EXPLORATION IN THE COSNA-NOWITNA REGION.

By HENRY M. EAKIN.

INTRODUCTION.

The area here called the Cosna-Nowitna region extends southward from Yukon and Tanana rivers to Lake Minchumina and the North Fork of Kuskokwim River. It reaches from the longitude of Cosna on the east to Nowitna River on the west. (See index map, fig. 14.)

Prior to 1915 the topography and geology of this region were practically unknown except its eastern margin, which had been

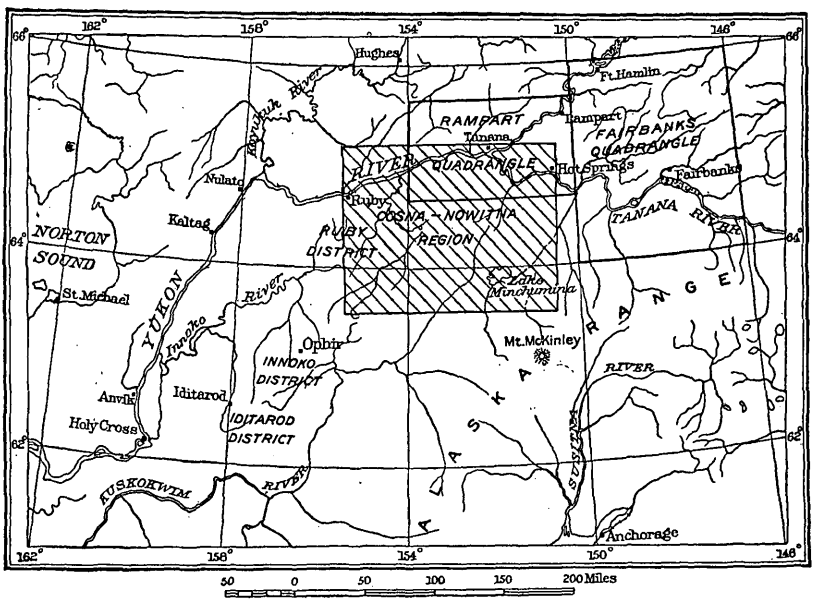


FIGURE 14.—Index map showing location of Cosna-Nowitna region.

traversed by Herron.[1] Few prospectors had visited it, and so far as known the region had no particular economic importance. In the summer of 1915 a small Geological Survey party in charge of the writer made a rapid exploratory trip from the Tanana at Cosna to the headwaters of Nowitna River, following in a general way the

[1] Herron, J. S., Explorations in Alaska, 1899: War Dept., Adjt. General's Office, No. 31, pp. 1–77, maps, 1901.

Yukon-Kuskokwim divide. A pack train of seven horses was used on this trip, which took from June 12 to August 26. The horses were abandoned on the upper Nowitna and the party proceeded down the river on a raft, arriving at Ruby September 3.

Topographic work was carried on by plane-table method, and most of the uplands between the plains of the Yukon and Kuskokwim were mapped. Geologic mapping was extended over practically the same area. The resulting maps will be published in connection with a more complete report on the region now in preparation.

RELIEF.

The topography of the region shows two contrasting types—the plains and the uplands occupying about equal areas.

The plains are developed on unconsolidated deposits at various altitudes up to about 1,200 feet above sea level. Their relief is generally low, as they have only minor surface irregularities such as dunes and hollows, terraces and canyon-like valleys of locally intrenched drainage lines. The plains border the uplands on the north, east, and south, extend broadly into the principal valleys of the upland areas, and in places continue through low passes from one drainage basin to another, dividing the uplands into several more or less distinct areas.

The uplands are bedrock features. They vary in contour from strongly rolling hills and ridges to fairly rugged mountains. The summits reach altitudes of 3,000 feet or more above sea level. Their relief is generally strong, measuring from 1,000 to 2,000 feet within short distances. They are higher and are continuous over broader areas in the western part of the region than in the eastern part. Still farther east, beyond the area surveyed, several small isolated ranges and hills were seen, rising above the plains like islands from the seas.

DRAINAGE.

The region is drained by streams of the Yukon and Kuskokwim river systems. The main divide in the central and western parts of the region has a general northeasterly trend and lies very close to the course of the North Fork of Kuskokwim River. The northeasterly trend continues to a point about 40 miles north by northeast of Lake Minchumina. Here the divide turns abruptly around the head of North Fork and runs south by southwest past the west end of the lake and then in a general southerly direction to the Alaska Range.

The drainage of the upland area northeast of Lake Minchumina is divided among an extraordinarily large number of distinct streams. The south, east, and north slopes drain into the Kantishna, Zitziana, Cosna, and Chitanana rivers, tributaries of the Tanana; the

west slopes into a branch of Titna River, tributary to the Nowitna, and into the North Fork of Kuskokwim River. Thus there are six streams, all of considerable size, that head within a few miles of the same point.

The upland of the western part of the region for the most part drains northward into the Nowitna through Titna and Sulukna rivers. The North Fork of Kuskokwim River receives only short northerly tributaries in this part of the region.

The Kantishna River basin includes only a small area in the southeastern part of the region. Several small streams that drain southward from the upland flow out upon the alluvial plains and empty either into Lake Minchumina or into the Kantishna a short distance below the outlet. The Kantishna flows northeastward from Lake Minchumina to Tanana River, a direct distance of about 80 miles. The distance along the course of the stream is probably more than twice as great. The Kantishna receives most of its water from a number of large southerly tributaries that head in the Alaska Range. It is said to be navigable for launches or small steamboats from its mouth to Lake Minchumina.

Zitziana River has not been shown hitherto on the maps of this part of Alaska and has been known only to the natives and a very few hunters and prospectors. Its basin lies east of that of Cosna River and north of the area drained by the Kantishna. A few southwesterly headwater tributaries head against the North Fork of Kuskokwim River. The basin lies almost entirely in the area of alluvial plains, as only the extreme southwesterly headwaters drain any part of the uplands. The main stream flows northeastward for a direct distance of about 40 miles to Tanana River in the vicinity of Hot Springs. Its valley, which is deeply intrenched in the silt plains, is a quarter to half a mile wide. The stream has an extreme meandering habit, so that the distance along it from mouth to source is several times as great as the distance by a direct line. It is navigable for canoes or poling boats well up to its head. The gradient is very low and the current correspondingly slow.

Cosna River is of about the same size as the Zitziana. Its tributaries head against those of the Zitziana on the east, the North Fork of Kuskokwim River on the south, and the Chitanana on the west. The westerly and southerly tributaries head in the uplands and flow out upon the silt plains, which have a broad extent in the basin. In its lower course the stream has a low grade and is sluggish and meandering. Toward the uplands the grade steepens and the courses of the tributaries are more direct. The Cosna is navigable only for canoes or poling boats.

Chitanana (Redlands) River drains an area lying west of the Cosna River basin and about twice as large. Its southerly tributaries head

against those of the Titna, and its westerly tributaries against those of Nowitna River below the Titna. The greater part of the drainage basin is in the area of the silt plains. Uplands partly border the basin on the east and south only. The extreme distance in a direct line from the mouth of the Chitanana to the rim of its basin is probably less than 50 miles. Yet, owing to its very devious general course and meandering habit the distance along the stream is probably at least three times as great. The main stream is deeply intrenched in the silt plains, exposing in places sheer bluffs of silt 400 to 500 feet high. The stream is said to be excellent for canoes or poling boats far up its course.

Nowitna River drains considerably more than half of the central and western parts of the region, through Sulukna, Titna, and Big Mud rivers, its chief easterly tributaries, named in order going downstream. The Sulukna has its source in the highest uplands of the region, the limestone mountain range about 50 miles southwest of Lake Minchumina and near the North Fork of Kuskokwim River. It flows in a general northerly direction for an air-line distance of about 45 miles to its junction with the main river, 10 miles above the head of the canyon. Its easterly tributaries head against two large southerly tributaries of the Titna; its westerly tributaries against those of the upper Nowitna. All its tributaries head in prominent uplands, but the lower course of the main stream is through a broad silt-filled basin which marks the western limit of the present survey. Poling boats have been taken up the Sulukna to points well back in the mountains, 30 to 35 miles in a direct line from its mouth. To do this, however, required numerous portages around beaver dams.

Titna River drains a broad area bounded on the west by the Sulukna basin, on the south by the North Fork of the Kuskokwim, on the east by the Cosna and Chitanana basins, and on the north by the Big Mud River basin. Its extreme easterly headwaters head against the Cosna and it flows in a general westerly direction a straight distance of about 45 miles to the Nowitna 20 miles below the mouth of Suluka River. In this distance it receives three large and several small southerly tributaries. The upper southerly tributary is called the main head of the Titna, although smaller than the easterly branch or the other two southerly branches, all of which have headwaters farther from the mouth of the Titna. The next southerly tributary below this stream is the Sethkokna, a large clear-water stream that heads against the North Fork of the Kuskokwim and Sulukna River 40 miles southwest of its mouth. The other southerly tributary, the Telsitna, joins the Titna 15 miles downstream from the Sethkokna and heads 25 miles to the southwest, against an easterly tributary of Sulukna River. Thus the Titna has four large branches that are navigable for poling boats well toward their

heads. All flow through rather broad valleys with a strongly meandering habit. The Sethkokna and Telsitna have relatively steep grades and swift water on numerous riffles. There are said to be rapids on the Telsitna near its mouth and also on the Titna below the Telsitna. The Titna rapids are reported to be rather difficult at low stages, but easily traversed by skillful boatmen at medium or high stages.

Big Mud River is an easterly tributary of the Nowitna and joins it about 8½ miles below the Titna. Its easterly tributaries head against the Chitanana and its southerly tributaries against the Titna. It is somewhat smaller than the Titna, but can be traversed by poling boats for a considerable distance. The Big Mud drains a large area of silt plains and derives its name from the great amount of silt which it carries during high stages.

The main upper branches of Nowitna River head against Nixon Fork of Kuskokwim River. The mouth of the Nowitna is about 14 miles above Kokrines village, on the Yukon. The direct distance between its mouth and the divide at its extreme head is about 125 miles, but the actual course of the stream between these points is about 360 miles long. Below the Sulukna the river flows for 166 miles to cover an air-line distance of 57 miles. In its lower course the grade is very low and the current is correspondingly slow, from half a mile to 2 miles an hour at ordinary stages. For a long distance above its mouth the depth of water at mean stages is from 20 to 40 feet. It is navigable for launches, scows, and shallow-draft steamboats for at least 100 miles.

The North Fork of Kuskokwim River heads against Cosna, Zitziana, and Kantishna rivers in the uplands of the eastern part of the region. It flows in a general southwesterly direction beyond the area of the present survey without receiving any large tributaries. The northern limit of its drainage basin is near the south margin of the principal upland area, which is drained mainly by the tributaries of the Nowitna, already described. The southerly tributaries of the North Fork head against streams that belong to the Kantishna system. It is favorable for the use of canoes or poling boats to a point within a few miles of its head.

FORESTS AND VEGETATION.

The Cosna-Nowitna region is almost entirely forested, owing to its generally low altitude. Only a few small areas lie above timber line. which is about 2,000 feet above sea level. Below timber line there are small untimbered areas in places where soil conditions are apparently unfavorable. However, such areas are of only negligible extent, so that the entire region, so far as ordinary users are concerned, may be regarded as forested.

Spruce and birch are generally the dominant species, but in some places cottonwood and tamarack are the more abundant. The largest specimens of spruce grow along streams and at the heads of valleys, where trees 2 feet or more in diameter may be found within any considerable area. Along the main rivers there are large areas of heavy spruce timber. Stunted spruce trees grow generally over poorly drained areas and are the chief form of forest growth in the swampy areas of the alluvial plains. Birch, on the other hand, does better on well-drained slopes and finds a favorable habitat on the scarp faces and dunelike hillocks of the alluvial plains, where it vies with the cottonwood. The tamarack grows sparingly in all parts of the region, but appears in perfection only in the areas underlain by limestone, especially on northerly slopes. In some such areas tamarack trees form the forest growth exclusively, and the largest specimens are a foot or more in diameter.

Willow and alder are the most useful of the smaller species growing in the region. They thrive along water courses and at timber line. The alder is valuable for fuel for high camps and is to be had in all parts of the region. The willow is less valuable for fuel, but supplies agreeable forage for horses and browsing animals. In some places the pack horses subsisted on willow for days at a time and showed a preference for this food even when grass was available. The willow growth along some of the low-lying streams is remarkably heavy, attaining heights of 30 to 40 feet. Some very old trees, 18 inches in diameter, were seen on a branch of the Sethkokna.

The vegetation of the region, besides trees, consists of mosses, grasses, shrubs, and a great variety of herbaceous plants. The sphagnum varieties of moss are prevailingly abundant and, growing in company with bunch grass, blueberry bushes, and trailing birch, give a soft, laborious footing over the whole region except in the limestone areas. Grass is not plentiful in the region, but outside of the areas underlain by limestone it can be found in quantities sufficient for the needs of pack animals, provided camp is held only a day or two at any one place. The scarcity of grass in parts of the region was of considerable inconvenience to the Survey party, and had it not been for the willow used as forage in the limestone belts the horses would have fared still worse than they did.

Blueberries, currants, raspberries, and cranberries are found in the region. The blueberries and cranberries are to be had in unlimited amount, but the others are rather scarce.

FISH AND GAME.

Food fishes are fairly abundant in the streams and some of the lakes of the region. Salmon were seen on the North Fork of Kuskokwim River near its head and on the Sethkokna near the middle of

its course. Grayling are plentiful in both large and small streams. Trout were taken only in the clear-water streams that drain the limestone mountains. Pickerel and other species are said to be found in the larger lakes that have outlets.

Large game is very abundant in parts of the region. Moose and bear were seen almost daily in the area between Lake Minchumina and Sulukna River, and bright game trails indicate this to be an unusually favorable game country. No brown bear were seen, but the black bear is so numerous in most of the region as to be more or less of a nuisance. Caribou were not so plentiful, a single specimen shot on a tributary of North Fork being the only one seen. However, well-worn caribou trails in the eastern part of the region and old Indian fences, now in disrepair, show that this animal frequents the region, at least during its migrations.

Waterfowl, including ducks, geese, cranes, and swans, were seen on the lakes and streams. Land fowl were almost entirely lacking, but this is probably a temporary condition, as these species are said to disappear and grow numerous again more or less periodically. They were formerly plentiful and undoubtedly will be so again in a few years.

Fur animals, including fox, lynx, martin, mink, and beaver, were seen in different parts of the region, and trappers report good catches during the last few years. Beaver are very numerous on the tributaries of North Fork and of Nowitna River. Their dams so obstruct some of the valleys that it is difficult to travel through them with a pack train.

INHABITANTS.

The region is practically uninhabited during the summer, but in winter half a dozen white prospectors and trappers and a few natives sojourn for a longer or shorter period within its boundaries. The nearest native settlement is Cosna, on Tanana River, which consists of but a few families. Formerly there was a considerable native population in the region of North Fork and Lake Minchumina, but they have been so depleted by measles and other diseases that there are now said to remain scarcely 50 individuals—mostly adults. Parts of the region serve as hunting grounds for natives of both Tanana and Kuskokwim tribes, but there are large areas that apparently are seldom if ever visited by either natives or whites.

ROUTES OF TRAVEL.

The most available routes of travel in summer are those furnished by the principal streams of the region. Winter travel across the region from the vicinity of Lake Minchumina to Yukon and Tanana River settlements mainly follows two principal routes, which are

marked by more or less definite trails. These trails are apparently very old, and at present where seen they are somewhat overgrown and in disrepair.

The route from Cosna to Lake Minchumina leads up Cosna River for about 25 miles; thence eastward across a low divide to the headwaters of the Zitziana, and thence around the east margin of the uplands through another low pass into the valley of a stream flowing southwestward into the lake. The other winter route from the lake to the Yukon leads northwestward across the upper basin of North Fork across a low divide to the Titna, down this stream to a point below the mouth of the Sethkokna, and thence northward across the low country to the Yukon above Ruby.

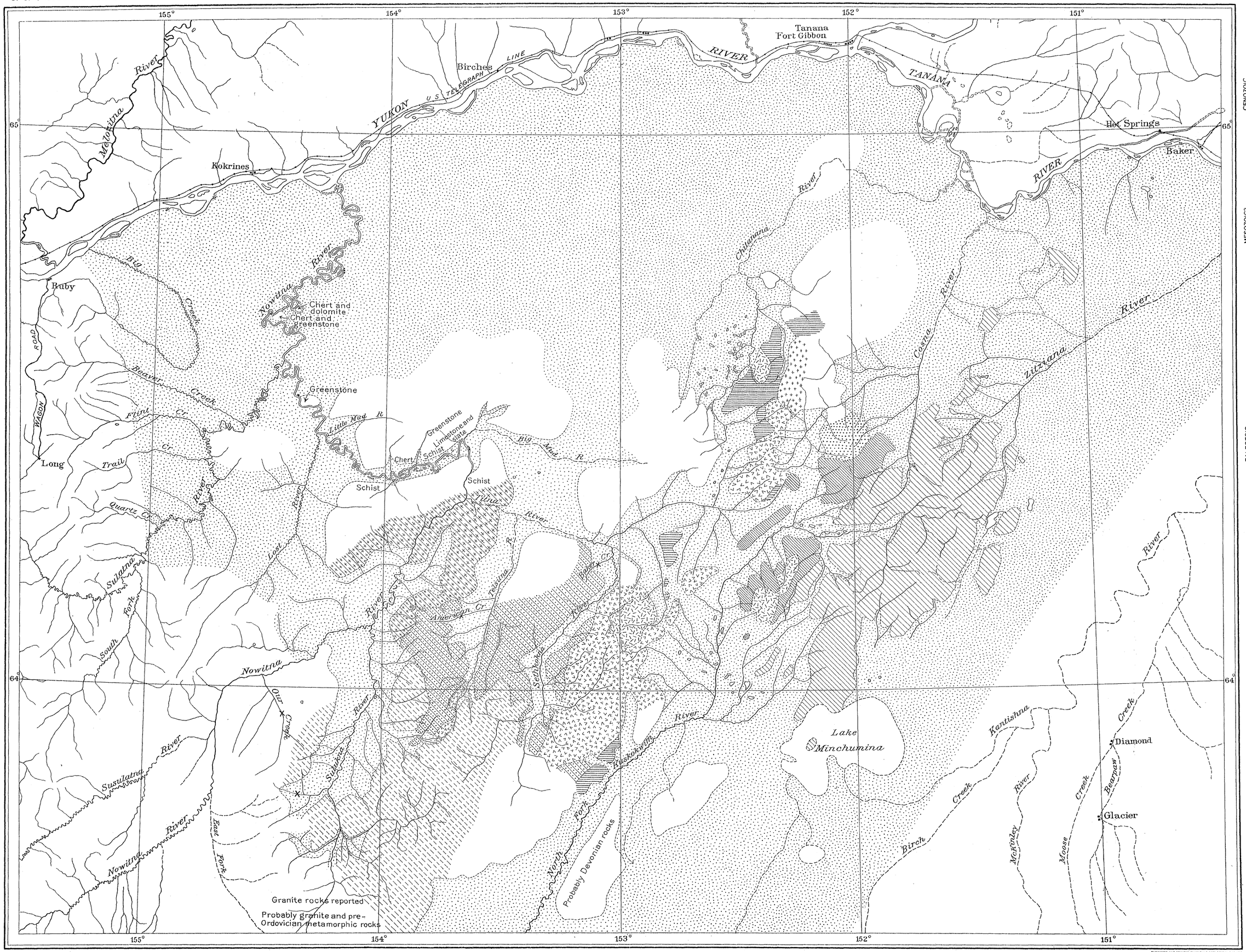
A number of other trails were seen, chiefly those made by trappers for short distances along their trap lines. These follow the crests of many of the timbered ridges in the eastern part of the region. Farther west, where the upland ridges and divides are more uneven and lack timber, the trails are located chiefly along the streams in the valley bottoms.

The trappers and prospectors who frequent the region generally outfit at Tanana or Ruby and get their supplies to their base camps during the open season by poling boat, going up Nowitna River. They bring out their furs in the spring by the same means, following the break-up of the ice on the navigable streams.

GENERAL GEOLOGY.

The geology of the region is rather complex. The rocks are of many different kinds and ages, as is indicated on the accompanying geologic sketch map (Pl. X). They are here separated into 11 different groups, according to their lithologic and structural affinities. The ages of some of these groups are definitely known from the fossils which they furnish; the relative ages of other groups may be inferred from their structural relations; and still other of the groups can not, from the data at hand, be assigned with any great assurance to even a general position in the geologic column.

Fossils were collected from limestone beds at three different localities. Two of the collections represent a Middle Devonian and one an Ordovician horizon. The Ordovician fossils were taken from a single bed in a thick limestone series that occupies a large area in the southwestern part of the region. One of the Devonian collections was made on the headwaters of Chitanana River, and the other near the North Fork due west of Lake Minchumina. The Devonian rocks include, besides the fossiliferous limestones, calcareous and carbonaceous slates. These rocks crop out at intervals along a zone lying between the two fossil localities.



LEGEND

CENOZOIC

- Unconsolidated sedimentary deposits (*silts, sands, and gravels*) — QUATERNARY
- Granitic intrusive rocks (*chiefly granite and monzonite*)
- Younger volcanic rocks (*rhyolitic and andesitic flows tuffs, and breccias. Lavas commonly porphyritic*) — LATE CRETACEOUS OR EARLY TERTIARY

UNCONFORMITY

MESOZOIC?

- Chert and slate
- Grits and sandstone
- Quartzite and phyllite — PROBABLY EARLY MESOZOIC
- Diabase and basalt (*largely altered to greenstone*) — DEVONIAN OR YOUNGER
- Limestone and slate — MIDDLE DEVONIAN

UNCONFORMITY ?

PALEOZOIC

- Limestone — UPPER ORDOVICIAN

UNCONFORMITY

- Schist and quartzite (*includes some limestone, slate, and altered igneous rocks*)
- Limestone and greenstone (*limestone in part dolomitic. Includes some schist and slate*) — PRE-ORDOVICIAN

× Gold prospect

GEOLOGIC SKETCH MAP OF COSNA-NOWITNA REGION, ALASKA

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

10 5 0 10 20 30 Miles

ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

The Ordovician limestones are underlain unconformably by a metamorphic series, which is separated into two groups—an upper group composed chiefly of schists and quartzites and a lower group composed chiefly of limestones and greenstones. These metamorphic rocks extend northward from the Ordovician limestone area to the margin of the silt plains.

The eastern part of the region is occupied mainly by a thick series of sedimentary rocks that are separable into three different groups. The lower group is composed dominantly of banded quartzites and phyllites; the middle group of grits, sheared sandstones, and slates, and the upper group of cherts and slates.

Two groups of volcanic rocks are distinguished on the map. The older group consists of more or less altered diabase and basalt flows which form the highest part of the Cosna-Chitanana divide, east of the Devonian fossil locality. The younger group includes an assemblage of lavas, tuffs, and breccias that are extensively developed along the same general belt with the Devonian rocks. There are two other small areas of volcanic rocks near the head of Telsitna River, covering part of the fault contact between the Ordovician limestones and the schist and quartzite group.

Intrusive igneous rocks occur in large masses at several localities indicated on the map and also in the form of dikes that are too small to be shown on a map of this scale. The larger masses are batholithic in form and typically have the composition of monzonite. The dike rocks are mainly rhyolite or rhyolite porphyry, although more basic rocks that are probably in the form of dikes were found.

The rocks noted in the foregoing descriptions constitute ten separate groups and include all the igneous and consolidated sedimentary rocks noted in this region. Their masses form the upland features that cover about half the area of the region. The other half is occupied by unconsolidated sedimentary deposits, chiefly of silt, which form broad terraces and plains at different altitudes up to about 1,200 feet above sea level. These deposits extend broadly up the principal valleys and spread over large areas to the north, east, and south of the immediate region under discussion.

ECONOMIC GEOLOGY.

VEINS AND MINERALIZATION.

Quartz veins or other signs of mineralization are not generally abundant in the region. Veins were noted only locally about the granitic intrusives, in the area of the quartzite-phyllite group of rocks between the forks of Cosna River and in the pre-Ordovician metamorphic rocks. At none of these places, however, were they very abundant or highly mineralized, so far as could be noted in the field examination.

Sulphide mineralization has affected the rocks of the quartzite and phyllite group to some extent, but not in a manner that suggests any economic possibilities. These rocks in places carry finely disseminated granules of pyrite, and they are cut by rhyolite dikes that are similarly mineralized. Weathered surfaces of these rocks in places show iron and copper stains.

Auriferous mineralization is nowhere evident from the study of rocks in place. However, placer gold is known to occur at two localities within the region—on Baker Creek, a westerly tributary of Sethkokna River near its mouth, and on American Creek, a westerly tributary of the Telsitna about the middle of its course. Placer gold has been reported also from the head of Our Creek, a tributary of the Nowitna next above the Sulukna, and from a tributary of the Sulukna that heads against Our Creek.

PROSPECTING.

A great deal of time has been spent by a few prospectors in the search for placer gold on the tributaries of Nowitna River, and the occurrences enumerated above have been known for a long time. Exaggerated reports of gold placers in the region have been circulated among the river settlements at different times, and several so-called stampedes have occurred, when large numbers of people hurried away to this or that locality. So far the occurrence of commercial placers in the region has not been demonstrated, and during the summer of 1915 the creeks were entirely deserted. However, it should be noted that new discoveries on the tributary of the Sulukna heading against Our Creek were reported during the summer, and a number of prospectors were on their way to that locality.

Except in the Our Creek locality, where the alluvial deposits are comparatively shallow, the region holds out great difficulties and little promise to the prospector, owing to the great depth and breadth of the alluvial filling of the larger valleys. This condition has limited prospecting to the smaller streams, which lie relatively high in the uplands. Such streams naturally have narrow valleys and steep grades and, as they have performed only a small amount of erosion, large concentrations of placer gold in their gravels are not to be expected. The concentrations that might have been made by the larger streams can be looked for only in the broad depressions that are now floored with deep alluvial deposits. The distribution of the alluvial deposits is shown on the map. They extend up all the larger valleys well toward their heads. Wherever these valleys were occupied, prior to their alluviation, by streams of considerable size, such as might have formed large placer concentrations, these deposits probably measure scores if not hundreds of feet in thickness. Furthermore, the present streams generally do not follow the exact

courses of the original streams, and there is no definite indication as to the position of the earlier deposits. Under these conditions it seems that erratic prospecting in the broad, deeply filled valleys is not justified.

As gold is known to occur on some of the small and relatively shallow streams of the region, it is likely that prospectors will continue, in some measure, the search for profitable placers. The most intelligent plan to follow would appear to be that of tracing the known auriferous deposits down the smaller streams and out in the broader valleys by means of successive crosscuts. Once the trend of the auriferous gravels is established the hazard of succeeding operations will be reduced to a minimum. Whether a systematic plan of prospecting, such as this, is justified will depend on the showings in the smaller streams where work might be begun. Upon this point the writer was unable to obtain any data. The occurrence of any large concentrations in the major valleys is, of course, an open question.

In this connection mention should be made of the relation of auriferous mineralization to intrusive igneous rocks that is evident in the Innoko and Iditarod districts, to the southwest of this region. It seems clearly proved that the introduction of gold into the rocks of those districts was a phase of the same igneous activities that produced the granitic intrusives, and areas in the vicinity of such intrusives have proved to contain the most valuable placers. The monzonites and granites of the Cosna-Nowitna region are probably closely related to the intrusives of the Innoko and Iditarod districts in age and character, and it would not be surprising if auriferous mineralization were to be found associated with them also. However, it is equally possible that such mineralization may not have occurred, for there are granites and monzonites in many places in interior Alaska that apparently have no such association. Still, on the whole, the vicinity of igneous intrusive rocks would seem to be a more logical place for prospecting than the areas more distant from them.

MINERAL RESOURCES OF THE RUBY-KUSKOKWIM REGION.

By J. B. MERTIE, Jr., and G. L. HARRINGTON.

INTRODUCTION.

The region here described is an irregular area lying between Yukon, Nowitna, Tuentna (Nixon Fork of the Kuskokwim), Kuskokwim, Takotna, Iditarod, Innoko, and Yuko rivers, or between meridians 153° 40′ and 158° 20′ west longitude and parallels 65° and 61° 40′ north latitude. The index map on Plate XI shows the location of the region with respect to the surrounding territory.

Portions of the area discussed in this paper have been visited previously by a number of Survey geologists. Spurr,[1] in his trip down the Yukon in 1896, passed the present site of Ruby and made some geologic observations on the crystalline limestones that crop out along the south bank of the river, near the mouth of Melozi River. In 1898 also Spurr,[2] in the course of his exploration of Kuskokwim River, skirted the southern edge of this region. His notes on the geology along that part of Kuskokwim River shown on Plate XI remain still the only geologic data bearing upon that stretch of the river. The Survey has also in its possession some unpublished notes on the Ruby Bluff made by Collier in 1902, incidental to his study of the coal resources of the Yukon.[3] In 1907 Gilmore[4] ascended Nowitna and Yuko rivers for considerable distances from the Yukon and made some geologic notes. In 1908 a portion of the field season was spent by Maddren in an investigation of the region about the headwaters of Innoko River, and in 1910 he visited the Innoko and Iditarod districts.[5] In 1910 C. G. Anderson carried a topographic reconnaissance from the present town of Ruby to the Innoko and Iditarod districts. H. G. Birkner, who was attached to the Anderson party, collected geologic data along the route, and these data were used in

[1] Spurr, J. E., Geology of the Yukon gold district, Alaska: U. S. Geol. Survey Eighteenth Ann. Rept., pt. 3, p. 173, 1898.

[2] Spurr, J. E., A reconnaissance in southwestern Alaska in 1898: U. S. Geol. Survey Twentieth Ann. Rept. pt. 7, pp. 31-264, 1900.

[3] Collier, A. J., The coal resources of the Yukon, Alaska: U. S. Geol. Survey Bull. 218, 1903.

[4] Gilmore, C. W., Smithsonian Misc. Coll., vol. 51, No. 1807, 1908.

[5] Maddren, A. G., The Innoko gold-placer district, Alaska: U. S. Geol. Survey Bull. 410, 1910; Gold placer mining developments in the Innoko-Iditarod region: U. S. Geol. Survey Bull. 480, pp. 236-270, 1911; The Ruby placer district: U. S. Geol. Survey Bull. 520, pp. 287-296, 1912.

the reports prepared by Maddren. In 1912 Eakin [1] spent about eight weeks in a geologic reconnaissance of the Iditarod-Ruby region and an examination of the placer-mining operations in the Ruby, Innoko, and Iditarod districts, and in 1913 he visited the Ruby district again and reported on the mining developments there. The region between Georgetown, on the Kuskokwim, and Iditarod was mapped topographically and geologically on a reconnaissance scale in 1914 by Sargent and Smith.[2]

During the summer of 1915 a strip of country extending from Ruby to Iditarod by way of McGrath and adjoining on the east the area examined by the Anderson party in 1910 was surveyed topographically and geologically on a reconnaissance scale. In all, about 8,000 square miles of territory was covered, of which, however, about 2,100 square miles was resurveyed, having been covered by the work done in 1910.

Two Geological Survey parties were engaged in this work. The northern party was in charge of C. E. Giffin, with G. L. Harrington attached as geologist. Mr. Harrington devoted his attention to the geology and mining operations in the vicinity of Ruby, Long, and Poorman. A topographic map was prepared, which supersedes the older map of this district and covers an area extending eastward to Nowitna River and adjoining there an area mapped by H. M. Eakin.[3] On the south connection was made with the work of the southern party. All the producing creeks were visited by Mr. Harrington and the geology and mineral resources were studied in such detail as the time and character of the country permitted.

The southern party, in charge of R. H. Sargent, began work at Poorman and carried the survey through to Iditarod, passing through the mining districts at Candle Creek and Moore Creek. To this party J. B. Mertie, jr., was attached as geologist. The mining properties on these two creeks, together with most of those in the Iditarod district, were visited and examined by Mr. Mertie. A. H. Brooks also spent 10 days in the Iditarod district, and the results of his observations and study are incorporated in the present paper.

This paper aims chiefly to sketch the progress of mining in 1915, and to present a brief discussion of the mineral resources of the Ruby-Kuskokwim region. It will be followed by a more complete report, dealing in greater detail with the geology of the region. The writers, however, have visited only a portion of the area included on the map that accompanies this report (Pl. XI). Hence, with the

[1] Eakin, H. M., Gold placers of the Ruby district and the Innoko-Iditarod region: U. S. Geol. Survey Bull. 542, pp. 279–303, 1913. The Iditarod-Ruby region, Alaska: U. S. Geol. Survey Bull. 578, 1914; Gold placers of the Ruby district: U. S. Geol. Bull. 592, pp. 363–369, 1914.

[2] Smith, P. S., Mineral resources of the Lake Clark-Iditarod region: U. S. Geol. Survey Bull. 622, pp. 247–271, 1915; The Lake Clark and central Kuskokwim region: U. S. Geol. Survey Bull. (in preparation).

[3] Eakin, H. M., The Cosna-Nowitna region: U. S. Geol. Survey Bull. (in preparation).

view of presenting all the available information about the area, the observations of the earlier workers have been freely used.

Special acknowledgments are due to Messrs. Sargent and Giffin, in charge of the field parties, for their ready assistance and cooperation in furthering the geologic work; and to the other members of the field parties, who showed at all times a willingness to help that was very gratifying.

Without exception the operators and prospectors in the region displayed an unfailing hospitality and evinced a desire to assist the writers so far as lay within their power. Information sought of them was given freely. To Mr. Vance McDonald, of Long, and Mr. David Strandberg, of Flat, the writers are particularly indebted for courtesies extended in this and other ways.

GENERAL CHARACTER OF THE REGION.

GEOGRAPHIC FEATURES.

The underlying conception of the Ruby-Kuskokwim topography should be that of a rolling country of low ridges, from which long, flat-topped spurs extend laterally into broad stream valleys. The monotony of this topography is broken at a number of localities by higher mountain groups, which, however, are not connected but stand out in isolated relief from the surrounding country. This region is a part of the great central plateau region of interior Alaska and is in reality the southwestward continuation of the Yukon-Tanana belt, at a lower level.

Yukon and Kuskokwim rivers, the trunk streams of central Alaska, drain this region, but the watershed between the two streams is near the southeastern limit of the region, so that most of the surface water finds its way to the Yukon. Nowitna, Sulatna, and Yuko rivers, the Innoko and its various headwaters, and Iditarod River drain into the Yukon; Nixon Fork, Takotna River, and Tatalina River are the main tributaries of the Kuskokwim.

The region comprises two rather distinct physiographic provinces. The northern province lies between Poorman and Ruby, extending east and west to the limits of the area mapped. It is drained mainly by Sulatna and Nowitna rivers. The southern province begins at the hills south of Poorman and continues south and west to Ophir and Iditarod and south to the Kuskokwim. The northern province is distinguished from the southern by its generally lower elevation and relief, by the extreme width and flatness of its stream divides, by the tortuous courses of the streams, and by the abnormally wide spacing of the headwater tributaries.

The character of the drainage is worthy of note. The larger streams meander in broad, open valleys, over much aggraded flood plains, which contain many swamps and oxbow lakes. In their

upper reaches the streams characteristically flow in deep, narrow channels, between cut banks, with a general absence or marked scarcity of gravel bars. This is particularly true of Sulatna and Nowitna rivers, which drain the northern part of the region. To the south, where mountain groups tend to steepen the headwater grades, this characteristic is not so marked.

In two areas within the region local glaciation has been pronounced enough to leave a record of its existence in the present topography. About 15 miles east of Ophir there is a high mountain group, the highest peak of which has an altitude of 4,600 feet. The area about the headwaters of one of the tributaries of Folger Creek which heads in this group shows a well-developed glacial topography. Several glacial cirques, one of which forms a hanging valley, drain into a U-shaped valley, in the lower part of which are undoubted glacial deposits. The other locality in which glaciation played an important part is in the Beaver Mountains. This locality was visited by Maddren and later by Eakin, both of whom report the presence of cirques, U-shaped valleys, and glacial deposits.

TIMBER AND FORAGE.

Timber grows in the valleys and on the upland slopes over much of this region. Nowhere is the growth very thick or the trees very large, but in most places the supply is sufficient for the local demand. Along the valley floors may be seen trees as much as 24 inches in diameter, which are available for lumber and for use in mining. The smaller trees serve a useful purpose as fuel.

Spruce is the most common variety and occurs from the valley bottoms up to timber line. With it are associated birch, tamarack, and cottonwood. Along the creek banks and near timber line, especially along small drains, alder and willow brush grows very thickly.

The upper limit of timber is a variable line in the country between Ruby and Iditarod, which is a transition zone between the wooded portion of the interior and the treeless tundra of southwestern Alaska. In the vicinity of Ruby and Long little timber grows above an altitude of 1,800 feet, and in the country around Iditarod and Flat there is little above the 1,500-foot line. Untimbered spurs extending well down into the valleys are common everywhere, yet in some especially favored gulches timber is found at altitudes above 2,000 feet. In general, timber becomes scarcer toward the southwest, as indicated by the figures given above.

Forage for stock is plentiful along the valley floors of some of the larger streams, such as the Sulatna, the Nowitna, and the Takotna, but on the upland slopes grass is scarce. Where the country has been burned over and the moss destroyed, however, good grass may usually be found.

GAME AND FISH.

Game is by no means plentiful, especially near the settlements. In the mountain areas, back from the mining camps, caribou may be seen occasionally, but nothing comparable to the immense herds of the Yukon-Tanana region is known in this region. A few bears are present. Moose are seldom seen.

Small game, such as rabbits, ptarmigan, and grouse appears to vary in abundance from year to year. Occasionally a porcupine is encountered. During the summer of 1915 very little small game was in the country, but earlier travelers record an abundance of it.

Salmon, pike, and other large fish are taken in Yukon and Kuskokwim rivers. In the uplands between these rivers grayling are caught in many streams, and in the mountain areas trout inhabit the creeks.

SETTLEMENTS AND POPULATION.

The principal settlements in this region are Ruby and Long in the northern part, Ophir in the central part, and Iditarod and Flat in the Iditarod district. There are smaller settlements at Poorman, Cripple, Takotna, McGrath, and Discovery (Iditarod district).

In all, the white population probably does not exceed 1,900, of whom about 500 are at Ruby, about 100 at Ophir and on the creeks in the Innoko district, about 700 in the Iditarod district, including Iditarod, Flat, Discovery, and the near-by creeks, and the rest in the smaller settlements and on the producing creeks, including a small number of men who are prospecting in the region. According to Eakin,[1] there are also several small Indian settlements along Innoko River, the largest of which is Dishkakat, about 20 miles below the mouth of Dishna River. Another small Indian settlement is at the base of Joaquin Mountain on Takotna River.

In 1912 the population was estimated by Eakin at 3,100, which is 1,200 more than the present estimate, showing a decrease of nearly 40 per cent. Elimination of the floating population that accompanies the opening of a new mining district and the concentration of producing ground in the hands of larger companies, accompanied by the inevitable introduction of modern mining machinery and labor-saving methods, have brought about this decrease in population.

TRANSPORTATION.

River steamboats ply on Yukon, Kuskokwim, Innoko, and Iditarod rivers during the summer. A regular passenger and freight service is maintained on the Yukon from Whitehorse and from St. Michael. On the Kuskokwim one river boat made three round trips

[1] Eakin, H. M., The Iditarod-Ruby region, Alaska: U. S. Geol. Survey Bull. 578, p. 18, 1914.

from Bethel to McGrath during the summer of 1915. From McGrath freight is carried by gasoline launches up Takotna River to Takotna. The Innoko is navigated by small river steamboats up to the mouth of the North Fork, whence supplies are brought up to Ophir by horse scows and poling boats. At ordinary stages of water the Yukon River boats ascend Iditarod River to Dikeman, and gasoline boats relay the passengers and freight up to Iditarod. Small launches go on up the Iditarod as far as the mouth of Otter Creek.

A wagon road and a winter trail connect Ruby with Long and Poorman. Small launches, however, navigate Sulatna River up to the mouth of Tamarack Creek, where the wagon road crosses. Most of the supplies intended for summer delivery at Poorman are therefore brought up to this point by boat and freighted the rest of the way.

In the Innoko district there is a wagon road between Ophir and Gaines Creek, and summer and winter trails connect Ophir with the other creeks near by and with Takotna.

A tram road equipped with wooden rails and with an automobile rebuilt on a railroad truck transports passengers between Iditarod and Flat. In addition, wagon roads connect Iditarod with Flat and Discovery. The wagon road to Flat continues up to the head of Flat Creek, serving the mining properties on the creek and at the summit. The Government winter trail between Iditarod and Seward passes through the mining camp on Moore Creek, and through Takotna and McGrath. Moore Creek also has communication with Discovery over a summer trail.

SUPPLIES.

Ruby is the distributing point of supplies for Long, Poorman, and the creeks in the neighborhood. The average freight rate from Seattle to Ruby is about $45 a ton. The winter freighting charge from Ruby to Long is from 1½ to 2 cents a pound, and to Poorman from 4 to 5 cents (1915). In summer it costs from 6 to 7 cents a pound to bring supplies from Ruby to Long, and about 9 cents to Poorman by way of Sulatna River (1915).

Candle Creek receives its supplies from McGrath. The winter rate is 1½ cents a pound. In summer supplies are brought down the Kuskokwim from McGrath, landed at a point about 4 miles from the creek, and brought over the hill by a pack train, at a total cost of 6 cents a pound. The freight rate from Seattle to McGrath is probably not greatly different from that to Ruby.

Ophir, the central point for the Innoko district, obtains supplies by way of both the Yukon and the Kuskokwim routes. The latter in time will probably be the more used, because of the relative cheap-

ness of supplies at Takotna, compared with the cost of boating up Innoko River from Holy Cross.

Iditarod is the supply point for Discovery, Flat, and the surrounding creeks. According to Eakin[1] freight from Seattle may be laid down at the mines along Flat and Discovery creeks at a total cost of 4 to 6 cents a pound (1912). Supplies are taken to Moore Creek on the main Seward trail in winter at a cost of 6 cents a pound from Iditarod. During the summer the rate by way of Discovery is 24 cents a pound.

OTHER MINING FACTORS.

The general wages paid for labor in 1915 were $5 a day and board, but men performing work that requires experience or special knowledge, such as winchmen or engineers, received as much as $7. In 1915 labor was plentiful.

Wood has been so far the only fuel used. Around Long and Poorman it is fairly plentiful and sells at $7.50 to $9 a cord, and 16-foot tree trunks about 1 foot in diameter cost $1.25 laid down at Long. In the Iditarod district the supply is smaller and the cost higher, and much of the neighboring country has been deforested to supply the demand. In another year or two it will be necessary to bring wood from the head of the Ditna or from the Iditarod River valley above Otter Creek. It is possible that some small coal seams between Flat and Iditarod may be developed and prove useful as fuel.

The problem of obtaining an adequate supply of water for mining purposes is serious at some localities, especially where the producing ground lies in the upper basin of a creek. The owners of the properties that surround the monzonitic mass at the head of Flat Creek have dug many ditches along the upper slopes to catch the surface water, and this supply is augmented by the construction of snow fences, which cause the snow to pile up in huge drifts in the winter and last late in the summer. At Candle Creek, where the workings are also close to the head of the creek, a bedrock basin has been excavated to collect the surface and underground water. Along creeks where many operators are at work, as at Long, the water supply is sometimes insufficient, especially during a dry spell of weather. Where the pay streak is several miles down the creek, however, and too many are not tapping the supply, it is usually adequate, because the heavy carpet of moss over the country acts as a sponge, preventing the rapid run-off of surface water after hard rains.

[1] Eakin, H. M., The Iditarod-Ruby region, Alaska: U. S. Geol. Survey Bull. 579, p. 19, 1914.

GENERAL GEOLOGY.

SUBDIVISIONS.

Between Ruby and Iditarod occur a number of geologic formations, including rocks of many varieties. These formations are of widely differing ages, ranging from the ancient rocks of the Ruby district down to the recent fillings in the present stream valleys. Lava flows and intrusive rocks of several kinds add further diversity to the geologic sequence. On the geologic map (Pl. XI) six mappable units of sedimentary rocks and five varieties of igneous rocks are recognized. These divisions may be modified or further subdivided in the final report on this region.

The sedimentary sequence consists of Paleozoic and older rocks, a chert formation of uncertain age, the Cretaceous rocks, and the unconsolidated deposits. The Paleozoic and older rocks are treated under three subdivisions—the undifferentiated metamorphic rocks, the crystalline limestone, and the Devonian limestone and slate. The igneous rocks include greenstone, presumably of Paleozoic age, and intrusive and extrusive rocks of later date.

PALEOZOIC AND OLDER ROCKS.

UNDIFFERENTIATED METAMORPHIC ROCKS.

The rocks grouped under the head of undifferentiated metamorphic rocks predominate in three general localities—the area extending from Ruby south to the Sulatna-Innoko divide, the area encircling Mount Hurst, and the Iditarod Valley near Iditarod.

This group includes schist, phyllite, slate, quartzite, chert, and Paleozoic limestone. In the present report certain areas of greenstone and of crystalline limestone, which really form a part of this complex, have been mapped separately, so far as possible, but much of the bedrock is concealed by a mantle of unconsolidated deposits and vegetation, so that the series as grouped doubtless includes unknown areas of greenstone and crystalline limestone. The scale of the map forbids the delineation of certain small areas of Paleozoic limestone in the Ruby district, but these will be shown on the map accompanying the final report.

The rocks of this series are dominantly recrystallized and represent in large part ancient sediments which have been brought to their present condition through severe and long-continued metamorphism. The complex history of the series is indicated by the intricacy of the folding and faulting, by the secondary structure which has been developed, and by the amount of quartz and calcite veining wherever these rocks occur.

The intensity of the metamorphism and the thoroughness of the recrystallization in some of these older rocks is comparable with that shown by the Birch Creek schist (pre-Ordovician and possibly pre-Cambrian) in the Yukon-Tanana country, and it is quite likely that sediments as old as this are present. Yet the degree of metamorphism is inadequate as an ultimate criterion for correlating geologic formations. It is therefore unsafe, in the absence of fossils, to make any definite correlation of this complex as a whole. The present grouping should be understood to represent a composite treatment of Paleozoic and older rocks, which it has been found impracticable to divide into separate units or true geologic formations.

Little information is available as to the structure of the metamorphic rocks, for exposures showing their attitude are unknown except along the river sections and a few of the creeks. Some indication of trends may be obtained from these sections and from the joining of isolated outcrops of similar rocks. It is thus found that the principal structural direction is about N. 25° E., with variations of from 20° to 30° to the east and west from this direction. The dip is generally to the west at a moderate angle. Folding and faulting along axes parallel to the main trend of the rocks are indicated by the shattered nature of some of the heavier beds and by the deformation and brecciation of quartz veins; and in places the fault planes are distinctly evident. From the general structure, the oldest beds should crop out, the farthest to the east in the vicinity of Ruby, and that this is the case seems to be borne out by the lithology, for the rocks on the east show greater metamorphism, being in fact garnet schists, while the rocks on the west contain less of the metamorphic minerals.

CRYSTALLINE LIMESTONE.

At two localities in the Ruby district crystalline limestone has been found in sufficient quantity to warrant its representation on the accompanying map (Pl. XI). One is along the south bank of the Yukon above Ruby; the other is at Sulatna Bluff, on the east fork of Sulatna River.

This limestone is a dark to light gray granular crystalline, nondolomitic rock and is so distinct in appearance from the Devonian limestone described below as to justify its separation from the metamorphic complex as a distinct unit. Along the Yukon it is associated with garnetiferous mica schists, phyllites, and other recrystallized rocks; and at Sulatna Bluff it is bordered by quartz-mica schist. It should therefore be considered as belonging with the older members of the metamorphic complex. No more exact statement of age is justified by present knowledge.

DEVONIAN LIMESTONE AND SLATE.

Under the designation Tachatna series Spurr[1] describes a series of "gray limestones (generally thin-bedded and fissile) having carbonaceous and chloritic slates and occasional generally fine-grained arkoses, which outcrop along Kuskokwim River from a point 20 miles above the present town of McGrath down to below Vinasale." He says further that these rocks have been considerably folded, contain numerous quartz veins, and are cut by granitic dikes. Middle Devonian fossils were collected by Spurr in this series at one locality.

Certain small areas of Paleozoic limestone, not here separately mapped, exist within the metamorphic complex in the Ruby district. From a limestone bed at one locality Devonian fossils were collected by Eakin in 1912. The limestone in the other areas is similar in appearance and is likewise believed to be of Devonian age. The writers have reasons, however, to be set forth in more detail in the final report, for believing that these limestones and certain other rocks closely associated with them represent sediments infolded with older rocks.

CHERT AND ARGILLITE.

A formation consisting essentially of chert and argillite begins on the hills just south of Poorman and continues southward almost to the Cripple Creek Mountains. It is bounded on the east largely by the rhyolitic and basaltic lavas of the Sulatna basin. Its western limit is unknown. Another band of chert borders the Mount Hurst metamorphic complex on the southeast. Rocks of this nature also occur in association with the greenstones near Yuko Mountain.

The rocks of this formation are distinct from the rocks north of Poorman and do not resemble the Cretaceous beds to the south. Green and white chert and a hard dark-gray argillite constitute the typical exposures. Here and there are bands of thin-bedded sandstone and grit. Banding is very common, and in many places the chert and argillaceous beds finger out laterally into one another. Brecciation is noticeable at certain places, but recrystallization is absent. The general structural trend of these rocks is about N. 55° E., but the dips are markedly inconstant. Both northwest and southeast dips were observed within short distances, and evidently close folding is common.

No definite statement as to the age of this formation can be made, for determinable fossils have not been found in it, and its relation to surrounding rocks is obscure. The rocks, although they are closely folded, differ markedly from the complex of the Ruby district in their lack of recrystallization. They are apparently much younger even

[1] Spurr, J. E., A reconnaissance in southwestern Alaska in 1898: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, p. 158, 1900.

than the infolded areas of Devonian rocks to the north. On the other hand, they are much older than the Cretaceous rocks to the south. It seems best to regard them tentatively as early Mesozoic without making any more definite correlation.

CRETACEOUS ROCKS.

Rocks that are assigned generally to the Cretaceous system form the bedrock over more than half of the area treated in this paper. Beginning at the southern limit of the cherts, argillites, and lavas in the Susulatna Valley, they continue south and west through Ophir to Iditarod and thence south to Kuskokwim River.

The Cretaceous beds consist dominantly of sandstone, with considerable areas of grit and conglomerate in certain localities. Locally, near intrusive masses or along zones of compression, the sandstone has been highly indurated, forming quartzite, and the shale has been altered to argillite and slate. As a rule the sandstone is impure, plagioclase feldspar and fine-grained igneous material being the constituents other than quartz. The conglomerate pebbles are usually chert, vein quartz, and a dark slaty rock. Bowlders as much as 3 feet in diameter were noted by Eakin[1] in the conglomerate in the vicinity of the Cripple Creek Mountains, but at the head of Folger Creek and near Iditarod 6 inches is the maximum size.

The sandstone and conglomerate of this series are associated with a variety of igneous rocks, of effusive and intrusive character. These will be considered in detail in the final report. They include acidic and basic coarse and fine grained intrusives, largely of Tertiary age, and basic lava flows.

Fossils of Upper Cretaceous age have been found at the headwaters of Folger Creek. It is not certain that all the rocks of this series are Upper Cretaceous, but it is rather unlikely that any beds older or younger than Cretaceous are included in the area mapped.

IGNEOUS ROCKS.

GREENSTONE.

Greenstones are present in a number of areas. The largest area is in the Kaiyuh Mountains, where much of the country rock is believed to be greenstone. The actual extent of the greenstone in this range is not known, but its northeastern limit has been mapped southwest of Ruby. In going up Innoko River in 1910 Maddren noted what is probably its southeastern limit along the northwest bank of the Innoko River at several places. Twin Butte, at the headwaters of the North Fork of Innoko River, is probably the next

[1] Eakin, H. M., The Iditarod-Ruby region, Alaska: U. S. Geol. Bull. 578, p. 23, 1914.

largest occurrence of greenstone. A number of smaller areas in the upper Sulatna basin are also mapped, and numerous other small unmapped bodies are included with the undifferentiated metamorphic rocks.

Under the single term greenstone have been grouped altered intrusive and extrusive rocks, mainly of basic character, together with some tuffaceous and cherty beds. It may be found possible later to subdivide the group into several rock units, for it shows a great diversity in petrologic character. The rocks range in texture from aphanitic and vesicular to medium granular, and in composition from basic basalts and diabases to more acidic rocks. Monzonite may be present. Some of the cherts are mapped with the greenstones on account of their small extent and intimate relations with the other members of the group. An equally wide variation appears in the degree of metamorphism exhibited by different members of the group, though they are a unit in displaying a greenish color, due, in part at least, to surficial weathering. Some of the rocks show little or no effect of shearing; others have been converted into schists.

But little can be said regarding the age of these rocks. Part of them have some of the characteristics of intercalated flows and so are contemporaneous with the undifferentiated metamorphic rocks in which they occur. Others are more clearly intrusive and therefore younger than a part of the metamorphic rocks.

MONZONITE.

Monzonite, the granular igneous rock intermediate between granite and diorite, is present as intrusive bodies at a number of localities. The principal ones, named from north to south, are the Cripple Creek Mountains, Twin Mountain (east of Ophir), the mountain southeast of Takotna, Joaquin Mountain, the head of Candle Creek, the head of Willow Creek (a tributary of Moore Creek), Discovery (on Otter Creek), and the head of Flat Creek in the Iditarod district). In the high mountain group a few miles east of Twin Mountain many dikes and smaller bodies occur. In the Ophir district dikes of such material cut the Cretaceous rocks; and this fact, together with the evidence of mineralization in that area, suggests strongly the presence of a larger underlying body of intrusive rock. Smaller bodies and dikes are present elsewhere.

The monzonite is a light to dark gray granular rock, consisting essentially of quartz, potash, feldspar, and soda feldspar in approximately equal amounts and black minerals, usually hornblende or mica or both. Microscopic examination will probably show that variations from this average type exist, grading in composition toward granite on the one hand and toward diorite on the other. These acidic intrusive rocks are of the highest economic importance, be-

cause they have been found to be intimately associated with and genetically related to the gold deposits.

The intrusive monzonite invades rocks of Upper Cretaceous age, and its granularity indicates that it was intruded at considerable depth. This conception involves the deposition and burial of the Upper Cretaceous beds prior to the intrusion and leads to the conclusion that the monzonite is of Tertiary age.

Certain altered granular rocks in the Ruby district, which are suspected to be of monzonitic or dioritic character, are in this paper, grouped with the Paleozoic greenstone. Subsequent microscopic work may justify the differentiation of these rocks as representing a Paleozoic or Mesozoic period of intrusion.

DIORITE, GABBRO, ANDESITE, AND BASALT.

A striking feature in this region is the constant association of gabbro, diabase, and basalt with the monzonitic intrusive bodies. Such basic rocks usually surround or nearly surround the monzonitic areas, as at Twin Mountain, at the mountain southeast of Takotna, at Candle Creek, on the headwaters of Moore Creek, and at Flat and Discovery. At other localities, where the basic intrusive is the dominant intrusive rock, as in a mountain group at the headwaters of Folger Creek and in the high mountains east of Twin Mountain, monzonitic and dioritic dikes are found in great abundance.

The basic material seems to have come to the surface in most places, being outpoured as surface lava. The intrusive and extrusive types grade into each other, and separation of the flows from the intrusives is difficult. The presence of tuffaceous beds in certain localities is a helpful criterion in recognizing the flows.

In composition, these rocks range from basic diorite and basic andesite to gabbro and basalt; and differences in granularity, arrangement of the minerals, and the presence or absence of phenocrysts lends variety to their appearance. They are composed essentially of plagioclase feldspar, pyroxene, and magnetite. The pyroxene diorite and gabbro are coarse grained, and the pyroxene andesite and basalt are their fine-grained equivalents.

The basic intrusives, like the monzonitic rocks, invade the Upper Cretaceous sediments, and are therefore younger than that part of the Upper Cretaceous which they intrude. They are invaded, however, by the monzonite, which is considered to be of Tertiary age. It is possible, then, for the intrusion of the basic rocks to have taken place either in late Upper Cretaceous time or in the Tertiary. The common association of the basic intrusive rocks with the basic extrusives, which are assigned to the Tertiary, is interpreted as evidence that the intrusion of basic lava occurred in Tertiary time.

RHYOLITE.

Rhyolite occurs in two general localities in this region, covering considerable areas about the headwaters of the South Fork of Sulatna River, and occurring in small bodies far to the south, on the headwater tributaries of Takotna River, near the Moore Creek mining camp.

Little microscopic work has yet been done on these rocks. In a general way, however, they are known to be fine grained and composed largely of quartz and alkali feldspar. The rhyolites in the northern area seem to be badly altered, but those to the south appear fresher and better preserved.

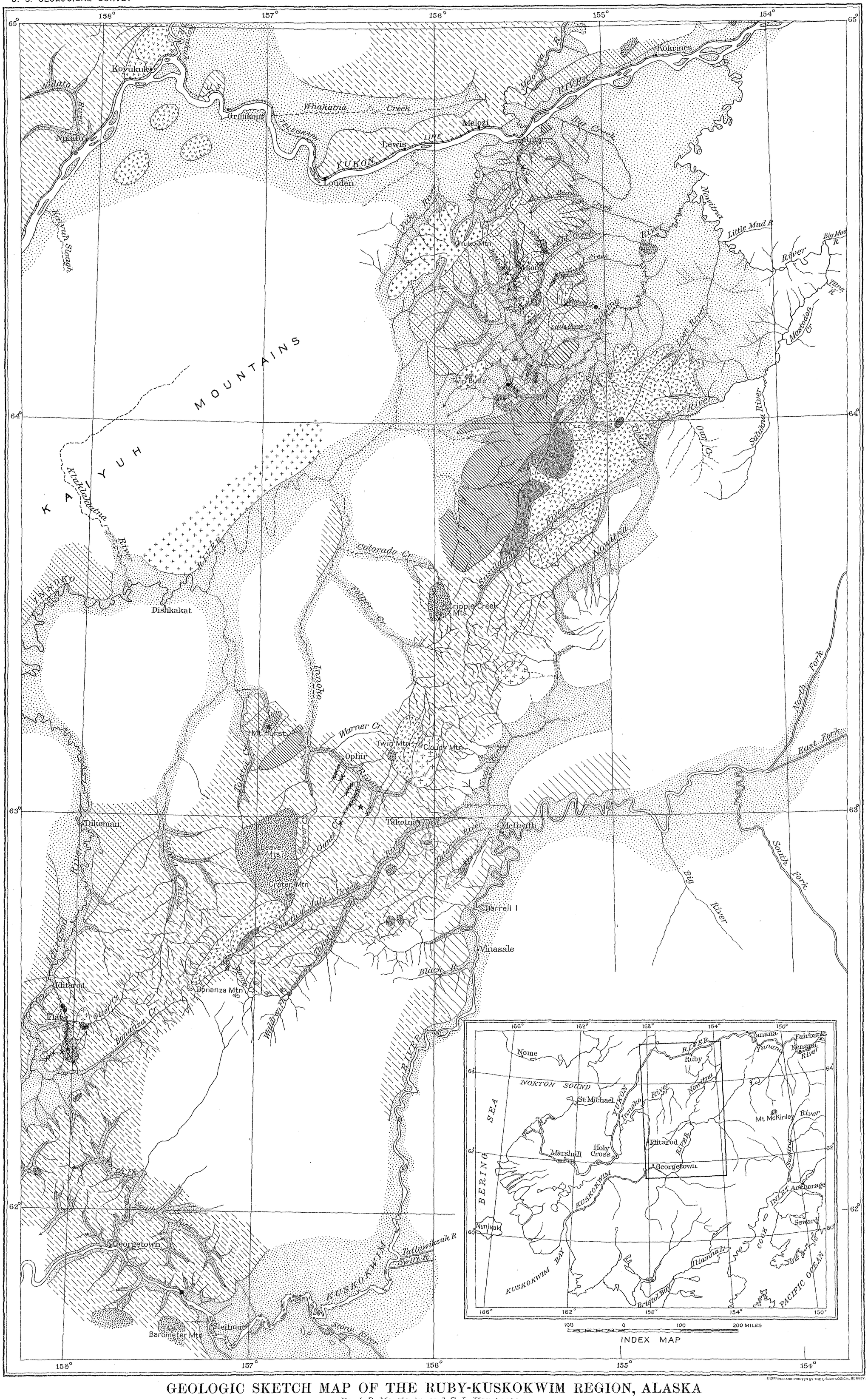
The northern rhyolites appear to represent surface flows, which are intimately associated and apparently interbedded with the chert and argillite formation and which were therefore probably erupted in early Mesozoic time. On the other hand, the southern rhyolites are intrusive in nature, for they clearly cut the Cretaceous rocks. It is highly probable that these rocks are contemporaneous in a general way with the Tertiary granitic intrusives, of which indeed they may be fine-grained representatives. On the accompanying map both rhyolites have been grouped together as a single unit, but they will be separated in the final report.

ANDESITE AND BASALT.

Surface flows of intermediate and basic composition occur at a number of localities. They are usually associated with the Cretaceous rocks and with the basic intrusives previously described. It is believed that the extrusion of the basic lavas and the invasion of the Cretaceous sediments by basic intrusives are contemporaneous features of the geologic history of this region. No Tertiary sediments are present, so far as known, so that direct stratigraphic evidence of the age of the basic lavas is lacking. But certain structural features of the lavas and the surrounding Cretaceous rock, which will be presented in detail in a later report, favor the view that the outpouring of this lava occurred chiefly in Tertiary time.

QUATERNARY DEPOSITS.

Quaternary deposits cover practically the entire surface of the region north of Poorman and much of the country south of Poorman. In the Ruby, Long, and Poorman districts unconsolidated deposits extend well up toward the headwaters of the creeks, and residual débris mantles the slopes, in most places clear to the tops of the ridges. Farther south the stream valleys are likewise filled with alluvium and gravel, but the relief is greater and the quantity of residual material



LEGEND

SEDIMENTARY ROCKS

- Unconsolidated silts, sands, gravels, and morainic deposits *(of fluvial, glacial, lacustrine, and littoral origin)* — QUATERNARY
- Sandstone, shale, grit, and conglomerate — CRETACEOUS
- Chert and argillite — EARLY MESOZOIC(?)
- Limestone and slate — DEVONIAN
- Crystalline limestone — PALEOZOIC OR OLDER
- Metamorphic complex of schists, limestones, slates, quartzites, and greenstones *(probably equivalent in part to Birch Creek schist)* — PALEOZOIC OR OLDER

IGNEOUS ROCKS

- Basic lava flows *(including pyroxene andesite, basalt, and tuffs)* — TERTIARY
- Intrusive igneous rocks *(including granite, monzonite, and diorite)* — TERTIARY AND OLDER
- Intrusive igneous rocks *(including pyroxene diorite, gabbro, pyroxene andesite, and basalt)* — TERTIARY
- Rhyolite *(flows, tuffs, and intrusives)* — EARLY MESOZOIC(?) AND TERTIARY
- Greenstone *(metamorphosed gabbro and diabase, including some tuffs)* — LATE PALEOZOIC

× Gold placer

★ Gold lode

● Coal

■ Antimony-quicksilver lode

GEOLOGIC SKETCH MAP OF THE RUBY-KUSKOKWIM REGION, ALASKA

By J. B. Mertie, jr., and G. L. Harrington

Scale 1/750,000

10 0 10 20 30 40 50 Miles

1916

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less. High-lying gravels were noted by Eakin [1] at several localities in the Innoko district. Among the higher mountain groups glacial and glaciofluviatile deposits are present in a few places.

The valley fillings consist of silt, sand, and gravel, in various relations. The silt and finer deposits commonly lie at higher levels, and the gravels and coarser material near bedrock. On the headwaters of the creeks little silt is present, the deposits consisting mainly of gravel. The deposits farther downstream become very deep in the broad valleys of such rivers as the Sulatna, Nowitna, Takotna, Iditarod, and Innoko.

The residual material consists of unconsolidated rock breccia and clay, derived from the disintegration of the country rock. It is widespread and of considerable depth, especially in the area between Poorman and the Yukon. At the head of Flat Creek, in the Iditarod district, placer gold is associated with residual deposits.

MINERAL RESOURCES.

GENERAL FEATURES.

Placer gold is the only mineral deposit in the Ruby-Kuskokwim region that has been exploited on a commercial scale. There are several general areas where placer mining is now being carried on. These areas are considered and discussed separately below.

Where so much placer gold is found it is reasonable to expect the development of gold lode mining some time in the future. As yet, however, little lode mining has been done. Eakin [2] reports the development of a gold lode in a small way in the Innoko district. At the head of Flat Creek, in the Iditarod district, there are numerous small quartz stringers which look promising as potential gold lodes. On the hills north of Moore Creek vein quartz carrying gold was picked up by the senior writer. It is probable, however, that the placer gold areas in this region will be more or less depleted before the advent of lode mining, for in much of the region rock exposures are not plentiful, and prospecting for gold lodes means much development work.

During the summer of 1915 considerable stibnite (the sulphide of antimony) was shipped from the Fairbanks district, showing the possibility of the exploitation of antimony deposits in Alaska under the present demand for that metal. Stibnite ore has been uncovered at several localities in the Innoko and Iditarod districts. Such deposits may be exploited at some later date.

Cinnabar (the sulphide of mercury) is found in the concentrates on a number of creeks in the region. The economic importance of cinnabar as a mineral product for export from this region is questionable,

[1] Eakin, H. M., The Iditarod-Ruby region, Alaska: U. S. Geol. Survey Bull. 578, p. 26, 1914.
[2] Idem, pp. 28-29.

but probably in time it will be used as a local source of mercury for use on the copper plates which are utilized in catching the fine gold. The cinnabar in the concentrates at Candle Creek is already being treated in retorts and used for this purpose. The abundance of cinnabar in the concentrates at certain localities lends encouragement to the belief that future prospecting may uncover cinnabar lodes of economic importance.

Cassiterite (the oxide of tin) occurs on several creeks in the Ruby district, in the concentrates from the gold-bearing gravels. The amount is too small, however, for this to be considered as a possible important source of tin.

Scheelite (the tungstate of calcium) occurs in the concentrates taken from Otter Creek, in the Iditarod district. It is therefore present in the basin of that creek, and probably the bedrock source will sometime be discovered. The possible value of such a discovery depends on the character and extent of the deposit. Scheelite-bearing pegmatites in the Fairbanks district are now being prospected as a possible source of tungsten. The present high value of tungsten would justify the recovery of the scheelite from some of the concentrates of placer mining.

Coal has been found in several places in the Ruby and in the Innoko-Iditarod districts. In the Ruby district it has been found on Poorman Creek and has been reported from Quartz Creek. There is also some evidence of coal on one of the tributaries of Basin Creek, and Maddren [1] states that coal is reported from Homestake Creek, a tributary of the upper Nowitna.

In the Iditarod district two seams are known to exist at the crest of the ridge between Flat and Iditarod. These seams have not been prospected to a depth sufficient to learn the true character of the coal; but if there is any place in the Ruby-Kuskokwim region where native coal would prove valuable, it is in this locality, where wood is so scarce and costly.

GOLD PLACERS.

RUBY DISTRICT.

GENERAL CHARACTER.

The placers of the Ruby district are in general of uniform character. Most of them are deeply covered, irregularly distributed, discontinuous bodies lying in the bottoms of the broad silt-buried valleys, and though numerous producing placers are on so-called bench claims, they are generally little if any higher than the bedrock bottom of the filled valleys in which they lie. Colors of gold may be found in the bottom of almost any valley throughout the slate and schist area, but the gold is not concentrated sufficiently to make its recovery commercially

[1] Maddren, A. G., oral communication.

practicable, and it is only where there has been considerable primary concentration or a local reconcentration that the deposits are being worked. On none of the creeks throughout the district is there an extensive continuous pay streak. An increase in richness may be noted at the mouths of some small lateral draws, and this result might be obtained by concentration of the placer gold from the breaking down of gold-bearing quartz ledges within the drainage basins of these small tributaries. Even where the basins of lateral feeders are very small, there is at the mouths of some of them a marked enrichment of the gravels of the main stream.

RUBY CREEK.

The gold deposits on Ruby Creek are of greater interest historically than economically, as it was on this creek that the first mining was done in the Ruby district. The creek is less than 2 miles in length, and the placer ground lies near its mouth on a small bench on the east bank. The gravels and overlying muck average a little more than 12 feet in thickness. At the bottom is a layer of finer wash filling the interstitial spaces in a blocky limestone bedrock, overlain by and interbedded with other thin layers of gravel. Above this is the muck, which contains larger, well-rounded bowlders of intermediate igneous rocks, together with cobbles of vein quartz. The fine gold is associated with the sediments in and on bedrock. The total production from Ruby Creek is probably little over $2,000. During the summer of 1915 work was done intermittently on the creek, but the small catchment basin makes it possible to work only while the seepage from rains affords water for sluicing.

LONG CREEK AND TRIBUTARIES.

Regarding the deposits in the Long Creek basin Eakin[1] says:

> The valleys of Long Creek and its tributaries contain remnants of older alluvial deposits that stand considerably above the present flood plains of the streams. The bedrock floors of the valleys are practically level in cross section, so that the depth to bedrock often increases away from the streams toward the valley wall. There is also a general increase in depth to bedrock downstream.

Above Long all the mining has been done on the left side of the stream at distances of 100 to 600 feet from it. Just above the mouth of Bear Pup the ground is only 20 to 30 feet deep, but farther up it ranges from 30 to 50 feet, of which the bottom 6 to 8 feet is gravel. In places the pay streak is on bedrock; in others it is above a false clayey bedrock, which may be 2 or 3 feet above the true bedrock. The muck contains numerous fragments of unworn, brecciated vein quartz. Over half the gold on "No. 3 above" is in nuggets, and although many of these show some rounding, a very considerable

[1] Eakin, H. M., The Iditarod-Ruby region, Alaska: U. S. Geol. Survey Bull. 578, pp. 40-41, 1914.

number have a spongy appearance, and their edges are but slightly rounded, indicating that the gold has traveled only a short distance from its bedrock source.

Gold has been mined on lower Long Creek from Long to a point below Snow Gulch, and most of the workings are farther from the stream than those above Bear Pup. It is about 75 feet to bedrock on the Mascot bench, at Long, but this depth is due to the distance from the creek up the hill slope. The workings are at about the creek level. Farther downstream the gravels are covered by less overburden. At the lower end of the Novikaket Association's ground, a mile below Fourth of July Creek, the depth to bedrock ranges from 20 to 40 feet, depending on the distance from the main stream. A little below Snow Gulch Long Creek flows over a bedrock riffle, and from this point downstream the bedrock slope is greater than the present stream gradient. Eakin[1] estimates that the depth to bedrock increases at least 10 feet to the mile below the last workings on Long Creek.

The section encountered varies somewhat in the different localities. The uppermost 15 to 30 feet consists of muck; below this is 5 to 30 feet of mixed gravel and muck, commonly termed "slide," in places represented by a layer of rather fine gravel called "chicken feed," and below this is the auriferous gravel, or "sediment," which may be 8 feet thick. The nature of the pay streak varies greatly. In some places it lies within the top 1 or 2 feet of bedrock or in gravel on the bedrock; in others it is above a false bedrock or clay seam which lies 2 or 3 feet above true bedrock and below which there is usually no gold.

The gold is almost everywhere associated so closely with a gravel containing rather large pebbles embedded in a clayey matrix that it is necessary to break up the material before it passes through the sluice boxes, for it would not only pass out without releasing its gold but would perhaps pick up gold from the boxes as it rolled through them. To avoid this result the gravels are washed into the dump box by a jet of water from a nozzle, the pressure for which is obtained by pumping; thus the clay lumps are disintegrated before reaching the sluice boxes.

In general the gravels are frozen, and little timbering is necessary. On the Mascot bench, however, thawed ground was encountered, and it was found necessary to advance the drifts by forepoling, thus increasing the cost of mining very appreciably. Under average conditions ground can be profitably worked by underground methods when it carries from 85 cents to $1.25 to the square foot of bedrock. There is much ground which just affords wages, but one place is said to have averaged over $15 a square foot of bedrock surface over a considerable area, and most of the operations are conducted on ground averaging $1.50 to $3 to the square foot of bedrock.

[1] Op. cit., p. 41.

On upper Long Creek two men worked during the winter on the fraction just below No. 2 above Discovery, and a mine on "No. 1 above" employing about 10 men was operated during the early part of the summer. Two other mines in the vicinity, employing about 28 men, were worked until August 1. In June two men were prospecting the bench claim above "No. 1 above." During the winter prospecting was done on the Mascot bench with a Keystone drill, and nine other outfits, employing a total of about 70 men, were prospecting or mining on lower Long Creek. During the summer some prospecting was done on the hillside and the crest of the ridge above Long. There were also eight or nine outfits mining or sluicing their winter dumps, employing about 65 men, but this number was decreased at the end of the summer to four or five, employing 25 to 30 men.

The tailings on the Mascot bench were reworked early in the summer, cable-drawn scrapers being used. Some $25 nuggets were obtained, and it seems noteworthy that nuggets so large should be found during operations of this nature. An explanation may be afforded by the possibility that they had been transported through the sluice boxes the first time in clay-cemented lumps of gravel. Another explanation may be sought in the fact that the water used for the first sluicing was impounded, pumped back into the sluice boxes, and used over and over again. The fineness of the suspended silts and the small area of the settling pond prevented anything near complete clarification, consequently the water for sluicing was exceptionally dirty. The amount of silt present increased the viscosity and specific gravity of the liquid and decreased the relative weight of the gold, so that it was more easily carried or rolled. The following principles, discussed by Gilbert,[1] may serve to explain why the coarse particles of gold should be more easily transported in a silt-laden stream:

> The law found for stream traction is that the load of the initially transported grade is increased by the moderate addition of other débris, provided the added débris is relatively fine. * * * In stream traction the pathway for larger particles is smoothed by the presence of smaller particles and rolling is promoted.

The gravels of Bear Pup are so shallow that they can be mined by open-cut methods. The section consists of 6 to 8 feet of gravel, overlain by about 15 feet of muck. The muck is sluiced or scraped off, and the gravels are then hoisted in order to get elevation for the line of sluice boxes. The stream has been practically worked out in the channel for about a mile and a half above its mouth. In the season of 1915 operations were confined to the southeast side of the stream, where one small outfit worked in the spring and two outfits, employing about 30 men, operated late in the summer.

[1] Gilbert, G. K., The transportation of débris by running water: U. S. Geol. Survey Prof. Paper 86, p. 213, 1914.

Some of the stream gravels were fairly rich, and several nuggets worth $50 or over were found. This gold shows some wear but is far from being completely rounded. The largest nugget in the Ruby district, valued at $1,900, was found on the Mascot bench at the mouth of Bear Pup. A $200 nugget is reported from the bench claim below, and the gold apparently gets finer down Long Creek, that from the claim below the Novikaket group being very fine. It is said to assay from $17 to $17.65 an ounce. No consistent difference is to be noted in the value of the gold from the upper and lower workings.

Three miles below Long, in a small depression between Snow Gulch and Fifth of July Creek, about a third of a mile from Long Creek, some mining was done during the winter and spring of 1915 by a small plant. The working shaft, 75 feet deep, passes through 40 feet of muck and 35 feet of gravel and slide rock. Most of the gold lies close to the white clay bedrock, but some of it is scattered through 4 feet of the clay. The ground is extremely spotted. The gold is fine and the nuggets found are few and small, the largest being worth about $5.

Short Creek valley is less deeply filled with alluvium than the valleys farther up the main stream. The covering of muck amounts to but 6 or 8 feet and lies above 4 to 6 feet of well-worn gravel and sands containing numerous iron-stained bowlders of quartz and cobbles of greenstone. These deposits are being worked by open-cut methods about half a mile above the winter trail and are said to contain a little gold for half a mile farther up the creek. The gold content is low but generally runs in a somewhat irregular and poorly defined channel. The pay streak usually lies within a foot of bedrock. Open-cut operations have been carried on for the last two years but were seriously hindered in 1915 by the frequent lack of water in Flat Creek, from which water for sluicing was obtained. Besides the gold, some cassiterite is obtained in the concentrates from the boxes. It is rather finer grained than that found on other creeks in the district. No attempt has been made to save it.

The gravels on Midnight Creek are worked by underground methods. The only property being worked in 1915 lies about a mile above the winter trail to Sulatna River. Operations were carried on at a relatively shallow depth, the muck being only about 14 feet thick, and the 4 feet of gravel immediately beneath was being mined. Apparently the mining was done on a false bedrock or clay-cemented band, as true bedrock was not seen nor was angular blocky gravel found on the dump, which contained many large quartz and greenstone bowlders. The depth to bedrock increases considerably downstream, as a hole sunk near the winter trail is said to have been 80 feet deep. If the depth at the locality where mining was being done is 20 feet, a continuation of this grade would give a depth of over 125 feet to bedrock at the mouth of the creek. The gold found has all

been very fine, with a few 25-cent nuggets. Associated with the gold is a considerable amount of cassiterite, which it might prove advantageous to save, although the annual production from gold placer operations would amount to only a few hundred pounds.

Greenstone Creek is like Midnight Creek in many respects, and its valley includes extensive deposits of auriferous gravels, though their tenor is said to be low. The placer ground is said to be over 100 feet wide in the bottom of the valley, which is considerably wider, and to extend for over 2 miles along the valley. Considerable development work has been done in preparation for working on a large scale. On the lower part of the creek a large amount of stripping has been done, and a dam has been put in for storage of water for sluicing. During the winter of 1914–15 about 40 prospect holes were sunk on the upper part of the creek, and in the following summer about 65 more were put down from 5 to 17 feet deep to test the ground for dredging. Favorable results were obtained, and a dredge is being installed. Tin is also found on this creek and may prove a valuable accessory mineral in dredging operations.

Last Chance, Basin, and Ptarmigan creeks are tributaries of Long Creek from the west. They have been prospected, but Basin Creek is the only one upon which mining has been done. Two of its tributaries, Willow and Swift creeks, received attention in 1915. Some prospecting was done on the headward tributaries of Willow Creek in an effort to locate shallow ground for open cutting, but the results were unfavorable. A few holes were also sunk about a mile from the mouth of the stream. The upper holes are 35 feet deep, and a quarter of a mile farther down bedrock was not reached at 70 feet. Mining was being done on a false bedrock of clayey gravel. Owing to lack of water, only a small amount of gravel was taken out. The gold is fine, bright, and but slightly rounded. Little or no sulphide is associated with it, but there is a considerable amount of magnetite.

The upper part of Swift Creek has been worked by open cutting, and two men are now working on a single claim farther down. On this claim there is 6 to 8 feet of gravel overlain by 10 to 12 feet of muck. The muck is removed by sluicing, and the gravel is hoisted by a windlass. A considerable amount of the gold is in nuggets; one valued at $50 was the largest seen. One layer of the gravel is very carbonaceous. The source of this material is doubtful, but it may be decomposed débris from a buried coal seam farther upstream, as coal fragments are said to have been found near by.

UPPER SULATNA RIVER AND TRIBUTARIES.

Long Creek joins Sulatna River about 3 miles below the mouth of Greenstone Creek. The next tributary on the east is Monument Creek, on which prospecting has been done for several years and some

mining operations were conducted in 1913. Since then there has been further prospecting, and two small outfits were on the creek in 1915. Ophir Creek has been prospected, but there were never any extensive mining operations on it, and nothing was being done in 1915. Late in the summer a small prospecting outfit was working on Star Creek, but this was not visited.

On the south side of the Sulatna there are several creeks which have received attention. Gold Run, Banner, and Spangle creeks were early staked, and good prospects are said to have been found on Gold Run and Banner creeks, but no mining was undertaken. Spangle Creek was prospected and then the claims were allowed to lapse. It was restaked in 1915, and one party of three men did some prospecting in August, but without results. Fourth of July Creek is being held, but little or no work has been done to ascertain the value of the ground.

Spruce Creek was among the creeks early staked and then left idle after a nominal amount of prospecting. A part of it was still held in the winter of 1914–15, but the lower part was open to location. Active prospecting on this ground showed workable deposits and led to the restaking of the creek below the mouth of Schist Creek. During the summer six outfits, comprising about 15 men, were on the creek for a part of the summer engaged in prospecting or mining, and obtained considerable gold. The stream flows in a rather broad valley with a gentle gradient, apparently about the same as that of the bedrock channel, which lies at depths of 55 to 70 feet. Mining operations have been conducted for about 3 miles along the valley. The ground is generally frozen to bedrock, but thawed ground and water were encountered at one place, and the hole was abandoned for summer work. The gravel is from 2 to 5 feet thick and is made up of several varieties of igneous rocks and dark siliceous slates, usually with considerable clayey material. The gold is found in the gravel close to bedrock. Most of it is well rounded and rather fine, though several $2 to $3 nuggets have been found. Some of these nuggets contain vein quartz. The workable gravels range from some yielding 75 cents a square foot of bedrock to rich spots from which $12 pans are reported.

Tamarack Creek, staked in 1912, was actively prospected in 1913, and mining has been carried on since. During the summer of 1915 four plants, employing about a dozen men, were at work; three were using steam hoists and the other a hand windlass. A number of holes were sunk about 1½ miles from the Sulatna, but the first plant is located about half a mile farther upstream, and work is being done for about 1½ miles along the creek above this. The holes average 60 feet in depth throughout that part of the creek which is being worked. The bottom layer consists of 1 to 5 feet of "soft" bedrock

above the true bedrock. Above this is 3 to 8 feet of gravel, and the rest is muck. The gold lies in the upper foot of soft bedrock and in the lower 3 feet of gravel, on what appears to be the rim of an old channel.

The gold is rounded and shotty, not flaky, running mostly in pieces worth 10 cents to $2. One $50 nugget has been found. Assay returns show that the gold ranges from $16.50 to $17 an ounce. Mining costs are reported to range from 40 cents to $1 to the square foot of bedrock, and the gravels worked yield 75 cents to $2.50 to the square foot of bedrock.

TRAIL CREEK.

Workable ground extends for over 2 miles along Trail Creek, and colors are said to have been obtained down the valley for 17 miles. During the winter of 1914–15 four plants were working on the creek and three of these continued operations during the summer. There is a small difference in the thickness of the valley filling within the area where mining is being done. The upper workings show a thickness of 30 to 35 feet of frozen muck and gravel, in which the gravel amounts to 2 to 5 feet. At the lower workings the thickness increases to about 40 feet, with about the same amount of gravel. It is said that 7 miles downstream the depth to bedrock is 70 feet. The upper course of the creek presents conditions similar to those on Long Creek, the depth to bedrock increasing away from the creek, owing to the difference in bedrock and surface profiles.

The gold lies close to bedrock, in the little-rounded, coarse gravels. It is irregularly distributed, but the gravel is reported to be richer at the mouths of small tributary gulches. The average value is said to be between $1 and $2 to the square foot of bedrock surface. On the upper part of the creek about 10 per cent of the gold is in nuggets worth over $5, the largest having a value of about $300. Some of the gold is spongy in appearance and shows little rounding, but some is well rounded. Assay returns give the value of gold in this vicinity at about $16.85 an ounce. The gold and silver occur in the ratio of 5.5 to 1.

FLINT CREEK AND TRIBUTARIES.

During the winter considerable prospecting was done with a churn drill near Root Gulch, on upper Flint Creek, but without result, and no mining is being done. In former years there has been considerable prospecting of the creeks between Root and Glen gulches, but no extensive mining. Most of the dumps from the prospect holes show angular granitic débris, associated with the gravels of metamorphic rock, both near the creek and on some of the ill-defined terraces that are considerably above it.

Two mines on Glen Gulch took out small winter dumps in 1915 at a locality about a mile and a half above the mouth of the creek, and two other plants did some winter prospecting, but nothing was attempted during the summer. At the locality where the work was done, on the south side of the creek, it is 25 to 30 feet to bedrock, of which from 1 to 7 feet consist of gravel. Farther upstream the ground is shallower, and some open-cut mining was done. Considerable good ground was found about a mile up from Flint Creek, but it has been mined out. Prospecting at the mouth of Glen Gulch in the deeper gravels has thus far proved fruitless. The ground is frozen, and thawing is necessary. Here the gold is usually found in the first foot of gravel or in the shattered bedrock. The gold is somewhat rough, and some of it is coarse, nuggets worth as much as $150 being reported.

When the mining operations were begun on Glen Gulch ground was staked on Lucky Gulch, and there was some prospecting, but the results obtained were not promising and no mining has been done.

In 1914 Birch Creek was staked and considerable prospecting was done on it. During the winter of 1914–15 three mines were being worked and some other claims were being prospected. Bedrock on this creek is deeper than on any of the others worked, as it lies 70 to 90 feet or more below the surface. On the south side of Crooked Creek to its mouth there is an ill-defined silt terrace several feet above the creek level but below that on the south side of Birch Creek. As the bedrock slope is less than that of the surface of the terrace, holes sunk on the terrace are considerably deeper than those put down in the present stream valley. Normally they show 40 to 50 feet of silts and sands, and the rest of the depth to bedrock is made up of gravel with clayey layers. Some of the silt layers are reported to contain leaf impressions. It is said that near the mouth of the creek there are layers of iron-cemented gravel near the bottom. The iron is probably derived from the oxidation of the pyrite in the sands or from the leaching of the pyritiferous slates, which, with numerous large bowlders of vein quartz, make up the gravels on lower Birch Creek. On the upper part of this stream igneous rocks constitute a larger proportion of the gravels.

Gold is found for 2 miles or more along the lower course of Birch Creek and between Straight and Crooked creeks. It occurs on or near bedrock, which is said to be granite on the upper workings and black pyritiferous slate farther downstream. The gold from the granite is fairly coarse, much of it is badly tarnished, and the concentrates contain tin and a little pyrite. The concentrates from the lower workings are composed mainly of pyrite, and the tailings dumps emit a distinct odor of SO_2, produced by its oxidation.

Mining and prospecting are rendered difficult by thawed ground and live water, which may be encountered below 80 feet. The amount of water and the depth make it almost impossible to prospect without a rather large plant having sufficient boiler capacity to do the necessary pumping.

POORMAN CREEK AND VICINITY.

Poorman Creek lies in the Innoko River basin, being separated from the Sulatna drainage basin by a broad ridge whose altitude is between 1,050 and 1,100 feet. Duncan and Tenderfoot creeks, tributaries of Poorman Creek, rise in this ridge opposite the heads of Tamarack and Spruce creeks, which flow into the Sulatna.

Poorman Creek was staked early in 1913, and in the same year some prospecting was done and a small amount of gold produced. In the last two years mining has been actively carried on. In 1915 eight mines employing about 40 men were operated during most of the summer, and three or four other outfits of two or three men each worked for short periods or were engaged in prospecting during a part of the season. The work was confined to a distance of about 3 miles along the north bank of the creek, except for one outfit working on Little Pup, a tributary from the south. In general the work is being done on bench claims, and the old channel in places lies on the second-tier bench.

The north bank is the gentler, and, as in the vicinity of Long Creek, the bedrock floor of the old valley is wider than the present stream, and depths to bedrock increase with distance from the creek. There seems also to be a slight increase in depth downstream. The thickness of the valley filling ranges from 45 to 80 feet, as determined by mining operations; the deepest shaft was on one of the bench claims.

The section consists of coarse gravel, 2 to 12 feet; fine, sharp, clean gravel or "chicken feed," 6 inches to 12 feet; and muck to the surface. The material is frozen down to bedrock. The coarse gravels consist largely of bowlders of vein quartz and rusty quartz breccia or conglomerate, with varying amounts of igneous rocks, quartzite, slate, and chert. In the concentrates pyrite is the most common mineral, but it decreases in amount downstream. Rounded and polished pebbles of cassiterite showing concentric structure are common, as is also barite, and there is a small amount of magnetite.

Most of the gold lies close to the bedrock surface, but it may extend up into 2 or 3 feet of gravel. Its assays average about $17.30 per ounce. Nuggets worth $25 have been found, but as a rule the gold is rather fine. It is mostly somewhat rough, and small pieces of vein quartz are attached to many of the larger pieces. Though usually bright, the gold from at least one prospect was dull and

nearly black. The minimum cost of mining is about 60 cents to the square foot of bedrock, but some ground running a little less has been worked. The richest ground is said to run about $5 to the square foot.

Flat Creek was staked during the winter of 1913–14 and yielded considerable gold in the following summer. The production was materially increased in 1915, when there were 18 men working on seven claims. The creek is a small tributary of Timber Creek, which heads against Little Pup. The gradient is gentle, but there is an abrupt headward steepening. The uppermost workings lie less than a quarter of a mile from the head, and others extend down the creek for about 1½ miles. Near the head the depth to bedrock is 50 feet, 2 feet of which is gravel. Farther downstream the depth increases to 55 feet, including 5 feet of coarse material. In the workings of the two outfits farthest downstream the depth increases to 65 feet, including over 20 feet of gravel. Of this 20 feet the lower 15 feet is somewhat rusty and oxidized, differing from the upper layer of unoxidized gravels characteristic of the rest of the creek, and probably represents an old channel of Timber Creek. These gravels carry some gold on bedrock. On the upper part of the stream most of the gold is found in or near bedrock in the subangular gravels, but some of it occurs above a clay seam constituting a false bedrock a short distance above the base of the gravels. Associated with the gold are pyrite, rounded grains of cassiterite, magnetite, and a small amount of arsenopyrite. It is peculiar in its fineness and extreme roughness and in the amount of quartz attached to even the smallest particles. Such nuggets as have been found are small. It is stated that assays show the gold to have a value of about $15.75 an ounce. Mining costs are in the vicinity of 75 cents to the square foot of bedrock and the ground carries from 50 cents to $4 a square foot.

OTHER CREEKS.

There are numerous other creeks in the district that contain some auriferous gravels, and many of the tributaries of the Sulatna have been prospected in the endeavor to locate workable deposits. Easy Money and Tip creeks were prospected in 1913. At their junction it was 80 feet to bedrock. On White Channel, a tributary of Trail Creek, holes were sunk more than 150 feet without reaching bedrock, but disclosed the presence of an unknown depth of white quartz gravels. Some prospecting was done here during the winter of 1914–15. Quartz Creek has also received some attention, and holes sunk on the main stream and on Rabbit Creek early in 1915 represent the last work done. Fine colors were obtained, but no workable placer ground was located.

More or less prospecting has been done along Big Creek, a tributary of the Yukon, ever since the first discoveries were made in the district. No mines have yet been developed. During the summer of 1915 a churn drill was working near the head of the stream and holes were also being sunk on small tributaries southeast of Ruby.

Late in the summer of 1915 there was a stampede from Ruby to take ground a few miles upstream and across the Yukon on one of the lower terraces. The auriferous gravels lie below 20 feet or more of clean white quartz bowlders, which are covered with several feet of fine sediment or muck. Sufficient work had not been done in the fall to determine the value of the deposits.

At various times prospectors have sunk holes on the creeks between Tamarack Creek and Nowitna River, but the so-called "hard formation" has never yielded even a fair prospect, and their endeavors were shifted to creeks lying within the metamorphic area, which gave greater promise.

CRIPPLE CREEK MOUNTAINS.

The gold-bearing creeks in the Cripple Creek Mountains were not visited by the Survey party in 1915. It was reported to the senior writer, in Iditarod, that this locality is still in the prospecting stage, although some mining is being carried on both by drifting and open-cut methods. The status of operations there in 1912, when the creeks were visited by Eakin,[1] was as follows:

> The work that has been done in the vicinity of the Cripple Creek Mountains on Cripple Creek, Fox Gulch, Colorado, and Butte creeks has been all prospecting. Workable deposits of placer gold apparently exist on some of these streams, but the existence of large placers has not yet been demonstrated. The gravels on the streams range in depth from 10 to 20 feet. Values vary and probably range in places up to $2 a square foot of bedrock surface. The future of placer-mine development in this locality will depend upon the extent of such deposits, which will be known only when much additional work has been done.

INNOKO DISTRICT.

The Innoko district was west of the line of travel of the Survey party in 1915 and therefore was not visited. For the sake of completeness, however, the latest information on this district, obtained by Eakin[2] in 1912, is included:

> Prior to the summer of 1912 the only workable placer-gold deposits known to exist in the Innoko district were those on Ophir, Spruce, Little, Ganes, and Yankee creeks. These streams are practically parallel and are tributary to Innoko River from the southwest—except Little Creek, which is tributary to Ganes near its mouth— in the order given, progressing upstream. The placers on all are within a few miles of the Innoko. Gold prospects are said to occur on several other streams in the same neighborhood. * * *

[1] Eakin, H. M., The Iditarod-Ruby region, Alaska: U. S. Geol. Survey Bull. 578, p. 38, 1914.
[2] Idem, pp. 35-36.

All placers of the Innoko district are of medium or shallow depth. The bedrock throughout the placer areas consists of members of the Cretaceous sedimentary series and of igneous intrusives. The latter are mainly acidic dikes and sills. * * *

PLACER MINES.

Ophir Creek.—The mines of Ophir Creek have been among the chief producers of the Innoko district, but the available placer ground is now nearly exhausted.

Auriferous gravels formerly extended almost continuously along Ophir Creek valley for about 2 miles. They ranged up to 70 feet in width. The alluvium is 30 feet deep at the lower end of the valley. Its depth gradually becomes less upstream, and in the upper mines it is less than 20 feet.

Bench gravels have been exploited at a single point at claim No. 6 above Discovery. The bedrock floor of the bench is 7 feet above the flood-plain level and is overlain by a 10-foot thickness of gravels.

The alluvium of Ophir Creek is largely composed of slightly worn materials of the local bedrock. Well-worn gravels are rare. Silt and muck are also included in the upper part of the deposits. Practically all the alluvium is permanently frozen.

Spruce Creek.—The developed placers on Spruce Creek are on a low bench on the east side of the valley about 3 miles above the mouth of the stream. Two claims have proved rich enough to support mining by economical open-cut methods. A ditch delivers water from a point farther upstream, at the upper margin of the bench deposits. The overburden is groundsluiced off, and the gold-bearing material is then shoveled by hand into lines of sluice boxes.

The gold occurs in the shattered surface of bedrock and in an overlying stratum of gravels 2 to 6 feet thick. The gravels are overlain by 10 to 15 feet of very wet frozen muck or silt. The width across valley of the deposit available for mining differs from place to place, but is at some places more than 100 feet. The gold tenor of different parts of the deposit depends largely upon the roughness of the bedrock surface beneath and is extremely variable from place to place. Little is known of the gold tenor of the gravels farther downstream, where the bench continues for the length of several claims.

Little Creek.—Auriferous deposits occur for about 2 miles along the valley of Little Creek. They have proved to be rich enough to support mining through much of this extent. They are in part the gravels of the present flood plain and in part bench deposits. The flood-plain deposits are relatively narrow and those of the benches relatively broad.

The lower creek claims and the bench claims contain shallow placers worked by open-cut methods. The stream gravels are 18 to 30 feet deep farther upstream, where underground methods of mining are employed.

The alluvium in the lower creek placers is made up almost entirely of gravels. It includes a few large bowlders, but they offer no special hindrance to mining by the methods in use. There is usually a slight overburden of muck. The greater depth of the creek placers farther upstream is due chiefly to the greater thickness of muck above the gravels.

The benches are best developed along the middle reaches of the stream's course, and where widest they extend 500 feet from the creek. About 300 feet of this width is said to carry values sufficient for profitable mining. The gold occurs throughout a considerable thickness of gravel that is overlain by a thin deposit of muck. In mining a method is employed that is similar to that used on Spruce Creek—that is, the overburden is removed and the gravels are concentrated as much as possible by groundsluicing, after which the gold-bearing materials are shoveled by hand into lines of sluice boxes.

Ganes Creek.—Ganes Creek has a pronounced development of gravel-covered benches along the right side of the valley and below the canyon a rather broad gravel-

covered flood plain. Gold occurs in the gravels of both types of deposits, but thus far only the bench gravels have proved available for mining. It seems likely that the flood-plain gravels may contain fairly high values in places, but the work of prospecting them is difficult because they are thawed.

The original concentration of gold in the Ganes Creek valley occurred in preglacial time, when the stream was much shorter and had less volume. Apparently a continuous pay streak was formed at that time extending for miles along the stream. When the stream cut down to its present level part of the old pay streak was carried down and reconcentrated in the present stream gravel and should be found in the reaches between the gold-bearing benches. Parts of the original concentration remain in the bench gravels. Where lateral streams cross the course of the old pay streak they have concentrated its values from the width of the tops of their recently cut valleys to the narrow gravel deposits in their bottoms. This form of reconcentration has probably produced some of the richest spots of the Ganes Creek valley.

The Ganes Creek placers have been worked almost entirely by open-cut methods. Water for sluicing is taken from the small tributaries of Ganes Creek, and in many places work has progressed slowly on account of the small supply. The bench gravels have now been nearly worked out, and the future of Ganes Creek as a producer will depend largely upon the gold tenor of the flood-plain gravels. If systematic prospecting should prove their worth, these gravels would be admirably adapted for dredging.

Yankee Creek.—The Yankee Creek placers are between 6 and 7 miles above the mouth of the stream and are all included apparently in two association groups of claims, each comprising 160 acres. Yankee Creek has an exceptionally broad, flat valley, and the auriferous deposits have a correspondingly wide cross-valley extent. The alluvium consists of a stratum of gravel 5 to 7 feet thick, which is overlain by a thin bed of muck. The ground is mostly thawed in summer and is worked exclusively by open-cut methods.

A placer gold strike is reported to have been made on Tolstoi and Boob creeks during the winter of 1915–16. Tolstoi Creek is about 40 miles in length and is tributary to Dishna River (known locally as Ditna), which is part of the Innoko system. It heads in the Beaver Mountains, but has also a number of tributaries which head around Mount Hurst.

The Beaver Mountains contain much monzonite, a rock which, as elsewhere pointed out, is an important source of the gold in the Ruby-Kuskokwim region. In the Mount Hurst area, however, the country rock consists mainly of phyllite, slate, quartzite, chert, and crystalline limestone. Prospecting has been carried on intermittently in this area since 1908, and gold has been found in small quantities on a number of creeks. If the productive ground is in this general vicinity, it is most likely that the gold is derived from quartz veins, which are plentiful here, as in the Ruby district. If so the gold is likely to be less localized than where the bedrock source is a body of granitic or monzonitic rock.

CANDLE CREEK.

On the upper part of Candle Creek, a tributary of Tatalina River about 12 miles long, active mining was begun on a four-claim association by the owners in 1914 and continued by laymen in 1915.

The laymen had been working only two weeks at the time when this creek was visited (July 31), and no clean-ups had yet been made. This outfit, consisting of two laymen and nine others, represents all the mining activity in this vicinity at present.

A ham-shaped body of monzonite, with the shank pointed downstream, forms the bedrock in the upper part of Candle Creek. It extends downstream about 3 miles, ending about three or four claims above Discovery claim. The divide at the head of Candle Creek is made up of a hard, dense basalt, but the spurs on both sides of the valley are composed largely of sandstone and shale, presumably of Cretaceous age. The stream gravels are from 9 to 15 feet thick in the upper part of the creek, where they are being worked, and increase gradually downstream. Bowlders 4 feet in diameter occur in the gravel, and smaller ones are numerous. Basalt and monzonite are the chief materials of the gravel.

Open-cut methods were being used at the time this creek was visited, but a hydraulicking outfit was nearing completion. On account of the scarcity of water in the headwaters of the creek, a bedrock basin has been excavated above the workings to catch surface and ground water, and a head of 100 feet will be developed.

The gold is irregularly distributed through the gravel in grains averaging about 1 per cent. Very little flour gold is reported. The heavy sand recovered with the gold is reported to be largely cinnabar, with some magnetite.

There can be no doubt that the gold at this locality is connected genetically with the monzonite. Quartz veins cut the monzonitic bedrock, and it is entirely probable that these veins, with perhaps mineralized zones in or adjacent to the monzonite, constitute the source of the gold. Furthermore, it appears that the richest ground is on the upper part of the creek, where the bedrock is monzonite. Below the monzonite prospect the tenor of the gravel is lower. From 250 to 350 drill holes have been sunk with a No. 8 Keystone drill in the monzonite area, on the four-claim association which is being worked, and on claims Nos. 8, 9, and 10 above Discovery, which adjoin the association on the downstream side. The values reported for these prospects are exceedingly high and if this is true point to the future development of Candle Creek as a small but very rich placer-mining district.

MOORE CREEK.

The workings on Moore Creek, the south fork of Takotna River, are on the upper part of the creek, about 10 miles below its source. The gold-bearing gravels at this locality were discovered and staked about 1910, and mining has since been carried on in a small way. During the season of 1915 two outfits were engaged in mining, one on

claim No. 5 above Discovery and the other on a bench association and an adjoining fraction. Two men were at work on the creek claim and four on the bench claims.

The bedrock here is sandstone and shale, standing vertical or dipping steeply to the north and striking in general to the northeast. On the creek claim the gravel is about 10 feet thick and is composed of cobbles ranging from 6 inches to 3 feet in size, mainly sandstone, shale, granitic material, and basic igneous rock. On the bench claims the gravel is only 3 feet thick and is covered by 2 feet of clay and vegetation.

On the bench diggings mining is carried on by pick and shovel methods. Hydraulicking is used only for stripping off the overburden. The water is brought in a ditch from Willow Creek, a tributary of Moore Creek. On the creek claim hydraulicking is utilized in moving the gravel. The water coming from the bench diggings is impounded and delivered to the nozzle under a head of about 20 feet.

The gold is little worn and contains much quartz. Cinnabar is the chief heavy sand found in the concentrates, but this is much more plentiful on the creek claim than on the bench claims. Zircon and a little magnetite are also present.

As on Candle Creek, the gold is connected genetically with the mineralizing effect of monzonite. A body of monzonite occurs in the hills to the north, at the head of Willow Creek, and it is not unlikely that similar bodies may be present farther up Moore Creek, for a considerable amount of granitic rock has been noted at Camelback Mountain (known locally as Bonanza Mountain), at the head of Moore Creek.

IDITAROD DISTRICT.

GENERAL FEATURES.

Placer gold was discovered in the Iditarod district in 1908, on Otter Creek. Mining operations began in 1909 and have continued to the present time. This district is now a well-established mining community and a constant producer of placer gold. Two towns, Iditarod, on Iditarod River, and Flat, on Otter Creek, at the mouth of Flat Creek, have post offices and, together with Discovery, farther up Otter Creek, handle the business of the district. Flat and Discovery are the supply points for the adjoining mining operations.

All of the mining is of the placer type, no gold or other lodes having yet been developed into producing mines. Placer ground is being worked on Otter, Flat, Black, Slate, and Willow creeks, and Glen Gulch, and on the slopes of the granitic dome at the heads of Flat, Chicken, and Happy creeks.

CHARACTER OF DEPOSITS.

Eakin,[1] in discussing the placer deposits of this district, has divided them into two types—the alluvial deposits of gravel in the present stream valleys and the residual deposits, or those in the development of which water has played a minor part. Some of the stream deposits, such as those in Glen Gulch and on Otter Creek, at Discovery, partake of the nature of residual deposits, in that they lie in an area of monzonitic bedrock, which is the source of the gold. The residual deposits proper, however, are those in the formation of which stream action has had no place; and the deposits on the slopes of the granitic mass at the heads of Flat, Chicken, and Happy creeks exemplify this type particularly well.

STREAM PLACERS.

Otter Creek.—Mining is being done both on creek and bench claims on Otter Creek, in the vicinity of Discovery. There are six creek claims, running from claim No. 2 above Discovery claim to claim "No. 3 below." These are joined upstream and downstream by association claims. A tier of bench claims on the north bank and two tiers of bench claims on the south bank lie alongside the creek claims. About six single and association claims were being worked during the season of 1915.

The bedrock at Discovery is a body of monzonite, which extends upstream to the mouth of Slate Creek and ends downstream about three claim lengths below Discovery claim. The valley wall north of Discovery is a basaltic rock, so that the monzonite on that side of the creek is confined to the present valley floor. To the south the monzonite reaches well up into the head of Glen Gulch, where it attains its maximum width. Above and below the monzonite on Otter Creek the bedrock is sandstone and shale, supposedly of Cretaceous age, with a general strike of about N. 70° E. and a steep dip to the northwest. The gravel is composed of granitic and basaltic material, together with considerable sandstone and shaly material. The maximum depth to bedrock is about 15 feet in the creek bottom, but becomes gradually less on the bench claims.

Mining on the bench claims near Discovery is being done by means of mechanical scrapers. These remove all the loose gravel and convey it to cars, which are hauled up an inclined track and dumped into the dump box, at the head of a chain of sluice boxes. The upper part of the bedrock, which also carries some gold, is picked by hand and wheeled in barrows to the cars.

A dredge of the bucket-elevator flume type, using distillate for fuel, is at work mining the gravels of the creek. The gravels are frozen and are prepared for the dredge by thawing with steam points.

[1] Eakin, H. M., The Iditarod-Ruby region, Alaska: U. S. Geol. Bull. 578, p. 31, 1914.

According to Brooks,[1] there are two kinds of gold on Otter Creek, a coarse and a finer variety. These two are of different appearance. The coarse gold is darker than the fine and much waterworn. The fine gold is angular and bright. The concentrates contain cinnabar, arsenopyrite, and scheelite.

The monzonite that lies in the bed of the stream is undoubtedly the source, directly or indirectly, of the gold on Otter Creek. The fine, bright, unworn gold comes directly from quartz veinlets and mineralized zones within the monzonite. Brooks is inclined to believe that the coarser and darker gold has its source in antimony or cinnabar lodes that closely adjoin the monzonite.

Glen Gulch.—An association claim on Glen Gulch was worked during the season of 1915. Mining operations were suspended before this locality was visited, but it is said that manual methods were employed. The bedrock is monzonite, as on Otter Creek, and the gold occurs at the base of the gravel and in the disintegrated bedrock.

Black Creek.—Two plants were at work on Black Creek in 1915. The following, written by Eakin,[2] is an adequate description of conditions there.

> The placers of Black Creek are not well defined as to extent. It seems likely that continuous placer deposits do not extend for any great distance in the valley. However, workable deposits have been discovered locally at several places. The bedrock in general consists of members of the sedimentary series and of local bodies of intrusive monzonite. As on the other creeks, the depth of the Black Creek placers is not great, the usual range being 12 to 16 feet.

Slate Creek.—Small placer-mining operations were carried on at the lower end of Slate Creek in 1915. It is reported that the bedrock is much the same as on Black Creek and that the gravels are unfrozen.

Flat Creek.—On Flat Creek a dredge, two plants operating on bench claims, and a bucket hoist operating in the upper part of the creek were at work in 1915. The company working the dredge owns all the creek claims in the lower 3 or 4 miles of Flat Creek, down to Otter Creek, and its operations are the most extensive.

The bedrock at the extreme head of Flat Creek is monzonite. Below, down to Otter Creek, sandstone and shale, rather more indurated than other Cretaceous rocks near by, form the rock floor of the valley. Locally beds of quartzite and slate were recognized. Dikes of igneous rock cut the sedimentary rocks. Along the wagon road, about halfway up Flat Creek, the rocks strike N. 60° E. and dip 50° NW. This general northeasterly direction is believed to be the regional strike in this vicinity. The creek gravels at the point where the dredge is at work are about 10 feet deep and carry little or no overburden.

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[1] Brooks, A. H., unpublished notes on Iditarod district, 1915.

[2] Eakin, H. M., The Iditarod-Ruby region, Alaska: U. S. Geol. Survey Bull. 578, p. 32, 1914.

The bedrock configuration of Flat Creek, according to Brooks,[1] differs markedly from that of Otter Creek. On Otter Creek the bench and creek deposits merge gradually into one another, there being no sharp break or bedrock rim between the two. On the east side of Flat Creek, in its upper part, there is a bedrock reef which sharply separates the bench deposits from the creek deposits. Moreover, the gravel deposits are of different thickness and character at several localities. The bench deposits, however, merge into the creek deposits farther downstream.

The creek mining is of two kinds. The bench claims are worked by mechanical scrapers, much as at Discovery, on Otter Creek. The dredge operates in the creek gravels, which are frozen and have to be thawed ahead of the dredge by steam points.

The gold is of two grades.[1] That taken from the bench gravels is coarser and of higher grade than that taken from the creek gravels (known as the "formation gold"). There is, however, more or less intermingling of these two types, especially farther downstream, where the bench and creek deposits coalesce.

The gold of Flat Creek is undoubtedly derived from the monzonitic mass at the head of the creek. Unlike the gold around Discovery, on Otter Creek, it can not be considered to have any of the characters of a residual gold deposit, for nearly all of the Flat Creek valley has a sedimentary bedrock. The Flat Creek gold, therefore, is a typical creek placer deposit.

Willow Creek.—Willow Creek was visited in 1915 by A. H. Brooks, who states that two plants were operating there. One of these employed a drag-line excavator, and the other was operating underground, raising the gravel with a bucket hoist.

Bench and creek claims are staked, as on Otter Creek. Like that of Otter Creek, the valley is unsymmetrical, the valley wall on the west being abrupt. The bedrock is slate, and the gravels are made up largely of sedimentary rock, with lesser amounts of granitic and basaltic material. There is about 10 feet of muck overlying from 3 to 4 feet of gravel on the bench ground, but the muck thins rapidly toward the creek. The gold lies in the lower 1 or 2 feet of gravel and in the decomposed bedrock.

The source of gold is not established. It apparently is not a continuation of the Happy Creek pay streak, for Happy Creek does not carry gold to its mouth. Moreover, the gold is coarser and of somewhat higher grade. Brooks is inclined to believe that outlying lodes from the main monzonite mass have been the source of the gold.

[1] Brooks, A. H., unpublished notes on Iditarod district, 1915.

RESIDUAL PLACERS.

The residual placers have been described by Eakin. Ten claims and associations may be described as belonging to this type. Five of these are at the head of Flat Creek, two at the head of Chicken Creek, and three at the head of Happy Creek.

The monzonitic bedrock which is the source of these placer deposits is much sheared and mineralized. The mineralization appears to have been accomplished in two or more ways. Numerous quartz veinlets, from an eighth of an inch to 2 inches in width, cut the monzonite. These carry free gold, and are therefore a known source of some of the gold. Many of them have a general east or north of east direction. There are also numerous iron-stained joint planes which are probably also sources of gold. Most of them strike in accordance with the quartz veinlets, but some have a northwesterly strike. Brooks [1] has observed that on several claims there is little evidence of quartz veining or of extensive sheeting. The monzonite is iron-stained and massive, and the inference is that the rock may have been completely saturated with the mineralizing solutions.

The monzonite is deeply weathered, commonly to a depth of 5 to 10 feet and in some places deeper still. It weathers out into great rounded bowlders, which very much resemble water-worn material. Some of these have moved down the slope and are found overlying finer gravel, and in such places gravel may appear to underlie bedrock.

Mining on this granitic dome is attended with difficulties. Most of the work is done by open cuts and hydraulicking. The great difficulty, especially in the hydraulicking operations, is the scarcity of water. Ditches have been dug at numerous places along the upper slopes of the dome to catch the surface and ground water. These ditches lead the water to reservoirs, where it is impounded to give the necessary head for hydraulicking or to give a steady flow for open-cut work. Obviously the length of time during which gravel may be washed is limited by the amount of water available. The work begins when the reservoir is full and ends when the water is exhausted, giving the work an intermittent character during the day. The owner of the claims at the head of Flat Creek has built snow fences during the winter to cause the snow to collect in huge drifts, thus augmenting the summer water supply. This method will probably be followed by other operators.

The gold is bright and angular and contains much quartz. Much of the gold is very fine, and one of the operators reported that 10 per cent of his total output was recovered by amalgamating on copper plates, a process that is commonly followed. The richest part of the placer is usually near the bedrock.

[1] Brooks, A. H., unpublished notes on Iditarod district, 1915.

GOLD LODES.

Little gold-lode mining has been done in this region. Quartz and quartz-calcite veins are very common in the Ruby district, but it remains to be demonstrated how many of these are capable of supporting lode mining. Several good-sized quartz veins near Ruby have been prospected, and although small quantities of gold are reported, none of the veins have yet proved to be of commercial importance. The fact, however, that good-sized nuggets with intergrown quartz are often found favors the belief that richer veins are present and will ultimately be located and mined.

Eakin [1] reports that in the Innoko district quartz veining is common, especially in the vicinity of acidic dikes. One such quartz vein was being worked in 1912. Of this he says:

> The Independence mine is near the head of Carter Creek, an eastern tributary of Ganes Creek. The ore body is a quartz vein, averaging about 2 feet in thickness, that occurs along the hanging wall of a rhyolite dike intrusive in the sedimentary series. The microscope shows that the gold lies in iron-stained crevices and vugs in the quartz and is also embedded in grains of magnetite within the quartz vein. Veinlets of iron carbonate cut the quartz, and iron carbonate is abundantly present in the altered sedimentary rock on the one hand and in the altered dike on the other. The dike is much altered in places, so that the original character of the rock is obscure.
>
> The altered sedimentary and igneous rocks both contain more or less gold. The workings show that the vein is continuous to a depth of more than 90 feet, and there are no evident geologic reasons that it may not extend to a much greater depth.

In the Iditarod district quartz veining is not common in the sedimentary rocks except close to the intrusive rocks. The monzonite, however, contains many quartz veins. In the monzonite at the head of Flat Creek much of the quartz is bluish in color and carries free gold in grains that are visible to the naked eye. The presence of arsenopyrite and cinnabar in the concentrates here indicates that these minerals probably occur in the quartz veins. Over 500 pounds of the rich gold quartz material has been gouged out from veins in the monzonite at the head of Flat Creek and shipped to the Selby smelter, in Tacoma, Wash.

ANTIMONY AND QUICKSILVER LODES.

Vein deposits of stibnite and of stibnite and cinnabar are known to exist in the vicinity of the monzonite intrusive bodies. None of these have been worked, but it is quite possible that some of them or other lodes as yet uncovered may become producers in the future.

At the head of Wyoming Creek, in the Cripple Creek Mountains, Eakin[2] reports the presence of a 30-inch vein of stibnite and quartz. A specimen from this locality shows that quartz and cinnabar form

[1] Eakin, H. M., The Iditarod-Ruby region, Alaska: U. S. Geol. Survey Bull. 578, p. 28, 1914.
[2] Eakin, H. M., oral communication.

the walls and stibnite the center of the vein. The vein is said to occur in the contact zone between the monzonite and the sedimentary rocks.

In the Innoko district Eakin[1] saw a 12-inch vein of stibnite and quartz at the Kaatz prospect, 1½ miles above the mouth of Copper Gulch, a tributary of Ganes Creek. This vein strikes N. 30° E., dips 75° SE., and is traceable, in association with a rhyolitic dike, for 6,000 feet. Stibnite is disseminated through the vein, but is concentrated along the footwall. An examination of a thin section of this ore shows conclusively that the quartz was injected into the vein and was followed later by the stibnite.

At the border of the monzonite area at the head of Flat, Chicken, and Happy creeks lodes carrying stibnite and cinnabar are present. A sample from one of these, collected by Eakin at the head of Chicken Creek, shows a vein 2 inches thick. It is mentioned, not because of its potential significance as a lode deposit, but because it shows very well the same feature that was noted in the ore from Wyoming Creek—that is, quartz and cinnabar along the edge of the vein and stibnite in the center.

At the head of Glen Gulch a stibnite claim known as the Mohawk lode has been staked. This is a mineralized shear zone about 2 feet wide, at the contact of the monzonite with the country rock. The strike of this zone so far as could be determined is N. 45° E. and the dip 45° S., according to Brooks.

This zone, like most of the others mentioned, carries gold. Some narrow stibnite-bearing veins have also been found on the lower part of both Glen Gulch and Black Creek.[2]

The Parks prospect, on the north bank of Kuskokwim River, about 15 miles above Georgetown, has been described in considerable detail by Smith and Maddren.[3] The ore is cinnabar and stibnite, and the lode is in a shattered or brecciated zone at the contact between the country rock and intrusive igneous rock. The intimate association of granitic and diabasic material, the characteristic feature of the igneous rocks in this region, is also to be seen here. According to the authors cited, the cinnabar and stibnite are intimately intergrown, and the deposition of the two minerals was almost contemporaneous. The gangue is quartz and ferruginous carbonates.

STREAM TIN.

Stream tin in the Ruby-Kuskokwim region is not considered by the writers to be plentiful enough to warrant a discussion of its possible economic significance. Many queries, however, were made by

[1] Eakin, H. M., oral communication.

[2] Brooks, A. H., The antimony deposits of Alaska: U. S. Geol. Survey Bull. 649, 1916.

[3] Smith, P. S., and Maddren, A. G., Quicksilver deposits of the Kuskokwim region: U. S. Geol. Survey Bull. 622, pp. 274-280, 1915.

miners regarding the nature of certain heavy brown pebbles recovered by them in the concentrates. The following notes are intended as an answer to such queries:

Tin in the form of the oxide, cassiterite, is obtained in the concentrates on Short, Midnight, Greenstone, Monument, and Trail creeks, in the vicinity of Long, and represents a phase of mineralization which is doubtless associated with the coarse-grained granite occupying the crest of the ridge at the head of Flint Creek. A similar granite intrusion and its attendant mineralization accounts for the presence of tin on upper Birch Creek. On Ruby Creek there is no known exposure of granite, but the concentrates likewise contain cassiterite. The cassiterite occurring at these places is in the crystalline form, translucent to opaque, and from yellow-brown to black. It resembles rutile or wolframite in appearance.

On Poorman and Flat creeks, in the vicinity of Poorman, the cassiterite is in the form known as wood tin, showing no crystal form, but having surfaces which are mamillary or reniform and internally showing concentric structure in which bands range from yellow to dark brown. The source of this tin is unknown, but probably it is of vein origin. This form much resembles limonite and is with difficulty distinguished from it.

A simple test for both forms of cassiterite consists in placing fragments of the mineral in a glass or enameled dish with some granulated zinc, and pouring over them sulphuric or hydrochloric acid. After heating a few minutes cassiterite shows a coating of tin, which becomes more evident after rubbing on a piece of cloth to brighten it.

COAL RESOURCES.

Coal-bearing rocks of Cretaceous age occur at numerous places in the lower Yukon basin, and some small mines have been opened in them, but the demand for coal has been slight and consequently the development has not been extensive. In the Ruby-Iditarod region coal has been reported from several places. A prospect hole 9 or 10 miles from the head of Quartz Creek, in the Ruby district, is said to have reached coal at a depth of 100 feet. On Swift Creek, a tributary of Basin Creek, a layer of the gravel shows a high percentage of carbonaceous material, resembling the detritus from a coal seam, and coal fragments are said to have been found near by.

Coal has been found in a prospect hole sunk to a depth of 50 feet on lower Poorman Creek. Water filled the hole at the time of the writer's visit, and the extent of the coal was not observed. A crosscut driven from the foot of the shaft is said to show coal having a 70° dip. This indicates a seam of considerably greater thickness than is found elsewhere in the adjacent regions. There is said to be 15 feet of a yellow gummy gouge between the coal and the overlying

gravel, and this gouge also forms partings in the coal. Only a small quantity of the coal has been mined—at most a few tons. It is subbituminous, igniting with difficulty but burning readily after ignition. Some of it has been used as blacksmith coal, but has not proved wholly satisfactory for this purpose. On exposure to the air it slacks badly, although it is probable that the material seen was obtained near the surface of the seam and in consequence would tend to disintegrate more readily than coal taken at greater depths beyond the influence of atmospheric agencies. Owing to the depth and the distance from any considerable market, the present utilization of this coal seems extremely doubtful.

Maddren obtained information in 1910 from a prospector to the effect that coal had been found on Homestake Creek, in the Nowitna basin, at a depth of 46 feet, and that it also occurred at the head of the Nowitna.

The open-cut mining on Moore Creek has exposed the bedrock along the creek, and at one place there is a very carbonaceous layer in the shales. Little is known of this occurrence, but it is probably only a thin carbonaceous seam.

In the Iditarod district coal croppings have been reported from a number of localities. Smith [1] has described these in detail and given an analysis of some coal taken from a prospect on the tramroad between Iditarod and Flat.

During the winter of 1914–15 another coal prospect was opened in the same vicinity, near the juncture of the wagon roads from Flat and Discovery. Additional work was to be done on this property during the winter of 1915-16. The owners stated that the strike of the beds is N. 38° E., and the dip of the coal seam about 80° SE. A shaft 30 feet deep has been sunk, the lower 25 feet of which is in frozen ground. The section of coal, as given by the owners, is as follows: Shale (hanging wall); coaly shale, 10 inches; clean coal, 14 inches; shale (footwall). The coal appears to be subbituminous. A sample was taken from the dump and will be analyzed for a report later.

It is likely that there are a large number of coal beds in the Cretaceous rocks in this general neighborhood, and other beds will therefore probably be discovered in the course of time. The fact, however, that only small beds have so far been uncovered indicates that these are the rule rather than the exception. Nevertheless, in the Iditarod district, where wood is becoming scarce, such beds may prove to be of considerable importance as a source of fuel for local consumption. They certainly merit further prospecting.

[1] Smith, P. S., Mineral resources of the Lake Clark-Iditarod region: U. S. Geol. Survey Bull. 722, pp. 268-270, 1915.

MINERALIZATION.

The rocks collected during the field season of 1915 have not yet been studied in detail, and it may be necessary later to modify some of the conclusions reached in this paper. At the present time, however, the data at hand points to mineralization at two periods in the Ruby-Kuskokwim region. This conclusion is based on evidence regarding the genesis of the placers, on the character and distribution of the quartz veins, and on the character of the concentrates taken with the gold.

In the Ruby district, exclusive of the Cripple Creek Mountains, quartz veins are very common throughout the sedimentary and igneous rocks, and Eakin [1] has assigned these as the source of the gold in this district. Many such veins, however, are apparently barren, and it is rather likely that there may be several series of quartz veins, of which certain ones, related perhaps to a definite period of mineralization, are the sources of the gold. It may be that some of the intrusives grouped in this report under the term greenstone are of original monzonitic or dioritic nature and have a genetic relation to the auriferous quartz veins. It is hoped that later microscopic work will shed some light on this problem. It is certain, however, that in this district placer ground is found overlying sedimentary bedrock at considerable distances from any known bodies of granitic rocks, and it is necessary to postulate auriferous quartz veins to explain the presence of gold.

In the other placer gold areas to the south, including the Cripple Creek Mountains, the Innoko district, Candle Creek, Moore Creek, and the Iditarod district, different conditions prevail. In some places, as at the head of Flat Creek, the gold placers are residual, being weathered out of granitic bedrock. In other places the placer ground is some distance downstream from such rock or from gold lodes, but the gold is always definitely related to acidic intrusive rocks. Moreover, in the districts above named, quartz veining is uncommon, except within intrusive bodies and near their peripheries, a condition which is in sharp contrast to that prevailing in the Ruby district. A further difference exists in regard to the character of the quartz veins. The only accessory sulphides observed in the quartz veins in the vicinity of Ruby, Long, and Poorman are pyrite and arsenopyrite. In the southern areas cinnabar and stibnite, as well as pyrite and arsenopyrite, are found in the quartz veins and lodes.

The concentrates present a most striking illustration of the difference in character of the northern and southern mineralization. The rock-forming iron minerals, magnetite and ilmenite, are found uni-

[1] Eakin, H. M., The Iditarod-Ruby region, Alaska: U. S. Geol. Survey Bull. 578, p. 43, 1914.

versally. Pyrite and arsenopyrite likewise are not localized. Around Ruby, Long, and Poorman, however, cassiterite is very common in the concentrates, and on Poorman Creek barite also occurs. Neither of these minerals, so far as known, are present south of Poorman. On the other hand, cinnabar is found universally in the southern zone, with stibnite and scheelite in some places. The only known occurrence of any of these minerals in the northern zone is at Spruce Creek, northeast of Poorman, near the south end of the northern zone, where cinnabar occurs in the concentrates. If, as is supposed, the southern zone represents a later period of mineralization, it is quite possible that this period should be represented in the north, especially near the boundary between the two zones. Hence the occurrence of cinnabar on Spruce Creek is not anomalous. On the other hand, the restriction of cassiterite to the northern zone is quite essential to the truth of the hypothesis to be proposed.

From the foregoing considerations the writers are led to believe that there were two distinct periods of mineralization in the Ruby-Kuskokwim region. The mineralization in the vicinity of Ruby, Long, and Poorman is the older, but its age can not be assigned with certainty. It may be either Paleozoic or Mesozoic, but the facts that Mesozoic intrusions elsewhere in Alaska are connected with mineralization and that there is no record of definite Paleozoic mineralization afford presumptive evidence in favor of considering the northern mineralization to be of Mesozoic age. The monzonite of the southern zone, to which the placers are related, has been considered to be of Tertiary age, and the mineralization which accompanied it is of course also Tertiary. It seems necessary, if this hypothesis is correct, to believe that the northern mineralization took place in the old Paleozoic and Mesozoic land mass prior to the deposition of the Cretaceous sediments that cover much of the country south of Poorman.

One other factor bearing on the age of the mineralization in the Ruby-Kuskokwim region remains to be considered. It is probable that the northern and southern types of mineralization do not represent single periods of mineralization in the Mesozoic (?) and Tertiary. Direct evidence on this point is lacking in the northern zone, but the presence of cassiterite in some of the concentrates and its absence in others, as well as the occurrence of barite on a single creek (Poorman Creek), suggest this possibility. Microscopic work has already shown that in the southern zone the stibnite is later than some of the vein quartz; and gold is known to exist both in quartz veins and in the stibnite and cinnabar lodes. Attention has already been called to the two different kinds of gold which are found in the

Iditarod district. Such facts are certainly suggestive of the possibility that the gold mineralization may have taken place in two or more distinct stages, within the same general period of mineralization.

POSSIBLE AREAS FOR PROSPECTING.

The areas in which the two types of mineralization above referred to have occurred coincide in their distribution in a general way with the two physiographic provinces of the region, and both the mineralization and physiography are factors that must be taken into account in giving advice to the prospector.

In the Ruby district, exclusive of the Cripple Creek Mountains, placer gold is not known to be directly dependent for its position on bodies of intrusive rock, though such bodies were probably influential in the formation of the quartz veins. Were it possible to know the character of the country rock in this district, the best advice would probably be to prospect in creeks in whose upper basins the country rock is cut by numerous quartz veins. It happens, however, that in the major part of the Ruby district bedrock is effectually covered by a mantle of unconsolidated deposits. The prospector and geologist are therefore alike in the dark as to what creeks are likely to become producers. The ultimate solution of the problem lies in prospecting.

In the Cripple Creek Mountains and in the Innoko-Iditarod district the conditions are different. Here, too, the valleys are filled with alluvium, but the ridges are higher, and bedrock exposures may usually be found on the interstream divides. Such exposures afford a general idea of the character of bedrock in the valley bottoms. It is now commonly recognized that the gold placers in this part of the region are closely associated with granitic rocks. Streams which head in areas of granitic rocks or which have a granitic bedrock are therefore the logical places to prospect. It does not follow, however, that gold will be found universally around granitic rocks, for such is not the case, but it may be stated negatively that in this region gold is never found very far from granitic bodies.

There is one point which may be of value to the prospector in searching for granitic rocks. It sometimes happens that such rocks are present in the valley bottom covered by alluvium and the interstream divides give no indication of this fact—that is, the granitic body may be small and confined to the valley bottom. This condition actually occurs on Candle Creek and Otter Creek. It has been observed, however, that most of the granitic intrusives in this region are surrounded, adjoined by, or in some way associated with basic intrusive rocks such as gabbro, diabase, and basalt, and it seldom

happens that both the basic and acidic intrusives fail to crop out on the divides. Therefore where basic intrusives are found the prospector should look carefully down the valley slopes and in the valley wash for granitic detritus. On Otter Creek and Candle Creek the presence of large masses of basic rock on the adjoining divides would have caused the initiated to search for granitic rock in the neighborhood.

MINING IN 1915.

RUBY DISTRICT.

Mining was done in 1915 in the Ruby district, including the Cripple Creek Mountains, about two principal centers, Long and Poorman, and in addition some gold was taken out from Ruby Creek at Ruby and from Colorado Creek, in the Cripple Creek Mountains. Long Creek and its tributaries, Bear Pup, Short, Midnight, Monument, and Basin creeks, together with Glen Gulch, Birch Creek, tributaries of Flint Creek, and Trail Creek were the sources of placer gold in the vicinity of Long. Spruce and Tamarack creeks, tributaries of the Sulatna, and Flat and Poorman creeks were the producers near Poorman.

In all 61 outfits were at work in the Ruby district, employing 254 men. Six claims were operated by open-cut methods, some of which used steam hoisting machinery as an accessory to convey the gravel to the elevated line of sluice boxes, or in stripping. On 21 properties the hoisting was done by hand, and on 34 it was done by steam hoists. It is estimated that gold to the value of about $700,000 was produced in the Ruby district in 1915.

INNOKO DISTRICT.

In the Innoko district the same creeks were productive in 1915 as in former years, including Ophir, Spruce, Little, Ganes, and Yankee creeks, with some of their tributaries. The returns that have been received indicate that most of the mining was done by open-cut and hydraulicking methods, except on Little Creek, where underground mining was done on two claims. Reports have been received from 12 properties, employing a total of 49 men. The gold produced in 1915 had a value of about $190,000.

CANDLE AND MOORE CREEKS.

Seventeen men were at work on Candle and Moore creeks, on three properties. On two of these the work is being done by hydraulicking and on the other by open-cut and manual methods. Complete dates on the value of the gold produced are not available at this writing.

IDITAROD DISTRICT.

In the Iditarod district mining was done on Flat, Chicken, Happy, and Willow creeks and on the divide at the head of Flat Creek. In the vicinity of Discovery mining was in progress on Otter, Black, and Slate creeks and on Glen Gulch. In all, 24 mines were worked, and from 350 to 400 men employed. Two dredges were active, but most of the plants used mechanical scrapers and hydraulicking operations. Open-cut work, involving shoveling and sluicing, as well as little drift mining, was also done. The total value of the gold produced in 1915 is $2,050,000.

INDEX.

RECENT SURVEY PUBLICATIONS ON ALASKA.

[Arranged geographically. A complete list can be had on application.]

All these publications can be obtained or consulted in the following ways:

1. A limited number are delivered to the Director of the Survey, from whom they can be obtained free of charge (except certain maps) on application.

2. A certain number are delivered to Senators and Representatives in Congress for distribution.

3. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they can be had at prices slightly above cost. The publications marked with an asterisk (*) in this list are out of stock at the Survey, but can be purchased from the Superintendent of Documents at the prices stated.

4. Copies of all Government publications are furnished to the principal public libraries throughout the United States, where they can be consulted by those interested.

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