MINERAL DEPOSITS OF THE KOTSINA-KUSKULANA DISTRICT, WITH NOTES ON MINING IN CHITINA VALLEY.

By Fred H. Moffit.

INTRODUCTION.

The Kotsina-Kuskulana district includes part of the west end of a belt of mineralized rocks extending along the north side of Chitina Valley from the southwest flanks of Mount Wrangell to Nizina River and possibly to the headwaters of Chitina River. (See Pl. IV.) This mineralized belt has already produced considerable amounts of copper and of placer gold and gives promise, as its resources are developed, to continue producing these metals for many years to come.

The Kotsina-Kuskulana district receives its name from the two principal streams that drain it, and owes its present importance to its copper deposits. Copper, however, is not the only mineral resource of the district, for both gold and silver have been found in amounts that may make them of commercial value.

Before the Copper River & Northwestern Railway was completed, in 1911, the Kotsina-Kuskulana district and the rest of Chitina Valley also received supplies and mining equipment by way of Valdez, and during the summer were practically cut off from the outside world, so far as freighting and transportation were concerned, for the cost of carrying freight was prohibitive except in cases of absolute necessity. Since 1911 Cordova has been the distributing point for Chitina Valley, as well as for much of the Copper River valley, and owes such measure of prosperity as it has enjoyed to the interior trade made possible by the railroad. The most important local distributing points along the railroad are Chitina, at the mouth of Chitina River, which is connected by wagon road with the Valdez-Fairbanks road; Strelna, where most of the freight for the Kotsina-Kuskulana district is discharged; and McCarthy, from which supplies are carried into the upper Nizina River valley and across Skolai Pass to White River. Kennicott, the terminus of the railroad, is the point from which the Kennicott-Bonanza ore is shipped, and has more traffic than any other point on the road, yet Strelna and McCarthy are more properly called the distributing points for

Chitina Valley, inasmuch as they serve considerable areas rather than single mining properties.

The building of the railroad contributed greatly to the solution of the transportation problems that prevented the development of this region, but the difficulties are not yet entirely overcome, for each minor district and property has its own problems that must be solved before the full development of the mining resources can be reached. A complete system of transportation for the region will involve the construction of many short railway branches and many thousand feet of aerial tramway.

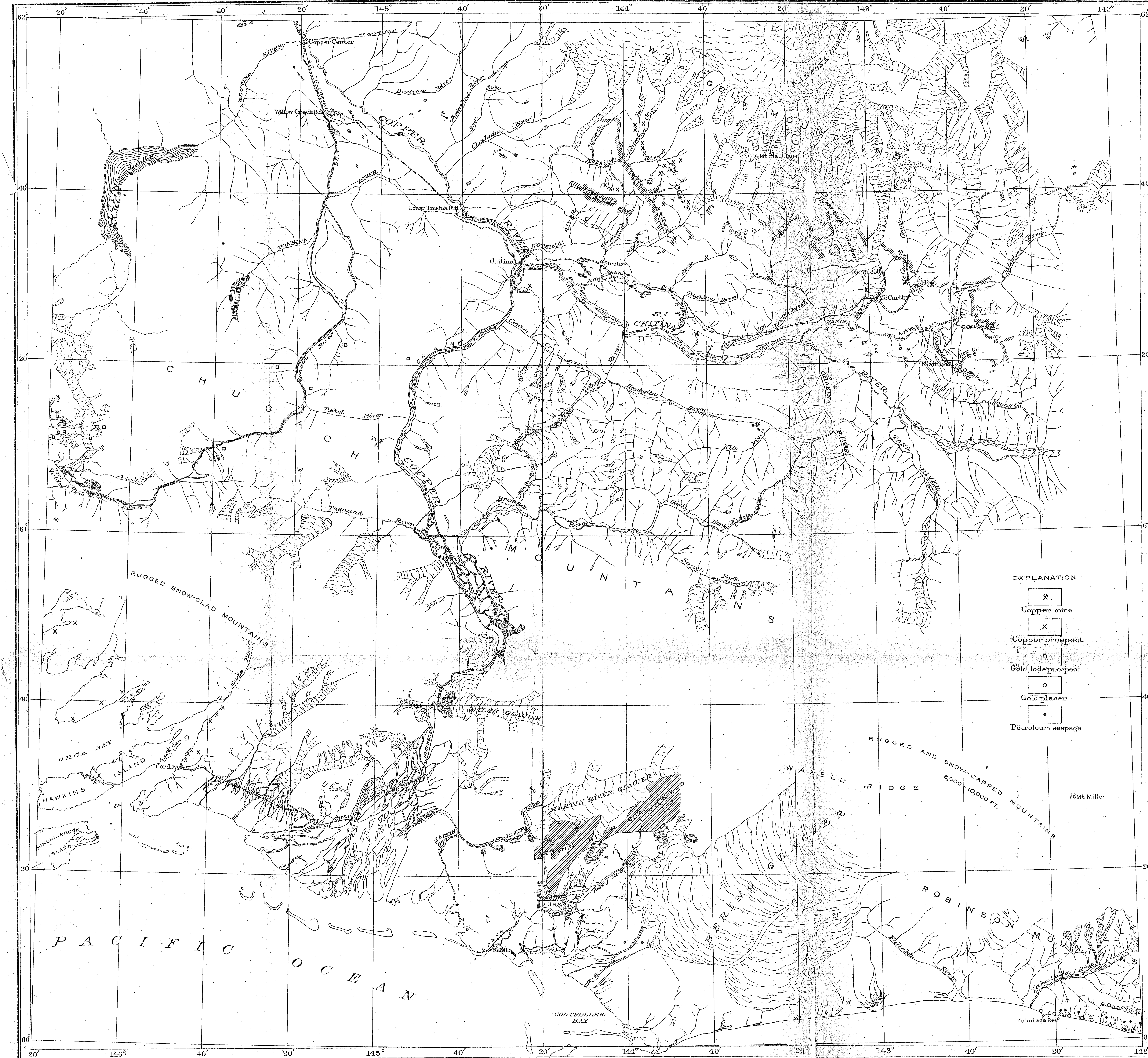
The development of mining in this region is favored by the presence of both timber and water power. Chitina Valley contains spruce of fair quality in sufficient quantity to supply ordinary local needs for many years, but most probably it will never furnish lumber for export. Abundant water is at hand in many of the mountain streams and will be available for use during much of the year, although on some of the streams it could not be depended on in winter. Data on the water-power resources of the region have been given recently in a report by Ellsworth and Davenport.[1]

Mining in this region will be aided further by the opening of the Bering River coal field, which, because of its nearness (see Pl. IV) and the fact that it contains coking coal, is likely to be of much importance in helping to develop the copper resources. This field can be opened to transportation by a line less than 40 miles long connecting it with the main line of the Copper River & Northwestern Railway 38 miles from Cordova. Surveys for such a road have been made. The construction does not involve unusual difficulties but could not be undertaken while title to coal lands was unobtainable.

Prospecting began in Chitina Valley in 1898 and has continued to the present time. The first metal produced came from the gold placers of Chititu and Dan creeks in 1901 or 1902. These two streams rank next to Slate Creek and the other streams of the Chisna district as regards gold production within the Copper River basin. Commercial shipments of copper ore were begun from the Kennicott-Bonanza mine in 1911, and since then small shipments have been made from a number of other properties. The progress of mining development in the region has been described from time to time in earlier reports of the United States Geological Survey.

There was little change in the general mining situation in Chitina Valley during 1914. Development and assessment work was done on many claims, as in previous years. Shipment of copper ore from the Kennicott-Bonanza was continued with little interruption, and

[1] Ellsworth, C. E., and Davenport, R. W., Preliminary report on a water-power reconnaissance in south-central Alaska: U. S. Geol. Survey Bull. 592, pp. 155–193, 1914.



MAP SHOWING MINERAL RESOURCES OF LOWER COPPER RIVER REGION, ALASKA

Scale $\frac{1}{500,000}$

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1915

shipments were also made from the Mother Lode mine. Yet, aside from the Kennicott-Jumbo, no new properties were brought to the producing state, though development work has placed several almost in that condition. Furthermore, little active search for new ore bodies was carried on. Without doubt the depression in the copper market and the difficulty of interesting capitalists in copper-mining ventures were largely the causes of this condition. The season, however, was a favorable one for the placer miners of Dan and Chititu creeks, so that the production of placer gold from these streams and their tributaries in 1914 was greater than for any other season since the early days of mining in the district.

Chititu Creek was visited early in September by S. R. Capps, of the United States Geological Survey, and the notes furnished by him are used in this paper. The Kotsina-Kuskulana copper prospects were visited by J. B. Mertie and the writer, who during the summer completed a detailed geologic map representing an area of about 200 square miles in this district. This work brought to light some new facts concerning the regional geology and the distribution of the ore deposits. These facts will be referred to later.

Plate IV, which represents the lower Copper and Chitina valleys and the Pacific coast of Alaska from a point a short distance east of Cape Yakataga to Prince William Sound, shows the location of most of the better-known copper and gold lode prospects of the region, the gold placers, and the Bering River coal field. The geographic relations of the Chitina Valley copper deposits and the coal fields are illustrated by this map. Reference will be made in this paper, however, to only a part of the prospects of the Chitina Valley.

COPPER.

KOTSINA-KUSKULANA DISTRICT.

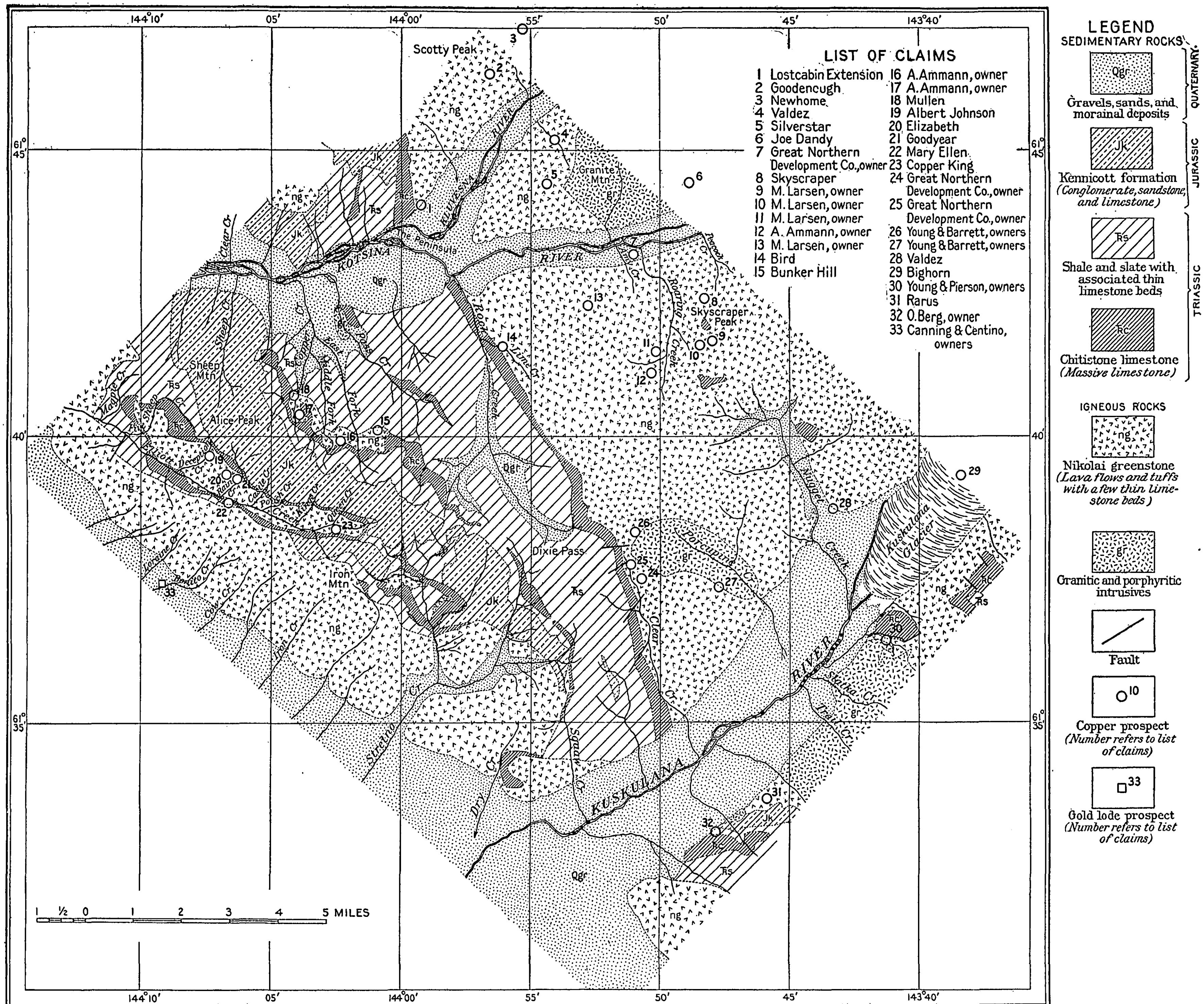
A few tons of copper ore for assay, mill tests, and similar purposes have been brought out from the Kotsina-Kuskulana district, but no shipments of commercial ore have been made. Probably no large shipments will be possible in the near future, for none of the copper properties are equipped for mining and handling ore in a commercial way and none of them have any connection with the railroad adequate for the transportation of ore in large quantities. Ore could be sledded from some of the properties to Strelna or other points on the railroad in winter, but the most favorably located deposits, those of Kuskulana Valley, are 15 to 20 miles from the railroad, and the cost would be high. This method of transporting ore from Elliott Creek and the upper Kotsina Valley would be out of the question, owing to the excessive cost.

The geologic mapping done in 1912 and 1914 has modified some of the ideas gained from earlier surveys, particularly that of Schrader and Spencer[1] in 1900, and has made it possible to represent the areal geology more accurately than was possible from the reconnaissance work.[2] Inasmuch as the distribution of copper deposits appears to be controlled chiefly, if not entirely, by a group of rocks commonly known as the Nikolai greenstone, the areas occupied by these rocks are shown on the map (Pl. V), and a brief summary of their geology and that of the associated formations is given. Plate V shows in a generalized way, necessitated by the scale of the map, the areal distribution of the rock formations and the location of those groups of claims on which most work has been done. Five principal formations are represented. At the base of the geologic section is a group of rocks that in previous maps and reports have been called the Nikolai greenstone. These rocks are divided into two parts. The lower part consists prevailingly of dense, hard, water-laid tuffs interbedded with flows of fine-grained black, green, and red basalt. Associated with these rocks are a few beds of limestone in varying stages of silicification, containing Carboniferous fossils. Locally beds of chert, argillite, and slate are found. This lower division has a thickness of several thousand feet. On this prevailingly tuffaceous lower part was poured out a succession of lava flows, in large degree vesicular, and showing a somewhat coarser grain than the basaltic flows included in the tuffs. These upper basalt flows are green in color. Their thickness is probably less than that of the underlying tuffaceous beds, but amounts to several thousand feet. The copper prospects are found mainly in the upper basalt flows, but are not confined to them, for both the underlying tuffaceous beds and the overlying limestone contain copper.

Resting on the Nikolai greenstone is the Upper Triassic Chitistone limestone, a bluish-gray limestone from 100 to 700 feet thick, consisting of one or more massive basal beds without lines of stratification, overlain by thinner beds of the same color and appearance. In places the Chitistone limestone is succeeded by thin beds of limestone that assume a brownish color on weathering and in their upper part are separated by thin shale beds that become thicker and more prominent toward the top of the section till they predominate over the limestone and finally replace it altogether. Probably not less than 4,000 feet of these Triassic thin-bedded limestone and limestone-shale beds overlie the Chitistone limestone on Rock Creek. They are much less developed or are absent on Elliott Creek and the head of Copper Creek, where their place is taken by the black

[1] Schrader, F. C., and Spencer, A. C., The geology and mineral resources of a portion of the Copper River district, Alaska: U. S. Geol. Survey Special Pub., 1901.

[2] A detailed description of the geology and mineral resources of the Kotsina-Kuskulana district, based on the work of 1912 and 1914, will appear in a forthcoming bulletin.



GEOLOGIC SKETCH MAP OF THE KOTSINA-KUSKULANA DISTRICT.

shale that forms the top of this limestone and shale formation or group of formations. No well-marked and easily recognized dividing planes separate the Chitistone from the overlying thin-bedded limestones nor the thin-bedded limestone and shale series from the overlying black shale. The thickness of the Upper Triassic beds is not less than 5,000 feet, and it may be much greater.

The Nikolai greenstone, the Chitistone limestone, and the overlying limestone and shale series were folded, faulted, and intruded by granitic rocks of several types. They were subjected to atmospheric erosion and then were submerged below sea level. Finally there was deposited on them, in late Jurassic time, not less than a thousand feet of coarse conglomerate, grit, and sandstone, with a small amount of limestone, all of which in previous publications have been referred to—the Kennicott formation. Erosion has since removed much of this material, so that the remaining areas are small and scattered, but it is probable that the conglomerate and sandstone beds were irregular in thickness and distribution even when they were first laid down. They are the youngest of the hard-rock formations of the district. The most recent formation includes the unconsolidated Quaternary sands, gravels, and glacial deposits covering the valley floors and strewn over the lower mountain slopes.

The disturbing forces that folded and faulted all the rocks older than the Kennicott formation did not cease to act when the Kennicott was deposited, for it, too, is folded and faulted, though not so severely as the older formations. It is believed that these disturbances, by which the rocks were broken and made permeable to circulating water, in connection with the intrusion of the granite and related igneous rocks, have played an important part in the formation of the copper deposits.

The common copper minerals of the district are bornite, chalcocite, chalcopyrite, malachite, azurite, and native copper. They are associated with epidote, quartz, and calcite. Epidote and quartz, however, are the prevailing gangue minerals, and ordinarily are not accompanied by calcite. A comparison of the mineral content of ores from different parts of the district brings out the fact that the deposits may be grouped in five classes, according to the association of copper minerals in them—deposits that consist chiefly of chalcocite, of bornite and chalcocite, of bornite and chalcopyrite, of chalcopyrite and pyrite, and of native copper. Of these five classes the bornite-chalcocite and bornite-chalcopyrite deposits are the most common. Chalcocite alone is found in only a few places. In several deposits native copper is present, probably as a secondary mineral, in association with chalcocite and with bornite. At one place it is the principal copper mineral present and occurs as a filling in the vesicles of basalt flows and as grains and slugs disseminated through the rock.

The copper minerals of the Kotsina-Kuskulana district occur in the fissures and fracture planes of shear zones and along fault planes. They are also disseminated through the rock adjacent to such zones and faults. The major shear zones and faults show a more or less well-defined parallelism to the principal structural lines of the greenstone, so that outcrops of ore when considered in relation to one another commonly show a similar disposition. Within the shear zones the rock is so crushed and the minor faults and joints so irregular in number and position that no systematic arrangement of ore-bearing fissures was recognized. Well-defined veins are unusual and commonly show the effects of faulting and crushing that took place subsequently to the ore deposition. Some of the basalt flows appear to be particularly favorable for the deposition of copper minerals.

The genesis of the copper ores of the district is not well understood. There can be no doubt that a very great proportion of the copper deposits on the north side of Chitina Valley are in the basalt flows and tuffs of the Nikolai greenstone. In a few places, notably at the Kennicott-Bonanza and its continuation the Mother Lode, at the Kennicott-Jumbo, and at the Westover claim on Dan Creek, the copper minerals are in the Chitistone limestone. One such occurrence, on Copper Creek, is known in the Kotsina-Kuskulana district.

The Nikolai greenstone was subjected to a regional metamorphism that brought about certain widespread chemical alterations, seen particularly in the chloritization and serpentinization of the feldspars and dark minerals of the basalts, and later it underwent other more local alterations, recognized in the quartz and epidote, that are probably connected with the intrusion of granitic rocks into it. These intrusive rocks are less abundant in the greenstone than in the overlying Triassic shales, but are believed to have had an important influence in the formation of the copper deposits.

One of the chief questions concerning the origin of the copper deposits relates to the source of the copper. Was it present in the basalt flows when they solidified, afterward taken into solution by circulating waters during the alteration of the greenstone, and then redeposited in the present ore bodies, or was it introduced from outside sources by the solutions accompanying the intrusive rocks forced into the greenstone? Arguments to support an affirmative answer to each of these questions may be advanced, but the evidence is not yet sufficient on either side to determine the matter.

Most of the copper prospects of the district (see Pl. V) are described in a previous publication[1] of the United States Geological Survey. The present report is concerned chiefly with more recent mining development and does not attempt to give a detailed descrip-

[1] Moffit, F. H., and Maddren, A. G., Mineral resources of the Kotsina-Chitina region, Alaska: U. S. Geol. Survey Bull. 374, pp. 54–74, 1909.

tion of the ore deposits. In describing the properties they will be taken up according to localities.

Assessment work was performed on a large number of claims on Kotsina River and its tributaries, particularly on Kluvesna River and its branches Fall and Mineral creeks, on Granite, Sunshine, Shower, Peacock, Roaring, Rock, Copper, and Elliott creeks.

The prospects on Kotsina River are in the upper valley. Those of the Great Northern Development Co., just below the mouth of Roaring Creek, have received most attention. The copper minerals here are in the tuffaceous part of the Nikolai greenstone and are being prospected by a number of tunnels. The company uses water brought by a ditch from Roaring Creek for developing power and has employed electric drills in its rock work. Mining operations have been partly suspended during the last two years, but assessment work was done on 10 claims in 1914.

The copper prospects of Kluvesna River and its tributaries are in the lower tuffaceous part of the greenstone except those nearest the Kotsina and those just below Fall Creek. The basalt flows near the Chitistone limestone contact west of Kluvesna River contain copper minerals, chiefly chalcopyrite and bornite, in many places, and a group of claims extending parallel to the contact and adjoining it has been staked. The development work consists of two short tunnels that are being driven to strike the limestone-greenstone contact. Near Fall Creek, west of Kluvesna River, about 140 feet of tunnel has been driven in greenstone cut by copper-bearing calcite veins. Native copper and chalcocite are the copper minerals present.

The recent work on Fall Creek consists of two tunnels, one south of Trail Creek and the other high on the mountain between Fall Creek and Kluvesna Glacier. Near Trail Creek the loose surface material on the hill slope was sluiced away to expose the outcrop of chalcocite-bearing quartz veins, and a tunnel was started to cut the veins a short distance below the surface. Native copper and veins of black copper-bearing carbonaceous material are found in the greenstone near by.

Mineral Creek crosses diagonally the strike of a series of tuffaceous beds, cut by granitic intrusive rocks and interstratified with thin light-colored cherty or siliceous beds. The siliceous beds, some of which closely resemble large quartz veins, are faulted and locally are well mineralized. In places, also, mineralized quartz was deposited along the fracture planes. Pyrite and chalcopyrite are the common metallic minerals. A number of short tunnels have been started in the mineralized beds and are being driven in the expectation of developing a workable ore body. One of the claims on Mineral Creek has shown a notable amount of gold associated with the copper. A tunnel is also being driven in similar beds near the south end of Kluvesna Glacier, northeast of Mineral Creek.

Veins containing copper and a considerable amount of silver cut the basaltic and tuffaceous rocks near the top of the ridge 1¼ miles southwest of Granite Peak. Azurite is conspicuous at a number of shear zones in the vicinity, but at this locality the copper and silver are contained in silver-bearing tetrahedrite, associated with quartz and deposited along joints and fissures. The rocks containing this mineral are much faulted and crushed, with the result that great difficulty is experienced in following the veins. Two short tunnels constitute the development work on the property.

A well-defined fault, striking north-northeast and mineralized with chalcocite, bornite, and a little pyrite in a gangue of quartz, cuts the greenstone on Sunshine Creek. This stream is a tributary of Surprise Creek, which flows into Kotsina River from the north at a point nearly opposite the mouth of Peacock Creek. The fault zone can be traced for more than a mile and evidently includes more than one plane of displacement or minor fault zone. The greenstone along the minor faults is crushed, and its fissures and joints are filled with copper minerals and quartz. Such zones of crushed rock and vein matter have thicknesses ranging from less than 1 foot to 6 or 8 feet. At one place the quartz vein alone is 8 feet thick. It does not form a continuous deposit along the main fissures, but appears as lenses and irregular-shaped masses. Much of the quartz and copper was deposited before the movements along the fault had ended, for the vein matter is crushed and in places slickensided surfaces and gouges are found on both walls of the quartz vein. The claims have been prospected by numerous open cuts and by a tunnel 135 feet long.

Copper deposits are being prospected at a number of places on Roaring Creek. Most of the claims are on the ridge extending north and south from Skyscraper Peak between Roaring and Peacock creeks. The copper deposits are in the upper part of the Nikolai greenstone and consist prevailingly of chalcocite, with which is associated, in a few places, a little native copper. In a general way the mineralized zone parallels the base of the Chitistone limestone exposed in Skyscraper Peak, but lies several hundred feet below it. Although the greenstone is everywhere much jointed, no conspicuous shear zone was observed. It is probable, however, that the fracturing was more extensively developed along the zone indicated by the chalcocite, yet inasmuch as this relation of mineralized greenstone to the limestone and greenstone contact is seen in many parts of the district a suspicion is aroused that the character of the greenstone along this zone had an influence on the deposition of copper. The principal development work on the Skyscraper group of claims is a tunnel about 100 feet long. Several other shorter tunnels have been started on other parts of the property, but the work of development progresses slowly, for only enough is done each year to fulfill the assessment requirements. With the exception of two or three properties the same statement can be made about the other deposits of the district, and will doubtless remain true till more outside capital can be brought into the region.

The copper prospects west of Roaring Creek are in the lower part of the greenstone. Those that have received most attention are on a spur between two small gulches about half a mile above the forks of the creek. Chalcocite with malachite as an alteration product is associated with quartz and epidote in small fractures in the greenstone. A little native copper, also believed to be an alteration product of the chalcocite, is present in small amounts at one or two outcrops. The development work is represented by two or three short tunnels.

Copper deposits indicated by malachite staining along a shear zone in amygdaloidal basalt occur high on the mountain slope south of Kotsina River and about halfway between Roaring and Rock creeks. The development consists of two short tunnels, but not enough has been done to indicate the character or extent of the deposit. These prospects are near the contact of the upper and lower parts of the Nikolai greenstone, probably in the upper part, but the position of the boundary in this locality is so difficult to trace that the geologic position of the prospects was not fully determined.

Near the contact of the limestone and greenstone on the lower end of Lime Creek, a tributary to Rock Creek, the greenstone is cut by a number of small faults which carry copper minerals. The copper occurs as bornite associated with a small amount of chalcopyrite and is accompanied by quartz and epidote. Small veins or lenses of the bornite cut the greenstone in an irregular way, but most of the ore consists of copper minerals disseminated through the greenstone, though the richest part of the disseminated ore is near the veins. Many of these veins probably represent a replacement of country rock along fracture planes, although they may be in part the material deposited in joint cavities or similar openings. Two tunnels are being driven to prospect the deposits. One of them, on the west side of Lime Creek, is just below the limestone and greenstone contact and follows the strike of the beds. The other, across and a little farther up the creek to the east, is being driven away from the contact. These two tunnels are extended a short distance each year as the assessment work is performed.

All the prospects of Copper Creek except one are in the upper part of the greenstone, and most of them are near the limestone contact. One, the Mullen claim, is in the base of the limestone. The limestone and greenstone are faulted and shattered, allowing mineral-bearing waters to circulate through them. The limestone along some of the fracture planes is replaced by bornite and chalcopyrite and in part has been oxidized to azurite and malachite, azurite being very prominent. A short tunnel, driven as assessment work, exposes the ore. The other claims on Copper Creek follow the limestone and greenstone contact from the West Fork to the top of the ridge between the East Fork and Pass Creek. One or more of the minerals bornite, chalcopyrite, pyrite, and chalcocite are found in many places along this contact, and a number of open cuts and short tunnels have been made in prospecting the deposits.

The claims on Elliott Creek are owned by the Hubbard-Elliott Copper Co., and extend along the valley of the creek for about 6 miles. Most of them are on the north side of Elliott Creek and cover the ground, including the creek, as far north as the limestone and greenstone contact. A few claims lie on the south side of the valley. A large amount of open-cut work has been done, and many feet of tunnels have been driven on the claims. The most recent work includes the tunnel on the Albert Johnson claim and assessment work on unpatented claims. On September 1, 1914, the main Albert Johnson tunnel had reached a length of nearly 700 feet, not including crosscuts. Since the close of the season, the company reports that the length of the tunnel has been increased to 850 feet. This tunnel is on the southeast side of Deception Creek and is being driven in a northeasterly direction, nearly parallel to the creek, toward the limestone and greenstone contact. It lies wholly in greenstone cut by fault and joint planes, along which copper minerals have been deposited. Bodies of ore consisting of chalcopyrite and bornite were uncovered at several places in this tunnel and its crosscuts. The other work on the claim includes a short tunnel with a winze and crosscuts, farther up the creek and nearer the limestone. This tunnel shows bornite ore and in places considerable amounts of chalcopyrite.

It seems evident that the copper-bearing solutions made their way by devious courses through a shear zone in the greenstone. The bodies of ore are irregular in shape and distribution and without definite boundaries. Most of the ore is a replacement of the greenstone by copper minerals. As the solutions slowly percolated through the openings of the shattered basalt the rock was taken up by them and the copper was left in its place. Nowhere on Elliott Creek are the deposits of the type described as fissure veins.

A tunnel has been started on the Mary Ellen claim, on the south side of Elliott Creek just above the mouth of Rainbow Creek, in the hope of revealing a gold deposit like that of Benito Creek. The shattered greenstone at this place is mineralized with pyrite and a small amount of chalcopyrite. Assays of the weathered surface material showed considerable gold, which, however, decreased in the less weathered material exposed by the tunnel.

The Great Northern Development Co. owns claims and has done a large amount of work on Clear Creek, tributary to Kuskulana River. Clear Creek follows closely the boundary between the Chitistone limestone and the Nikolai greenstone, which here dip steeply west-southwest. The greenstone on the east side of the creek near its head is intruded by a mass of dark porphyritic igneous rock that appears to be rather generally mineralized in this locality and possibly has been influential in mineralizing the greenstone also. Pyrite and chalcopyrite are disseminated through both the intruded and the intruding rocks. In places they fill minute veinlets, parallel to one another, which represent fractures in a shear zone. In places also they form larger veins along fracture planes, but in general the ore is a low-grade disseminated deposit that will have to be mined as such. Three principal tunnels, with a total length of nearly 5,700 feet, have been driven, and a fourth is now under way. At present active development work is suspended on Clear Creek pending the granting of patents to the property, but the assessment work necessary to hold the claims has been done.

Several claims have been staked on ore of similar nature on the Porcupine Creek side of the same intrusive body and are being prospected by short tunnels.

The copper prospects of Nugget Creek are the property of the Alaska Consolidated Copper Co., which has concentrated its efforts on the Valdez claim, on the point of the hill between Nugget Creek and Kuskulana Glacier. A well-defined east-west fault plane cuts the greenstone and has made possible the deposition of copper minerals, chiefly chalcopyrite and bornite. Large masses of calcite vein filling are associated with the copper minerals, but are not everywhere present, for much of the ore is disseminated through the rock or fills minor cracks and fissures in it. A shaft about 170 feet deep and tunnels aggregating over 1,500 feet constitute the workings. The company also has a tunnel over 400 feet long on the Rarus claim, on the east side of Kuskulana River opposite the mouth of Clear Creek. Half of this tunnel is in silicified limestone, and the remainder is in a dark porphyritic rock containing large crystals of hornblende and in mineralized sandstone. The igneous rock is sheared and contains a large amount of magnetite together with pyrite and chalcopyrite. The sulphide minerals are present in the sandstone also, but magnetite was not seen there. When this property was visited the tunnel had penetrated 15 feet into the sandstone.

Several copper prospects on the mountain between the main forks of the Kuskulana Glacier are held by the Alaska United Copper Exploration Co. A large mass of ore, consisting of a mixture of granular even-grained chalcocite, bornite, and quartz, was discovered on the mountain side about 1,000 feet above the glacier and has been prospected by several short tunnels and open cuts. No other ore of this nature is known in the district. The proportions of the three minerals are diverse. Chalcocite is the prevailing copper mineral, but in some specimens the bornite equals it in amount. Quartz shows a similar variation, as it may predominate over the copper minerals or may be very subordinate to them. The mass of ore at the surface is in place, but the tunnels have not yet shown its continuation below the surface.

Assessment work was done on a number of other claims east of Kuskulana River, besides that on the Rarus claim already mentioned. They include claims east of Kuskulana Glacier and on a small stream near its lower end and the Berg claims, 3 miles south of Trail Creek. Two or three tunnels have been started on the Berg claims, but development work was interrupted in 1914 on account of financial difficulties, and only the assessment work was performed.

One of the claims adjoining the Rarus is the War Eagle, on the first stream south of Trail Creek. The mineral deposit is near the contact of the quartz porphyry and overlying limestone and sandstone. It consists chiefly of magnetite, but contains iron and copper pyrite. Samples of the ore sent for assay are reported to contain gold and silver in addition to copper.

Copper is found on the head of Chokosna River, where claims have been staked and development work has been carried on in a small way for several years. The property was not visited by the writer, but samples of the ore examined by him showed sulphides of copper and iron in greenstone.

NIZINA DISTRICT.

Mining and development work were carried on at the Kennicott-Bonanza and Kennicott-Jumbo mines throughout the year. In winters previous to that of 1913–14 much delay in ore shipments from Kennicott was caused by snowslides on the railroad, as a result of which all traffic was suspended for weeks at a time. Little delay arose from this cause last winter, however, and ore was hauled to Cordova almost without interruption. Most of this ore was taken from the Kennicott-Bonanza, but a part of it was produced at the Kennicott-Jumbo and hauled over the ice from the mine to the railroad, a distance of nearly 3½ miles. From January 1 to the end of September, 1914, over 4,000 feet of crosscutting, sinking, and raising was done at the Kennicott-Bonanza, and nearly 3,700 feet at the Kennicott-Jumbo. Ore had been developed at the 400-foot level of the Kennicott-Jumbo, and the shaft was being sunk to the 500-foot level. In addition a tramway was constructed for conveying the ore to the railroad. The Kennicott-Jumbo ore is chalcocite, like that of the Kennicott-Bonanza mine.

Development work was continued on the Mother Lode property, about 1¼ miles north-northeast of the Kennicott-Bonanza mine, and on the Westover claim, on Dan Creek. The Mother Lode deposit consists of chalcocite and is situated in the same shear zone as the Kennicott-Bonanza mine but is on the McCarthy Creek side of the ridge, between Kennicott Glacier and McCarthy Creek.

This property was productive in 1914. The company reports the completion up to the close of 1914 of about 1,150 feet of underground work. A tramway 7,000 feet long conveys the ore from the mine to the main camp on McCarthy Creek, from which it is hauled 13 miles on sleds to the railroad at McCarthy. Plans have been made for building a new road down McCarthy Creek in 1915 and for installing a concentrator at the main camp.

Assessment work was done by the Great Northern Development Co. on the claims between the forks of Kennicott Glacier. Such work was also done on claims on Hidden Creek and Lakina River, but details of the operations have not been received.

GOLD.

KOTSINA-KUSKULANA DISTRICT.

Interest in prospecting for gold in the Kotsina-Kuskulana district was aroused two years ago by the finding of a gold-bearing vein on Benito Creek, but although search was made for similar veins in the same neighborhood no others of promise have yet been found. The vein on Benito Creek is a short distance below timber line and consists of quartz and calcite containing chalcopyrite, bornite, pyrite, and free gold. At its outcrop in the creek it is about 2 feet thick. It strikes N. 10° W. and stands nearly vertical or with a high easterly dip. Numerous shallow shafts were sunk and a considerable surface area was ground-sluiced off with water brought by a ditch from Benito Creek, in the endeavor to discover the extent and value of the vein. No other attempt has been made to exploit the vein for the owners are unable to do so and do not care to solicit outside capital. Very beautiful specimens of free gold in quartz were produced by dissolving away the calcite with acid. Apparently the gold is not evenly distributed along the vein, for much of the rock shows no gold to the unaided eye and the specimens of gold mentioned came from only a few places.

NIZINA DISTRICT.

Gold mining in the Nizina district is restricted to the gold placers of Dan and Chititu creeks and to certain of their tributaries, Copper, Rex, and White creeks. Young Creek is not an important gold producer, although considerable ground on it is held by men who expect to prospect it with a view to installing hydraulic mining machinery.

The placer gold credited to Dan Creek comes in part from Copper Creek, one of the two branches of Dan Creek. Several small parties were at work on the gravels of Copper Creek in 1914, but the principal workings and the greatest production of the two streams belong to the lower part of Dan Creek below the canyon. A well-equipped hydraulic plant has been installed there, replacing the one destroyed by the floods of 1912. Water is conveyed to the workings by a flume 650 feet long and a steel pipe line from 15 to 30 inches in diameter and 10,200 feet long. It is delivered to four hydraulic giants, ranging from 3¼ to 5 inches in diameter, at a pressure of 112 pounds. The sluice line is 1,400 feet long. All bowlders over 15 inches in diameter are broken with powder, but smaller ones are carried through the sluice boxes. At the beginning of September 52,000 square feet of bedrock surface had been uncovered, and it was expected that 80,000 feet would be stripped before the season ended. Four frame buildings and a sawmill complete the equipment. The working season in 1914 lasted about 50 days, and during that time 25 men were employed on the property.

A small amount of placer gold is obtained by drifting in the bench gravels on the south side of Dan Creek. The gold-bearing gravels occupy in part the former channel of Dan Creek, but were left as bench gravels when the creek cut its present channel below them. Mining in these gravels has been handicapped by the difficulty of obtaining water for sluicing, but the work has been carried on for a number of years and has yielded a small quantity of gold each season. The owner of this property has added to his yearly gold production through sluicing operations on Copper Creek.

The two hydraulic plants established on Chititu and Rex creeks a number of years ago were in operation in 1914. Weather conditions were favorable, the destructive floods of 1912 and 1913 were not repeated, and sluicing went on without serious interruption, so that a large amount of gravel was moved and an exceptional gold production for these streams resulted.

The lower or larger plant, on Chititu Creek, was employed in mining the creek gravels of claims Nos. 5 and 6, where a cut with a length of 354 yards and an area of 25,144 square yards was made. A total of 102,465 cubic yards of gravel was put through the sluice boxes. The mining season extended from June 8 to September 1, and of this time 67 days, or 79 per cent, was employed in mining. It was found that the gold content of the gravel increased upstream as the cut advanced.

The smaller plant was employed on claim No. 5, on Rex Creek. Less gravel was moved there, but the greater value of that put through the sluice boxes tended to equalize the production.

These two plants require more men for their operation and produce much more gold than all the others in the Chititu drainage area.

They have been employed and probably will be employed for a number of years in mining creek gravels only. It seems probable, however, that the bench gravels of Chititu Creek and its branches may sometime add considerably to the gold production of the district.

The work of one operator on the bench east of Rex Creek is of interest as shedding some light on the extent of gold-bearing gravels in the Chititu Creek basin. Heretofore the producing gravels have been those of the creek. Considerable work was done in prospecting bench gravels during the early days of mining on the stream, but no gold-bearing gravels were found that could be mined profitably under the conditions prevailing at the time. In 1914 L. H. Carvey operated a small hydraulic plant on the east side of Rex Creek above claim No. 3. The bedrock rim of the creek consists of shale and is 55 feet higher than the stream. From 100 to 150 feet of gravel, forming the bench previously mentioned, rests on the shale at this place. The gravel is largely of local origin, consisting for the most part of shale like the country rock but including also material from other sources. It contains fewer large bowlders than the gravel of Chititu Creek, yet bowlders are numerous. All of them would pass through a 30-inch sluice box. The gold is coarse. It is said to be rather evenly distributed throughout the gravel, although the gold content at bedrock is slightly greater than in the upper part of the deposit, and to range from 65 to 75 cents to the cubic yard. One nugget valued at $5.50 was found.

This claim is worked by a small hydraulic plant. Water was conveyed through a steel pipe from 6 to 11 inches in diameter, and was delivered at a pressure of 20 pounds to a hydraulic giant using 2 to 2½-inch nozzles. Unfortunately the water supply is uncertain, for it is subject to the demands made on the stream by the larger plant on Rex Creek, and furthermore a dump that does not interfere with mining on the creek is not available. About 500 feet of timbered tunnels have been driven in the gravel of the bench at various times for the purpose of testing its gold content.

Other placer-mining operations of the Chititu basin are those in the gravels of upper Rex Creek and White Creek. They are less extensive than those previously mentioned, but add to the total production of the district and have helped to make 1914 the most profitable season there in recent years.

Except as previously stated, the gold of Rex Creek comes chiefly from the creek gravels. That from White Creek comes in part from the creek gravels and in part from the benches. An immense amount of gold-bearing bench gravel is present in this vicinity, and probably will receive more attention from miners as the creek gravels become worked out.

AURIFEROUS GRAVELS OF THE NELCHINA-SUSITNA REGION.

By Theodore Chapin.

INTRODUCTION.

This paper is a preliminary statement of the geology and mineral resources of the region which embraces that part of the Susitna Valley lying between the mouth of Maclaren River and Tsusena Creek, most of the drainage area of Nelchina River and its tributaries, the lower parts of the Tazlina and Klutina basins, a part of the foothills of the Chugach and Talkeetna mountains, and a part of the mountain ranges between Susitna River and the Alaska Range. A more complete report, including topographic and geologic maps and sections, is in preparation.

The eastern border of this area was visited in 1898 by F. C. Schrader,[1] and the same year W. C. Mendenhall[2] crossed this region on a reconnaissance trip. W. C. Mendenhall[3] and T. G. Gerdine continued the studies of Copper River in 1902 and mapped the south and west slopes of the Wrangell Mountains and portions of the Alaska Range drained by tributaries of Copper River. In 1906 Adolph Knopf and T. G. Gerdine made geologic and topographic surveys of the headwater regions of Nelchina, Little Nelchina, and Oshetna rivers, and Sidney Paige and R. H. Sargent extended these surveys westward along Talkeetna River to its mouth.[4] In 1910 J. W. Bagley, D. C. Witherspoon, and C. E. Giffin mapped the headwater regions of the Gulkana and Susitna rivers, and F. H. Moffit and B. L. Johnson studied the geology of the same region.[5] Two years later Mr. Moffit and J. E. Pogue extended the geologic surveys to

[1] Schrader, F. C., A reconnaissance of a part of Prince William Sound and the Copper River district, Alaska, in 1898: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 341–423, 1900.

[2] Mendenhall, W. C., A reconnaissance from Resurrection Bay to Tanana River, Alaska, in 1898; Idem, pp. 271–340.

[3] Mendenhall, W. C., Geology of the central Copper River region, Alaska: U. S. Geol. Survey Prof. Paper 41, 1905.

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

[5] 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.

Broad Pass[1] and J. W. Bagley carried the topographic mapping over the same area. The same year G. C. Martin and J. B. Mertie, jr., studied the geology of the upper Matanuska Valley and the headwater region of Little Nelchina River.[2]

The field work on which this report is based was done by the writer in the summer of 1914 while attached as geologist to a topographic party under the leadership of J. W. Bagley, topographic engineer. The purpose of the work was to connect these former topographic and geologic surveys and carry the work westward. Mr. Bagley connected his own work of 1913 with that of D. C. Witherspoon east of Susitna River and with that of R. H. Sargent and T. G. Gerdine in the Talkeetna Mountains and Nelchina and Copper River regions. The accompanying sketch map (Pl. VI) was prepared by Mr. Bagley and the writer in advance of the topographic and geologic maps now in course of preparation. Field work commenced June 25 at Albert Creek, a branch of Crooked Creek, and closed October 10 at Willow Creek, tributary to Copper River.

Fine colors of alluvial gold may be washed from nearly every stream in this region. Although this fact has been known to prospectors for some time, previous to 1913 gold had not been found in quantity sufficient to be mined profitably or even to encourage prospecting. A fresh impetus, however, was recently given to prospecting in the Nelchina region by the report of a rich find on Albert Creek, one of the branches of Crooked Creek, itself a tributary of Little Nelchina River, and during the open season of 1914 about 400 men were working on the tributaries of Little Nelchina and Oshetna rivers. Gold was found on a number of the creeks near by, but for the most part the results of the season's work were discouraging and few men stayed in the district during the winter. Prospecting has not yet been exhaustive enough, however, to determine adequately the mineral value of the region.

GEOGRAPHY.

SURFACE FEATURES.

The dominant topographic forms bear evidence of the intense glaciation to which the region has been subjected. Three distinct types of topography are represented by the débris-filled lowland with characterless forms, the rounded foothill areas with ice-scoured

[1] Moffit, F. H., Preliminary report on the Broad Pass Region: U. S. Geol. Survey Bull. 592, pp. 301–305, 1914; The Broad Pass region, Alaska: U. S. Geol. Survey Bull. 608, in press.

[2] Martin, G. C., and Mertie, J. B., jr., Mineral resources of the upper Matanuska and Nelchina valleys: U. S. Geol. Survey Bull. 592, pp. 273–299, 1914; Geology of the upper Matanuska Valley, Alaska; U. S. Geol. Survey Bulletin in preparation.

knobs and ridges, and the rugged mountains with numerous cirques. These types, although diverse, are all characteristic of a profoundly glaciated region and are varied expressions of glacial action. Although divisible into smaller topographic units this region falls naturally into four physical divisions, comprising an extensive lowland and, around its borders, three isolated mountain provinces of diverse character—parts of the Talkeetna and Chugach mountains and the rugged ranges lying between Susitna River and the Alaska Range.

The most prominent of these divisions is the lowland province, a broad basin extending the length of the area mapped and including portions of the valleys of Susitna and Copper rivers and the low divide that separates them. This province is floored with glacial silts and gravels that form part of an extensive gravel sheet reaching from Mentasta Pass and the headwaters of Chitina River to Cook Inlet. It is of late geologic age, and its glacial origin is evident from its poorly drained, lake-dotted surface and the character of its deposits. It has a rolling, nearly level surface broken by gravel ridges and sharp canyon-like stream valleys. The drainage is young and undeveloped. The streams have cut into the gravels in V-shaped troughs, and the interstream areas contain ponds and swamps with no apparent outlets.

The lowland province is bordered on the southwest by the Chugach and Talkeetna mountains. The Chugach Mountains form a complex belt 50 to 60 miles wide that extends from Mount St. Elias to Kenai Peninsula in a course roughly parallel to the coast. Their peaks reach elevations of 8,000 to 10,000 feet.[1] East of Tahneta Pass the bold front of these mountains rises abruptly from the gravel lowland, flanked in places by the outlying foothills, the only portion of the Chugach Mountains included within the area here mapped.

The Talkeetna Mountains are separated from the Chugach Mountains by Tahneta Pass and Matanuska Valley. They form a rudely circular mass, with no definite trend line. They are rugged in outline, ranging in general elevation from 5,000 to 6,000 feet, though individual peaks are 8,000 to 9,000 feet high. On the south they rise abruptly from the floor of Matanuska Valley. On the north the low, rounded, flat-topped foothills of this range are carved from an extensive peneplain, which dips gently to the north and is abruptly terminated by the depressed trough that is now covered by the gravels of the lowland province. The foothill area is marked by sharp canyon-like valleys that have been widened and deepened by glacial erosion.

[1] Brooks, A. H., Geography and geology of Alaska: U. S. Geol. Survey Prof. Paper 45, p. 30, 1906.

Northwest of the lowland province, between the Alaska Range and Susitna River, is a tract of rugged mountains, the crests of whose ridges, ranging in elevation from 5,000 to 7,000 feet, form the watershed between the Susitna and the southern tributaries of the Nenana. This mountain mass is made up of several ranges, whose general trend is about parallel to that of the Alaska Range. Within the area mapped they trend about east. To the west they bear toward the southwest, following the general direction of Susitna River. They form a part of a crescentic mountain mass that extends more or less continuously from the vicinity of Gulkana Lake to the junction of Susitna and Chulitna rivers. The valleys are straight, with truncated spurs, oversteepened walls, and hanging valleys. The higher parts contain numerous cirques, in some of which are small active glaciers and in others the heavy accumulations of rock débris that have the form of glacial flowage and are termed "rock glaciers," which are considered to be descended from true glaciers that formerly occupied the cirques. The rugged topography is due in large part to the modifying influence of glacial erosion, which was controlled essentially by the drainage existing at the time of the glaciation.

The drainage of the region is all tributary to Copper and Susitna rivers. Only a small part of Copper River lies within the area mapped, but this part receives several large tributaries that drain the Talkeetna and Chugach mountains. Klutina River heads in Klutina Glacier and flows through Klutina Lake, a body of water 22 miles long. Below the lake the river occupies a recent gorge cut in glacial deposits for about 25 miles to its mouth.

Tazlina River is similar in many respects to the Klutina. Its course lies through Tazlina Lake, which it enters a short distance from its source in Tazlina Glacier. From the lower end of the lake the river flows for 30 miles in a winding course through a deep gravel gorge and enters Copper River 9 miles above the mouth of the Klutina. Nelchina River is tributary to Tazlina Lake. Its south fork, generally regarded as the main fork of the river, issues from Nelchina Glacier. Its main confluent is Little Nelchina River, which, with its tributaries, Crooked and Flat creeks, rises in the Talkeetna Mountains. Mendeltna Creek, the outlet of Old Man, Benzemina, and other lakes, enters Tazlina Lake half a mile below the mouth of Nelchina River. Tolsona and Moose creeks, the principal direct tributaries of Tazlina River, enter from the north and drain flat lowland areas.

The watershed separating the Copper and Susitna drainage basins is poorly defined. It lies on a broad interstream area dotted with swamps and lakes, and the direction in which many of these drain is doubtful. Susitna River and its tributaries drain the western part of the region. Tyone River issues from a large lake, and after receiving Tyone Creek, a large tributary, locally known as Little Tyone, that rises in the Talkeetna Mountains, enters Susitna River near the "big bend." East of Tyone River are Oshetna River, with its two tributaries, Little Oshetna and Black rivers, and Kosina River. The main tributaries entering the Susitna from the north, named in order from east to west, are Coal, Watana, Deadman, and Tsusena creeks.

POPULATION.

Copper Center, the principal settlement of this region, is situated at the confluence of Copper and Klutina rivers, 101 miles north of Valdez, on the Fairbanks-Valdez Government road, and may be reached from Cordova by rail to Chitina, a distance of 131 miles, and thence by wagon for 50 miles, or by wagon road direct from Valdez. Copper Center is a distributing point for the Nelchina, upper Susitna, Gulkana, and Chistochina regions. A post office, a Government telegraph station, and a Government school for the natives are located here.

Nelchina is a small settlement of 15 or 20 cabins, at the mouth of Crooked Creek. It is the seat of the Nelchina recording precinct and the general headquarters of the neighboring region. Aside from these two settlements the white population of the region is confined to the road houses along the Government road and the transient prospectors and miners.

The Indian population is small. Cabins and camps on Klutina and Tazlina lakes, on Susitna River, and in other places are temporarily used by natives on hunting and fishing expeditions, but aside from a few natives scattered over the region the permanent Indian population is confined to Copper Center.

ROUTES OF TRAVEL.

The Nelchina region may be reached either by way of Knik or by way of Copper Center from Cordova or Valdez. The route from Copper Center follows the wagon road for 10 miles to a point half a mile north of Simpson's road house, and thence goes by a trail along the north bank of Tazlina River and Tazlina Lake to the mouth of Mendeltna Creek. From this point the trail takes a northwesterly direction to Little Nelchina River, and then follows that stream to Nelchina, at the mouth of Crooked Creek. This is a winter trail, and winds around somewhat, to take advantage of several large lakes. For summer travel it is in places very swampy and is passable for horses with difficulty. The distance from Copper Center to Nelchina is about 90 miles.

The Knik route goes by trail up the Matanuska Valley to Chickaloon, from which several possible routes lead to the Nelchina-Susitna region. One follows the Matanuska around the east end of Sheep Mountain, goes up Squaw Creek, and crosses a low divide to the head of Crooked Creek. Another route is the Hicks Creek trail, by way of Billy Creek to the head of Little Nelchina River, or by way of Alfred Creek to the head of Albert Creek. Susitna River may be reached by way of Chickaloon and Talkeetna rivers to low passes at the headwaters of Kosina Creek, a tributary of the Susitna.

Supplies for this region are taken in during the winter from both Knik and Copper Center; but, as Knik is not an open port during the winter, freight from the outside usually goes by way of Copper Center from either Chitina or Valdez. The distance from Albert Creek to Knik is about 106 miles.

This region will be more accessible when the proposed Government railroad is constructed along Susitna River through Broad Pass to the Tanana and the branch line up the Matanuska to the coal field. When the coal-field branch of the proposed railroad is built to Chickaloon, Albert Creek may be reached by an overland journey of 50 miles.

CLIMATE.

The climate is characteristic of the district lying behind the coastal barriers. The rainfall is a medium between the excessive precipitation of the coast and the semiaridity of the interior. The summers are warm, but sudden changes of temperature are not uncommon and may be accompanied with a heavy frost or light fall of snow at any time during the summer. The winters are cold, but the snowfall is not heavy. The open season for placer mining lasts from May until October, varying somewhat from year to year and depending on the elevation of the region. Ice suitable for winter sledding usually forms in November and lasts until March or April.

VEGETATION.

Spruce covers the lowland area to an elevation governed somewhat by local conditions but ranging from 2,500 to 3,000 feet. The quality varies considerably, from the scrubby growth covering the poorly drained swampy areas to trees $2\frac{1}{2}$ feet in diameter, which are occasionally found in favored localities. Most of the timber is ample in size and quantity for building and mining purposes.

Birch, of which there are several varieties, is less abundant than spruce. Cottonwood, willow, and quaking asp are found at elevations higher than spruce, and in many localities furnish the only available firewood. Alder is not abundant.

Bunch grass and redtop grow luxuriantly in places but are not plentiful, so that it is not always easy for the traveler to find forage. A substitute for these grasses is a rank black-seeded swamp grass that horses will eat, though they do not relish it. A little grass appears about the 1st of June, but can not be depended upon until the middle of the month. Horse feed lasts until the time of heavy frosts, which varies from early in September to the 1st of October, depending on the season and location. After other grasses are gone a "pea vine," which grows along river bars and dry benches, is sometimes available.

GAME.

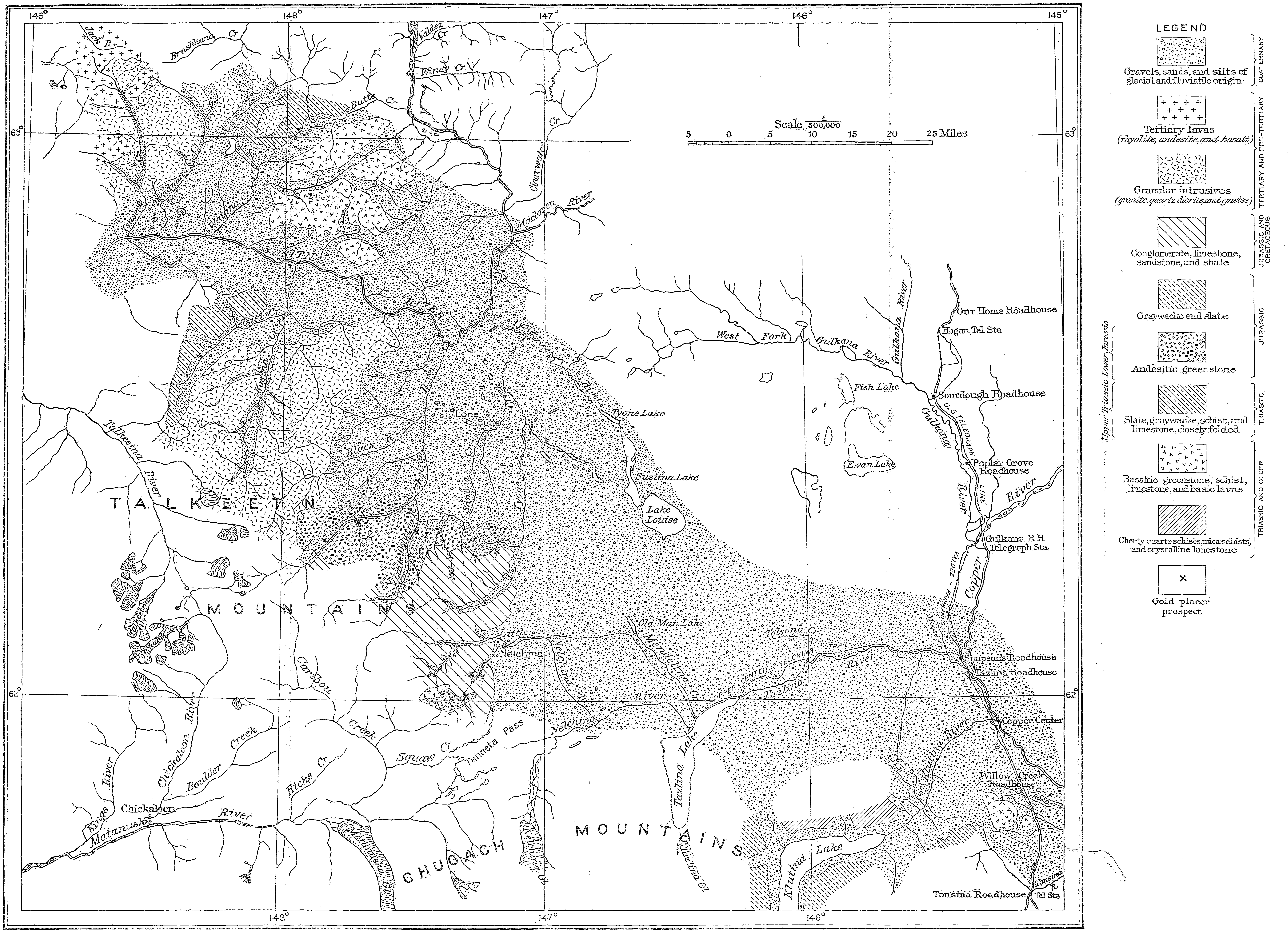
Caribou are the most plentiful large game of the Susitna region. Moose also may be found, but are more common in the low country and around Klutina and Tazlina lakes. A few sheep live in the Talkeetna Mountains and the ranges north of Susitna River. Brown bear are plentiful. Ptarmigan are found throughout the region and spruce grouse in places. Ducks, geese, and other water fowls spend the summer in the streams and lakes, but leave in the fall. In the Susitna drainage basin the clear-water streams abound in grayling, and there are also several kinds of trout, including a very large lake trout. Salmon are plentiful along Copper River and its tributaries, but are not found in the upper Susitna.

GENERAL GEOLOGY.

The geologic formations of the Nelchina-Susitna region comprises several series of lava flows and intrusive rocks, in part altered to greenstone, and a number of sedimentary formations that have been more or less metamorphosed. Both the lavas and the sediments have been invaded by large masses of granitic and dioritic rock. The area has been profoundly affected by glaciation, and is mantled by glacial deposits. The general distribution of the geologic formations is shown on Plate VI.

The oldest rocks recognized are basaltic greenstones, with associated schists and altered sediments, overlain by a great thickness of amygdaloidal basaltic and andesitic lavas. Outcrops of these rocks occur on Stuck Mountain, in the vicinity of Klutina Lake, on Lone Butte and other low buttes near Susitna River, on the round-topped hills south of Maclaren River, and on Watana Creek. The lavas are probably of Triassic age, and the greenstones and schists are evidently older.

The lava flows and associated tuffs on Oshetna River may be the extension of a large mass of similar rocks in the Talkeetna Mountains whose age has been determined as Lower Jurassic. The lavas are composed of andesites, rhyolites, and associated tuffs, in part



GEOLOGIC SKETCH MAP OF THE NELCHINA-SUSITNA REGION.

altered to greenstone. A complex series of lava flows on Tsusena Creek and the head of Jack River includes rhyolite, andesite, and possibly more basic rocks and contains tuffs, breccias, and thin beds of conglomerate. The rocks are fresh looking and appear to be of recent age, but are fractured and intruded by granite. They are provisionally correlated with Tertiary lavas and associated breccias and tuffs that cap the high peaks at the heads of Alfred and Albert creeks.

Sediments that include beds of Middle and Upper Jurassic and Cretaceous age occur in the headwater region of Little Nelchina River, Tyone Creek, and Oshetna River. These sediments, composed of conglomerate, sandstone, shale, and limestone, unconformably overlie the Lower Jurassic volcanic rocks.

The field term "granite" is conveniently applied to a number of granitic rocks which include, besides granite, dioritic and monzonitic varieties. A large batholith of quartz diorite extends northward from the Talkeetna Mountains near the head of Oshetna River to Susitna River, where it is concealed by gravels, and north of the river smaller masses occur. It is a fine-grained rock, composed essentially of feldspar and hornblende, with varying but subordinate amounts of quartz and accessory mica. From place to place it exhibits considerable variation in texture, becoming schistose with the development of considerable black mica. Diorite gneiss and granite are less abundant. Basic dikes have intruded both the granite and the lavas. The age of the quartz diorite intrusion is believed to be Middle Jurassic, but some of the associated intrusives are Tertiary.

MINERAL RESOURCES.

GENERAL FEATURES.

Auriferous gravels constitute the only mineral resource that is now attracting attention in the Nelchina-Susitna region. Though widely distributed, they are as yet of little economic importance. They have been found in encouraging amount in only a small area, confined to the tributaries of Little Nelchina River, Tyone Creek, and Oshetna River, and so far but little gold has been recovered from them. (See fig. 3.)

The prominent features of the occurrence of the alluvial gold are its widespread distribution and, with one notable exception, the apparent lack of concentration. Fine gold occurs in the glacial gravel which covers the region, and colors may be found even on the hilltops, where no concentration has taken place. The alluvial gold is distributed throughout the vertical section to bedrock. Even the stream gravels lack definite pay streaks, as if there had been but little lateral or vertical concentration since their deposition.

SOURCE OF THE GOLD.

These features indicate a glacial origin for most of the gold. The glacial source of the gravels has been pointed out, and it is evident from the widespread distribution of the alluvial gold throughout the gravels and its lack of concentration that it also was glacially transported. Its bedrock source is not clear. The glacial débris was derived from various sources and contains an abundance of rocks foreign to this region, which were evidently moved a great distance.

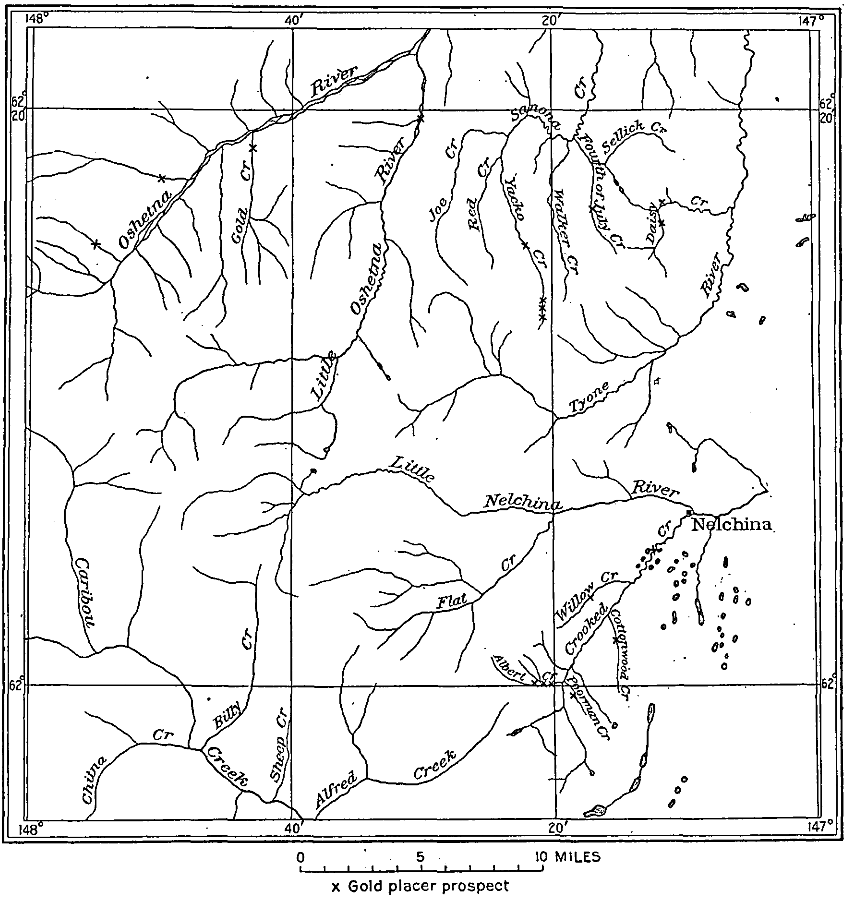


FIGURE 3.—Sketch map showing location of placers in the Nelchina region.

The stream gravels are largely of glaciofluvial origin, and except for a narrow strip along each stream course have not been reworked. These conditions account in part for the failure to find workable deposits in a region where auriferous gravels are so widely distributed. The extensive deposits of glacial gravel appear to contain a wealth of disseminated gold, but owing to lack of reconcentration they give little promise of yielding valuable returns.

Although most of the alluvial gold is believed to have been derived from the glacial gravels, it is possible that locally streams were enriched from other sources. Paige and Knopf[1] suggested that the gold content of the streams was derived by reconcentration from the Upper Jurassic conglomerates. These rocks, however, can not now be regarded as even a contributing source, for the beds of eroding streams show no gold enrichment where they cross the conglomerate formation. Small veins in the bedrock are regarded by Martin[2] as a possible source of the gold. Veins are not conspicuous in this region and are not regarded as a general source of gold, although they may have contributed a part of it.

The hope for developing workable gold placers in this region lies in finding either a stream in which a reconcentration of the glacial deposits has taken place or a channel of preglacial gravel.

The geologic formations of this region in which gold lodes are most likely to be found are the greenstone and schist formation, the Triassic schist and slate, and the Lower Jurassic lavas. These formations are all more or less mineralized, although they are not known to contain gold lodes in this region.

GOLD PLACERS.

CROOKED CREEK.

Crooked Creek is tributary to Little Nelchina River. It flows in a meandering course through a broad, flat, gravel-filled valley bordered by low glaciated hills. The entire course of the stream has been covered by locations, but little actual prospecting has been done except on its tributaries.

One claim, however, is being vigorously prospected. On "No. 19 below" a shaft was sunk during the summer of 1914 to a depth of 180 feet, and winter work was planned to drive the hole to bedrock if possible. The following log furnished by the operators shows the character of a part of the section:

Log of shaft on claim "No. 19 below," Crooked Creek.

	Feet.
Glacial capping, frozen muck, and gravel	85
Gravel	2
Silt	10
Blue-gray gravel composed of quartz and basaltic lava, with no clay or silt. Contains 5 colors in gold to the pan	9
Vegetable muck with willow twigs	12
Clay seam.	

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

[2] Martin, G. C., and Mertie, J. B., jr., Mineral resources of the upper Matanuska and Nelchina valleys: U. S. Geol. Survey Bull. 592, pp. 280–281, 1914.

	Feet.
Gravel	2
Gas-bearing vegetable muck[1]	15
Blue-gray gravel	8
Yellow gravel	6
Clean gravel containing no silt or clay	10

ALBERT CREEK.

Albert Creek is the only stream in the Nelchina region that has produced any gold. The discovery was made in the fall of 1912, and 10 claims were staked the next spring by Odin Olson, Fred Getchell, Joseph Palmer, and Duncan McCormick. Much of that season was spent on dead work, but a cut 34 by 39 feet was opened and yielded about 60 ounces of gold. The average yield of the gravel was over $10 a cubic yard. Development work was continued in 1914 on a lease. In June over half a mile of ditch was completed and a strip of ground was being ground-sluiced preparatory to sluicing. Work was suspended early in the fall. It is reported that 150 ounces of alluvial gold was recovered. Prospecting was done by a number of other men on the creek, with indifferent success.

Albert Creek is a small stream about 3 miles long that enters Crooked Creek 9 miles from its mouth. Three main tributaries are locally known as Money Gulch, Porphyry Gulch, and Noon Gulch. The bedrock on Albert Creek consists of tuffaceous sandstone and shale, associated with volcanic rocks. It is overlain by about 5 feet of poorly stratified coarse gravel containing many flat and angular bowlders of graywacke. The alluvial gold is disseminated through this gravel, with little or no concentration on the bedrock. The coarse gravel is overlain by 2½ feet of finer gravel and clay and lenses of ice and 2 feet of silt and clay. The pay streak does not appear to be continuous, but prospecting has not yet been adequate to prove or disprove its extent or value. Timber for cabins and mining purposes was brought from Startup, a camp at the head of Squaw Creek, 6 miles south.

OTHER TRIBUTARIES OF CROOKED CREEK.

Prospecting was being done in 1914 on other tributaries of Crooked Creek. Six men were at work on Poorman Creek and early in the summer had ground-sluiced 350 feet of ground and had boxes ready to set up. The bedrock on the lower part of the creek consists of conglomerate, shale, and sandstone and on the upper part of vesicular red andesitic lava with beds of white tuff. At the workings the bedrock is about 6 feet deep. The gold is rather flaky, but

[1] The gas that escaped from this stratum was sufficient to ignite and to cause a slight explosion.

contains small nuggets. It is reported that a small production was made. A little prospecting was done on Cottonwood Creek, but bedrock was not reached. Prospecting was also done on Bonanza Creek, South Creek, Willow Creek, and other small tributaries.

LITTLE NELCHINA RIVER.

A number of claims have been staked on Little Nelchina River, but little work has been done. The nature and depth of the gravels of the Little Nelchina are not known, as bedrock is not exposed. The gravels have not been exposed by mining and only slightly by erosion, as the stream is not actively cutting its channel. Low benches along its border are composed of coarse glacial material. To judge by the depth of the gravel on Crooked Creek the Little Nelchina bedrock is also deep.

YACKO CREEK.

Yacko and Joe creeks unite to form Sanona Creek, one of the tributaries of Tyone Creek. Several men were prospecting on Yacko Creek in 1914. Bedrock was not reached, but enough alluvial gold was found in the overlying gravel to encourage further work. The gold is coarse and flat. The contact between the volcanic rocks and the Mesozoic sediments crosses this stream. Above this contact the stream flows over a wide, flat valley bounded by rounded hills, but where it enters the volcanic rock the valley narrows into a canyon and the hills are much more rugged.

FOURTH OF JULY CREEK.

Two prospectors worked during the summer on Fourth of July Creek, a small tributary of Sanona Creek. They reported fine colors of alluvial gold but failed to find gold in encouraging amounts.

DAISY CREEK.

Daisy Creek is being worked at several places, and fair prospects have been found. The bedrock on the lower part of the creek is lava; on the upper part, sandstone and conglomerate. The upper valley is wide and flat, but where the stream enters the volcanic rock the valley narrows to a canyon, below which it widens out considerably. The gravel is shallow, ranging from 5 to 12 feet in depth, but the prospectors had considerable trouble with ground water. In the fall of 1914 a prospecting drill was taken in to prospect the creek during the winter.

OSHETNA RIVER.

Several prospects were located on tributaries of Oshetna River in 1914. Alluvial gold occurs in the gravels of Little Oshetna River, but there is little or no concentration in pay streaks on bedrock. Prospectors on Gold Creek found coarse gold but had difficulty in getting to bedrock on account of the ground water. They planned to continue winter development. Enough alluvial gold to encourage further prospecting was also found on Granite and Roaring creeks, small tributaries 11 and 13 miles, respectively, above the mouth of Little Oshetna River.