation from Knik is effected by wagon and that this port can be reached by ocean freight only from May to November. It is estimated that thus far the freight charges to the mines have varied from $50 to $85 or more a ton. Operations have also been hampered by the lack of water at the altitudes at which mills have been installed and by the great cost of fuel. Many of these conditions will be overcome if the Willow Creek district is made tributary to one of the proposed railroads into the Yukon or Kuskokwim basin.

MINERAL RESOURCES OF THE UPPER MATANUSKA AND NELCHINA VALLEYS.

By G. C. MARTIN and J. B. MERTIE, Jr.

INTRODUCTION.

The district described in this report comprises the upper half of the Matanuska Valley and a contiguous area on the headwaters of Nelchina River, which is tributary to the Copper through the Tazlina. It includes parts of the eastern Talkeetna and northern Chugach mountains, which are separated by the valley of Matanuska River. The district consists of moderately rugged mountains 5,000 to 7,000 feet high, which grade eastward into the rounded hills, about 4,000 feet high, lying on the western margin of the Copper River Plateau.

The Matanuska Valley can be reached either from Knik, which is the head of navigation on Cook Inlet and to which vessels of shallow draft can go at high tide, or from Cordova or Valdez by way of Chitina and Tazlina road house. Near the lower end of Knik Arm there is a good anchorage, which ocean-going vessels can reach at any stage of the tide except during the winter, when the upper part of Cook Inlet is frozen or filled with floating ice.

At present freight can not be taken in by way of Cook Inlet during the winter, as the inlet is usually blocked with ice from November 1 to May 1. Passengers can reach the region during the winter by going in from Seward with sleds, but the Seward route is not available for heavy freight. The best winter route to the upper Matanuska and Nelchina district is by way of Chitina or Valdez. The distances from Chitina and Valdez to the headwaters of the Matanuska by way of Tazlina road house are 125 and 170 miles, respectively.

A good wagon road has been built from Knik to Little Susitna River. From mile 25 on this road a trail has been cut for a distance of about 8 miles, to the mouth of Moose Creek, where it joins the old Matanuska trail from Cottonwood.

The trail from Moose Creek up the valley reaches Chickaloon River about 24 miles from Moose Creek. From the Chickaloon ford the trail ascends on a good grade until it reaches the forks near the south end of Boulder Creek flats, a distance of about 7½ miles. From this point the Nelchina district may be reached by either of three routes—by the old Matanuska trail around Sheep Mountain, by the Hicks Creek trail, or by way of Boulder Creek.

The old Matanuska trail extends east along the southern base of Anthracite Ridge to the forks of the Hicks Creek trail at Index Lakes, a distance of 11 miles. The trail turns east at Index Lakes and crosses Hicks Creek at a distance of a mile and a half.. From Hicks Creek to Caribou Creek, about 10 miles, the trail lies parallel to the river. After crossing Caribou Creek it follows the southern slope of Sheep Mountain. About 13 miles east of Caribou Creek it passes through a saddle at the east end of the mountain, descends to Squaw Creek, and goes up the Squaw Creek valley for about 5 miles, whence it turns northward along the western margin of the Tazlina Valley. The headwaters of Crooked Creek may be reached by turning up the hill at the lake about 4 miles above the Squaw Creek crossing. By the route thus described the junction of Albert and Crooked creeks is about 55 miles from Chickaloon ford, or about 110 miles from Knik.

The Hicks Creek trail leaves the Matanuska trail described above at Index Lakes, going up the valley of Hicks Creek to its head, a distance of about 10½ miles; down Divide Creek to Caribou Creek, about 3 miles; down Caribou Creek about 3 miles, to a point half a mile above the mouth of Alfred Creek, where it turns east to avoid the canyon half a mile up Alfred Creek; then up Alfred Creek for about 10 miles to the point where the main creek comes from the northwest; thence northeast for 3 miles. From Albert and Crooked creeks it is about 48 miles to the Chickaloon ford and 103 miles to Knik by this route.

The Boulder Creek trail turns up Boulder Creek flats at a point 7½ miles east of Chickaloon ford and follows the open gravel bars of Boulder Creek for about 13 miles. It then climbs sharply and reaches the summit of a pass about 3 miles distant, at an elevation of 4,800 feet. From this summit it descends into Caribou Creek. For about 3 miles, or nearly to timber line, the trail follows the creek closely, then climbs up the western bank, which it follows to the mouth of Chitna Creek. Thence it follows the gravel bars for about 3 miles to the mouth of Divide Creek, where it joins the Hicks Creek trail. By this route it is about 51 miles from Albert and Crooked creeks to Chickaloon ford, or about 106 miles to Knik.

Timber line in this district is at a general elevation of 2,500 to 3,500 feet, above which there is the customary growth of small bushes, moss, and grass. The trees include spruce, birch, and several kinds of cottonwood. The growth is in general not dense. Most of the spruce trees are under 12 inches in diameter, and the largest one which the writers noted had a circumference of 5 feet. The timber is moderate in amount and of only fair quality, but, except in the higher valleys, it is probably sufficient for local demands, provided that forest fires, which the dry climate favors, are kept under control. The local supply of timber will probably prove inadequate as soon as extensive mining is undertaken. There is no timber suitable for export.

The more open birch forests, as well as the areas which have lately been burned, are covered with a dense growth of grass, chiefly redtop. There are also large areas of bunch grass above timber line at some localities, especially in the eastern part of the district. These natural meadows are large enough to furnish feed for whatever stock is likely to be locally needed.

GEOLOGY.

West of Chickaloon River the Talkeetna Mountains are probably composed chiefly of granite, although metamorphic rocks and small bodies of sedimentary rocks are known to be present. East of the Chickaloon the Talkeetna Mountains are made up of stratified rocks of Jurassic and Cretaceous age, including both sedimentary and volcanic beds, overlain in parts of the area by Tertiary conglomerate and lava and tuff. The rocks immediately south of the Matanuska include Tertiary and Upper Cretaceous sediments, volcanic rocks of probable Lower Jurassic age, schists, and granitic intrusives. The geology of that part of the Chugach Mountains which lies south of a belt bordering the river is practically unknown, but the rocks are probably in the main crystalline and largely metamorphic.

The general stratigraphic sequence is given in the following table:

Stratigraphic sequence in the Matanuska Valley.

Age.		Lithologic character.	Thickness (feet).
Quaternary.		Alluvium.	
		Glacial and high-level terrace gravels.	
Tertiary.	Pliocene (?)	Basaltic lavas, breccias, and tuffs.	1,000+
	Miocene (?)	Eska conglomerate.	2,500
	Eocene.	Chickaloon formation; coal-bearing shale and sandstone with the flora of the Kenai formation.	2,000±
		Arkose, conglomerate, and shale.[a]	2,000±
Upper Cretaceous.		Shale and sandstone.	4,500±
Lower Cretaceous.		Limestone.	300±
Upper Jurassic.		Shale, sandstone, and conglomerate.	1,000±
Middle Jurassic.		Shale and sandstone carrying the fauna of the Chinitna shale of Cook Inlet.	2,000±
		Sandstone with the fauna of the Tuxedni sandstone of Cook Inlet.	1,000±
Lower Jurassic.		Andesitic greenstone, tuffs, agglomerates, and breccias; rhyolites, dacites, and tuffs.	3,000±
Early Mesozoic or older.		Graywackes, slates, basaltic, greenstones, and rhyolites, and tuffs of the Knik River district.	(?)
Paleozoic.		Mica schists and other schistose and gneissic rocks.	(?)

[a] The stratigraphic position of these rocks is not definitely established. They may include beds equivalent to part of the Eska conglomerate and Chickaloon formation, as well as beds older than the Chickaloon. (See pp. 285-286.)

MINERAL RESOURCES.

METALLIFEROUS DEPOSITS.

GENERAL CONDITIONS.

The geologic formations of this district which seem most likely to carry valuable metalliferous deposits are the schists and the Lower Jurassic volcanic rocks.

The schists south of the Matanuska are in general similar to the gold-bearing schists of Willow Creek, but, unlike those rocks, they have not yet been found to contain gold-bearing veins or to be the source of gold placers. Their area is not easily accessible and has probably not yet been thoroughly prospected.

The Lower Jurassic volcanic rocks have been in general considerably altered. They are extensively fractured and at many places contain multitudes of small calcite veins or are impregnated with much fine disseminated pyrite. The copper deposits described on pages 281-282 occur in these rocks, which have not elsewhere been proved to contain valuable deposits. Paige and Knopf [1] said of these rocks:

> Though placers have not been found within the areas of older volcanic rocks, mineralization has occurred. West of Hicks Creek a large cropping of gossan about 100 feet wide was found. This red capping 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 Middle and Upper Jurassic, Cretaceous, and Tertiary beds and the intrusive rocks which cut them are not known to contain metalliferous deposits, although there is a possibility (see p. 280) that some of the placer gold is derived from the small veins in the Middle Jurassic shale and sandstone or in the dikes which cut those beds, or from the Tertiary conglomerate.

The extensive Quaternary gravels at the head of Matanuska River may contain small amounts of finely disseminated placer gold, but are not likely to be either of direct economic importance or even the indirect source of reconcentrated placers. Their glacial origin is unfavorable to the occurrence of extensive placer deposits, as their rapid mode of accumulation precluded the sorting and concentration which is necessary for the formation of workable placers.

The present stream gravels are largely derived from the reworking of these older gravel sheets. Even with this partial reconcentration the gold content, at least in most places, has not been increased sufficiently to pay for working. Productive placers are more likely to be found on such streams as are directly engaged in eroding a gold-bearing bedrock, especially rock containing mineralized quartz stringers.

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[1] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: U. S. Geol. Survey Bull. 327, p. 65, 1907.

PLACER GOLD.

INTRODUCTION.

The stream gravels of the upper Matanuska and Nelchina district had been prospected for many years prior to 1913 without marked success. Promising indications of workable placer ground have been reported many times from various places, but owing either to the difficulty and cost of transporting supplies, or to lack of diligence in prosecuting the work, or to the lack of the gold itself, no producing mines have developed.

Interest in this district was renewed in 1913 by the discovery of workable placers on Albert Creek, a small tributary of Crooked Creek, which flows into the Nelchina. About 65 ounces of gold was obtained in a few weeks from the Discovery claim. Probably only about 20 men were in the district during the working season, and most of these accomplished little or nothing except the requisite amount of assessment work. At the close of the season 100 or more prospectors went in from Knik, Valdez, and other places and a large amount of ground was staked. It is to be hoped that sufficient machinery and supplies were sledded in during the winter to test the district adequately during the coming summer.

ALBERT AND CROOKED CREEKS.

Albert Creek is a small stream which enters Crooked Creek from the west about 9 miles above its mouth, at an altitude of about 3,500 feet. Albert Creek has two named tributaries—Dick Creek, entering it from the southwest about 2,200 or 2,300 feet above Discovery, and Porphyry Gulch, entering it from the north at about the center of claim "No. 2 above." Crooked Creek, to which Albert Creek is tributary, flows into Nelchina River, which in turn is tributary to the Copper through Tazlina River. Crooked Creek, so named from its meandering course, flows at a low gradient over swampy bottom lands where the depth to bedrock is not known and may be considerable. The country surrounding Albert Creek consists of low, rounded hills which, like the valley of that creek itself and of the other tributaries of Crooked Creek, are entirely devoid of timber. Small cottonwoods and willows grow along the creek, but even these are few. The nearest timber is about 3½ miles east of the mouth of Albert Creek, on the edge of the Copper River flats. There is also timber about 8 miles to the northeast, near the mouth of Crooked Creek, and about 9 miles to the southwest, on Alfred Creek. At none of these places is the timber abundant or of good quality, but at any of them enough can be obtained to supply a small camp with houses, sluice boxes, and fuel. There is abundant bunch grass along the upper slopes of Albert Creek and probably at numerous other localities in the vicinity.

The rocks exposed along Albert Creek are mostly sandstones and shales, probably of Middle Jurassic age. They dip at moderately steep angles and are cut by dikes which are mostly small. The hill south of the lower course of the creek consists of altered igneous rocks which were regarded by Paige and Knopf [1] as "lower Middle Jurassic" (subsequently called Lower Jurassic) greenstones. There is a possibility that these rocks are altered intrusives. Albert Creek heads at the east end of a ridge capped by late Tertiary lavas. These may be underlain by Tertiary conglomerate, as they are at other localities farther west. If this conglomerate is here present it is a probable source of the placer gold. Bench gravels probably occur in the valley of Albert Creek, but they were not noted by the writer, there being snow on the ground when he was there. They were observed, however, in the valley of Crooked Creek 2 miles southeast of Albert Creek, up to an elevation of at least 3,800 feet.

Placer gold was discovered on Albert Creek by Fred Getchell, Duncan McCormick, and O. D. Olsen in 1912. The first ground was staked in March and April, 1913. In August, 1913, claims had been staked from "No. 4 below," which lies at the mouth of Albert Creek, crossing over Crooked Creek, to "No. 7 above," and also on Dick Creek and Porphyry Gulch, two of the tributaries.

Sluicing began on the Discovery claim on July 12, 1913, and at the close of the season, about September 1, it was reported that 65 ounces of gold had been obtained. The gold is bright and clean and well rounded, of very uniform size, a large proportion being worth from 1 to 3 cents and the largest nugget found being 1½ pennyweights.

From 3½ to 4½ feet of gravel was shoveled in. This was said to run as high as $14.50 to the yard and to average about $6. The gold-bearing portion is said to extend throughout a width of 30 feet, with only one side found. It lies on a shale bedrock, and has about 9 feet of overburden.

Only prospecting and assessment work was done on other claims than Discovery. Claims were staked and gold reported to be found on Crooked Creek and on several of its other tributaries, including North Creek and South Creek, which enter Crooked Creek from the west half a mile north and 1 mile south, respectively, of Albert Creek, and on Sleigh Creek, which enters it from the east near the mouth of North Creek.

ALFRED CREEK.

Alfred Creek is a large stream tributary to Caribou Creek from the east about 13 miles above its mouth. The upper part of the valley is open and lies among rounded hills, but the lower part is deeply incised, the creek passing through several canyons, of which the low-

[1] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: U. S. Geol. Survey Bull. 327, Pl. II, 1907.

est one, which is about half a mile long, terminates about half or three-quarters of a mile above the mouth of the creek in a broad flat. The trail follows the creek except at this lower canyon, which it avoids by passing over the bench to the north. A moderately dense growth of small spruce extends along the lower half of the stream. In the upper part of the valley there is no vegetation larger than willows and small cottonwoods along the stream course. There are numerous patches of good grass on the hillsides.

The rocks exposed along the upper half of Alfred Creek consist of Jurassic sandstones and shales cut by small dikes. Along the lower half of the creek the only rocks exposed are Upper Cretaceous shales, except at the lower end of the lowest canyon, where there is a large dike of coarse diabase. The rocks exposed on the tributaries are probably in large part the same as those on the main creek, except that the high ridge north of the creek is known to be capped by Tertiary volcanic rocks. These may be here, as they are at so many places in this district, underlain by Tertiary conglomerate. If so, this conglomerate is a likely source of the placer gold.

Alfred Creek has apparently been staked throughout the greater part of its length, but on only a few claims has more than technical assessment work been done. The discovery was made in 1911. A total of about $1,500 of gold is said to have been recovered from this creek.

MAZUMA CREEK.

Mazuma Creek is tributary to Caribou Creek from the northeast at an altitude of about 3,300 feet. The lower part of its course is in an inaccessible canyon, but the upper open part of its valley may be reached by a trail leading across the hills from the mouth of the stream entering Caribou Creek next below Mazuma Creek. The entire valley is above timber line and contains no vegetation larger than moderate-sized willows and small cottonwoods. The nearest timber is on Caribou Creek about 2 miles below Mazuma Creek, where there is a sparse growth of small spruce. Grass is abundant along the trail leading into the upper Mazuma Valley.

The rocks on Mazuma Creek are basaltic lavas and tuffs, underlain along the upper part of the creek by coarse conglomerate. An exposure at an altitude of about 4,600 feet shows coarse, poorly consolidated conglomerate overlain by angular blocks of lava which were probably transported from the hillsides above. The conglomerate is well consolidated near creek level, but looser above. This difference may be either the result of local cementation, local leaching, or reworking. It is probably due to reworking, for the looser part is decidedly coarser than the well-consolidated conglomerate at the creek level. The well-consolidated conglomerate consists of bowlders, in general not over 6 inches in diameter, and contains lenses of shale and sandstone, while the looser conglomerate has numerous bowlders from 1 to 2 feet long. The bowlders are chiefly granitic and fine-grained igneous rocks with some sandstone, shale, and porphyry. The conglomerate, both above and below the contact of the better and the less consolidated part, is thoroughly indurated along vertical fissures which stand out like dikes. The creek gravels, so far as noted, contain only material which might be derived from the conglomerate or the overlying volcanic rocks and include numerous large bowlders.

Claims have been staked from 3 to 5 miles above the mouth of the creek. The discovery was made in 1906. Nuggets up to 16 or 18 cents in value are said to have been found. It is reported that a large number of them have "cement" sticking to them. There has apparently been little or no production from this creek. The improvements consist of a wing dam, several prospect holes, and a ditch which will deliver water from a tributary stream under moderate head.

Whatever gold occurs in the gravels of Mazuma Creek was probably derived by reconcentration from a more disseminated deposit in the conglomerate. If there is, as there appears to be, a loose reworked conglomerate lying upon and derived from an older and more thoroughly indurated conglomerate, the contact of the two is possibly gold bearing.

NELCHINA RIVER.

Nelchina River itself was not visited by the writers, and no later information is at hand than that published by Paige and Knopf,[1] as follows:

> Two prospectors from Copper Center, who were met in the headwater country of the Nelchina and Tyonek rivers, reported that gold was present in all the stream gravels, but in very small quantities. The gold obtained on the Tyonek is almost exclusively in the form of small round plates, worth about a cent apiece. Occasional small shotty nuggets occur, not exceeding 5 or 10 cents in value.
>
> It is reported that the hard conglomerate interstratified with Jurassic shales and sandstones, when panned, failed to yield colors. Yet in view of the unaltered and unmineralized character of the prevailing sandstones and shales, and in view of 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.

SOURCE OF THE GOLD.

The source of the placer gold in this district is not known. There seem to be at least three possible sources—(1) concentration from small veins in the bedrock, (2) reconcentration from disseminated gold in the glacial gravels, and (3) reconcentration from disseminated gold in the Tertiary conglomerate. It may be that there is either a general source, which will account for all the placer gold, or that the various occurrences have sources of different kinds. If the latter

[1] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: U. S. Geol. Survey Bull. 327, p. 67, 1907.

possibility is admitted, then none of the three sources suggested above can be denied, and the problem must be dismissed until further local evidence is obtained.

If one general explanation is insisted upon, then it may be concluded that the source can not be assigned to local mineralization of the bedrock, unless it is assumed that the rocks of Alfred and Crooked creeks and those of Mazuma Creek have been mineralized. The former include Jurassic and Cretaceous sandstones and shales cut by small dikes; the latter include Tertiary lavas, tuffs, and conglomerates. In none of them are veins conspicuous. This explanation, as a general one, accordingly seems improbable.

Reconcentration from glacial gravels will not answer as a general source, for such gravels are not present on Mazuma Creek. This explanation would perhaps serve for the deposits on Crooked and Alfred creeks if it were assumed that these streams lie in the course of an ancient spillway from the Copper River basin. Such is apparently not the case, however, for the valleys of Squaw Creek and of the main headwaters of the Matanuska would naturally serve as such a spillway rather than the higher divide between Crooked and Alfred creeks.

Reconcentration from disseminated gold in the Tertiary conglomerate will not explain all these occurrences unless it is assumed that the Tertiary lavas on the headwaters of Alfred and Albert creeks are underlain by such a conglomerate. It is not known positively that the conglomerate is present there, but probably it is. However, this conglomerate has not yet been shown to be gold bearing, although similar conglomerates in other places probably carry gold.[1]

COPPER.

There is an interesting occurrence of copper ore on Sheep Mountain, near the headwaters of the Matanuska.[2] Sheep Mountain is an isolated rugged mountain mass lying north of the Matanuska, east of Caribou Creek, south of Squaw Creek, and west of Tahneta Pass. The rocks composing the mountain consist of andesitic tuffs, breccias, and lavas of Lower Jurassic age, with some interbedded shale, sandstone, and chert. They have been intruded by at least one mass of granite. The volcanic rocks are greatly shattered, and are traversed by a network of small veins which consist mostly of calcite. Considerable alteration has taken place. These rocks were described by Paige and Knopf [3] as follows:

For several miles 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

[1] Prindle, L. M., A geologic reconnaissance of the Circle quadrangle, Alaska: U. S. Geol. Survey Bull. 538, p. 57, 1913.

[2] Brooks, A. H., The mining industry in 1912: U. S. Geol. Survey Bull. 542, p. 39, 1913.

[3] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: U. S. Geol. Survey Bull. 327, p. 65, 1907.

some points the sulphuric acid formed during the oxidation of the pyrite has bleached the greenstones to a pure-white color. The rugged range, thus tinted in vividly contrasting colors, presents a marked scenic effect. Certain streams emerging from the range are so highly charged with iron salts as to color their gravel red with oxide. The pyritization of the greenstones, which are here roughly schistose, has affected a great thickness of rocks but is of a diffused character. An assay of a sample selected as showing the maximum mineralization yielded only a trace of gold and no silver.

The copper prospects are on East End Creek, which heads just west of the easternmost high peak in Sheep Mountain, and is the third creek west of the eastern extremity of the mountain. It enters the Matanuska about 7 miles above Caribou Creek, or 2 miles above the forks of the Matanuska.

The copper ore apparently occurs as irregular lenticular masses in the more porous and shattered parts of the rock. The abundance and wide distribution of small fragments of copper ore on the talus slopes indicate that the mineralization is general rather than localized and apparently promise the discovery of many small, lenticular ore bodies rather than a few large, persistent ones.

A mineralized zone was observed by the writers on the west bank of the creek at an altitude of about 4,200 feet, near the upper forks. It trends N. 40° E. and stands about vertical, being approximately parallel to the bedding. Disseminated sulphides (mostly chalcopyrite) occur in small masses throughout a width of about 5 feet, and the zone is thoroughly stained with malachite and a little azurite. Specimens (No. 252) taken at this locality were found to contain chalcopyrite, malachite, a little pale-blue carbonate, quartz, and calcite. Veins containing quartz, calcite, chalcopyrite, etc., occur in a shattered basic igneous rock. The chalcopyrite is weathering to copper carbonates. Specimens (No. 252–a) obtained in the creek bed and on talus slopes near by contain bornite and chalcopyrite. The gangue appears to be quartz, epidote, and calcite. The copper sulphides are weathering to malachite. A specimen (No. 251) obtained at the camp site at the mouth of the gulch of East End Creek, which is believed to have been obtained on this creek, appears to represent a sulphide replacement of basic igneous rock. The copper sulphides, which appear to be bornite and chalcocite, are altering to malachite. Epidote occurs in the gangue.

COAL.

AREAL DISTRIBUTION.

The coal of the Matanuska Valley occurs in several detached fields, part of which lie within the area here described and part of which are in the lower Matanuska Valley, a description of which has already been published.[1]

[1] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 500, 1912.

The coal of the upper Matanuska Valley is found in two separate fields which are distinct not only areally but in the geologic occurrence and probably in the character of the coal. One of these two fields (neither of which may be strictly a unit) lies in the Matanuska Valley proper below Hicks Creek, including the Anthracite Ridge area and an area south of the Matanuska, and is the eastern extension of the Chickaloon, Kings River, and Coal Creek area of the lower Matanuska Valley. The other is the upper Boulder Creek and Caribou Creek field.

The areal extent of the assemblage of rocks which carry the coal is indicated on Plate XI. The areas indicated as coal-bearing are those which may carry coal, as distinguished from the areas shown in blank on the map, which are believed not to carry coal. The areas represented as probably coal bearing, or as containing the so-called "coal-bearing rocks," can not be assumed to be underlain wholly by beds of coal of workable character and thickness. Moreover, parts of these areas probably have no coal under them. The lack of knowledge as to the exact stratigraphic position of the coal beds, the uncertainty as to what stratigraphic part of the "coal-bearing rocks" is represented by each of the observed surface outcrops, and the concealment of the rocks by gravels over broad areas make the precise areal distribution of the coal a problem which can be solved only by drilling or other underground exploration.

The tables given below indicate the probable and possible areas of supposed "coal-bearing rocks" in the lower Matanuska Valley as previously published [1] and with subsequent revision. The Chickaloon and Kings River area and the area south of the Matanuska, as given in the first of these tables, include lands as far east as longitude 148° 20′, as is shown on Plate VIII of Bulletin 480. These are larger tracts than were described in detail in Bulletin 500 and include land lying in the area described in the present paper. The first of these tables shows the areas of probable coal or the areas known to be occupied by the so-called "coal-bearing rocks," as defined above, and by the conglomerates and other beds which overlie them. The second table shows the areas of possible coal or the areas which may also be underlain by these rocks, but in which, because of concealment by gravels or of other lack of definite information, there is a possibility that other formations may be present. These estimates when first published were described as "provisional and subject to modification, perhaps considerable, when the region is more thoroughly prospected." It should be noted that they have already been modified by the later geologic work, which has shown that part of the area, east of Chickaloon River and both north and south of the

[1] Martin, G. C., Preliminary report on a detailed survey of part of the Matanuska coal fields: U. S. Geol. Survey Bull. 480, p. 134, 1911. Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 500, p. 76, 1912.

Matanuska, included in the 44 square mile and 8 square mile items, is not occupied by the coal-bearing Chickaloon formation, but by the non coal-bearing marine Upper Cretaceous, while another part of the 44 square mile area is occupied by a conglomerate of uncertain horizon which contains no coal outcrops and may not be underlain by coal.

Areas of supposed coal-bearing rocks in the lower Matanuska Valley.

[Square miles.]

	Original estimate.	Revised estimate.
Valleys of Chickaloon and Kings rivers	44	41.1
South of Matanuska River in vicinity of Kings Mountain and Coal Creek	8	6.4
Valley of Young Creek	3	3.0
Valleys of Moose and Eska creeks	19	19.8
	74	70.3

Areas of possible extensions of the supposed coal-bearing rocks in the lower Matanuska Valley.

[Square miles.]

	Original estimate.	Revised estimate.
Lower parts of valleys of Kings River and Granite Creek	8	9.1
Valleys of Moose and Eska creeks	16	15.8
	24	24.9

The following tables contain similar estimates of the areas which probably or possibly contain some coal in the upper Matanuska Valley proper, below Hicks Creek:

Areas of probable coal-bearing rocks in the upper Matanuska Valley.

[Square miles.]

Anthracite Ridge and low country south of its eastern half	22.7
South of the Matanuska near O'Brien Creek	3.0
	25.7

Areas of possible coal-bearing rocks in the upper Matanuska Valley.

[Square miles.]

Conglomerate and trap ridge district south of west half of Anthracite Ridge and of lower Boulder Creek	21.1
Alluvial flats of the Matanuska near O'Brien and Gravel creeks	3.2
Conglomerate area west of Gravel Creek	2.3
	26.6

These areas added to the revised estimates for the lower Matanuska Valley, as given above, show that the entire Matanuska Valley proper below Hicks Creek has an area of 96 square miles that probably contains some coal and an additional area of 51½ square miles that possibly contains some coal.

The area of coal on upper Boulder Creek and Caribou Creek can not, for reasons which will be discussed below, be estimated with even approximate certainty. The total area within which some tracts of coal may occur—namely, that of the conglomerate and of the overlying lavas (which may not everywhere be underlain by conglomerate)—is possibly 200 or 300 square miles, but it is reasonably certain that only a small fraction of this area is actually coal bearing.

STRATIGRAPHIC OCCURRENCE.

The coal beds of the part of the Matanuska Valley proper which is here under discussion, like those of the lower Matanuska Valley, are all known to be of Tertiary age and to agree approximately in general stratigraphic position with the coal of the Kenai formation on Cook Inlet. They all, except those at the Gravel Creek locality described as section No. 24 (p. 293), occur in the Chickaloon formation, which is the middle local division of the Tertiary rocks as described in the report on the geology of the lower Matanuska Valley. Their exact position within this formation has not been determined, but they seem to be in general distributed throughout the greater part of its thickness. Nothing definite is known as to the persistence of individual beds or of groups of beds.

The coal on Billy Creek and elsewhere in the Caribou Creek and Nelchina valleys has hitherto been assigned to the Jurassic, and has been described [1] as follows:

The coal-bearing rocks of this [the northeastern] field include an area of about 500 square miles. Coal is found at various localities, but never in thick beds, the best discovered having a thickness of 3 feet. The rocks are of Jurassic age and from fossil evidence are divided into a Middle and an Upper Jurassic series. The character of the coal appears in a general way to be in accordance with this separation—that is, the older rocks carry bituminous coal, and the younger, coal of a lignitic character.

The Middle Jurassic rocks generally are severely shattered and crushed, or sheared and slickensided, and as a rule present a decidedly unfavorable appearance for the presence of workable seams of coal. Locally the strata are closely folded, as on Billy Creek, where the coal has developed a strong cleavage and has assumed a semianthracitic character. That the high-grade coal is restricted to such belts of sharp deformation is rendered probable by the fact that the rocks in the less disturbed areas are found to contain only fragments of carbonized wood and small stringers of lignite.

The Upper Jurassic strata lie in comparatively undisturbed attitudes, with prevailing low dips. Minor dislocations of the beds are of widespread occurrence. More extensive faulting is occasionally met with, as on Billy Creek, where faults of several hundred feet throw are revealed with diagrammatic clearness. Coal was seen at only two localities, on the head of Billy Creek and on the south fork of the Tyonek. At these localities the outcrops were obscured by mud and slide material, but the amount

[1] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: U. S. Geol. Survey Bull. 327, pp. 56–57, 1907.

of coal represented was probably small. The coal found is a black lignite which checks on drying. Mendenhall reports thin beds of coal interstratified with the shales and sandstones along the south fork of the Nelchina.

The writers believe that at least the greater part of the coal in this district, and probably as much of it as occurs in distinct beds (that is, otherwise than as coalified sticks and small stringers), is not Jurassic but Tertiary. The evidence for this belief is as follows:

The coal-bearing rocks at the locality on Billy Creek described above contain abundant, well-preserved, and distinctive Tertiary plants. The lithologic character of the beds in which the fossils occur is similar to that of the recognized Tertiary rocks of the Matanuska Valley and entirely unlike that of the undoubted Jurassic rocks. The "greenstone amygdaloids" of the section on Billy Creek resemble some of the Tertiary igneous rocks at least as closely as they do the Lower Jurassic volcanic rocks, and consequently they may be regarded as either an infaulted block of late Tertiary basaltic lava or as an intrusive mass injected under light load.

A bed of coal exposed near the headwaters of Boulder Creek lies beneath the Tertiary lavas and above a massive conglomerate which rests upon Upper Cretaceous rocks. These coal-bearing beds carry fossil plants, which are either Upper Cretaceous or Tertiary.

Coal float was seen by the writer on several of the other tributaries of Billy and Caribou creeks, and in each place it was on a stream that heads in the conglomerate underlying the Tertiary lavas. No coal was seen by the writers in place in the Jurassic rocks, and no coal float was seen on streams other than those that head in areas of Tertiary rocks.

According to Knopf's notes coal was not seen in the undoubted Jurassic rocks except as "stringers" and was found as float only on those creeks (except for Tyonek Creek) which head in known or probable Tertiary areas.

There is consequently little doubt that the coal beds of this district are Tertiary. They evidently can not be assigned to the Chickaloon formation. The conglomerate with which they are associated may either hold the position of the Eska conglomerate or be the equivalent of beds lower down in the Tertiary sequence. It is believed that the beds at this horizon are only locally coal bearing.

COAL BEDS.

The following pages contain measured sections of all the coal beds that were accessible. These measurements were all made at natural exposures, there being no prospect openings or tunnels. No attempt has been made to correlate the beds, as the complex structure and the fact that none of the beds can be traced from point to point make correlation impossible. The sections in the Matanuska Valley proper are arranged in order from northwest to southeast.

1. Creek flowing northwest into Boulder Creek from near the west end of Anthracite Ridge, altitude 3,700 feet. Coal blossom (bed concealed) near outcrop of dark shale. Strike N. 68° W., dip 63° SW.

2. South face of Anthracite Ridge, 2 miles east of its west end, altitude 3,900 feet. Coal blossom. No exposure obtainable.

3. Creek bed 1.2 miles S. 52° W. from 6,280-foot peak at head of Purinton Creek, altitude 3,350 to 3,500 feet.

	Ft.	in.
Crumpled shale	85±	
Coal	1	1
Shale		6
Sandstone	21	0
Shale	25	0
Coal	1	0
Shale	25	0
Sandstone	18	0
Shale	18	0
Sandstone	36	0
Shale	3	0
Coal		8
Shale	12	0
Sandstone	24	0

Strike N. 62° W., dip 45° S.

4. West Fork of Purinton Creek, altitude 4,200 feet.

	Ft.	in.
Intrusive rock (diabase).		
Shale roof.		
Coal		6
Diabase sill		6
Shale		3
Coal with much shale	1	6
Shale		1
Very carbonaceous shale and coal		5
Shale.		

Strike N. 88° E., dip 43° S.

5. West Fork of Purinton Creek, altitude 4,100 feet. Apparently two beds of coal, each 5½ or 6 feet thick, 2 or 3 feet apart, but more probably one bed repeated by surface slipping. Strike N. 65° W., dip 30° SW.

6. West Fork of Purinton Creek, altitude 3,900 feet. Coal, 40± feet. Neither roof nor floor of this coal bed could be found. The coal is apparently cut off at each end of the exposure across what appears to be the bedding. This is the exposure which has previously been described [1] as a 38-foot bed of anthracite and of which an analysis is given on p. 295. It should probably be regarded as a swollen pocket lying in a closely folded overturned syncline and probably cut by a fault. An exposure of shale in the creek 15 or 20 feet below the coal gave three readings on the bedding as follows: Strike N. 72° E., dip 11° NW.; strike N. 76° W., dip 12° NE.; strike N. 73° E., dip 21° NW.

[1] Martin, G. C., A reconnaissance of the Matanuska coal field, Alaska, in 1905: U. S. Geol. Survey Bull. 289, p. 18, 1906.

7. West Fork of Purinton Creek, altitude 3,880 feet.

	Ft.	In.
Shale roof.		
Coal	1	0
Shale (some coal)		5
Coal	3	1
Shale	1	4
Coal	1	3
Shale with some coal		6
Shale	2	3
Shale with some coal	1	0
Shale	2	4
Coal	1	6
Black shale	1	4
Gray shale	12±	
Shale with some coal		6
Black shale	1	8
Coal	1	10
Shale		8
Coal with a little shale	1	4
Gray fissile shale floor.		
Strike N. 87° W., dip 55° S.		

8. East bank of East Fork of Purinton Creek, about 570 feet upstream from section 9.

	Feet.
Shale and sandstone, much folded.	
Coal with some shale	7±
Covered	6
Coal with some shale	4±
Shale and sandstone, much folded.	

9. East Fork of Purinton Creek, altitude 3,480 to 3,560 feet.

	Ft.	In.
Diabase.		
Shale (baked)	12	0
Sandstone	10	0
Shale, with coal blossoms	47	0
Coal	2	7
Shale floor.		
Strike N. 80° W., dip 55° S.		

The section given below was measured by Martin[1] in 1905 on the east fork of Purinton Creek or on the next creek east of it, on the south slope of Anthracite Ridge.

	Feet.
Flaggy sandstone.	
Coal and shale	3
Coal	7
Shale	4
Coal	1
Shale	3
Coal	2
Shale	2
Coal	7
Strike N. 89° E., dip 55° SE.	

[1] Martin, G. C., A reconnaissance of the Matanuska coal field, Alaska, in 1905: U. S. Geol. Survey Bull. 289, p. 19, 1906.

10. Creek bed 1.3 miles S. 24° E. from 6,280-foot peak at head of Purinton Creek, altitude 3,850 to 3,950 feet.

	Ft.	in.
Diabase sill	19	0
Shale	4	0
Coal	1	1
Partly shale, partly covered	21	0
Coal		8
Shale	15	0
Coal		10
Shale with thin sills	23	0
Coal	2	0
Shale (partly covered)	27	0

Strike N. 86° E., dip 44° N.

11. Creek bed 2.9 miles S. 55° E. from 6,280-foot peak at head of Purinton Creek, altitude 3,880 to 3,895 feet.

	Ft.	in.
Shale with coal blossoms	50	0
Coal	3	5
Shale	24	0
Coal	2	2
Shale	21	0

Strike N. 82° W., dip 20° N.

12. Creek bed 2.9 miles S. 54° E. from 6,280-foot peak at head of Purinton Creek, altitude 3,830 to 3,850 feet.

	Ft.	in.
Shale roof.		
Coal	1	2
Shale	3	8
Coal		9
Shale	2	2
Coal	3	2
Shale	1	1
Coal		7
Shale floor.		

Strike N. 82° W., dip 20° N.

The two following sections described by Paige and Knopf [1] were measured by Knopf on either this creek or the next one east of it:

Section of coal on Anthracite Ridge, altitude 3,100 feet.

	Ft.	in.
Diabase	50±	
Sandstone and shale	10±	
Coal and shale	6	0
Coal		2
Shale		1
Coal		10
Shale	2	0
Sandstone	7	0

Strike N. 70° W. (magnetic), dip 40° S.

[1] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: U. S. Geol. Survey Bull. 327, pp. 55-56, 1907.

Section of coal on Anthracite Ridge, altitude 3,600 feet.

	Ft.	in.
Sandstone.		
Coal	2	6
Coal and shale		4
Coal		6
Coal and ferruginous clay		2
Coal [1]		10
Shale		6
Coal		4
Shale	12	0
Coal	1	3
Shale	5	0
Sandstone	1	0
Shale	1	6
Clay ironstone nodules		6
Shale	1	6
Clay ironstone nodules		6
Highly carbonaceous shale	5	0
Coal	1	5
Shale	9	0
Sandstone	4	0
Shale	15	0
Coal		10
Shale	4	0
Coal	2	2
Shale	4	0
Coal		10
Shale	2	6
Coal and shale		6
Shale footwall.		

Strike N. 80° E. (magnitude), dip 34° S.

13. Muddy Creek, altitude 3,700 feet. West bank of creek.

	Ft.	in.
Sandstone	20	0
Carbonaceous shale, locally coal		6
Coal	1	7
Shale	3	0
Coal	1	1
Carbonaceous shale		6
Shale, with flattened ironstone nodules	3	0
Coal	1	2
Shale		10
Ferruginous sandstone	1	2
Drab shale	1	7
Carbonaceous shale, locally coal		4
Coal		4
Carbonaceous shale, locally coal		6
Shale floor.		

Strike N. 32° W., dip 45° W.

[1] See analysis No. 22 in table of analyses, p. 295.

14. East bank of Muddy Creek, altitude 3,690 feet.

	Ft.	in.
Shale roof.		
Coal	1	2
Shale	6	0
Sandstone	4	0
Shale	7	0
Coal	1	7
Shale parting		2
Coal	1	10
Shale	8	0
Sandstone	5	0
Shale	3	0
Coal	1	1
Shale	6	0
Coal	1	7
Covered.		

Strike N. 65° E., dip 45° S.

15. Bed of Muddy Creek, altitude 3,340 to 3,415 feet.

	Feet.
Diabase sill	100
Carbonaceous shales containing 6 to 12 coal seams ranging in thickness from 1 inch to 18 inches. Badly crushed and sheared	22
Sandstone, thin bedded, and shale	28

Strike N. 8° E., dip 25° W.

16. Crest of spur between Muddy Creek and Packsaddle Gulch, altitude 4,400 feet.

	Feet.
Covered.	
Coal	11+
Covered.	

Strike approximately east, dip 90°±.

17. North bank of Matanuska River, half a mile above Gravel Creek.

	Ft.	in.
Fissile gray shale.		
Coal, clean	1	4
Coal, somewhat shaly		9
Fissile gray shale.		

Strike N. 49° E., dip 30° NW.

The entire exposure at this point consists of about 200 feet of shale and sandstone, with several carbonaceous zones 10 to 40 feet thick, in some of which there are coal beds several inches thick. The coal bed described above is near the base of the section and extends along the face of the bluff for a considerable distance, in which it shows no indication of lenticularity.

18. Gulch 0.3 mile west of O'Brien Creek, altitude 1,800 feet.

	Ft.	in.
Black shale with some coal.		
Gray sandy shale	8	4
Black shale		7
Coal		7
Gray nodular shale	3	3
Coal	2	0
Gray shale, much stained by iron		10

	Ft.	in.
Coal		9
Shale		2
Coal		4
Shale with a little coal	2	0
Ironstone band		9
Coal		7
Gray nodular shale	3	5
Coal		9
Shale		2
Coal	1	3
Concealed	8	0
Coal and some shale	6	0
Concealed.		

Strike N. 78° E., dip 40° S.

19. O'Brien Creek, altitude 1,500 feet.

Gray shale under clay.	Ft.	in.
Coal		½
Shale		1
Coal	4	1
Shale with some coal	1	9
Coal	1	6
Coaly shale		10
Coal	2	6
Shale with ironstone concretions	6	0
Shale and coal	4	7
Coal		2
Shale		1½
Coal	1	5
Shale		2½
Coal		11
Shale		½
Coal		1½
Shale		½
Coal	2	0
Coal and shale (squeezed)	1	6
Coal	2	8
Coal and shale		9
Shale	1	2
Coal	1	3
Coaly shale		10
Gray shale with ironstone concretions	13	6
Gray shale	31	0
Gray shale with ironstone concretions	3	0
Sandstone with some interbedded shale	14	10
Shale, somewhat sandy	15	0

Strike N. 70° W., dip 87° SW.

20. O'Brien Creek about 100 yards farther upstream. Coal with many thin partings, 25 feet. This bed is apparently below the one described above.

21. Near top of west bank of O'Brien Creek a short distance above No. 20. Large coal outcrop which apparently consists of the bed represented in section 20 folded back upon itself in an overturned syncline.

22. Gulch one-third mile east of O'Brien Creek, altitude 1,800 feet.

	Ft.	in.
Shale roof.		
Coal	3	9
Coal and some shale	2	0
Concealed.		
Rocks dipping gently northeast.		

23. Gulch one-third mile east of O'Brien Creek, altitude 1,900 feet.

	Ft.	in.
Sandy gray shale roof.		
Coal		8
Shale with some coal	2	0
Sandy shale.		
Concealed.		
Rocks dipping about 20° NE.		

24. About 1½ miles up the creek which enters Gravel Creek from the west 2¼ miles above its mouth, altitude 2,100 feet.

	Ft.	in.
Covered.		
Coal, impure, sheared	1	7
Shale		7
Coal, impure, sheared	1	2
Covered.		
Dip 75° S.		

The rocks at this locality can not with certainty be assigned to the Chickaloon formation, which includes all the other known coal beds in the main valley of the Matanuska. The coal at this locality may represent either a local coal-bearing bed in the pre-Chickaloon strata, or a small block of the Chickaloon formation folded or faulted into the mass of rocks which are otherwise barren of coal.

Information concerning the coal of the upper Boulder and Caribou valleys is much less abundant than that already presented concerning the coal of the Matanuska Valley itself. This is due partly to the fact that the examination of this field was less detailed than that of the other, but chiefly to the fact that the field contains far less coal. The following is a typical section:

Section near waterfall on northwest side of Boulder Creek 16½ miles northeast of its mouth.

	Ft.	in.
White sandstone and shale with carbonaceous beds.		
Coal and shale	1	6
Coal [1]	1	3
Shale	1	0
Coal		7
White sandstone and shale.		
Strike N. 11° W., dip 20° NE.		

The exposure of coal-bearing rocks on the small tributary to Billy Creek from the east 2½ miles above its mouth contains numerous carbonaceous beds and coaly streaks and several thin beds of coal. The largest observed bed attains a maximum thickness of 3 feet, a large portion of which is shale and bone. The greatest observed thickness of pure coal at this locality is not over 12 inches.

[1] Included in sample No. 19346, p. 295.

Small fragments of coal were also observed in the beds of several of the other tributaries of Billy Creek, notably the one entering it from the east 6 miles above its mouth, on some of the creeks tributary to Caribou above Billy Creek, and on Hicks and Tyonek creeks.

CHARACTER OF THE COAL.

PHYSICAL PROPERTIES.

The coal of the Matanuska Valley is of three kinds—anthracite, high-grade bituminous, and low-grade bituminous. All of these have been found within the area here described. The last two occur also farther west in the lower Matanuska Valley and have been described in an earlier report.[1]

The anthracite is known only in a small area near Purinton Creek on the south face of Anthracite Ridge. The high-grade bituminous coal occurs on the south side of the Matanuska and probably on Anthracite Ridge. The low-grade bituminous coal occurs at the east end of Anthracite Ridge and on upper Boulder and Caribou creeks. The investigations that have thus far been made are not sufficient to permit an attempt to outline precisely or to estimate the areas of the several kinds of coal.

The anthracite has the ordinary physical characteristics of most coal of this kind. It is heavy, firm, hard, and not much fractured for surface coal and has a high luster. Pyrite was not observed in it.

The high-grade bituminous coal is fragile and soft, like all coal of this variety, and the beds show the effects of having been severely crushed and at many places are without any well-defined bedding planes or places of fracture. The friability of the coal is so great that it will probably not stand shipment without being badly crushed. This is not so great a detriment as might at first seem, because many of the beds contain so many impurities that the coal from them ought to be crushed and washed. It is, moreover, highly probable that some of this coal can be used in the manufacture of coke, a purpose for which lump coal is not desired. Coal which possesses coking properties, as much or all of this coal does, can, by proper handling, be burned as slack about as well as in lumps, for the slack coal when thrown into the furnace will fuse and cake, thus preventing loss of coal through the grates.

The low-grade bituminous coal is on the border line between bituminous coal and black lignite. It is harder than the higher-grade bituminous coal. Many of these beds too have been crushed, and a large proportion of lump coal can not probably be obtained from them. This coal probably possesses no coking properties and is likely to be used only under stationary or locomotive boilers. It is not so good

[1] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 500, 1912.

for this purpose as the higher-grade coal, but the latter, being better suited for the manufacture of coke and for use as smithing and naval coal, will command a higher price and may thus leave a lower-price market for the poorer coal. Some of the low-grade coal can probably be mined more cheaply than the high-grade coal. The two kinds of coal will, to a certain extent, be noncompetitive, each having its own special markets.

CHEMICAL ANALYSES AND TESTS.

The following table includes a few analyses of characteristic samples of coal from various parts of the area. Sample No. 19346 was taken during the investigations here described. The analyses of samples 1 and 22, which were collected in 1905 and 1906, have been published in Bulletins 289 and 327. The other analyses represent samples collected in 1911 by Dr. Joseph A. Holmes, Director of the Bureau of Mines. All the samples were obtained from surface prospects or from outcrops, and were consequently somewhat weathered. The reason that more samples were not obtained is that the absence of openings made it impossible to obtain other than samples of weathered coal, which are of comparatively little value.

Analyses and tests of Matanuska River coals.

Sample No.	Thickness of coal in feet.	Proximate analysis.					Ultimate analysis.					Calorific value.	
		Loss on air drying.	Total moisture.	Volatile combustible.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
[a] 1	38.0	([b])	2.60	5.26	86.15	5.99	0.57	3.07	84.30	1.13	4.94	7,586	13,655
19346	1.3	......	5.95	35.25	50.20	8.60	.43	......	......	......	......	......	......
[a] 22	.9	([b])	2.18	30.60	50.06	9.16	.70	4.83	71.43	1.50	12.38	7,303	13,145

[a] These analyses were made by F. M. Stanton on the same samples as those with corresponding numbers on pp. 60, 61 of Bulletin 327. The differences in proximate analyses are due to the fact that the samples dried somewhat in the months which elapsed between analyses and that somewhat different methods of analysis were used. (See U. S. Geol. Survey Bull. 290, pp. 29-30, 1906.)
[b] Not determined.

1. West fork of Purinton Creek, altitude 3,900 feet. (See section 6, p. 287.)
22. South face of Anthracite Ridge. (See p. 290.)
19346. Near waterfall on northwest side of Boulder Creek 16½ miles above its mouth. (See p. 293.)

COKING PROPERTIES.

Comparatively little is known of the coking properties of the coal of this part of the Matanuska Valley. A rough coking test[1] made on some of the coal from Chickaloon River indicated that by proper treatment a coke of satisfactory grade can probably be produced.

No further tests have been made by members of the Geological Survey. The analyses indicate, however, that the high-grade bituminous coal of the upper Matanuska Valley, like that on Chicka-

[1] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 500, p. 92, 1912.

loon and Kings rivers and on Coal Creek, is probably coking coal at least in part, and that such of the low-grade bituminous coal as is similar in composition to the coal on Moose, Eska, and Young creeks, in the west end of the lower Matanuska Valley, is probably non-coking.

MINING CONDITIONS.

The possibility of mining the Matanuska coal at a profit depends on a variety of factors, some of which are geologic and will be discussed below, while others, such as the cost of labor and supplies, purchase or leasing charges, transportation, and markets, are economic and do not belong strictly within the province of this report.

The geologic factors that affect the possibility of mining include the character of the coal, such as its composition, heating power, firmness, smoking and clinkering qualities, and coking or other special properties; the character of the coal beds, such as their thickness, persistence, freedom from partings and binders, and the nature of the roof and floor; the attitude of the coal beds, including their depth below the surface, steepness, and structural regularity; and the presence of extraneous detriments, such as intrusive rocks, water, gas, and dust.

A large number of these factors are variable within the field, either regionally or from bed to bed. These must be considered in detail, both locally and by beds, in connection with each proposed mining project, and they can not be the subject of a general discussion here. Others of these factors have already been considered in the preceding pages, so far as the available information permitted. There remain, however, several factors concerning which it is possible and desirable to present brief general discussions.

EFFECT OF FOLDING AND FAULTING.

The steep dips and complex structure of large parts of the coal areas introduce serious problems in coal mining and call for careful investigation of the structural conditions of each individual tract before the development of mines is attempted. It is believed that in some areas in the Matanuska Valley the structure is so complex that coal mining will be practically impossible. Such areas probably include at least part of Anthracite Ridge and part of the coal area south of the Matanuska.

The exposures on the north bank of the Matanuska from a point 1 mile above to a point 4 miles below the mouth of Gravel Creek show gently dipping and regular beds. If the coal exists beneath these beds there should be no difficulty in mining it. The distribution of the coal outcrops, which occur in two belts, one of them along the south face of Anthracite Ridge and the other south of the Matanuska, indicates that the broader structure of this part of the valley is synclinal and that the coal beds occur low in the stratigraphic sequence. In this case the center of the valley should be underlain by coal, but there is no evidence as to the depth at which the beds may lie.

The hill north of Boulder Creek and immediately east of Chickaloon River is composed of gently dipping Eska conglomerate. If the coal beds persist beneath the conglomerate, and if the coal-bearing rocks were not folded before the conglomerate was laid down, mining should not be difficult, at least so far as structural conditions are concerned. It should be remembered, however, that the vertical distance from the Eska conglomerate to the workable coal is not known and that the coal may at this point be at a prohibitive depth or under a prohibitive load.

Throughout the greater part of the main Matanuska Valley the structural details are not known, but there are indications that complex structure is the general condition. It is probable that there are areas in which the structure will permit the mining of the coal, but also that there are larger areas in which the structural conditions will make the mining of the coal difficult and expensive, if not impossible. It will probably be found that where the structure is simple the coal is of low grade. The character of the structure must be regarded as a problem to be solved by underground exploration before the feasibility of mining at a profit the coal of any particular tract can be demonstrated.

The coal areas on upper Boulder and Caribou creeks in general possess simple structure, although intense folding was noted on Billy Creek. (See p. 285.) In this district sharp folding is restricted to narrow zones between which the rocks are nearly flat. The coal of this district is, however, of small amount and low grade and is not easily accessible.

EFFECT OF INTRUSIVE ROCKS.

Intrusive rocks are abundant throughout the area of coal outcrops in the upper Matanuska Valley. They are both large and numerous along the south front of Anthracite Ridge in the area of both the anthracite and the low-grade bituminous coal. The areal distribution of the larger of these intrusive masses is indicated on the map (Pl. XI, p. 292). Small dikes and sills, not represented on the map, are also present throughout practically all the coal areas. Where the intrusive rocks cut the coal beds the coal is rendered worthless for a distance of a few inches from the contact. The small dikes and sills, on account of the short distances to which their effect extends, do not affect the coal seriously, except that the sills show a habit of seeking coal beds for their planes of intrusion. It is clear that if a sill is intruded into a coal bed for a long distance a large amount of worthless coal will result, but if it is intruded between rock strata, even if only a few feet away from a coal bed, or if it cuts across the coal bed in the form of a dike, its effect on the coal will be slight.

The larger intrusive masses are of much more serious importance than the small dikes and sills, first, because their size is of itself sufficient to reduce the coal areas considerably, and second, because each of them is likely to have sent off many apophyses in the form of sills in or along the surfaces of coal beds. The dimensions of these masses are, moreover, probably greater underground than at the surface. There may also be many intrusive masses which do not outcrop but which are near enough to the surface to be encountered in mining.

In conclusion, it must be stated that the presence of intrusive rocks in the coal field introduces factors that make an undetermined percentage of the coal areas of very doubtful value. The size and distribution of these intrusive masses beneath the surface, as well as at the surface in the areas of scanty outcrops, can not be determined without underground exploration. The effect of the smaller intrusive masses on the coal depends on the extent to which these masses have been intruded into or along the surfaces of coal beds. Where the intrusive mass is in contact with the coal the coal is worthless, but where it is a few feet away the quality of the coal is probably unimpaired or may even be improved.

UNDERGROUND WATER AND GAS.

In any large mines which are opened in this region it will be necessary from almost the beginning of mining to pump or hoist mine water. It is not believed that it will be possible to open any large mines having natural drainage. The amount of underground water which will be encountered will probably not be great, unless the mines are opened on the outcrop. Precipitation in this region is so slight that large amounts of water can get into the mines only from the streams. If ordinary precautions are taken to prevent streams from breaking into the mine openings the mines ought to be fairly dry.

The heavy cover of gravel which exists at the lower altitudes throughout most of the Matanuska Valley will cause certain dangers in mining. Unless the depth of the gravel at different points and the shape of the underlying rock floor are determined by drilling there will be danger of the mine workings breaking through the surface of the rock into the gravels. The gravels probably carry large amounts of water in some places and serious accidents might thus result.

Gas will probably be a serious problem in local mining from the very start. The experience of the tunnels on Chickaloon River indicates that these coal beds will yield large amounts of dangerous gases. Some provision ought to be made in advance of mining for the enforcement of suitable regulations insuring the protection of the miners and the mines against gas explosions.

CONCLUSION.

The outlook for profitable coal mining on a large scale in the upper Matanuska Valley is not promising. The doubt concerning the workability of the coal of the lower Matanuska Valley [1] applies with greater force here, where the coal is apparently of lesser amount and of lower grade, is folded and intruded to at least the same degree, and is less accessible than it is in the lower part of the valley. If mining is attempted in the upper Matanuska Valley the proposed mine sites should be selected only after a careful study of local conditions, which should be accompanied by drilling. The selection of a site should be governed by the accessibility to the railroad and by the structure of the rocks. The structure should be determined in detail for each property by careful drilling or otherwise, in order that the mine may be opened at such a point that the underground haulage of the coal and the disposal of the mine waters may be accomplished at a minimum expense.

Although many of the coal beds outcrop at the surface, they dip for the most part at steep angles. No localities have yet been found in this district at which it would be possible to mine any considerable amount of coal above the level of the outcrop of the coal bed. The amount of coal above the general drainage level is not great, and it will be necessary from the very beginning of mining to sink shafts or slopes to considerable depths. If any large mines are opened it will probably be found desirable to sink shafts to the coal beds at considerable distances from their outcrops.

The local region will furnish none of the supplies needed in coal mining, except timber, and even this is not abundant and is of poor quality. Everything else in the line of mine equipment and tools will have to be shipped from points outside of Alaska, which would add greatly to the expense of mining.

The development of the Matanuska coal fields on a large scale is dependent on the construction of a railroad to tidewater, and on the existence of an outside market for the high-grade coals. Under existing conditions of the mineral-fuel market on the Pacific coast it is only such coal as is suitable for coking, smithing, or for the Navy that will probably find such a market. The local conditions under which coal of this character has been observed indicate that its mining and preparation for market may be so expensive that it can not compete with high-grade coal from other regions.

The possibility of mining the low-grade coal at a profit is dependent either on the construction and operation of a railroad for other purposes than the shipping of such coal alone, or on the development of a local market. The latter may follow from the possible extensive development of gold mines.

[1] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 500, p. 94, 1912.

PRELIMINARY REPORT ON THE BROAD PASS REGION.[1]

By Fred H. Moffit.

INTRODUCTION.

The Broad Pass region includes the upper parts of Chulitna and Nenana rivers. As here used, the name Broad Pass designates an area of indefinite boundaries, extending westward from Susitna River and for the most part lying south of the main axis of the Alaska Range.

The headwaters of Chulitna River and the vicinity of Broad Pass were first visited by Government exploring parties in 1898. In that year G. H. Eldridge[2] and Robert Muldrow, of the United States Geological Survey, ascended Susitna River from Cook Inlet to the mouth of Indian Creek, whence they made their way northeastward through the Indian Creek valley and a valley parallel to the upper Chulitna, which succeeds the Indian Creek valley, to Jack River. They then descended Jack River and the Nenana to the mouth of Yanert Fork, where the failure of their supplies obliged them to turn back.

The same year Sergt. Yanert,[3] of the Fourteenth Infantry, United States Army, with one companion and an Indian guide, ascended Chulitna River from a point near the mouth of Indian Creek to Broad Pass and Nenana River, but he, like the Eldridge party which preceded him a few days, was compelled by lack of food to return to Susitna River without seeing the Tanana.

Many prospectors and hunters have visited the region since that time. In 1903 a private reconnaissance railroad survey, crossing Broad Pass, was run from Cook Inlet to the Tanana, yet neither topographic nor geologic mapping was done in this region until 1913, although the adjacent Bonnifield and Valdez Creek districts were surveyed in 1910[4] and the exploratory expedition under Brooks[5]

[1] A more extended account of the Broad Pass region will be published in a forthcoming bulletin. Mr. J. E. Pogue has rendered efficient assistance in both the field and office work, of which this report is the result.

[2] Eldridge, G. H., A reconnaissance in the Sushitna Basin and adjacent territory, Alaska, in 1898: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 1–29, 1900.

[3] Yanert, William, A trip to the Tanana River: Explorations in Alaska, pp. 677–679, Washington, 1900.

[4] Moffit, F. H., Headwater regions of Gulkana and Susitna rivers, Alaska, with accounts of the Valdez Creek and Chistochina placer districts: U. S. Geol. Survey Bull. 498, 1912.

[5] Brooks, A. H., The Mount McKinley region, Alaska, with descriptions of the igneous rocks and of the Bonnifield and Kantishna districts, by L. M. Prindle: U. S. Geol. Survey Prof. Paper 70, 1911.

crossed the Nenana just above Yanert Fork in 1902. Plans were formulated for making such surveys in 1912, but could not be carried out on account of delay in the appropriation, although supplies had been sent to Valdez Creek in the early part of that year. The work was therefore not undertaken till 1913, when two parties were sent into the field. The season included less than 55 working days, and the working time was reduced still further by frequent rains and by a heavy fall of snow on August 27.

The Broad Pass country may be entered from the south by the Susitna River, Indian Creek, and Chulitna River valleys; from the north by the Nenana Valley; and from the east by any of the trails leading westward from the military road through the Valdez Creek district. There are no established trails leading into it, and each of the general routes mentioned presents difficulties of one kind or another. Nenana River is unfortunately too swift and has too many rapids in its course to afford a summer route from the Tanana for small boats. The Susitna-Chulitna route is long and difficult. The route from the east is perhaps the best for summer travel. Any one of the three may be used in winter, but the Nenana route is of course available only for those who are already in the interior of Alaska.

RAILWAY ROUTES.

Broad Pass offers one of the most favorable railway routes from the Pacific seaboard to the Tanana and Yukon basins. The Chulitna, flowing into the Susitna on the south, and Jack River, flowing into the Nenana, a tributary of the Tanana, on the north, both head in Broad Pass, which therefore marks the watershed between the Cook Inlet and Yukon drainage basins. The waters of the Nenana in the past ran through Broad Pass into the Chulitna but were diverted by the glacier that formerly occupied the region. Since the disappearance of the ice the drainage has not reverted to its preglacial course.

The approach [1] to Broad Pass from the south along the headwaters of the Chulitna is so far as known a gradual ascent, and a railway route of comparatively low grade could probably be found along it. The pass itself is a flat about 4 miles in width affording no engineering difficulties. It stands about 2,500 feet above sea level. North of the pass the railway route would be down the valley of Jack River to the Nenana, and here, too, a good grade could probably be found. The main Alaska Range would be traversed by the valley of the Nenana River, which for about 10 miles flows through a steep-walled canyon.

While Broad Pass probably affords the most feasible railway route, because it is most direct, there are other low divides leading from the Susitna into the Nenana basin. A gravel-floored flat connects the

[1] Railway routes in Alaska (report of Alaska Railroad Commission): H. Doc. No. 1346, 62d Cong., 3d sess., p. 83, 1913.

upper Susitna Valley near Valdez Creek with Nenana River. Another low pass lies between the headwaters of Deadman Creek, flowing into the Susitna on the south, and Brushkana Creek, flowing into the Nenana on the north.

VEGETATION AND GAME.

Most of the mapped area is above timber line; that is, more than 2,500 feet above sea level. Vegetation is therefore not so dense as at lower altitudes. A sparse growth of spruce is seen along Susitna River as far north as the glaciers at the heads of its two main forks. A similar growth of spruce covers the broad, flat divide between Susitna River and the Nenana. Spruce of much better quality grows on Butte Creek and near the mouth of Jack River, but the timber on the head of Chulitna River is similar to that on the upper Nenana and the Susitna. The better timber, like that on Butte Creek, is suitable for local mining needs and has been used on Valdez Creek for all purposes since the supply close at hand was exhausted.

In most of the region travelers are dependent on willows or alders for camp use. Good willows can nearly always be found on the smaller streams at elevations between 2,500 and 3,000 or 3,200 feet above sea level. The large willows are rarely found higher than 3,500 feet above the sea. The elevation of about 3,000 feet also affords the best traveling, for brush as well as timber is absent and grass for horse feed is most abundant.

Game is fairly plentiful in most of the region, but would doubtless disappear, as it has in the vicinity of Valdez Creek, if mining or other enterprises should bring in a considerable number of white men. The Indians, of whom there are about 30 at Valdez Creek, live almost entirely on game during a large part of the year and find their best hunting grounds on Jack River and Yanert Fork of Nenana River.

Ptarmigan, caribou, moose, and sheep are the principal game animals. Ptarmigan are abundant in most of the willow thickets above timber line. Caribou may be seen at certain seasons in nearly all parts of the area mapped. Moose appear to be most numerous on the head of Chulitna River and in that vicinity. Sheep are found chiefly in the Alaska Range, particularly on the north side, and are especially plentiful in the mountains about Yanert Fork. Bear also are numerous in this vicinity. Yanert Fork, on the whole, is much the best hunting ground of the region. Grayling and trout are taken from many of the lakes and clear-water streams. Some of the lake trout grow to very large size.

GEOLOGY.

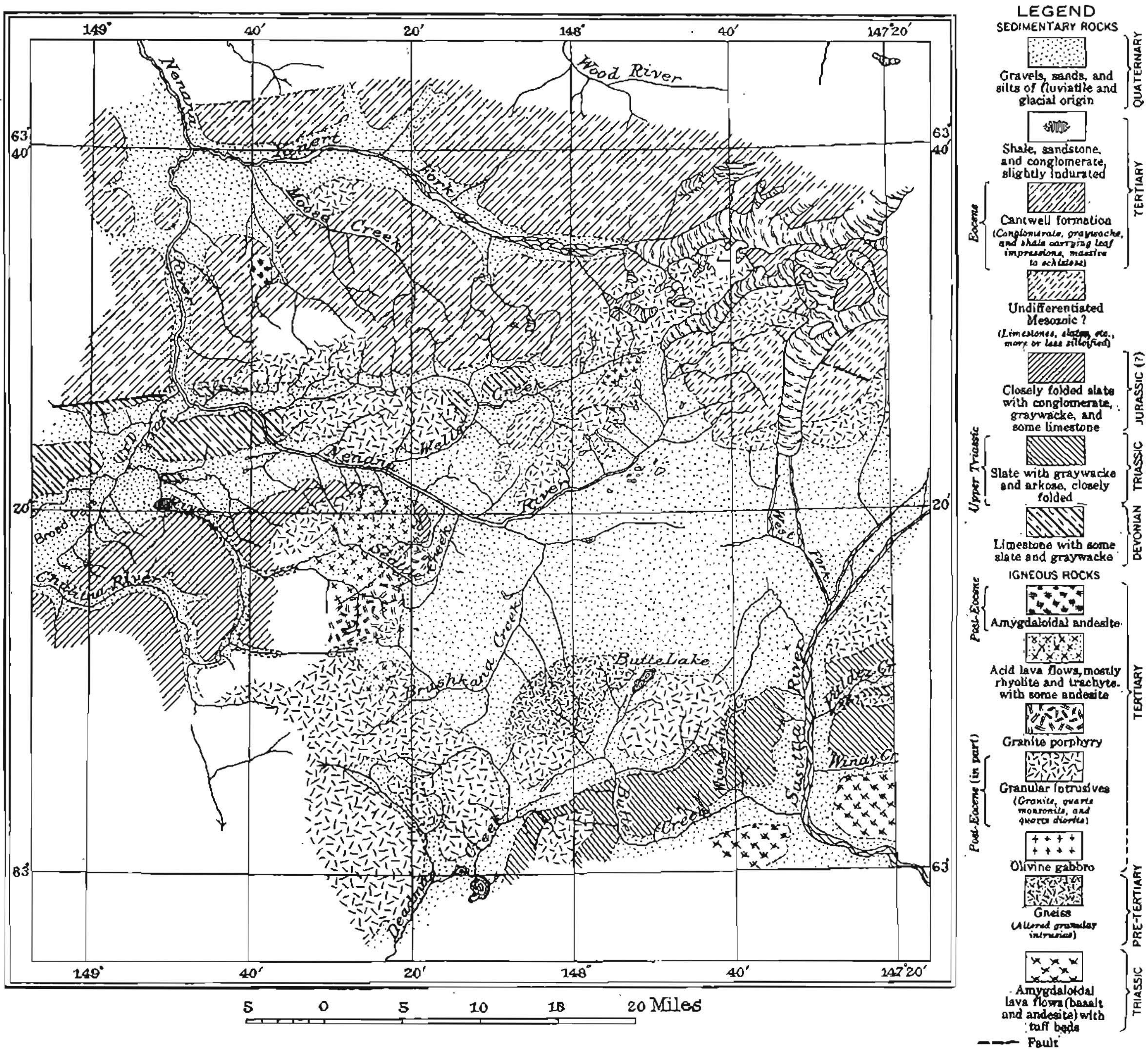
In most of the area mapped on Plate XII unconsolidated morainal deposits and granular igneous rocks such as granite and diorite predominate, yet slate, graywacke, conglomerate, and limestone are widespread.

The consolidated sedimentary formations range in age from Devonian to Tertiary. All are folded and metamorphosed but in places show these alterations in little or only moderate degree. In general, the more argillaceous and siliceous rocks range from slate, graywacke, and dense hard conglomerate to crystalline schist. Some of the more highly altered limestone beds are so silicified as to retain little of their original character.

The granular igneous rocks may for field use be designated as granites. They include granite, quartz, diorite, and related rock types and present no unusual features. They are associated in at least one locality with rhyolitic lava flows. More basic igneous rocks, of which the most widespread are basaltic and andesitic lavas, are present in the southeastern part of the region, but are subordinate in amount to the granite and quartz diorite.

The general distribution of consolidated sedimentary and igneous formations in the region (see Pl. XII) is described in the following paragraphs:

Granite and quartz diorite predominate in the mountains south of Nenana River. The basalt mountains south of Butte Creek, the Triassic slate belt north of it, and the Jurassic(?) slate, graywacke, and conglomerate mountains about upper Jack River make up the rest of this area except that occupied by unconsolidated deposits. Granite and diorite occupy a large part of the mountain area between Nenana River and Yanert Fork, but are associated with a variety of sedimentary formations that differ greatly in age and include slate, shale, graywacke, limestone, conglomerate, and schist. Devonian fossils were collected from limestone in a succession of limestone, slate, and conglomerate beds on lower Jack River. At this place the beds form a narrow east-west belt between younger sedimentary formations on the north and south. This narrow belt of Devonian beds comprises all the Paleozoic rocks known in the district. The Devonian formations are succeeded on the east by a group of sedimentary beds, including slate, limestone, graywacke, and schist, that form the mountain mass about the heads of Nenana River and the West Fork of Susitna River. The age of the rocks included in this group is not known but is considered provisionally to be Mesozoic. The higher ridges of the Alaska Range, north of the belt of Devonian and Mesozoic (?) formations is made up of conglomerate, sandstone, shale, slate, graywacke, and schistose equivalents of the same rocks, all belonging to the Cantwell formation (Tertiary). The Cantwell formation was formerly provisionally assigned to the Carboniferous, but was found in the Broad Pass region to carry Eocene plants. This formation is an important structural member of this part of the Alaska Range, having a maximum width of at least 18 miles and extending westward from Cathedral Mountain to Muldrow Glacier.



GEOLOGIC SKETCH MAP OF BROAD PASS REGION.

One peculiarity of the Cantwell formation is the progressive increase in closeness of folding and intensity of metamorphism from west to east in the area between Nenana River and Cathedral Mountain, where the openly folded, little-altered conglomerate, shale, and sandstone pass into closely folded beds of slate and schist.

All this region has been profoundly glaciated and shows on every side the usual evidences of mountain glaciation, including modified topographic forms, moraines, and glacial lakes.

MINERAL RESOURCES.

The association of intrusive granite and diorite with the slate and limestone formations suggests the possibility of mineralization and the presence of metalliferous deposits, but so far as hasty observation shows the mineralization in the region visited is less than would be expected from a knowledge of the geology. Some of the slate formations, however, are gold bearing. Placer gold in small amount has been found on Butte, Wickersham, and other creeks near by and also on the head of the West Fork of Susitna River. Some copper is present in the lava flows south of Butte Creek, but is not known to be of commercial importance. Coal of commercial value is not known in the district, although it is present in thin beds on the head of Jack River and has been found in thicker beds on Coal Creek, a tributary of Susitna River south of Butte Creek.

Prospecting in the Broad Pass region is difficult on account of the distance from sources of supply and the lack of transportation. The region has not been thoroughly prospected, but it may be said that such work as has been done has not yielded very encouraging results.

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MINING IN THE VALDEZ CREEK PLACER DISTRICT.

By Fred H. Moffit.

Valdez Creek is a headwater tributary of Susitna River. It lies about 65 miles west of the Valdez-Fairbanks road and is one of the three known placer-gold districts on the south slopes of the Alaska Range.

Gold was discovered on Valdez Creek in the fall of 1903. The first gold produced was taken from gravel deposits along the stream, but gold was found later in an old buried channel of Valdez Creek that joins the present channel on claim No. 2 above Discovery. The claims along this gravel-filled canyon proved to be some of the most valuable property in the district, although other claims on Valdez Creek and some of its tributaries, notably Lucky Gulch, have been gold producers.

The district was visited by United States Geological Survey parties in 1910, and the progress made in exploiting its gold deposits at that time was described in a paper published the following year.[1] During the three years since 1910 mining has been carried on in the old channel gravel deposits, on one or two of the creek claims near by, and on Lucky Gulch. In addition, assessment work has been performed on many other claims that have not been important gold producers.

Since 1910 the Monahan tunnel in the old canyon gravels has been extended about 500 feet, or from 700 to 1,200 feet, thereby proving that the gold-bearing gravels continue that distance but yielding no evidence to indicate where the east end of the canyon is situated. Bad air made work in the tunnel slow and difficult, yet mining was conducted profitably so long as the work was carried on. The tunnel is now abandoned, the need for it having been ended by the introduction of hydraulic mining.

Since 1910 nearly all the claims on the lower part of Valdez Creek, including the bench claims north of the creek through which the old channel runs, have come under the control of the Valdez Creek Placer Mines Co. This company in 1913 installed a small hydraulic plant

[1] Moffit, F. H., The upper Susitna and Chistochina districts: U. S. Geol. Survey Bull. 480, pp. 114–124, 1911. See also Moffit, F. H., Headwater regions of Gulkana and Susitna rivers, Alaska: U. S. Geol. Survey Bull. 498, pp. 53–65, 1912.

and began mining at the lower or west end of the old channel, where the Monahan tunnel begins. Nearly a mile and a quarter of ditch was constructed and a line of pipe was laid to the giant at the working face. With this plant enough of the gravel filling in the old canyon was removed between the first of August and the end of the season to lay bare a small area of bedrock.

This work was preliminary to the installation of a larger plant in 1914. It is planned to replace the small pipe now used by about 4,800 feet of pipe ranging in size from 36 inches at the penstock to 18 inches at the pit and to substitute 6-inch giants for the small ones. This equipment will make available an abundant supply of water under a head of nearly 300 feet. About 100 feet of head is lost under the present arrangement, for the pipe at hand was too short to reach from the giants to the ditch, and the water had to be turned into a depression and picked up again at a lower level. A sawmill will be built and also an electric plant, operated by water from Timberline Creek, to furnish light and power.

The old channel of Valdez Creek is favorably situated for hydraulic mining, there being a good supply of water and an excellent dump for tailings. It is probable, however, that the large number of granite bowlders in the upper part of the gravel deposit will cause considerable trouble.

The well-established winter trail on the ice of Gulkana, Maclaren, and Susitna rivers is still used for carrying freight to Valdez Creek, but the summer trail leaving the Valdez-Fairbanks road at Bear Creek below Gulkana is now practically abandoned in favor of the shorter trail from Paxson.

The gold production of the Valdez Creek district in 1913 was small, coming in large part from Lucky Gulch, for, as has been shown, most of the season was given up on the main stream to what may be called dead work. Probably not over 25 men were engaged in mining in the district at any one time during the summer, but it is expected that this number will be nearly doubled in 1914.