MINERAL RESOURCES OF THE CHISANA-WHITE RIVER DISTRICT.

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INTRODUCTION.

The district covered by this paper lies on the northeast side of the Wrangell and St. Elias mountains and includes parts of the upper basins of White and Chisana rivers. (See fig. 5.) The area is irregular in outline but lies between parallels 61° 30′ and 62° 20′ north latitude and meridians 141° and 142° 20′ west longitude. It includes

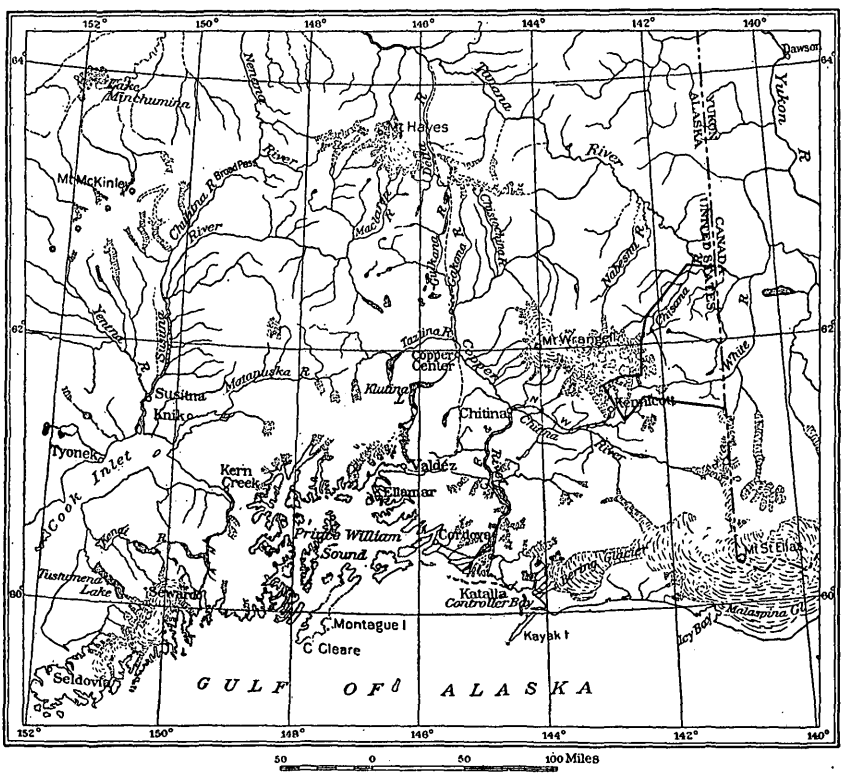


FIGURE 5.—Index map showing location of Chisana-White River district.

the northern front of the St. Elias and Wrangell mountains, the south slope of the Nutzotin Mountains between the international boundary and Chisana River, and the broad basins and less rugged hills between them. Figure 5 is an index map, showing this general region.

After the discovery of gold in the Klondike and the stampede to that field in 1897 and 1898, a number of prospectors worked southward into this general region, and in 1902 a reported discovery of placer gold in the basin of Beaver Creek brought on a small gold rush to the White River basin, but no workable placer gravels were then found and most of the gold seekers soon left. A few who stayed were led to the search for copper deposits, for Indian reports of rich occurrences of native copper in the White River valley had long been known. A number of copper-bearing localities were found, and the development of these and prospecting for other lodes have continued to occupy the attention of a few men ever since. The region, however, is difficult of access and had been visited by comparatively few white men up to the spring of 1913. The discovery of placer gold in 1913 and the widely circulated reports of the richness of the district led to a great influx of gold seekers in the fall and winter of that year and created a demand for more recent information about the district than was available. Accordingly two parties were organized to map the country both topographically and geologically. The topographic party in charge of C. E. Giffin, commenced work on Nizina River near the mouth of the Chitistone, resurveying the upper Nizina basin and the head of the White River basin and extending the mapping northward to the north front of the Nutzotin Mountains east of Chisana River. The geologic mapping was carried over much the same territory, but the north slope of the Nutzotin Mountains was not visited by the geologist. The topographic and geologic mapping was intended to supplement and extend the work which had already been done in portions of this area.

Geologic investigations of parts of this district have been made by a number of men in previous years. C. W. Hayes made the first geologic observations in 1891, and Alfred H. Brooks examined portions of the area in 1899. F. C. Schrader in 1902 and F. H. Moffit, Adolph Knopf, and S. R. Capps in 1908 again visited parts of this field, and D. D. Cairnes, of the Canadian Geological Survey, briefly examined the gold placer district in 1913. Fuller reference to the work of these writers and to their published reports will be given in a more complete report on this district, now in preparation, but the facts now known with regard to the geology and mineral resources of the district are the result of the work of these earlier investigations as well as of the expedition upon which this report is based, and their published reports have been drawn upon freely by the writer. The report by Moffit and Knopf [1] is the most complete description of the district that has so far been published.

[1] Moffit, F. H., and Knopf, Adolph, Mineral resources of the Nabesna-White River district, Alaska, with a section on the Quaternary by S. R. Capps: U. S. Geol. Survey Bull. 417, 1910.

The conclusions reached in this paper and the accompanying sketch map showing the geology of the Chisana mining camp (Pl. IX, p. 202) are the result of only a preliminary study of the material at hand and are subject to revision in the more complete report.

There is a regrettable confusion in the use of names for a number of the important streams in this district. Chisana River, the name used on Witherspoon's map of 1902, was approved by the United States Geographic Board and has so appeared on all official maps since. Many prospectors in that vicinity have, however, persisted in pronouncing the name as if it were spelled Shushana, and that spelling was for a time rather widely used by the newspapers in reporting the discovery of placer gold in 1913 and appeared on some sketch maps of the region. In a similar manner the prospectors ignored the authorized names of other streams in that vicinity and rechristened Chathenda Creek as Johnson Creek and Chavolda Creek as Wilson Creek. These names are still current among the miners, but in this report the approved names for these streams are used.

GENERAL DESCRIPTION OF THE DISTRICT.

GEOGRAPHIC FEATURES.

The Chisana-White River district is one of unusual scenic beauty. It is bordered on the south by the high and rugged Wrangell and St. Elias ranges, their summits capped by perpetual snows and each of the larger valleys holding a great glacier. The abrupt northern face of the St. Elias Mountains, on the south side of White River, culminates near the international boundary in Mount Natazhat, a double-peaked mountain 13,486 feet in elevation. The range has other higher peaks to the south, but none appear so conspicuous from the area here described. The Wrangell Mountains contain a number of peaks higher than Mount Natazhat, but from the district between White and Chisana rivers no single mountain appears greatly to overtop its neighbors, and the impression given is of a vast number of mountains of the same general height, all covered by snow and flanked by fields of glacial ice.

Between the Wrangell and St. Elias ranges on the southwest and the Nutzotin Mountains on the northeast there is a broad area of smoother hills and less rugged mountains. Here the alpine belt merges into a treeless area of broad, tundra-covered valleys and smooth, rounded hills of lesser elevation. The hills rise to elevations not generally exceeding 7,000 feet above sea level, and the broad valleys which cut them are between 4,000 and 5,000 feet high, so that the relief is much less than in the mountain ranges to the north and south. The area also contains no sharp, serrate ridges nor glaciers.

The northeastern portion of this area falls within the Nutzotin Mountains. This range is of alpine character and consists of a belt of sharp peaks and ragged ridges, separated by steep-walled mountain valleys. The highest peak is Mount Allen, which has an elevation of 9,489 feet, and many points reach heights of 7,000 to 9,000 feet. Some glaciers are present in the more favorably situated valley heads, and many mountains rise above the level of perpetual snow; but the glaciers are comparatively small and, unlike those of the Wrangell and St. Elias mountains, are not conspicuous features of the landscape.

Two large rivers receive the drainage from this district. Chisana River has its source in a great glacier of the same name and drains a portion of the Wrangell Mountain mass, part of the Nutzotin Mountains, and a part of the area between these ranges. White River heads in Russell Glacier and is fed by a number of glacial streams which rise in the ice fields of the Wrangell and St. Elias ranges. Beaver Creek, a tributary of the White, drains the south flank of the Nutzotin Mountains east of the Chisana basin. It receives only a small part of its waters from melting glaciers and is a clear stream except in times of flood. Chisana and White rivers, however, are largely fed by streams of glacial origin and are characteristic of streams of this type. They are heavily charged with sand, gravel, and silt, are turbid throughout the summer season, and flow over broad gravel and sand flats built up of the surplus load supplied by the glaciers. They are subject to rapid fluctuations in volume, the flow being influenced by the daily range of temperature in the tributary ice fields, as well as by seasonal changes and by local conditions of rainfall.

GLACIATION.

Although valley glaciers of large size are numerous in the Wrangell and St. Elias mountains, and many smaller ice tongues are to be found also in the higher portions of the Nutzotin Mountains, these glaciers are but the remnants of much greater ice fields which formerly occupied this region. At the time of their greatest development the glaciers completely covered all of the region except the higher mountain ridges. One vast glacial field extended from the White River valley to the Nutzotin Mountains, broken only by a few projecting mountains. The slowly moving glaciers had great erosive power and profoundly altered the shape of the land which they covered, smoothing off and rounding the hills and widening and deepening the valleys. They also disturbed the preglacial drainage to so great an extent that old stream courses were completely abandoned and new valleys formed. The results of the erosion of glaciers and of their disturbing effect upon the drainage are particularly significant in the district in which placer gold occurs,

and the present distribution of the gold can be properly accounted for only after the influence of the glacial ice is taken into account. A fuller discussion of the influence of the ice upon the distribution of placer gold will be given in the more complete report on this district.

ROUTES OF TRAVEL.

The Chisana district is remote from all the well-established systems of transportation in Alaska (see fig. 5), and the available routes to it offer certain difficulties, so that communication with it is slow and the transportation of supplies is tedious and expensive. During the winter of 1913–14 the cost of transporting supplies by sled varied greatly with different freighters, being controlled by the efficiency with which the work was done, by the route traveled, and by the quantity of material moved. Reported costs of sledding, not including railroad or steamer freights to the point from which sledding began, varied from 12 to 50 cents or more a pound, but most of the contracts for freighting were let at prices between 20 and 30 cents a pound.

Seven different routes of travel to this district are available, and each has been traveled by many people. The route chosen by any person is naturally determined by the direction from which he wishes to approach the district, but for one coming to Alaska from Seattle a number of routes are available. Various articles have been published which make much of the difficulties of approaching this district, and especially of the dangers encountered in traveling the trails that lead from McCarthy by way of Nizina and Chisana glaciers and over Russell Glacier. It is true that during the stampede several persons were drowned in rashly attempting to ford the glacial Chitistone and Nizina rivers or their tributaries during periods of high water, but so far as could be learned only one man of several thousand who crossed the glaciers was lost. None of the routes is easy, and none should be attempted without proper equipment, but one familiar with the conditions of travel by trail in Alaska may use any of the routes here described. (See fig. 5, p. 189.)

NIZINA–CHISANA ROUTE.

The shortest route from the coast and the one most used during the winter of 1913–14 was by way of the Copper River & Northwestern Railway from Cordova to McCarthy, a distance by rail of 191 miles. From McCarthy all travel goes up the Nizina Valley to the mouth of Chitistone River, where the trail forks. For winter travel a trail was established up the Nizina to Nizina Glacier and thence up that glacier to its head, across a high ice divide with an elevation of about 8,000 feet, down Chisana Glacier to its terminus, and down Chisana Valley to the town of Chisana, a total distance of about 75

miles from McCarthy, of which about 40 miles is on glacial ice. This route was much used both by foot travelers and for freighting during the winter of 1913–14 and has the advantage of being at a shorter distance from a railroad than any other route. It is, nevertheless, a difficult and dangerous trail and was made passable only by the building of many temporary bridges across crevasses in the glaciers and by a careful staking of the trail so that crevasses could be avoided when the snows had covered and concealed them. The movement of the glaciers also frequently caused the crevasses to engulf the bridges and opened new cracks which in turn required bridges. Furthermore, almost all work on the glacier portion of this trail must be renewed each fall, and new trails must be staked at places where changes in the ice conditions have rendered the old trail impassable. It seems probable, therefore, in view of the impossibility of establishing a permanent trail over the glaciers and the cost of restaking a trail and building new bridges each winter, that the route over Nizina and Chisana glaciers will not be long used.

NIZINA–WHITE RIVER ROUTE.

For summer travel a different route, by way of White River, was generally followed. From the mouth of Chitistone River two branches are available. One takes the same course as the glacier route up to and for a few miles on Nizina Glacier but branches eastward, crossing that glacier to the mouth of Skolai Creek. The Skolai Valley is then followed for 15 miles to its head in Russell Glacier. The other branch ascends Chitistone River to its head and crosses a high pass to the head of Skolai Creek, where the two branches join. Each of these branches presents some advantages over the other, and the travelers are about equally divided in their preferences. The Nizina-Skolai branch is several miles longer and necessitates the fording of Nizina River and the crossing of Nizina Glacier, but the trail is fairly good, the grade is moderate, and there is a better distribution of grass for horse feed. The Chitistone branch crosses Chitistone River several times, and that stream is subject to sudden floods. It also crosses a high divide over a narrow and somewhat dangerous trail known as the "Goat Trail." Furthermore, it is impassable on account of snow until early in July, and snows in the fall may block it by the 1st of September. To the cautious traveler the somewhat longer but safer Nizina-Skolai branch recommends itself.

At the head of Skolai Valley the two branches join, and a single trail extends for about 14 miles across Russell Glacier. For most of that distance the trail follows the moraine-covered portion of the glacier, winding back and forth over its irregular surface. Although the melting of the glacier affects the trail somewhat, rendering

certain portions impassable from time to time, so that short detours are necessary, the glacier crossing is not difficult and requires only five to six hours for pack horses. From the head of White River to the placer mines various routes may be followed through a rolling country with low passes, no difficulties being encountered other than some soft ground. One of these routes leaves White River near the mouth of Lime Creek and goes in a northwest direction across a high flat to the head of Gehoenda or Trail Creek and down that stream to Chisana River, at the town of Chisana. A branch of this trail leaves it near the head of Solo Creek and runs northward past Beaver Lake to the town of Bonanza.

COPPER RIVER-NABESNA ROUTE.

The Copper River-Nabesna route starts at the town of Chitina, on the Copper River & Northwestern Railway, 131 miles from Cordova. It follows the Government military road from Chitina up Copper River to Gulkana. From Gulkana a trail follows the north bank of Copper River to the Indian village of Batzulnetas, whence it takes an eastward direction to the head of Platinum Creek and follows that stream to Nabesna River. Crossing that river it follows Cooper and Notch creeks to Chisana River, 8 miles below the town of Chisana. By this trail the distance from Chitina to Chisana is about 235 miles, and the route is little used for summer travel. In winter, however, the greater distance is largely offset by the gentle gradient, the avoidance of glaciers, and the abundance of timber for fuel along the whole route. The only high pass to be crossed is Cooper Pass, an ice-free divide at an elevation of about 6,000 feet, approached by moderate grades. Considerable freight was taken over this route in the winter of 1913–14 in competition with the much shorter Nizina-Chisana route, although the sledding distance is nearly three times as great, and many freighters are said to contemplate a change from the Nizina-Chisana to the Copper-Nabesna route for future freighting.

DAWSON-WHITE RIVER ROUTE.

Many of the gold seekers in this district come from Dawson by way of White River. Freight may be taken by steamer up the Yukon to White River, a distance of about 70 miles, and by poling boats or shallow-draft power boats up White River as far as the mouth of Donjek River, or even to the mouth of Beaver Creek in favorable stages of water, and poling boats can be used to Canyon City, a village on White River a few miles below the international boundary. From White River freight is taken in winter by sled to the placer mines. A winter trail has now been cut from the mouth of Beaver Creek to the point where that stream first crosses the boundary, and this route is said to offer no great difficulties, although the distance by boat from

Dawson is about 175 miles to the mouth of Beaver Creek, and about 85 miles overland from the mouth of the Beaver to the placer mines.

TANANA-CHISANA ROUTE.

Upon the circulation of the report that rich placer discoveries had been made in the Chisana basin, a considerable number of men made their way up Tanana and Chisana rivers by launch and small boats. Under favorable conditions launches may be taken up these rivers as far as the north front of the Nutzotin Mountains, and boats were lined or poled all the way up to the mouth of Chathenda Creek. The route from Fairbanks, the base of supplies, is, however, long and difficult and, though possible, will never be an economical route for bringing in supplies. In the fall of 1914 many persons availed themselves of this water route and built boats in which they rowed downstream to Fairbanks.

WHITEHORSE-KLUANE ROUTE.

The route from Whitehorse to Canyon City by way of Kluane Lake is available for travel both in summer and in winter, though the winter trail makes some short cuts and is shorter than that used when the lakes are unfrozen. A wagon road has been built from Whitehorse to Lake Kluane, a distance of 143 miles, and a trail extends about 170 miles from the upper end of the lake to Canyon City, on White River, and thence 55 miles farther up Beaver Creek to the placer mines. The total overland distance by this route is therefore about 368 miles in summer and perhaps 20 miles less in winter.

COFFEE CREEK ROUTE.

Coffee Creek joins the Yukon 110 miles above Dawson. From the mouth of this creek a good trail has been built to the junction of Beaver Creek with White River, a distance of about 80 miles, and another branch leads to Canyon City, 120 miles by trail from the Yukon. From the mouth of Beaver Creek the trail to the Chisana placer mines reaches the Beaver at the international boundary and thence proceeds up the Beaver to its head. The total distance by this trail from the Yukon to the town of Bonanza is about 160 miles.

ACCOMMODATIONS ON THE TRAILS.

Along all the most used routes to the gold fields there were in 1913 and 1914 road houses at intervals of 15 to 30 miles at which meals and lodging could be procured. Thus along the Nizina-Chisana and Nizina-White River routes one could travel from road house to road house each day for the entire distance. On the Copper River-Nabesna route there are road houses along the Government military road as far as Gulkana. On the Whitehorse-Kluane route

road houses are maintained between Whitehorse and Kluane Lake, but none west of that portion of the trail. The rates charged at these road houses vary on the different routes and with the distance from established lines of transportation, but range from a minimum of $1 a meal and $1 for lodging to $1.50 or even $2 a meal in the more remote portions of the region.

VEGETATION.

Only a small portion of this area is timbered. Spruce trees grow along the lower valley slopes of Chisana and White rivers up to the glaciers in which these streams head, and the valleys of some of their tributaries also have some timber in their lower portions. In Chisana Valley, near the town of Chisana, trees 2 feet in diameter at the base were seen, but over most of the timbered portion of the district the trees do not commonly exceed 1 foot in diameter. At only a few places were trees seen above an elevation of 4,000 feet, and large areas below that elevation are untimbered. Much the greater portion of the region, however, is above timber line. In the placer camp wood for fuel and lumber for sluice boxes and other mining purposes must be brought several miles to the places at which it is to be used. Willow and alder brush grow in many places that are devoid of trees and furnish sufficient fuel for the prospector's camp, but in the area between upper Beaver Creek and White River and in all the higher mountain masses even small brush for fuel is almost entirely lacking, and for even the small requirements of a temporary camp wood must be brought from a distance.

Grass for horses may be found in favorable places throughout this region, although it is only locally abundant. Good forage for horses is specially plentiful in the valley of White River and on Beaver Creek near the mouth of Horsfeld Creek, and horses have passed the winter successfully at both places. In the spring the new grass appears about the first of June, and stock may be maintained on it until the heavy frosts begin early in September.

GAME.

Game was formerly abundant throughout the region but has now been greatly thinned out in the immediate vicinity of the mines. Elsewhere sheep are plentiful in the more rugged hills and mountains and furnish a valuable food of fine quality in this county where provisions are so difficult to obtain. Caribou, while less numerous, are easier to hunt and are fairly plentiful in the rolling country between Beaver Creek and White River. Moose are numerous in the White River valley near the boundary and occasionally range to other parts of the district. Black and grizzly bears are sometimes seen. Both rabbits and ptarmigan have been unusually abundant

during the last few years and have been killed in great numbers to supply food for both men and dogs. Some fur-bearing animals, notably fox, lynx, mink, and marten, are trapped each winter.

NATIVES.

This region as a whole is very sparsely peopled with Indians. A few families live in the vicinity of lower Beaver Creek and hunt and trap into adjacent territory, and there is a small settlement on Cross Creek, in the Chisana Valley. These natives had for a long time been little in contact with white men and supplied most of their simple needs from the products of the country. Now that a great influx of miners and prospectors has taken place it is probable that they will become dependent on the white man for a livelihood, as they have done at so many other places.

GENERAL GEOLOGY.

The rocks of the Chisana-White River district range in age from Devonian to Recent and comprise a wide variety of rock types, including all the common varieties of sediments and igneous rocks of many kinds, both intrusive and extrusive. In general it may be said that the portions of the St Elias and Wrangell ranges included in this region are composed dominantly of igneous rocks, with which are associated considerable quantities of sediments, and that the Nutzotin Range is composed primarily of sedimentary beds cut by dikes and intruded by large masses of crystalline igneous rock and contains also some surface lava flows. The surface lavas also cover a large area lying between the St. Elias and Nutzotin mountains.

In the reconnaissance surveys upon which this report is based only the more general features of distribution of the rock formations could be determined, and time was not available for a study of the many details of structure, character, and areal extent which are so important to a complete understanding of the geologic history of the area. Nevertheless, it is believed that the major geologic units have been separated with a fair degree of accuracy, and the paleontologic evidence obtained serves to confirm the conclusions reached in the field from structural and lithologic evidence. (See Pl. IX.)

The dominant rock structures of the district have a distinct northwesterly trend. This is the general strike of the Carboniferous rocks of the St. Elias and Wrangell mountains, of the Mesozoic sediments of the Nutzotin Mountains, and of the great fault which in general separates the Paleozoic from the Mesozoic rocks. Even in the Tertiary beds the strike, with local exceptions, is northwest, and all the major mountain-building movements that have been recognized are due to forces that have operated at right angles to this direction of structural trend.

The oldest rocks that have been recognized in this area are of Devonian and Carboniferous age. They consist dominantly of a great series of volcanic materials, including lava flows, interbedded with tuffs, and agglomerates of basaltic and andesitic character. For purposes of description these rocks in the aggregate will be grouped as "pyroclastic rocks" in the succeeding pages, following the usage of Moffit and Knopf [1] in their earlier report on this same general region. Associated with these pyroclastic rocks there is in many places a considerable amount of sedimentary rock, principally limestone and shale, but in general the sediments are subordinate in amount to the rocks of igneous derivation. At a single locality, near the mouth of Little Eldorado Creek, fossils were found which have been determined to be of Devonian age. This place is near the lowest exposed portion of the pyroclastic series and is the only place in the region at which rocks of greater age than the Carboniferous are known to occur. The rocks both above and below the fossil locality are pyroclastic rocks with interbedded shales and graywackes, similar to those which form a great portion of the Carboniferous series. In the field they were supposed to be Carboniferous and were not separated. Their areal extent is not known but is probably not large, and in this paper the Devonian at this place is included with the Carboniferous pyroclastic rocks for the sake of brevity in description.

On lower Skolai Creek, at several places in the White River valley, and on the north flank of the Wrangell Mountains there is a massive limestone which forms a conspicuous member of the Carboniferous section, in places reaching a thickness of several hundred feet. Locally the limestone carries abundant fossils, which give a definite determination of the age of the limestone and of the pyroclastic material with which it is interbedded. Both above and below the limestone there are locally developed thick beds of shale. The sedimentary portions of the Carboniferous are now discontinuous, for the whole series has been faulted and folded, but it is probable that the water-laid beds were once much more continuous than they are now and that their present patchy distribution is due, in part at least, to the deformation which they have suffered.

In addition to the great quantity of extrusive and fragmental matter which makes up a large part of the Carboniferous section, the bedded materials, both igneous and sedimentary, have been intruded at many places by bodies of granitic rocks, some of which are of large size.

The next younger system of rocks, the Triassic, is certainly represented in this region, although at present it is not possible to draw

[1] Moffit, F. H., and Knopf, Adolph, Mineral resources of the Nabesna-White River district, Alaska: U. S. Geol. Survey Bull. 417, 1910.

sharp lines of separation between the several Mesozoic formations. Fossiliferous thin-bedded Triassic limestones have been found on Cooper Creek, and it is possible that a great thickness of the unfossiliferous slates and graywackes of the Nutzotin Range may be of Triassic age.

The Jurassic beds consist of shales or slates, graywackes, conglomerates, and some thin limestones, the aggregation having locally a considerable thickness. Known Jurassic rocks occur in the Nabesna River basin and along the south flank of the Nutzotin Mountains, in the vicinity of the Chisana placer mines. At the latter locality they seem to grade insensibly into the slates and graywackes of the mountain range and to constitute an undetermined portion of that great series of sediments. Toward the south flank of the Nutzotin Mountains, near the placer camp, the Jurassic beds, although dipping at rather steep angles to the southwest, have been only slightly folded, and their structure is simple. A few miles to the north, in the higher mountains, the sediments have been intensely folded and crumpled, slaty cleavage has been locally developed, and the rocks as a whole have been much more severely altered and hardened than toward their southern margin. The Jurassic beds have in places, as on upper Chathenda and Bonanza creeks, been extensively cut by basic dikes.

Lower Cretaceous sediments have been recognized only within a small area in the neighborhood of the Chisana placer mines. So far as was determined, they appear to be structurally conformable with the Jurassic rocks and like them are composed predominantly of shales and graywackes. Apparently they were a part of a continuous series of beds deposited from Jurassic into Lower Cretaceous time. They carry rather abundant fossils of a single species, but only one or two species in all were found. Like the Jurassic, the Cretaceous beds are cut by numerous basic dikes and sills. Although in the vicinity of the placer mines the Cretaceous rocks directly adjoin the Carboniferous pyroclastic rocks and the granitic intrusions into the Carboniferous, the contact is not one of sedimentation, but the two formations have been brought together by a great fault, which is believed to extend generally between the older igneous rocks and sediments on the south and the dominantly sedimentary formations that make up the Nutzotin Mountains.

Sediments of Tertiary age occur in small areas at a number of places, surrounded by older rock formations. They consist of sandstones, shales, conglomerates, and some unconsolidated gravels, with locally some volcanic material in the form of agglomerates and tuffs, and at a few places they contain lignite. The lignite is generally in very thin beds or carbonaceous films and has no commercial value. At two localities beds of lignite occur in sufficient thickness to offer promise of yielding a moderate amount of fuel for local use.

Extensive areas are occupied by lava flows that have been considered to be of Tertiary age. The lavas cap the Carboniferous beds along Skolai Creek and west of Russell Glacier, as well as in parts of the Ptarmigan Creek basin, and are the prevailing rocks over much of the region between White River and Beaver Creek. They comprise dark basic lavas, some of which show well-developed columnar structure. In places these lavas have been warped and tilted, but in general they still preserve their original flat-lying attitude. Although the extrusion of this series of lavas probably began in Tertiary time, it continued at least into the Pleistocene epoch, and as Mount Wrangell is still a mildly active volcano, it may be that outpouring of lavas from this center has taken place in Recent time.

The deposits of Quaternary age consist mainly of the unconsolidated materials deposited by glaciers and by the present streams, and of talus and soil produced by the agencies of rock weathering and decay. In addition to these there are, as already stated, some lava flows interbedded with and overlying older glacial deposits, volcanic ash, and accumulations of organic material as peat or "muck." All the mountain valleys and much of the intermountain area of hills were formerly deeply covered by glacial ice, and the ice upon its retreat left in place a great amount of morainal material. The larger valleys of the Wrangell and St. Elias mountains still harbor great glaciers, and these constantly bring down quantities of rock débris. Some of this material is fed into the streams and transported for a distance, to be deposited on the stream flats in the form of great gravel trains, and some still remains near the borders of the glaciers as typical morainal deposits. As the mountain glaciers are still vigorous, as much of the detritus supplied to the streams is of glacial derivation, and as the glaciers have probably existed uninterruptedly from Pleistocene time to the present day, the extensive sand and gravel deposits of the present streams are of glaciofluvial origin, and the distinction between Pleistocene and Recent gravels can not be made.

The volcanic ash already mentioned is a persistent and conspicuous, though generally thin, member of the Quaternary deposits throughout this district.[1] Everywhere except in the regions of high, bare mountains, where erosion is rapid, a layer of this material may be found near the surface, in places covered by a few inches of moss. Near the placer mines it is present in a layer from a few inches to a foot thick, lying beneath a foot or so of muck. In the upper White River valley it is a few inches thick, but it becomes increasingly thicker to the east, toward the international boundary. Near the mouth of North Fork of White River the ash layer is 2 feet thick and lies beneath 7 feet of peat. The greatest thickness of this ash

[1] Capps, S. R., An ancient volcanic eruption in the upper Yukon basin: U. S. Geol. Survey Prof. Paper 95, pp. 59–64, 1915 (Prof. Paper 95-D).

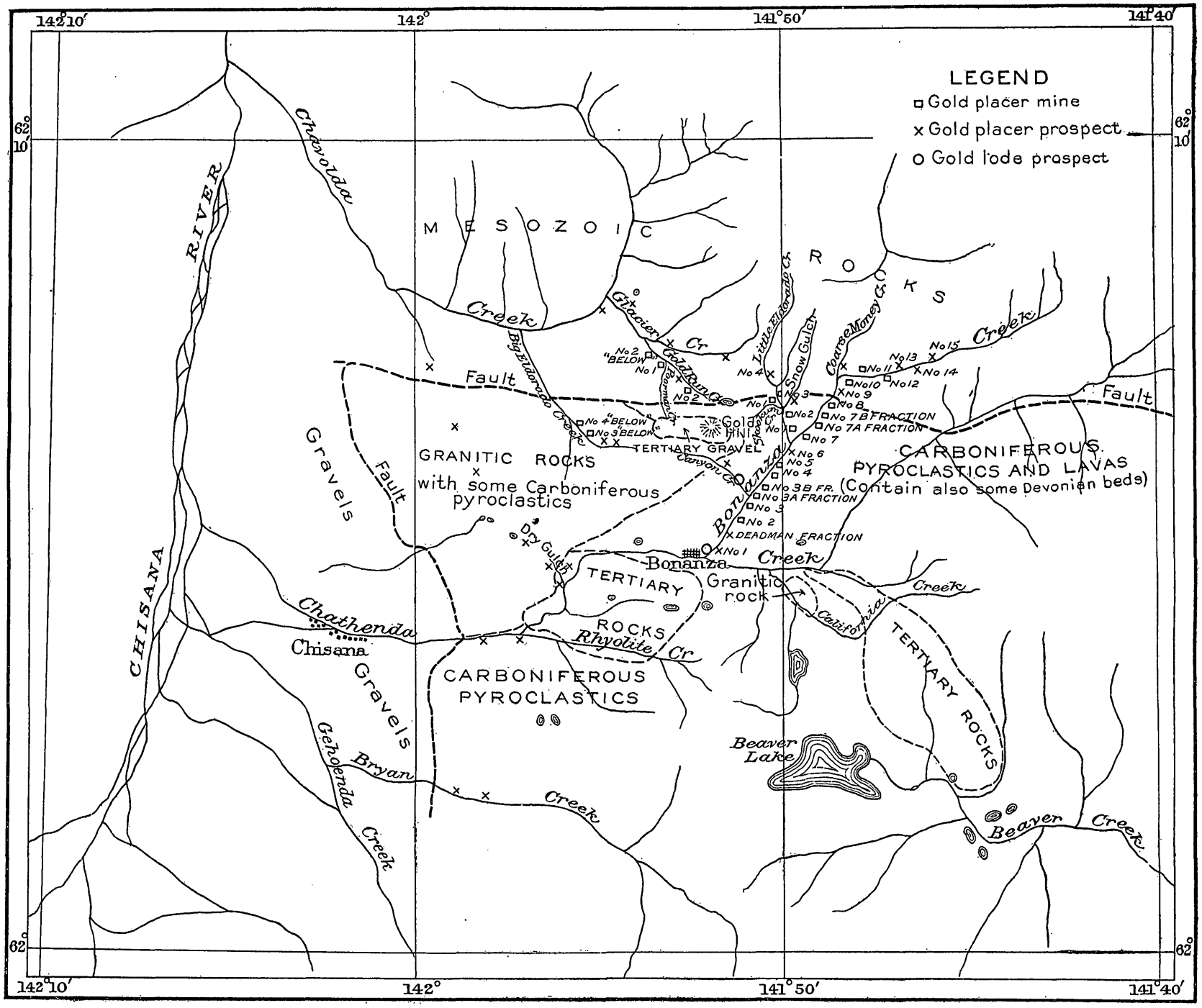
observed occurs on the north flank of the St. Elias Range near Mount Natazhat. There the ash forms great drifts at the base of the mountains, is in places nearly bare of vegetation, and has been blown by the wind to form great dunes 200 feet or more in height. It seems probable that the crater from which the ash was ejected lies somewhere in the mountains near Mount Natazhat. Thomas Riggs, jr., reports a small crater in the basin of Kletsan Creek that may be the one from which the ash came.

The last great geologic events of importance in this district were the advance and retreat of glaciers, which pushed down from the mountains and covered all of this region except the highest mountain peaks. That portion of the country over which the ice moved was eroded and changed by the wearing of the thick ice masses; deep, broadly U-shaped valleys were formed, and a striking and characteristic type of topography was impressed upon the land surface. With the withdrawal of the glaciers to their present positions the streams again established courses on the glaciated surface, but in many places the land forms were so changed that the streams deserted their preglacial courses and found new channels, leaving their former valleys unoccupied by streams. These changes of drainage have had a strong influence upon the present distribution of placer deposits, and the recognition of these changes is essential to a proper understanding of the causes which have led to the concentration of gold in the places where it now occurs.

GOLD PLACERS.

GENERAL FEATURES.

The productive gold placer gravels of the Chisana district occur in the basins of Chathenda (Johnson) and Chavolda (Wilson) creeks, within a very small area. Exclusive of a few claims from which some gold was taken during prospecting operations, all the gravels which have been profitably mined can be included within a circle only 5 miles in diameter, with Gold Hill as its center. (See Pl. IX.) The valley of Bonanza Creek, the largest of the gold-bearing streams, has been found to contain workable gravels almost continuously from a point near its mouth, on claim No. 2, to claim No. 12, a distance of about 3 miles. The lower three claims on Little Eldorado Creek and the lowest claim on Skookum Creek have been profitably mined, Glacier Creek and its tributaries have yielded a moderate amount of gold, and Big Eldorado Creek has some gravels that contain valuable gold deposits. In the whole district mining was actively carried on during the summer of 1914 on about 21 claims, and a large number of other claims received varying amounts of attention from prospectors. An average number of about 325 men were employed in mining during the summer season.



SKETCH MAP OF CHISANA DISTRICT, SHOWING DISTRIBUTION OF ROCK FORMATIONS AND LOCATION OF MINES AND PROSPECTS.

MINING CONDITIONS.

One of the most important of the factors which determine the cost of mining in this region is the shortness of the season during which open-cut placer mining can be carried on. Placer operations are dependent on stream flow and can be commenced in the spring only when the streams have run free of ice. Moreover, except at those places where artificial thawing is employed, mining can be done only when the gravels have thawed. In the Chisana camp there is a considerable range in altitude between the claims on lower Bonanza Creek and those on the headward portions of the streams, and the lower claims may be mined in the spring before the snow is gone from those at greater elevations. In general, however, mining can be started between the 1st and 15th of June and continued until early in September, when the streams become low and ice begins to form. A period of only 90 to 100 days is therefore available for open-cut mining.

The short season and the remoteness of the district from established lines of transportation are reflected in the wages paid for labor. The current rate for common labor is reckoned at $10 a day, or $6 a day and board. This high price seems justified by the conditions in the district, yet much ground can not now be worked that would yield a profit if the labor cost were less.

No timber occurs near the placer mines, and wood for fuel and lumber must be brought from lower Chathenda Creek or from Chavolda Creek, a distance of several miles. Two sawmills at Chisana and one at Bonanza were in operation in 1914, at which spruce lumber could be obtained. The price charged at Bonanza was $150 a thousand feet, and at Chisana from $125 to $150 a thousand feet, but in addition to the sawmill prices the cost of transportation to the mines is high. Cordwood is said to bring $40 a cord delivered at the mouth of Little Eldorado Creek.

Only the simplest of mining tools or equipment could be purchased at the stores, and practically all appliances were brought in by the individual operators for their own use. It has therefore been necessary for each miner to know in advance what equipment he will need, so that it can be brought in by sled during the winter. The result of the isolation of the camp and of high freight charges is that only the simplest forms of mining have been conducted, and the gold is recovered almost entirely with pick and shovel.

ORIGIN OF GOLD PLACERS.

It will be noted on reference to the map (Pl. IX) that most of the placer deposits occur within the borders of the areas of Carboniferous pyroclastic rocks and of the granitic rocks that are intruded into the Carboniferous formations, the only exceptions to this rule being the

claims above No. 8, Bonanza Creek, and the rather low-grade deposits in the basin of Glacier Creek, all of which lie on a bedrock of Mesozoic sediments. It is also a well-established fact that the headward tributaries of Bonanza, Chathenda, and Chavolda creeks, which flow over Mesozoic sediments exclusively, have little or no placer gold. The exceptions to this rule—claims No. 8 to No. 13 on Bonanza Creek and the placers in the Glacier Creek basin—are all in close proximity to Gold Hill.

Gold Hill, a high, smooth-topped mountain, lies about in the center of the producing placer claims and is drained by Canyon, Bonanza, Little Eldorado, Skookum, Poorman, Glacier, and Big Eldorado creeks, a group comprising all the streams that have been shown to contain workable placers. It is capped by a gravel deposit, which apparently has a thickness of more than 200 feet and which lies upon the intrusive granitic rocks and the materials of the Carboniferous pyroclastic series. The material in the gravels is composed for the most part of pebbles derived from the Carboniferous and its intrusive rocks but contains also an appreciable admixture of Mesozoic sedimentary pebbles. The material is unconsolidated but is deeply oxidized and contains pieces of lignitized wood, and many of the pebbles are decayed. The gravel is believed to be of late Tertiary age.

Prospect holes have been sunk in the gravels of Gold Hill, and some gold has been found, though not in sufficient concentration to be mined. As will be shown later, there are in the Carboniferous rocks near by a number of lodes which carry free gold, and it is believed that the gravels of Gold Hill received their placer gold originally from these lodes, which occur in the area where the Carboniferous rocks are cut by granitic intrusive masses. The close association of gold lodes with granitic intrusive rocks has been shown so often in Alaska that no further discussion of this relation is necessary here.

The placer gold on Bonanza, Little Eldorado, and Skookum creeks and in the Glacier Creek basin is characterized by its smoothed, worn appearance and has apparently been subjected to considerable handling by stream action. It seems evident to the writer that this placer gold is the result of a postglacial reconcentration, probably of materials from Gold Hill, and that the bedrock source of the gold is the veins in the Carboniferous rocks.

The placer gold of Big Eldorado Creek is in striking contrast to that of the other producing streams. It is bright and angular and shows almost no evidence of stream wear. Much of it has quartz particles attached to it, and sharp-angled pyramidal crystals of gold are common. This gold appears to be a primary concentration, for if it had been much handled by streams its sharp angles and crystalline

faces would have been worn away. The gold placer mines on Big Eldorado Creek are all in that portion of its basin which lies entirely within the area of Carboniferous pyroclastic rocks and granitic intrusives, and if the angular gold is a primary concentration, its bedrock source must have been in the materials of those rocks or in veins which cut them.

The gravels of Gold Hill are but a remnant of a gravel deposit which in former times was certainly more extensive than it is now and which has been removed by stream and ice erosion from some areas over which it is no longer found. A relatively slight extension of the area of these gravels would carry them eastward over all the claims on upper Bonanza and Little Eldorado creeks which contain placers. The mines on lower Bonanza Creek and on Glacier Creek may also have been within the area of the gravel deposit, but they all fall in valleys which have headward tributaries in Gold Hill, and as the gold may have moved downstream to its present position, its presence can be explained without resorting to the supposition that the old gravels once extended over them.

D. D. Cairnes, as the result of a visit of a few days that he made to this district in the fall of 1913 in connection with his study of a near-by portion of Yukon Territory, published an account[1] of the general geologic and physical conditions of the camp. He describes the rocks as being dominantly sedimentary and mainly of Mesozoic age. This description applies to only the northern portion of the placer district, and Cairnes failed to recognize the Devonian and Carboniferous age and pyroclastic character of the rocks which underlie nearly all of the most productive ground, or the fact that a great fault separates the Mesozoic sediments from the Devonian and Carboniferous rocks below. He noted that the Mesozoic sediments at the heads of the Bonanza Creek tributaries in the Nutzotin Mountains are iron stained and somewhat mineralized and states that "From these mineralized sediments of the Nutzotin Mountains the gold of the Chisana placers has most probably been derived." At another place he states that "Prospectors and others searching for placer gold in these portions of Yukon or Alaska are accordingly advised to confine their attention primarily to those creeks which flow through the shales and slates of the Nutzotin Mountains, and particularly where these rocks are highly mineralized and colored red with iron stain, as they are at Chisana." With these views the present writer is not in accord. The distribution of the placer gravels, as already shown, seems to point conclusively to the source of the gold in the older Carboniferous and Devonian rocks. Furthermore, none of the streams which lie exclusively within the Mesozoic sediments, such as the heads of the Bonanza and Glacier creek tribu-

[1] Canadian Min. Inst. Bull. 24, pp. 33-64, 1914.

taries and of both Chathenda and Chavolda creeks, which drain the same mountain mass, show workable placer ground, and many of them, after rather thorough prospecting, have yielded not so much as a color of gold. On the other hand, veins in the Carboniferous rocks near granitic intrusives have been found to carry gold on Nabesna River, in the Chisana district; on Beaver, Horsfeld, and Eureka creeks, near the international boundary; and at other places. It is not intended to imply here that the Mesozoic sediments nowhere contain gold veins, or that they may not yield gold placers. Some small quartz stringers from these sediments have been found on assay to carry some gold, but so far as the writer has been able to learn no gold deposits of commercial value have yet been found which were unquestionably derived from the Mesozoic sediments of the Nutzotin Mountains.

The belief that much of the present placer gold is a secondary concentration from the lower-grade Tertiary gold-bearing gravels of Gold Hill implies great changes in the topography of the district since the older gravels were deposited. These older gravels now occupy the top of a prominent mountain and are surrounded on all sides by lower valleys. At the time the gravels were laid down, the present position of Gold Hill must have been low compared with the areas from which the gravels were derived. After the gravels were deposited, probably over an area much greater than that which they now cover, the processes of normal erosion, stimulated by mountain building and uplift, carved valleys below the level of the gravels, and these, too, suffered erosion. What gold they contained was concentrated in the streams and, probably, rich gold placers were formed. In the course of time the glacial period began and glaciers formed in the mountain valleys and grew and joined in the lowlands, until at the time of their greatest development only the high peaks and ridges of the mountains projected. Gold Hill and the other mountains between Chathenda and Chavolda creeks were completely submerged by glacial ice, the valley and canyon of Chisana River were filled by ice to a depth of over 2,000 feet, and the glaciers were continuous between Chisana, White, and Beaver valleys. The erosion by this thick body of slowly moving ice was enormous, and its effect upon the present topography is still preserved with striking vividness. The submerged hills were rounded and smoothed, and the valleys were widened and deepened. Whatever deposits of stream gravels existed before the ice advance, together with the gold placers which they may have contained, were eroded and in large part swept away and scattered by the glaciers.

With the withdrawal and shrinkage of the glaciers, the rocks were again exposed to stream cutting. The valley gradients had, however, been changed by the ice erosion, and the streams found conditions

greatly different from those which had existed in preglacial time. In reestablishing their courses the streams in general reoccupied their preglacial valleys, but in places the old valleys were deserted and new ones formed. By the lowering of their outlets some streams acquired high gradients and soon cut canyons through portions of their courses. This is particularly true of Bonanza, lower Little Eldorado, and Glacier creeks. The present inner canyons of these streams have certainly been cut since the valleys were modeled by glacial ice.

The placer deposits are therefore almost entirely the result of postglacial concentration, and the gold-bearing bench gravels which have been found at places within the canyons, but above the present streams, are not properly to be called "old channels," but are merely remnants of the gravels of the present streams left behind as the valley was rapidly lowered.

Cairnes [1] recognizes the youthfulness of the present canyons and says of the changes of drainage: "Such may have been produced by a somewhat sudden uplift of the district or by the glacial damming of portions of the stream valleys, caused by great accumulations of morainal material derived from the mountains to the north." He therefore does not seem to recognize that in glacial time, as at present, the great ice movement was not from the north, but from the Wrangell and St. Elias mountains northward, augmented by the smaller glaciers from the Nutzotin Mountains; that the whole of the mining district was completely buried by glacial ice; and that the present topography is in large measure that which was impressed upon the district by glacial erosion.

Cairnes speaks of bench or "old channel" gravels, and says: [2]

> As the bottoms of the old channels are in places above and in places below those of the streams of the present creeks which they cross, these older gravels now occur both as bench deposits above those of the present streams and as buried gravels below the level of the present stream bottoms. * * * It seems possible, from what is now known of the different gravels in the Chisana district, that the bulk of the placer gold in the district was or is [in] the old channels and will be obtained either from the gravels of the old channels directly, or from gravels of the present streams where these cut the older gravels.

After a season of vigorous mining and prospecting in 1914 no single deposit of gravels was seen by the writer which could properly be called an "old channel" deposit or which could not have been laid down by the present streams during the postglacial cutting of their canyons, except the Tertiary gravel capping of Gold Hill. It may be that there still remain portions of the stream deposits of the preglacial streams which were not removed by glacial scour, but if so they have not yet been found. In Dry and Alder gulches there is a heavy fill of gravels along an old glaciated valley, deposited when the present mouth of Chathenda Creek was blocked by Chisana Glacier, but this

[1] Cairnes, D. D., op. cit., p. 53. [2] Idem, p. 61.

valley was occupied by a stream for only a short time during the recession of the glaciers, and its gravels are not preglacial.

MINES AND PROSPECTS.

During the present investigation all the mines that were being actively worked and most of the prospects upon which work was being done were visited. In the following pages the mining operations are briefly described. The separate properties are described in order along the streams, those on each creek being grouped under one heading and the descriptions beginning with the lowest claim and proceeding in order upstream. A number of claims were worked under one management, and the description of the mining done by this company on all its ground is given at only one place.

BONANZA CREEK.

No. 1 FRACTION.

No. 1 Fraction is a fractional claim lying immediately above claim No. 1, through which Bonanza Creek flows for a distance of about 100 feet, in a steep-walled canyon. During periods of high water the stream occupies the canyon bed from wall to wall, and at ordinary stages of flow there are gravel bars of small dimensions at only a few points. Prospecting and mining were carried on here in a small way by one man, who confined his work for the most part to cleaning out the crevices of the agglomeratic bedrock and to washing out the small accumulations of stream gravels. The gold recovered had been scarcely sufficient to justify mining, but the varying tenor of the gravels on other parts of this stream encouraged the expectation that some richer spots might be found. There is insufficient workable ground here to warrant operations on an extensive scale.

DEADMAN FRACTION.

The so-called Deadman Fraction is a fractional claim about 950 feet long, lying between No. 1 Fraction and No. 2. Like No. 1 Fraction, it lies along that portion of Bonanza Creek which is steeply intrenched in a deep canyon of Carboniferous pyroclastic rocks. At the time of visit, late in July, 1914, a party of four men was just beginning mining operations, and no clean-up had yet been made, so that the value of the ground was not known. The canyon floor is narrow and if worked from rim to rim would give a width of bedrock of only about 12 feet, and the gravels are only from 2 to 4 feet thick. Large bowlders were abundant, and the quantity of gravel which could be shoveled into sluice boxes was small.

CLAIM NO. 2.

Mining was conducted during most of the open season on claim No. 2 by laymen, seven men being continuously employed. Sluicing was begun on June 12, no work having previously been done on this ground. The workable width of the canyon floor there averages about 30 feet, and no flume was used, the creek being diverted first to one side of the flat and then to the other. The usual pick and shovel method was employed exclusively. The gravels consist for the most part of rather flat, slabby cobbles and bowlders and range from 3 to 12 feet in thickness, averaging about 5½ feet. Water for the sluice boxes was taken from the creek through canvas hose, and the boxes were set on a grade of 9 inches to the box length. The gravels here contain little clayey sediment, and the use of a dump box has been found to be unnecessary. The gold is said to occur almost entirely on bedrock or in the crevices within the bedrock, no considerable amount being found in the overlying gravels. The gold is rather irregularly distributed on the bedrock, which consists of lavas and agglomerates, some beds being much decayed and soft. The harder phases of the rock are in places worn smooth and have retained little gold, but immediately below such places there are often found spots of considerable richness. The high points of the hard, rough bedrock have in general retained the most gold.

The gold recovered from this claim is coarse, but nuggets are rare, the largest found having a value of $4. All the gold is smooth and flat, showing plainly that it has been subjected to much wear between the place of its bedrock source and its present position. On August 1, 1914, about 500 linear feet of the stream bed had been worked out.

CLAIM NO. 3.

Claim No. 3 includes a deeply intrenched portion of Bonanza Creek, the canyon being cut into the Carboniferous pyroclastic rocks, which strike N. 75° W. and dip about 40° SW. Canyon Creek joins Bonanza Creek near the upper end of this claim. Mining operations were carried on by one party of 10 men. Work was commenced in the spring at the lower end of the claim, but the gravels there were found to average 14 feet in thickness and to be too low in gold content to justify mining. Mining was then begun at a point 600 feet below the upper line of the claim and progressed during the summer until the upper part of the claim was worked out. The ground mined averaged only 20 feet in width and ranged from 2 to 4 feet in depth. Large bowlders were very abundant. Many of them were too large to move by hand and were not taken from the cut, but the finer gravel was removed from around them. About 300 feet of 42 by 20 inch flume was used to carry the creek past the cut, and eight lengths of sluice box and a dump box, set on a grade of 10 inches to the box length and

equipped with pole riffles, were employed. The mining was all done by means of pick and shovel. The gold was coarse and well worn and was irregularly distributed, rich spots alternating with less productive areas. The highest values were commonly found on the higher portions of hard bedrock. In places where the bedrock was decayed and soft there was not enough gold to justify mining. Most of the gold lay on bedrock or in the cracks in it, and the gold content of the overlying gravels was said to be small.

NO. 3 A FRACTION.

No. 3 A Fraction is the lower of two fractional claims which lie between claims No. 3 and No. 4 and has a length of about 500 feet. On this ground six men were engaged in mining throughout the summer. Bonanza Creek is here deeply intrenched in the Carboniferous pyroclastic rocks, and the stream flat is winding and narrow, the workable ground having an average width of only 12 feet and a thickness of 2 to 8 feet. The stream was carried across the working cut by a flume 120 feet long and 42 inches wide, and the gravels were mined by pick and shovel and washed through a set of 12 sluice boxes and a dump box, lined with pole riffles and set on a grade of 10 inches to the box length. The gravels are not well rounded, and angular pieces of rock are common. A sticky clay mixed with the gravel makes the use of a dump box necessary, and even this fails to disintegrate all of the clay so that some loss of gold must certainly take place. Much of the bedrock is hard and blocky and retains the gold well, and most of the gold occurs on bedrock or in the crevices in it. It is necessary to take up from 2 to 5 feet of bedrock in order to recover all the gold. As on many of the claims on lower Bonanza Creek, the best values are found not in the deepest channel in bedrock but on the higher points of it. The gold is bright, coarse, flat, and well worn. The largest nugget had a value of $61.80, and half of that recovered is said to be in nuggets worth $5 or more. Some pieces having a rusty, reddish coating are found on portions of the bedrock which are decayed and of a bright-red or purple color, the gold doubtless acquiring a rusty cast from the iron in the underlying bedrock.

3 B FRACTION.

The claim known as the 3 B Fraction is the upper of the two fractional claims lying between No. 3 and No. 4 and is about 900 feet long. Mining was begun on the lower end of this ground in 1913, and several thousand dollars' worth of gold was recovered. In June, 1914, mining operations were continued at the point where they were left off the fall before, and 10 men were continuously employed during the open season. The creek there flows through a deeply intrenched gorge in the Carboniferous lavas and agglomerates, and the bedrock is rough enough to retain the gold well. The creek

gravels average about 25 feet in width and are shallow, the average depth to bedrock being less than 2 feet. Although bowlders are rather abundant, most of them can be moved by hand and only a few require blasting. A flume 30 by 19 inches in section and 350 feet long is used to carry the creek past the cut and is adequate except in periods of flood. The pick and shovel method of mining is used exclusively, the gravels being washed through a set of 16 sluice boxes, each 12 feet long, 14 inches wide, and 12 inches deep, set on a grade of 8 inches to the box length and equipped with pole riffles. An abundance of sticky clay in the gravels requires the use of a dump box, and even this fails to disintegrate the clay completely, so that there is a constant loss of gold, equal, it is estimated, to about 10 per cent of that recovered. About 2 feet of bedrock is taken up and put through the boxes. The gold is practically all found on bedrock or in the cracks in the rock surface, the overlying gravels containing very little gold. The gold, which assays $16.36 an ounce, is bright, smoothly worn, and very coarse, the pieces averaging 10 to 15 cents in value, exclusive of the larger nuggets. One $40 nugget was found, and another worth $33.50, and pieces having a value of $3 to $20 constitute a large portion of the gold recovered. At the time this claim was visited it was said that the ground mined had carried an average value of about $2 to the square foot of bedrock.

A number of localities along the valley sides of this claim have small deposits of bench gravel, and the ground on which the tents are situated, 15 feet above the creek, is said to contain a good pay streak.

OPERATIONS BY F. T. HAMSHAW.

The claims staked in this district by James & Nelson, the original discoverers of placer in this camp, were leased by them to J. J. Price and J. J. Ives, who in turn assigned their lease to F. T. Hamshaw. The ground involved in these leases included, on Bonanza Creek, Discovery claim, No. 1 below and Nos. 1, 4, 5, 6, and 8 above Discovery; on Little Eldorado Creek, No. 1; and on Big Eldorado Creek, Discovery claim. With the exception of a few small subleases made by Price & Ives, all the mining done on these claims in 1914 was carried on by Mr. Hamshaw, the principal operations being on claims Nos. 4 and 5 on Bonanza Creek and No. 1 on Little Eldorado Creek.

The main camp was located on the south side of Bonanza Creek at the mouth of Little Eldorado Creek and consisted of about 16 tents in all, including offices, commissary, mess, and sleeping quarters. The camp is connected by fair trails and by telephone with the town of Bonanza, at which there is a general warehouse. The number of men employed varied considerably during the season, ranging from a minimum of 30 to a maximum of over 100. The general mining practice followed was to ground-sluice off the upper portion of the

creek gravels, leaving a foot or two above bedrock to be shoveled into the sluice boxes. Whenever a large gang of shovelers was employed, a horse team and scraper were used to clear away the tailings from the lower end of the sluice line. The average thickness of the stream gravels mined, including that portion of the bedrock which was removed, was only a little more than 6 feet, and the actual average thickness of the stream gravels was between 4 and 5 feet.

The following summary of mining operations on these claims is published because it is believed to contain valuable data on the actual cost of pick and shovel placer mining of shallow stream gravels in a region remote from established lines of transportation. Reliable figures on such operations are difficult to obtain, as they are rarely kept by the placer miner. Other operators in this same district claim lower mining costs than those given in the accompanying table, but their figures are not based on accurate measurements and can, therefore, not be given for comparison. It will be noted that the total working cost as shown would be somewhat reduced when proper account is made of the difference between the estimated and actual cost of board for the employees but would be increased if allowance were made for amortization, and if the cost of dead work were added.

Summary of mining operations by F. T. Hamshaw at Chisana, in the White River mining district, Alaska, during 1914.

[Published by permission of F. T. Hamshaw.]

	Linear feet of creek worked.	Value per linear foot.	Working cost per linear foot.	Square feet of bedrock mined.	Value per square foot of bedrock.	Working cost per square foot of bedrock.
No. 4, Bonanza	979	$22.17	$19.12	19,725	$1.23	$0.74
No. 5, Bonanza	833	26.45	20.13	23,182	.80	.67
No. 1, Little Eldorado	1,029	50.50	13.28	43,047	1.21	.32
Total or average	2,841	33.04	17.51	85,954	1.08	.576
Upper end of Little Eldorado Creek [a]	380	3.435	4.45	11,642	.14	.18
Operations of laymen	.....	.....	.....	24,904	.55	.37
Grand total	.....	.....	.....	122,500	.....	.....

	Cubic yards of gravel moved.	Value per cubic yard.	Working cost per cubic yard.	Gold production.	Total working cost.
No. 4, Bonanza	4,530.0	$5.51	$3.21	$24,128.00	$14,787.20
No. 5, Bonanza	5,619.5	3.65	2.73	20,528.00	15,473.00
No. 1, Little Eldorado	9,219.5	5.63	1.48	51,952.00	13,610.70
Total or average	19,369.0	4.93	2.473	96,608.00	43,870.90
Upper end of Little Eldorado Creek [a]	1,391.0	1.25	1.56	1,646.00	2,177.80
Operations of laymen	3,222.0	4.22	2.85	13,697.06	.....
Grand total	23,982.0	.....	.....	111,951.06	.....

[a] Not in pay channel; worked out to make dumping ground for pay streak on left bench.

NOTE.—Labor is calculated at $6 a day and board, or $10 a day. Boarding-house account shows a cost of $2.75 per day per man. Working cost does not include amortization and dead work, as follows: Cost of sluices, flumes, dams, and dead work before sluicing, No. 4, Bonanza, $5,280; No. 5, Bonanza, $4,975; No.1, Little Eldorado, $3,527; total, $13,782.

The gravels mined lie on bedrock composed of the Carboniferous and Devonian lavas and pyroclastic rocks, with some shales, all having a general northwest strike and dipping 10°–60° SW. The bedrock differs in character from place to place, some beds being much decayed and soft, while others are hard and rough. Throughout all this district experience has shown that the greatest concentration of gold occurs on the hard, rough bedrock, the softer phases being relatively lean. Bowlders in the gravels are rather abundant, although those too large to be rolled aside by hand are uncommon. In general the gravels are unfrozen, but locally frozen patches were encountered, and many of these were subleased to laymen to be mined.

The gold is bright, coarse, and smoothly worn. The largest nugget found had a value of over $130, and pieces weighing a quarter of an ounce or more make up about 5 per cent of the total gold recovered. The gold is said to assay $16.67 to the ounce.

The present stream gravels on claim No. 1, Little Eldorado, were about worked out during the summers of 1913 and 1914, but it is reported that late in the fall of 1914 rich ground was found on the left bank of Little Eldorado Creek several feet above the stream, and extending beneath the bench gravels at that place. On claim No. 5, Bonanza, paying ground was found high on the north valley wall, and at a number of places along both Bonanza and Little Eldorado creeks there are patches of bench gravels that have yielded good prospects.

CLAIM NO. 7.

Mining was carried on by two parties on claim No. 7. On the lower half of the claim four men were mining by pick and shovel methods. The creek there flows through a narrow gorge with steep walls of pyroclastic rocks interbedded with black shales. No flume was used, the creek being turned first to one side of the flat and later to the other. Ten lengths of sluice boxes, 12 by 14 inches in cross section, and a dump box were employed for washing the gravels, and in order to obtain sufficient grade for the sluice its upper end was set so high that in parts of the cut the gravels were lifted by shovel as much as 10 feet. A relatively small amount of ground required to be shoveled, for the surface gravels were first sluiced off by the use of an automatic dam before shoveling was begun. Water was carried to the sluice boxes by means of canvas hose. The gold was unevenly distributed, rich areas of hard, rough bedrock being succeeded by nearly barren stretches of smooth, decayed bedrock. The gravels washed were from 3½ to 4 feet deep and contained few large bowlders.

At the time of visit, in July, 1914, the operators reported that the output from this claim, which lies adjacent to the rich ground on Little Eldorado Creek, was disappointingly small.

On the upper half of No. 7 a number of men were engaged in mining, several hundred linear feet of the creek bed being worked out. Conditions were similar to those on the lower half of this claim, the distribution of the gold, however, being especially irregular. The gravels had an average width of about 20 feet and a depth of 3½ feet and contained an unusual quantity of sticky clay which made recovery of the gold difficult. Late in July the tenor of the gravels then encountered had become too low to justify mining, and a prospecting ditch 100 feet long had been run without having again encountered workable ground.

NO. 7 A FRACTION.

Mining was conducted on the lower of two fractional claims lying between No. 7 and No. 8, known as No. 7 A Fraction, which is between 500 and 600 feet long. Four men, as laymen, were mining gravels which averaged less than 2 feet in thickness. At the time of visit a section of the stream gravels 300 feet long and 20 feet wide had been worked out. Five lengths of 12-inch square sluice box and a dump box were used, with the upper end of the sluice line 9 feet above bedrock, the water being conducted to the boxes through canvas hose. Not many large bowlders were encountered, but numerous large pieces of angular rock were embedded in the gravels. The bedrock consists of the pyroclastic materials and some shales and in places is worn so smooth that little gold was retained on its surface. The gold occurred for the most part on bedrock or in the rock crevices, and the overlying gravels contained little. The distribution of the gold was uneven, relatively lean areas being succeeded by richer spots.

NO. 7 B FRACTION.

No. 7 B Fraction is a fractional claim about 700 feet long, lying between No. 7 A Fraction and No. 8. Four men had been mining on this claim, the title to which is in litigation. In an area 200 feet long and from 14 to 20 feet wide, which had been worked, the gravels averaged about 3 feet in thickness. The bedrock is composed of pyroclastic materials, and the richest ground was found on the harder portions of it, some of the ground yielding $2 to the square foot of bedrock. The distribution of the gold was very irregular, and late in July, 1914, the ground sufficiently rich to mine had been worked out and mining was discontinued.

CLAIM NO. 8.

On claim No. 8 mining was conducted by laymen for a part of the summer, and a stretch of the creek gravels about 400 feet long and having an average width of 12 feet was worked out. The gravels, of an average thickness of 3 feet, lay on a bedrock composed of pyroclastic materials. For several weeks 16 men were employed in two

shifts, 8 men working on each shift. Late in July the gold content of the gravels encountered became so low that active mining was discontinued, although 2 men were engaged in the endeavor to locate more ground which would warrant exploitation. The gold was said to be very unevenly distributed along the course of the valley floor and only locally to be abundant enough to justify mining under the present high cost of operation. The recovery ran from 10 to 22 cents to the square foot of bedrock. Practically all the gold was found on bedrock, the overlying gravels being of low tenor. There was considerable clay in the gravels, and although this clay contained some fine gold, the gold could not be recovered by the methods used. The largest nugget found on the ground had a value of $8, and the gold would all be classed as coarse, though large nuggets were much less common than on the next few claims below.

CLAIM NO. 10.

Two parties were mining on claim No. 10, one on the lower and one on the upper half of the claim. On the lower half four men, operating on a lease, were engaged in mining, although at the time of visit little ground had been sluiced. This claim lies above the contact between the pyroclastic rocks and the Mesozoic shale series, and the bedrock is composed of black shale, cut by numerous dikes. The gravels mined had an average thickness of about 4 feet, and the gold was for the most part on the surface of the bedrock, or less than a foot down into the crevices in it. The gravels are of comparatively small size and are easy to mine, few large bowlders being encountered. The gold is relatively fine and flaky, the only two nuggets recovered having values of $6 and $3.

On the upper half of the claim five men began mining late in July, 1914, and at the time of visit no sluicing had been done. A horse scraper was used to remove the surface gravels, but the sluice boxes had not yet been installed. It was said that the gold values all lay in the lower 3 feet of gravels and on bedrock, and that the gold content of the upper gravels was too low to warrant sluicing. The bedrock is black shale striking N. 65° W. and dipping 57° SW. The shales are cut by dikes which strike approximately parallel with the shale but dip at right angles to it.

CLAIM NO. 11.

On the lower end of claim No. 11 four men were prospecting in July, 1914, but had found no workable ground. The gravels were from 3 to 5 feet deep and lay on a bedrock of black shales with some interbedded sandstone, striking N. 55° W. and dipping 60° SW.

On the upper half of the same claim several men were beginning mining operations late in July. The gravels from a cut 4 to 5 feet in depth had been shoveled into the sluice boxes, but no clean-up had

yet been made. It is reported that late in the summer ground yielding $6 per square foot of bedrock was found on this claim, and that one nugget valued at about $64 and others worth $30 were obtained.

CLAIM NO. 12.

Three men, operating on a lease, were mining on the lower half of claim No. 12 in 1914. The gravels average about 5 feet in thickness, though they are locally as much as 9 feet thick, and lie on a bedrock of black shale. Wheelbarrows were used to take off the upper portion of the gravel, in which, it is said, not a color of gold could be found. The gravels are composed largely of rather flat pebbles of moderate size, and large bowlders were not abundant. The gold recovered was coarse and contained nuggets which had a maximum value of $8. No fine gold was found.

Three men were mining on the upper half of claim No. 12 and had sluiced the gravels from a cut 85 feet long and 18 feet wide. The gold found, almost entirely on the shale bedrock, was irregularly distributed but was said to average 60 cents to the square foot of bedrock. From 1½ to 2 feet of the bedrock was taken up to secure all the gold. The flow of water in Bonanza Creek at this place was just about sufficient to afford a sluice head.

UPPER BONANZA CREEK.

Late in July, 1914, no active mining was being done on upper Bonanza Creek, although prospecting was being or had been done at a number of places. On claim No. 13 one party had done considerable work, and it was reported that ground sufficiently rich to mine had not been found, although locally the returns were encouraging. Another party was just starting to prospect this ground.

Claims Nos. 14 to 18 have all received some attention from prospectors. On claim No. 15 several hundred feet of bedrock drains had been dug, but only an occasional color was found. On claim No. 18 there is a shaft said to be 85 feet deep, with a 25-foot drift from the bottom. The drift is on bedrock, but the bottom of the bedrock channel was not reached. No paying ground was found at this place.

LITTLE ELDORADO CREEK.

CLAIM NO. 2.

Active mining was conducted during the entire summer on claim No. 2, Little Eldorado Creek, seven men being employed. On this claim the stream flat, though bordered by steep bluffs, is wider than on the claim below, having a width of 75 to 150 feet. The gravels average about 3 feet in depth, contain few bowlders, and are composed largely of flat, shingle-like pebbles of banded shale and graywacke. The bedrock is of the pyroclastic series and is locally termed "porphyry." Its surface below the stream gravels is fairly flat in

cross section from one bluff to the other. The bedrock is much broken, and from 5 to 12 inches of it is shoveled into the sluice boxes with the overlying gravels. It is easily removed, as it comes up in angular fragments only a few inches in diameter. The gold is said to be recovered in large part from the bedrock, although the overlying gravels contain some gold. They are about 3½ feet deep throughout the claim, except in those places where detritus from the bluffs has moved down upon the stream gravels. At the time of visit 17 lengths of 11-inch sluice box, set on a grade of 8 inches to the box length, were in use, more boxes being gradually added as mining progressed upstream. The gravels contain little clay, and a dump box is not considered necessary here. The pay streak is 36 to 40 feet wide and is taken out in three cuts. Water under pressure is brought through canvas hose to the lower end of the sluice boxes, and a nozzle is so set as to keep the tailings from piling up at the end of the sluice line.

The gold is very coarse, a large percentage of that recovered being in nuggets ranging in value from 50 cents to $20. It is bright yellow in color and fairly well worn and is said to assay $16.90 to the ounce.

CLAIM NO. 3.

Mining was commenced in July, 1914, on claim No. 3 by three men and continued during the summer. At the time of visit a cut 65 feet long, about 50 feet wide, and averaging 3 feet in depth had been worked out. The gold was recovered from a false clay bedrock, underlain by 2 feet of gravels which rest on the true bedrock of lavas and intrusive rocks. The gravels are frozen at a depth of 2 feet below the surface and are stripped and thawed by water before being shoveled into the sluice boxes. They consist for the most part of shale and graywacke pebbles, with considerable material of various sorts which resembles the gravels found on Gold Hill. The gold, like that on claim No. 2, is bright and coarse, the largest nugget recovered having a value of $15.

SKOOKUM CREEK.

Skookum Creek is a small stream that joins Little Eldorado Creek from the west about 400 feet below the upper end of claim No. 2. The upper basin of this stream is a broad marshy tract lying on the east slope of Gold Hill, without conspicuous drainage lines. For the lower quarter mile of its course the creek flows through a well-defined though small gulch which shows outcrops of intrusive rock at a number of places, and the stream gravels lie on a bedrock, locally called "porphyry," which is composed of lavas and agglomerates, cut by later intrusive rocks. Six men were engaged in mining on the lower end of Skookum Creek throughout the summer of 1914. Work was begun near the mouth of the creek on ground which lies on claim

No. 2, Little Eldorado, and continued upstream onto claim No. 1, Skookum, the ground on both claims being operated on lease. At the time of visit, late in July, a strip of gravels 224 feet in length along the creek had been mined. The pay streak was narrow, averaging only 6 feet in width, but was unusually rich. The stream wash, consisting largely of rather angular material, is from 5 to 14 feet in thickness and averages about 6 feet. It contains also a considerable admixture of rounded gravels probably derived from Gold Hill. Numerous pieces of lignitized wood have been found during the mining operations. Both the stream wash and the bedrock were frozen. They were thawed by stripping and by surface water before they were shoveled into the boxes. Skookum Creek carries only a small volume of water, and even with an additional supply obtained from a ditch toward the head of Little Eldorado Creek only about one-third of a sluice head was available, and it was necessary to store the water and to sluice only intermittently. The gold occurs for the most part upon bedrock and is very coarse, little fine gold being recovered. The largest nugget found had a value of $52, and pieces worth from $10 to $20 were numerous. The gold is said to assay $16.50 to the ounce.

At the head of the cut, on August 1, 1914, the pay streak had widened to about twice the average width below, and on one side of the creek it was covered by 14 feet of overburden, of which 6 feet was nearly pure ice.

No prospecting had been done on Skookum Creek above the location of the mine.

GOLD RUN.

CLAIM "NO. 2 BELOW."

Claim "No. 2 below" on Gold Run, the lowest claim on that stream which had been mined, lies a short distance above the mouth of Glacier Creek. The stream has there a rather deep, narrow valley cut in shales, graywackes, and fine conglomerates, which form the bedrock of the gold-bearing gravels. Six men were mining on this claim throughout the summer with pick and shovel. By August 1 a strip of ground 150 feet long and 15 feet wide had been mined. The gravels range from 4½ to 5 feet in thickness and are for the most part composed of imperfectly rounded slabs of shale and graywacke, with a smaller proportion of well-rounded lava and diorite pebbles like those of the gravel capping on Gold Hill. From 1 to 4 feet of bedrock was also taken up and washed. Nine lengths of sluice box and a dump box, set on a grade of 8½ inches to the box length, were used. The gold is found both on bedrock and distributed through the overlying wash, is bright and fairly well worn, and is in finer and more flaky particles than that found on Bonanza Creek. The largest

nugget taken from this claim was worth $6.50. Operations on this claim are said to have yielded little more than the cost of mining.

CLAIM "NO. 1 ABOVE."

Mining operations were begun late in July, 1914, on claim "No. 1 above" Gold Run, four men being employed. Winter shafts had shown that bedrock lay about 14 feet below the surface and that an encouraging amount of gold was present. A pit 500 feet long and 40 feet wide was therefore ground-sluiced through about 11 to 15 feet of frozen gravel, but no sluicing had been done by August 3. As the water supply from Gold Run was too small for efficient mining, a dam was built to impound water for ground-sluicing and a ditch half a mile long to tap the upper part of Discovery Pup was under construction. It was thought that with this additional water supply sluicing could be started. The gravels are made up of poorly rounded shales and graywackes, with much well-rounded material derived from the gravels of Gold Hill. Few bowlders too large for two men to handle were encountered. The gold is said to be distributed throughout the gravels, without any noticeable concentration on bedrock.

CLAIM "NO. 2 ABOVE."

On claim No. 2 above Discovery, well toward the head of the Gold Run basin, one man was engaged throughout the summer in prospecting the benches 10 to 15 feet above the creek. The bedrock is composed of much fractured and broken shale and graywacke, covered by a mixture of shale fragments and rounded pebbles evidently derived from Gold Hill, against which this creek heads. Gold occurs in the detritus from the surface down but is most abundant in the shattered bedrock. It is for the most part fine and flaky, but a few larger pieces worth as much as $4 have been recovered. Some gold has been found in the creek bed on this claim, but the amount was insufficient to justify mining. The stream at this place is of small volume, and mining can be conducted on only a small scale.

POORMAN CREEK.

On claim No. 1, near the mouth of Poorman Creek, four men were mining throughout the summer. The stream flows in a narrow, steep-sided gulch cut through shales and graywackes intruded by dike rocks. The stream flow is normally too small to furnish a sluice head of water, and two dams were constructed to store water. Sluicing was therefore done only intermittently. The stream wash ranges in thickness from 4 to 12 feet and averages about 7 feet, and a section of the stream bed 100 feet long and from 10 to 15 feet wide had been mined. Nine lengths of sluice boxes, set on a grade of 13 inches to

the box length, were in use. The gold occurs both in the gravels and upon bedrock, of which about 2 feet is taken up and sluiced. The gold is fine and flaky compared with most of that recovered in this district, the largest piece having a value of only 35 cents. It is reported that the gold taken from this claim was insufficient in quantity to justify further mining.

BIG ELDORADO CREEK.

CLAIM NO. 4 BELOW UPPER DISCOVERY.

On claim No. 4 below Upper Discovery, Big Eldorado Creek, two men were mining on leased ground in 1914. On this claim the creek has cut a deep, narrow gorge into a mass of diorite, and the stream flat is steep and narrow, with many large bowlders. The stream gravels average 6 feet in thickness, and 4 feet of the surface material was ground-sluiced off before shoveling was begun. A pit 600 feet long and 12 feet wide had been mined. Most of the gold recovered was taken from the surface of the bedrock or the fractures in the rock, from 2 to 4 feet of the diorite being taken up and washed. The gold is unevenly distributed along the creek bed, fairly rich spots being succeeded by lean areas. The gold is bright and very rough. The operators reported that this claim yielded only a fair return for the labor expended on it.

CLAIM NO. 3 BELOW UPPER DISCOVERY.

Vigorous mining was conducted on claim No. 3 below Upper Discovery, 10 men, operating in two shifts, being employed. Big Eldorado Creek is here intrenched into the valley floor and flows through a narrow gorge cut in diorite, which forms the bedrock of the placer gravels. About 250 linear feet of the creek bed had been mined to an average width of 30 feet, the stream gravels there averaging only 2 feet in thickness. The gold-bearing gravels, while containing a good deal of angular material, are better rounded than those farther upstream and contain some well-worn gravels, probably derived from the ancient gravels that were formerly distributed along the hilltops adjoining this basin. Large bowlders of diorite of local derivation are common. Some gold is said to occur throughout the gravels, but the richest concentration is on the rough bedrock surface or in the crevices in the diorite. From 2 to 4 feet of the diorite is removed in mining. The gold is bright, coarse, and very rough. Few pieces were seen that showed signs of much wear, and most of the particles are angular and sharp, some crystal faces being discernible. Many pieces show the imprint of the crystals of vein quartz upon them, and gold with some quartz attached is common. The gold is markedly different in appearance from the well-worn, smooth gold of Bonanza and Little Eldorado creeks, and it is evidently of local

origin. The present creek placer is probably a primary concentration of gold derived from the rocks that form the upper basin of this stream.

CLAIM NO. 1 BELOW UPPER DISCOVERY.

Two men, operating on leased ground, were mining on claim No. 1 below Upper Discovery. The stream gravels average about 7 feet in depth and consist of a mixture of angular blocks and well-rounded pebbles. Large bowlders are not numerous, and most of those encountered could be handled without difficulty. The gold occurs mostly on bedrock, but some is distributed through the gravels. It is coarse, bright, and rough and shows little evidence of stream wear.

UPPER DISCOVERY.

Upper Discovery claim lies in the upper basin of Big Eldorado Creek. The valley of the stream is here a broadly U-shaped basin, and the creek has intrenched itself but little into the valley floor. Two men were prospecting this ground early in August. They reported many fine colors of gold throughout a vertical thickness of 10 feet of stream gravels, with a few small nuggets. The underlying rock is diorite, but the so-called bedrock in the cut made was a tough layer of clay, and no hard bedrock had been uncovered. The stream wash consists of bowlders and angular pieces of diorite intermingled with a goodly proportion of well-rounded gravels from Gold Hill. The ground is frozen and must be thawed before it can be sluiced. Insufficient sluicing had been done to afford a basis for reliable estimates of the value of this ground.

CHATHENDA CREEK.

Prospecting and some mining were done by two men on the Big Seven claim, on Chathenda Creek (locally called Johnson Creek) a short distance above the mouth of Rhyolite Creek. At that place Chathenda Creek flows in a deep, steep-walled canyon, cut through Tertiary sandstone, conglomerate, and shale and later gravels. The stream gravels average 4 feet in thickness and lie on a bedrock of sandstone. The south wall of the canyon is composed of a great thickness of gravels and shaly sand, and it is said that occasional colors can be found in these gravels and that the only stream gravels which carry encouraging amounts of gold are those immediately below the gravel bluffs. Considerable prospecting had been done, but little sluicing. The gold is rather fine and is unevenly distributed. The largest piece found had a value of $2. Numerous nuggets of native copper have been found in the stream gravels. Mining in this canyon is difficult on account of the large volume of Chathenda Creek, which in times of high water can not be controlled by ordinary means.

PROSPECTS.

Practically all the streams for many miles in each direction from this placer camp have been more or less thoroughly prospected, with varying degrees of success. In many places where little or no gold was found the prospectors have abandoned the ground and moved to other places, and the only evidence of their work is that given by the prospect holes and ditches which they excavated. Naturally the streams nearest to the rich placers of Bonanza and Little Eldorado creeks received the greatest share of attention, for all the adjacent streams were staked during the stampede late in the summer and fall of 1913. Thus Chathenda (Johnson) Creek was staked from the town of Chisana to the head of the stream, and numerous pits and cuts were made. It is worthy of note that in spite of rather thorough prospecting, Chathenda Creek above the mouth of Bonanza Creek has nowhere yielded even an encouraging prospect, and many of the excavations failed to show even a color of gold, although the stream lies parallel to and only a short distance south of Bonanza Creek and is eroding the same geologic formations. Below the mouth of Bonanza Creek the Chathenda gravels as far west as the mouth of the lower canyon are known to carry varying amounts of gold, and locally they have been rich enough to encourage extensive prospecting and even a small amount of mining. Several men prospected continuously throughout the summer of 1914 at points between the mouth of Dry Gulch and the lowest canyon.

Snow Gulch, a tributary of Little Eldorado Creek from the northeast on claim No. 2, is reported to contain workable gravels, both in the creek bed and on the benches, but mining there is being delayed until a suitable dumping ground shall be made available by the exhaustion of the gravels in claim No. 2.

The upper portion of Bonanza Creek and its tributaries, Coarse Money and Shamrock creeks, while only partly prospected, have as yet revealed no pay streak. Snow Gulch, Bug Gulch, and Pensive Pup, tributaries of Little Eldorado Creek from the northeast, have not yet been thoroughly prospected, but it is said that workable ground has been found on Snow Gulch. The benches along these streams and along Little Eldorado and Bonanza creeks are known to carry considerable gold locally and deserve further prospecting.

The valleys of Dry Gulch and Alder Gulch and the broad pass connecting them are known to be floored by a heavy deposit of gravels. In Alder Gulch and upper Dry Gulch several shafts, two of which are said to be more than 60 feet deep, penetrate gravels without reaching bedrock. The gravels are reported to carry some gold. Near the mouth of Dry Gulch a shaft 92 feet deep penetrates through gravels almost to the level of Chathenda Creek, without reaching

bedrock. This shaft is reported to have cut two layers of gravel which are sufficiently rich to warrant mining, but no gravels from this place had been sluiced.

Bryan Creek, the next tributary of Chisana River south of Chathenda Creek, was prospected in 1914. On claim No. 4 below Discovery six men were working throughout the summer. A number of pits were sunk, and a drain 10 feet deep was excavated without reaching bedrock. Some gold occurs throughout the stream gravels and especially on a clay false bedrock, the largest piece found having a value of $1.26. Copper nuggets are abundant. No sluicing had been done, and the work was all directed toward the endeavor to reach bedrock, in the hope of finding a valuable pay streak.

On claim "No. 3 below," Bryan Creek, one man had dug a long bedrock drain in gravels which were in places 12 feet in depth. The bedrock of sedimentary and intrusive rocks showed some gold, but no paying ground had been found at the time of visit.

The main valley of Chavolda (Wilson) Creek has been prospected at a number of places, with very little success. There are high bluffs of washed gravel on the south bank of the stream both above and below the mouth of Glacier Creek, but a tunnel driven 65 feet into the gravel bluff, with a 15-foot winze, is said to have yielded only a few fine colors. Other prospects farther upstream have given no encouragement. It is reported that during the winter of 1914–15 encouraging prospects were found on Chavolda Creek near the mouth of Alder Gulch.

Glacier Creek proper and its northeastern tributaries, Sargent, Paulson, and Chicken creeks, have not yet been proved to contain profitable gravels, although the southern tributaries, Gold Run and Poorman Creek, have yielded some gold.

Numerous tributaries of Beaver Creek and White River have been visited and prospected to a greater or less extent as a result of the stampede to the Chisana. It was reported that late in the fall of 1914 workable placer ground was found on lower Ptarmigan Creek, a northward-flowing tributary of Beaver Creek near the international boundary, but this report has not been verified. Lime Creek, a headward fork of White River, was the scene of one or two stampedes, but only small amounts of gold were found.

The possibilities of the general district near the headwaters of White and Chisana rivers have by no means been exhausted, and much unprospected ground remains which may prove to carry gold placers; but it is nevertheless significant that the large amount of prospecting that was done in 1913 and 1914 failed to enlarge greatly the area of productive ground, as determined during the early days of the gold rush, and it seems evident that the conditions which brought about the formation of gold placer deposits are of comparatively local development.

TOTAL PRODUCTION OF PLACER GOLD.

As already stated, the first production of placer gold from this district was made in 1913. During that year an amount of gold variously estimated as between $30,000 and $40,000 was recovered. In 1914 over 20 claims contributed to the production, and gold to the value of more than $250,000 was mined. It is therefore safe to say that the total production of the district up to and including the year 1914 was not far short of $300,000.

GOLD LODES.

For many years the existence of low-grade gold lode deposits in this region has been known. In 1906 a small stamp mill was erected at a gold lode on Jacksina Creek, a tributary of Nabesna River, and 60 tons of ore crushed in this mill is reported to have yielded $12 a ton of free gold. This marks the most serious effort to develop a gold lode property in the region, but other lodes have been staked, and varying amounts of excavation have been done on them. As a result of the gold placer stampede in 1902 from Dawson into the basin of Beaver Creek near the international boundary, a large number of gold lode claims were staked in that general district. These claims, situated on Beaver Creek near the boundary and on Eureka and Fourmile creeks, have already been described elsewhere,[1] and little development work has since been done on them. On Chathenda Creek at the mouth of Bonanza Creek a mineralized dike, known to contain some free gold, has been staked a number of times within the last eight years, but no serious attempts to prospect it have been made. The discovery of the rich placer deposits in 1913 naturally stimulated the search for the gold lodes from which the placers were derived, and a considerable number of gold lode claims have been staked in the district surrounding the placer mines. At the mouth of Bonanza Creek the mineralized area, which was first staked several years ago, was prospected by two tunnels each only a few feet long. For a distance of several hundred feet along Bonanza Creek the walls of the rock canyon are composed of an intrusive rock, from pink to gray in color, mottled with phenocrysts of darker minerals and containing abundant pyrite, the whole being oxidized on the surface to a rusty red color. There are in places bunches composed almost entirely of pyrite, and some small quartz veins cut the mass. The dike cuts Carboniferous lavas and pyroclastic rocks and apparently strikes N. 20° W. and dips about 75° N. The quartz veinlets are said to carry several ounces of gold to the ton, and the whole dike is reported to be auriferous. It is said that free gold can be panned from the oxidized and decayed surface portion of the out-

[1] Moffit, F. H., and Knopf, Adolph, Mineral resources of the Nabesna-White River district, Alaska U. S Geol. Survey Bull. 417, pp. 58-60, 1910.

crop. No assay reports of the gold content were available, and too little work has been done to determine the average gold tenor of the dike, the location of the ore shoots, or the extent of the auriferous portion of the dike.

In the canyon of Chathenda Creek, about halfway between the mouth of Dry Gulch and Bonanza Creek, there is a zone of mineralization in the Carboniferous rocks and the diorites which intrude them. This mineralized belt strikes approximately N. 65° W. and dips 78° SW., and a large group of claims has been staked upon it, extending from the canyon of Chathenda Creek up the mountain to the north. Two tunnels 10 and 15 feet long have been driven in a steep gully that joins the canyon, and several open cuts have been made. As shown by these disconnected openings, there is a belt reaching a width of 10 feet, of rusty mineralized country rock cut by some small quartz veins which carry sulphides and are stained by green copper carbonate. No sampling was done by the writer, but it is reported that assays taken from the quartz veins have shown a high gold content. Other claims, supposedly on the continuation of this mineralized zone, have been staked on both sides of upper Dry Gulch.

Some quartz claims have also been staked on Canyon Creek about three-fourths of a mile above its mouth, but no development work had been done there at the time of visit, in August, 1914.

CONDITIONS FAVORING THE FORMATION OF GOLD PLACERS.

Predictions as to the probable occurrence of commercially valuable deposits of gold in areas that have not yet been thoroughly prospected are not to be accepted with too much confidence, for of a dozen localities in which the conditions may seem to be alike, one may contain rich gold deposits and the others no ground sufficiently rich to mine. Nevertheless, prospecting in areas within which the geologic conditions are encouraging is likely to yield larger rewards than an equal amount of effort spent in unpromising areas. From a study of the Chisana placer district certain principles of broader application may be laid down. Among these are the following:

Placer gold should be sought only in those places where gold occurs in the bedrock, or where material derived from such gold-bearing bedrock has been brought by streams.

In those areas in which glacial erosion was severe the preglacial concentrations of placer gold are likely to have been removed and scattered. Locally portions of preglacial stream gravels may be preserved, but their discovery is likely to result only from thorough prospecting.

In such severely glaciated regions postglacial placers will be present only in those places in which postglacial erosion has been sufficient

to form new concentrations of gold, derived either from bedrock, from the scattered gold of preglacial placers, or from preglacial gold-bearing gravels which were not removed by ice erosion. In most places the postglacial erosion of bedrock has been too little to concentrate gold in sufficient quantities to form workable placers, although such a concentration seems to have taken place on Big Eldorado Creek.

In the Chisana district most of the stream placers have been formed by a concentration of gold derived originally from veins in the Carboniferous rocks near intrusive masses, somewhat concentrated in Tertiary gravel deposits, and later reconcentrated by streams before the last great period of glaciation. The glaciers scattered the stream concentrations of gold, but the postglacial streams have accomplished a later concentration into the deposits now being mined. This rather complicated chain of events may or may not have been duplicated in other parts of this general region, and therein lies the difficulty of stating the likelihood of other placer localities being discovered.

In a general way the conditions are promising. Between Nabesna River and the international boundary there are many places where granitic intrusive masses cut the Carboniferous sedimentary and volcanic rocks, and the borders of such intrusive masses deserve careful prospecting. If in such places bodies of unconsolidated Tertiary gravels are found, the streams draining the gravels should be prospected with care. Absence of severe glacial erosion would increase the probabilities for finding concentrations of placer gold.

COPPER.

Before the first white man entered the Chisana-White River region the Indians had brought out reports that great quantities of native copper occurred there, and instruments made of copper, as well as copper nuggets, said to have come from this region, were objects of barter between tribes of natives. As is usual with such reports the size reported for the metallic deposits increased with the distance from the area in which they were said to occur. The first authentic information published on the resources of this district was obtained in 1891, when Schwatka and Hayes[1] with one other white man made an exploratory trip from Fort Selkirk along the northern front of the St. Elias Mountains to the head of White River, across Russell Glacier, and thence southwestward to the mouth of Copper River. They failed to find the fabulously rich copper deposits reported by the natives but established the fact that placer copper occurs in the gravels of upper Kletsan Creek. Since their trip a considerable amount of prospecting for copper has been done in this

[1] Hayes, C. W., An expedition through the Yukon district: Nat. Geog. Mag., vol. 4, pp. 117-162, 1892.

region, and a number of copper lodes have been discovered. One large body of low-grade copper sulphide ore has been staked at Orange Hill, near the head of Nabesna River, a number of claims on deposits of native copper or copper sulphides are held between Nabesna and Chisana rivers, and a large number of claims, some of which have been patented, have been located in the White River basin. Many of these claims have been held for a number of years, but the remoteness of the region and its lack of transportation facilities make copper deposits of only prospective value, as mining under present conditions is out of the question. On some of the ground a good deal of development work has been done, but on most of the patented claims developments have ceased, and on the unpatented claims in general only the annual assessment work has been done.

With the exception of the discovery of a few new copper lodes, the value of which has not yet been demonstrated, and a moderate amount of development work on the ground already held, the conditions are much the same as in 1908, and the report[1] on the copper resources of the district published at that time is still sufficiently up to date, so that a republication of descriptions of the claims is unnecessary here. In the more complete report on this district, now in preparation, the individual copper lodes will be discussed more fully.

LIGNITE.

A formation consisting of conglomerates, sandstones, and shales, with some tuffaceous beds, all probably of Tertiary age, occurs at a few localities within this region and as shown by the structure and position of the beds was probably at one time much more widely distributed than at present. There is also a strong probability that other isolated patches of these same rocks occur within the area here discussed but have not been seen in the hasty reconnaissance work which has so far been done. These Tertiary rocks in places contain lignite, which occurs in thin carbonaceous layers and more rarely in beds of greater thickness.

On Coal Creek, a tributary of Rocker Creek, near the international boundary, some development work has been done on a lignite bed. A tunnel, said to be 30 feet long but now caved in, has been driven on a lignite cropping in a small gulch. The lignite strikes N. 50° E. and dips 68° NW. As exposed in the gulch outside the tunnel it occurs in two beds, one 3 feet and the other 1 foot thick, separated by a 1-foot clay parting. The lignite is clean and bright but rather friable and is said to burn readily and to be of sufficiently good grade to use in a forge for welding. A small amount has been mined and used by prospectors in this district, as this is the only known occur-

[1] Moffit, F. H., and Knopf, Adolph, Mineral resources of the Nabesna-White River district, Alaska: U. S. Geol. Survey Bull. 417, 1910.

rence of workable coal or lignite in a large region where the demand for such fuel is considerable. The lignite is interbedded with greenish sands and conglomerates, but the whole outcrop of this formation is of small area, being surrounded by intrusive rocks, and the amount of lignite at this place is probably not large.

At a point 1½ miles west of Ptarmigan Creek, 2 miles above its junction with Beaver Creek, there is a small area of Tertiary rocks reported to contain some lignite. The lignite is said to strike approximately north and dip steeply to the east and to be of rather poor quality.

The Tertiary conglomerates and sandstones crop out along the east side of the low pass between Chathenda Creek and Beaver Lake, but no lignite was seen there. Along Chathenda Creek below the mouth of Dry Gulch and in the basin of Rhyolite Creek there is an area of Tertiary sandstones and conglomerates, with agglomerates and tuffs, locally containing considerable carbonaceous material. Several prospect holes on Chathenda Creek show lignite on the dumps, although the lignite could not be seen in place. At the first forks of Rhyolite Creek above its mouth a bluff shows carbonaceous shale and sandstone with beds of lignite an inch or two in thickness, but no workable coal has been found.

Lignite is reported from the north side of the Nutzotin Range on a tributary of Beaver Creek. The locality is 7 miles west of the international boundary and about 1 mile south of the mountain front, and the outcrop is on a stream bluff. The area of Tertiary rocks at this place is not known, but the lignite is reported to form a bed about 8 feet thick, striking nearly east and dipping steeply to the south. It is said to be of fair grade and to burn readily.