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MINERAL DEPOSITS OF THE RAMPART AND HOT SPRINGS DISTRICTS ALASKA

BY

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PLACER CONCENTRATES OF THE RAMPART AND HOT SPRINGS DISTRICTS

BY

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By J. B. Mertie, Jr.

INTRODUCTION

LOCATION OF AREA

The Rampart quadrangle as previously defined [1] includes that part of the Yukon-Tanana region lying west of the 150th meridian. The Rampart and Hot Springs mining districts, however, include streams that lie east of the 150th meridian, and two of the accompanying sketch maps have therefore been extended eastward to meridian 149°40′ in order to include all of these two districts. The index map (fig. 4) shows the position of the Rampart and Hot Springs districts with respect to the rest of Alaska.

EARLY HISTORY

The first stage of exploration in the Yukon Basin took place in the period between 1867, when Alaska was acquired by the United States, and the late nineties, when the early gold rushes were still in progress. During this period the Yukon was visited at intervals by numerous men, with various motives. Some came in search of geographic or scientific data, some for adventure, and some for fur or gold. The results of some of these visits have been published, but many remarkable trips by early prospectors and traders have not been recorded and will therefore never obtain the recognition that they deserve.

Among the early visits to this part of the Yukon Basin may be mentioned Dall's trip [2] up the Yukon in 1866; the reported trip of George Holt down the Yukon as far as the 160th meridian in 1874; and the journeys of Harper and Mayo in the Tanana Valley in 1878. According to Spurr and Goodrich,[3] gold was first discovered in the Rampart district by the Schieffelin brothers, the original discoverers of gold at Tombstone, Ariz., who ascended the Yukon River from

[1] Eakin, H. M., A geologic reconnaissance of a part of the Rampart quadrangle, Alaska: U.S. Geol. Survey Bull. 535, 1913.

[2] Dall, W. H., Exploration in Russian America: Am. Jour. Sci., 2d ser., vol. 45, pp. 97–98, 1868.

[3] Spurr, J. E., Geology of the Yukon gold district, Alaska; with an introductory chapter on the history and condition of the district to 1897, by H. B. Goodrich: U.S. Geol. Survey Eighteenth Ann. Rept., pt. 3, pp. 103–133, 1898.

St. Michael to Nuklukayet (Tanana) in a small steamboat in the summer of 1882. In the fall of the same year they prospected some small creeks and rivers 80 miles above Tanana, where stream bars

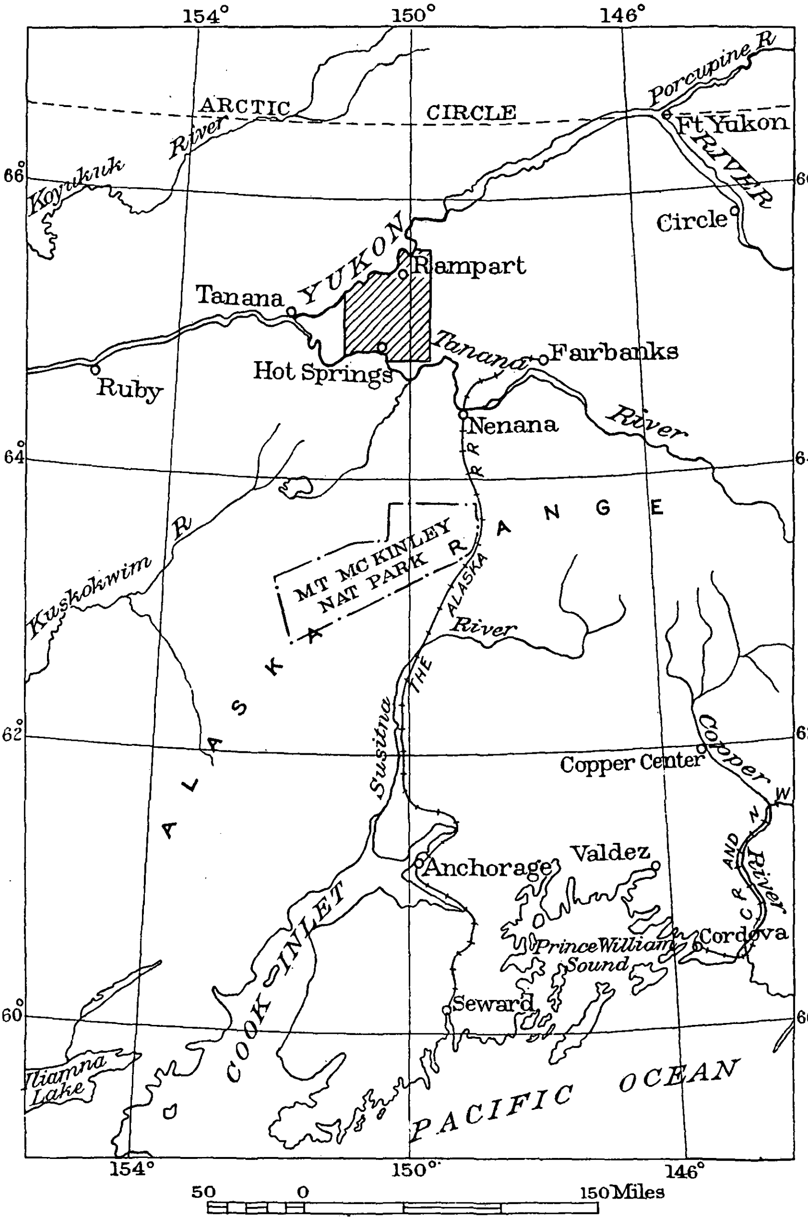


FIGURE 4.—Index map showing location of the Rampart and Hot Springs districts (shaded area).

were located that would yield a man $10 a day. These streams were probably Minook Creek, the Hess River, and their tributaries.

The Schieffelin brothers returned in 1883 to San Francisco by way of St. Michael and do not seem to have followed up their discovery. Their name is preserved in Schieffelin Creek, a stream that enters the Yukon about 20 miles above Tanana.

In the same year that the Schieffelin brothers returned to the States, Lieutenant Schwatka [4] made a trip from the headwaters of the Yukon to its mouth. Schwatka made the first reliable traverse map of the Yukon River, and it is of interest to note that his forty-seventh camp was along the river bank a short distance below the present site of Rampart. Two years after Schwatka's trip, Lt. H. T. Allen, of the United States Cavalry, made a remarkable trip through interior and northern Alaska, in the course of which he descended the Tanana River from the mouth of the Tok River to the Yukon. Allen made the first reliable map of the Tanana, as Schwatka did of the Yukon. Another early trip was that of Russell [5] in 1889, from St. Michael up the Yukon River to its headwaters. Russell's trip was devoted mainly to geomorphic studies.

In the 10 years that followed the original discovery of gold by the Schieffelin brothers little interest was taken in the Rampart district. In the spring of 1893, however, a Russian half-breed named John Minook found coarse gold in Minook Creek, the Hess River, and other nearby streams. At about the same time another prospector, O. C. Miller, who subsequently discovered gold on Miller Creek in the Sixtymile district, Yukon Territory, was prospecting on the Hess River and did a little mining in a gulch near its head. It was not until the spring of 1896, however, that a permanent white settlement was established at Rampart, and organized placer mining was begun. According to Hess,[6] the first placer mining was done on Little Minook Creek by F. S. Langford, but by the summer of 1896, when Spurr and his party arrived in this district, placer mining was in progress on both Little Minook and Hunter Creeks. Deposits on Little Minook Junior and Hoosier Creeks were discovered somewhat later, and mining on Slate Creek was begun in 1902.

The gold placers in the vicinity of Hot Springs, south of the Yukon-Tanana divide, have a different history. In 1898 a group of five or six men, originally from New England and nicknamed the "Boston Boys", came down the Yukon on a prospecting trip. The names of these men were Hebb, Gates, Ramsay, Moore, Russell, and perhaps one other. They ascended the Tanana to Hot Springs Slough and came up the slough to the present site of Hot Springs, but being unable to go farther by boat, they went back into the Tanana and

[4] Schwatka, Frederick, Report of a military reconnaissance in Alaska, made in 1883, Washington, Government Printing Office, 1885.

[5] Russell, I. C., Notes on the surface geology of Alaska: Geol. Soc. America Bull., vol. 1, pp. 99–156, 1890.

[6] Prindle, L. M., and Hess, F. L., The Rampart gold placer region, Alaska: U.S. Geol. Survey Bull. 280, p. 26, 1906.

ascended Baker Creek. At the mouth of Hutlinana Creek they split into two parties, one going up the Hutlinana and the other continuing up Baker Creek. The Baker Creek party finally struck pay on a tributary of Baker Creek, which they called Eureka Creek. As the other party found no high-grade placers on the Hutlinana they subsequently rejoined their companions on Eureka Creek. Boston Creek, a tributary of Eureka Creek, was also named by the "Boston Boys."

In the spring of 1899 some of the "Boston Boys" went over the divide to Rampart to get legal advice in forming a mining district at Eureka, whereupon a stampede started from Rampart, and the Eureka area soon became a recognized mining community. Rampart at first was the supply point for the new camp, and supplies were hauled over the divide at the winter rate of 4 cents a pound. About 1906 Frank Manley built a hotel at the springs near the present site of Hot Springs, and a town sprang up at this site, which soon became the supply point for the Eureka area. The hotel burned in 1913.

The third center of mining in the Rampart-Hot Springs district is in the vicinity of Tofty, about 12 miles northwest of Hot Springs. Gold placers were first discovered in this area in the winter of 1906–7, by three men named Snyder, Harter, and Kamper. The original discovery was on Tofty Gulch, a tributary near the head of Sullivan Creek.

GEOLOGIC INVESTIGATIONS

The report by Spurr,[7] above alluded to, may be said to represent the earliest geologic work in the Rampart-Hot Springs district. Spurr, together with Goodrich and Schrader, made a trip in 1896 from Chilkoot Pass down the Yukon as far as Nulato and on the way visited the Fortymile and Rampart mining districts. Spurr attempted a systematic classification of the rocks along his route and also presented the earliest published data regarding the character and extent of the gold placers of these two camps. Another geologic expedition, similar to Spurr's, was made 2 years later by Brooks,[8] who traversed the Tanana from its headwaters to its mouth and made the first geologic observations upon the rocks exposed along the north bank of the Tanana, between the Tolovana and Yukon Rivers.

In 1902 Collier[9] and Paige traversed the Yukon from Dawson to St. Michael, giving particular attention to the coal-bearing rocks along the river. This trip was repeated the next year by Hollick and Paige to obtain further plant collections from these coal-bearing

[7] Spurr, J. E., op. cit.

[8] Brooks, A. H., A reconnaissance in the Tanana and White River Basins, Alaska, in 1898: U.S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 431–494, 1900.

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

rocks. In 1902 Brooks and Prindle [10] visited the Rampart district in the course of a traverse from Cook Inlet to Rampart, and Brooks again visited this district in 1906. Systematic topographic and geologic surveys of the Yukon-Tanana region were begun in 1903, and as a part of this project a topographic map of the Rampart quadrangle was prepared in 1906 by D. C. Witherspoon and R. B. Oliver. Geologic mapping of the Yukon-Tanana region was begun by L. M. Prindle in 1903, and in the course of this work he and F. L. Hess [11] visited the Rampart district in 1904. Prindle [12] also studied the geologic section along the Yukon from Fort Hamlin to Rampart in 1907, touching at Rampart, and again visited this district with B. L. Johnson in 1909. Investigations of the surface water supply of the Rampart district were also carried on by Geological Survey engineers [13] in 1907–9. A geologic map of the Rampart quadrangle was finally completed by H. M. Eakin [14] in 1911.

Since 1911 several geologists of the Geological Survey have visited the Rampart district in connection with mineral investigations and geologic studies. Some of the results of these visits and studies have been incorporated in the annual reports of the Geological Survey dealing with the mineral resources of Alaska, but no separate report on this district has been issued for more than 20 years. In connection with the preparation of a new general geologic map of the Yukon-Tanana region, the writer had occasion in 1931 to visit all the placer mines in the vicinity of Rampart and Hot Springs, and the present report aims mainly to supply late information regarding these mining activities.

The writer takes this opportunity to acknowledge with thanks the capable field assistance rendered by Mr. A. E. Waters, Jr., of Baltimore. Mr. Waters also determined the minerals that occur in the placer concentrates in the Rampart and Hot Springs districts (see pp. 227–246); and the lists of heavy minerals of the concentrates given in this paper are taken from these determinations.

GEOGRAPHY

DRAINAGE AND RELIEF

The geographic features of the Rampart quadrangle have been rather fully described by Eakin,[15] and in the present paper an abstract of his account of the more noteworthy of these features seems ade-

[10] Brooks, A. H., and Prindle, L. M., The Mount McKinley region, Alaska: U.S. Geol. Survey Prof. Paper 70, 1911.

[11] Prindle, L. M., and Hess, F. L., The Rampart gold placer region, Alaska: U.S. Geol. Survey Bull. 280, 1906.

[12] Prindle, L. M., The Fairbanks and Rampart quadrangles, Yukon-Tanana region, Alaska: U.S. Geol. Survey Bull. 337, 1908.

[13] Ellsworth, C. E., and Davenport, R. W., Surface water supply of the Yukon-Tanana region, Alaska: U.S. Geol. Survey Water-Supply Paper 342, 1915.

[14] Eakin, H. M., A geologic reconnaissance of a part of the Rampart quadrangle, Alaska: U.S. Geol. Survey Bull. 535, 1913.

[15] Eakin, H. M., op. cit., pp. 8–16.

quate. The Rampart-Hot Springs district is a triangular area of about 4,000 square miles lying between the Yukon and Tanana Rivers. The divide between the Yukon and Tanana drainage basins trends nearly east and approaches very closely to the Yukon near the confluence of these two master streams. About two thirds of the district is drained by the Tanana River.

Minook Creek is the principal stream that drains to the Yukon, and most of the gold placers in the Rampart district have been found on its tributaries. East of Minook Creek lies the drainage basin of the Hess River, but most of this basin lies outside the area here considered. Troublesome and Raven Creeks, however, which are tributaries of the Hess River, drain a considerable part of the Rampart district east of the basin of Minook Creek. West of Minook Creek the principal tributaries of the Yukon from the south are Garnet, Fish, and Stevens Creeks.

South of the divide Baker Creek is the principal tributary of the Tanana River. In its lower valley Baker Creek receives two large tributaries from the northeast known as Hutlinana and Hutlitakwa Creeks, and in its upper course it splits into a large number of tributaries that drain from the north and west. Except for the extreme headwaters, most of the tributaries of Baker Creek flow in open valleys with low gradients, and the southern part of the valley of Baker Creek is a wide featureless flat that has obviously been extensively aggraded. The Tolovana River, the next stream to the east, and all the other tributaries of the Tanana from the north show the same aggradation in their lower courses. West of Baker Creek the two principal tributaries of the Tanana are Patterson and Boulder Creeks. Sullivan and Woodchopper Creeks, tributaries of Patterson Creek, contain valuable gold placers. Boulder Creek drains into a large lake called Fish Lake, and an outlet for this lake to the Tanana may be said to constitute the lower part of Boulder Creek. Two smaller creeks, known as American and Eldorado Creeks, also enter Fish Lake from the east. Of these, American Creek also contains workable gold placers. The lower valleys of Patterson and Boulder Creeks form a great swampy flat that merges gradually into the flats of the Tanana River.

The peculiar dendritic drainage of Baker Creek and the aggradation in the tributary valleys of the Tanana have developed lowlands that divide the Rampart and Hot Springs districts into four rather distinct highland areas. The largest and most rugged of these comprises the country in the headwaters of Minook, Troublesome, and Hutlinana Creeks. The three highest mountains of the region, known as Baldry, Elephant, and Wolverine Mountains, lie within this highland area; and their approximate elevations are respectively 4,200, 3,800, and 4,600 feet. West of Baker Creek and north of Patterson Creek is a smaller highland area, of which the dominating feature is Roughtop

Mountain (known locally as Moose Mountain), which rises to an elevation of 3,410 feet. Between the Patterson and Baker Creek lowland and the Tanana River is another small highland area, known as Bean Ridge, of which the highest point is the Hot Springs Dome, with an elevation of 2,650 feet. And, finally, between Hutlitakwa Creek, the Tolovana River, and the Tanana River is the fourth highland area, of which the highest point has an elevation of only 2,150 feet. As the Yukon and Tanana Rivers in this country flow at an elevation of about 300 feet above sea level, the maximum relief is over 4,000 feet, but the average relief of the highland areas is probably closer to 1,500 feet.

CLIMATIC CONDITIONS

The climate of the Rampart and Hot Springs districts is typically sub-Arctic, with long, cold winters and short but comparatively warm summers. The success of placer mining is dependent in considerable measure upon the local water supply and upon the number of days during the open season when such mining can be carried on. Again, certain placers that lie above the main drainage channels have no available water supply except what may be obtained from snow melting on nearby hillsides in the spring. Records of precipitation and temperature are therefore of considerable value to communities where placer mining is the major industry, and such records are particularly desirable for reference by strangers entering the country to engage in placer mining. Climatic records have been kept at Tanana and Rampart for more than 25 years,[16] but as the publications of the United States Weather Bureau are not generally available in interior Alaska, the mean values of precipitation, snowfall, and temperature up to 1930 are presented herewith:

Mean precipitation, snowfall, and temperature at Rampart and Tanana, Alaska

Month	Mean precipitation (inches)		Mean snowfall (inches)		Mean temperature (° F.)	
	Rampart	Tanana	Rampart	Tanana	Rampart	Tanana
January	0.63	0.72	8.5	9.0	−16.5	−12.5
February	.63	.74	8.0	9.7	−7.7	−4.7
March	.47	.69	6.0	9.1	4.1	5.4
April	.22	.27	4.0	2.9	22.9	23.5
May	.48	.82	.3	.6	44.9	44.5
June	1.03	1.10	0	0	57.8	57.1
July	1.40	2.42	0	0	59.7	58.5
August	1.56	2.34	0	0	55.0	53.5
September	1.38	1.47	1.2	1.0	41.2	40.8
October	.97	1.08	8.2	6.8	21.7	23.0
November	.54	.64	6.8	5.1	−.9	.1
December	.64	.69	7.2	9.4	−11.7	−10.5
Annual	9.95	12.98	50.2	53.6	22.5	23.2

16 Summary of the climatological records of Alaska, by sections: U.S. Weather Bur. Bull. W, 2d ed., vol. 3, 1926; also, Climatological data, Alaska section, vols. 8-16, inclusive, 1922 to 1930.

Climatic records have not been kept over a long period of years at Hot Springs, but from partial records of some years ago it is believed that conditions of temperature and precipitation at Hot Springs are not essentially different from those existing at Tanana. The following comparisons between the climates of Tanana and Rampart may therefore be considered also to apply as between Hot Springs and Rampart.

First, the mean annual temperatures of Tanana and Rampart are nearly the same, both being about 9° below the freezing point of water. Curiously enough, however, Rampart is colder in winter but warmer in summer than Tanana. August is the warmest and January the coldest month at both places. The total precipitation is about 30 percent greater at Tanana than at Rampart, but the snowfall is nearly the same at both places. At Tanana July is the rainiest month; at Rampart, August. A very sharp minimum in the precipitation curve occurs at both places in April, which is the driest month of the year. Probably the only precipitation at either place from November to March, inclusive, is snow. Under this assumption, the factor for converting snowfall into its equivalent amount of water, in this part of Alaska is 0.08 instead of the conventional factor of 0.1. In other words, it takes on the average in this country 12½ inches of snow to make 1 inch of water.

The ice breaks in the spring on the Yukon about the 10th to the 15th of May and begins to form in the fall about the first or second week in October. The Tanana usually breaks a little earlier and freezes later than the Yukon. The season during which water can be used in mining operations is in general from the middle of May to the end of September. Except under unusual conditions the alluvium is permanently frozen to a considerable depth, and the thawing of such ground constitutes one of the expensive items of gold placer mining in this region. Near the larger running streams, which do not freeze solid in winter, the alluvium is thawed for some distance back from the banks. At Hot Springs and elsewhere in these districts where hot waters come to the surface the heat from such sources keeps the ground unfrozen. The last frosts in the spring usually occur during the later part of May, and the first frosts of the following winter usually begin about the last of August, thus giving a summer season of about 3 months.

SETTLEMENTS AND COMMUNICATION

Rampart and Hot Springs are the two principal settlements. Rampart is on the south bank of the Yukon about 60 miles N. 65° E. of Tanana, and Hot Springs is about 44 miles S. 75° E. from Tanana, on a slough of the Tanana River. A post office called Tofty is also maintained on Woodchopper Creek. At the mouth of the Tolovana

River are a telegraph station, roadhouse, and fox farm, and at the mouth of Baker Creek are another roadhouse and a sawmill.

The population of Rampart, according to the census of 1930, is 103, of whom, however, a part are natives. The population of Hot Springs, according to the same authority, is 45, mainly white people. As most of the mining population on the creeks have domiciles in Rampart or Hot Springs, they are included in the figures above given. Therefore, the total present white population of the Rampart and Hot Springs districts is probably not more than 125 persons.

Rampart and Hot Springs are served during the summer by the fortnightly steamboat schedule of the American-Yukon Navigation Co., but Hot Springs has also the weekly steamboat service maintained by the Alaska Railroad. At Rampart the rates on supplies from Seattle by way of Skagway and down the Yukon are about equal to the rates over the Alaska Railroad train and steamboat service to Tanana, and thence up the Yukon to Rampart by launch. Practically all the supplies for Hot Springs, however, are handled by the Alaska Railroad.

A winter trail connects Rampart with the Eureka area, but an automobile road has been built from Hot Springs to Eureka Creek. From Rampart most of the supplies are transported to the outlying mining properties by winter sledding over the winter trail. Supplies for the placer-mining plants on Sullivan and Woodchopper Creeks are transported mainly in summer by launch from Hot Springs down the slough to its mouth, and thence over the ridge by wagon; the total freight rate is 3 cents a pound. From the Tofty post office another trail goes up Woodchopper Creek to its head and down American Creek to Fish Lake. This is essentially a winter trail, but it permits summer travel by wagon when the weather is not rainy. Supplies for the dredge and other placer mines on American Creek arrive in part by this route and in part by launch from Tanana to Fish Lake and thence up American Creek by a short road. The winter mail trail from Nenana to Tanana also passes through this district by way of Tolovana, Baker, Hot Springs, and Tofty.

The mail is carried in summer by steamboats on the Yukon and Tanana Rivers, and until recently the winter mail came by the Nenana-Tanana mail trail. A separate mail route conveyed the winter mail from Hot Springs to Rampart. Beginning in the winter of 1931–32, the old mail service between Nenana and Tanana was discontinued, and an air mail service was established between these points.

Wireless stations were formerly operated by the United States Army Signal Corps at Tanana and Hot Springs, but these have recently been replaced by commercial radiophone stations. The old telegraph line between Hot Springs and Rampart was abandoned about 20 years ago but served until recently as a telephone line. During the summer of 1931 this line was down at many places and could not be used for communication, but it will probably be repaired and put into operation again. The old telegraph line between Hot Springs and Tolovana can also still be used for telephone communication under favorable weather conditions.

GEOLOGIC SKETCH

Bedded rocks of Paleozoic, Mesozoic, and Cenozoic age and granitic rocks of Cenozoic age compose the geologic column in the Rampart and Hot Springs districts. The bedded rocks that lie in the zones where intrusion and mineralization have occurred are locally much metamorphosed, although some of these are as young as Cretaceous. On the other hand, some of the older Paleozoic rocks that do not lie in such zones are relatively little metamorphosed, considering their age.

The oldest sedimentary rocks are a group of rocks that were described by Brooks [17] as the †Nilkoka beds.[18] Later the name Nilkoka formation was applied by the Geological Survey. These rocks form most of the highland area between Baker Creek and the Tolovana River and consist essentially of ferruginous sandstones and slates. They are now considered to be of pre-Ordovician age. Stratigraphically above the Nilkoka formation lies a thick formation of crystalline limestone, which also crops out in the hills between Baker Creek and the Tolovana River. This limestone represents the same horizon as the limestone in the White Mountains, northeast of Fairbanks, and is known to be of middle Silurian age.

Two groups of later Paleozoic rocks are recognized. An older group of undifferentiated Paleozoic rocks crops out in a narrow belt north of the Silurian limestone and in a much wider belt that extends from Troublesome Creek west-southwest almost to Tanana. This older group is made up of slate, quartzite, chert, chert conglomerate, limestone, greenstone, and their metamorphic equivalents. The limestones can be separately mapped without difficulty. These rocks are mainly of Middle Devonian and Mississippian age, but some of them may be as old as upper Silurian. In the vicinity of Minook Creek these undifferentiated Paleozoic rocks are probably mainly of Mississippian age, but many of them have been rendered schistose by metamorphism, so that they appear to be older than they really are.

The youngest of the Paleozoic rocks is an assemblage of volcanic and sedimentary rocks known as the Rampart group, which crops out along the Yukon River from Fort Hamlin to a point below Rampart and extends back into the hills several miles on both sides of the

[17] Brooks, A. H., A reconnaissance of the Tanana and White River Basins, Alaska, in 1898: U.S. Geol. Survey, Twentieth Ann. Rept., pt. 7, p. 472, 1900.

[18] A dagger (†) preceding a geologic name indicates that the name has been abandoned or rejected for use in classification in publications of the U.S. Geological Survey.

river. These rocks consist mainly of diabasic and basaltic lava flows and tuffs but include also interbedded chert, shale, slate, sandstone, and a few beds of limestone. The Rampart group is of Mississippian age.

The Mesozoic bedded rocks lie in a belt from 12 to 20 miles wide, extending from the headwaters of Hutlinana and Hutlitakwa Creeks west-southwest to the Tanana River. These rocks consist of argillite, slate, quartzose sandstone, and their metamorphic equivalents. They are mainly of Lower Cretaceous age, but some Upper Cretaceous rocks are also found in the vicinity of Wolverine and Elephant Mountains.

The Cenozoic bedded formations include the early Tertiary coal measures and unconsolidated deposits of Pliocene (?), Pleistocene, and Recent age. The coal-bearing rocks occur only along the Yukon River, chiefly at and above Rampart. The coal is a black lignite. The Pliocene (?) deposits consist of high gravel that lies on the ridge tops east of Minook Creek and south of Hunter Creek, in the Rampart district. This gravel is locally auriferous and is the proximate source of much of the gold in the placers near Rampart. Below the level of the Pliocene (?) deposits, a well-developed system of terraces exists along the east side of lower Minook Creek. These terraces represent successive levels of erosion and sedimentation between Pliocene (?) and Recent time. Pleistocene and Recent gravel deposits are also present in the Eureka and Tofty areas. The Pleistocene gravel is everywhere overlain by carbonaceous silt, or muck, and in the lower parts of the valleys draining to the Tanana thick deposits of such material are present. The Recent deposits consist of gravel, sand, and silt of fluviatile origin.

The principal igneous rocks of the Rampart and Hot Springs districts are intrusive masses of granitic rock, which are found chiefly at Hot Springs Dome, Roughtop Mountain, Elephant Mountain, Wolverine Mountain, and along the Yukon River at the rapids, or "Ramparts." Another large mass of granitic rocks forms the core of the Sawtooth Mountains, which lie east of Troublesome Creek, just outside the area shown in plate 3. Several smaller bodies of granitic rocks are also present in this area, two of which lie northwest and southeast of Wolverine Mountain. A third crops out along the ridge at the heads of Rhode Island and Omega Creeks. The intrusive rocks at Roughtop, Elephant, and Sawtooth Mountains are monzonite; the intrusives at and near Wolverine Mountain are quartz monzonite; and the mass at Hot Springs Dome is a biotite granite. All the granitic rocks of the Rampart and Hot Springs districts are of Tertiary age. Further details regarding the petrographic character of these rocks are given by Waters on pages 229–230.

ECONOMIC GEOLOGY

The principal mineral industry in the Rampart and Hot Springs districts has been and still is the exploitation of gold placers. Stream tin is also recovered as a byproduct in the working of some of the placers, and other metallic minerals that are found in the placer concentrates show that other metals besides gold are present in the country rock, though not necessarily in commercial quantities. One gold lode northwest of Hot Springs has been prospected for many years, but the ore is admittedly of low grade and would require large-scale methods for its exploitation.

Coal is present in the Tertiary rocks along the Yukon River and was at one time mined and utilized for local needs. At present the population in and around Rampart is small, and wood serves all its requirements.

Another potential resource of this area is the supply of thermal mineral waters. Thermal springs that are close to the town of Hot Springs not only deliver an unfailing supply of hot water, suitable for medicinal purposes, but also have a beneficial heating effect upon the soil nearby, so that fine garden products can be grown. The town of Hot Springs, moreover, has a location that is particularly favorable for a watering place, because the quiet clear-water slough on which it is located is a splendid site for summer aquatic amusements, and the nearby hills afford an opportunity for mountain climbing and hiking.

GOLD PLACERS

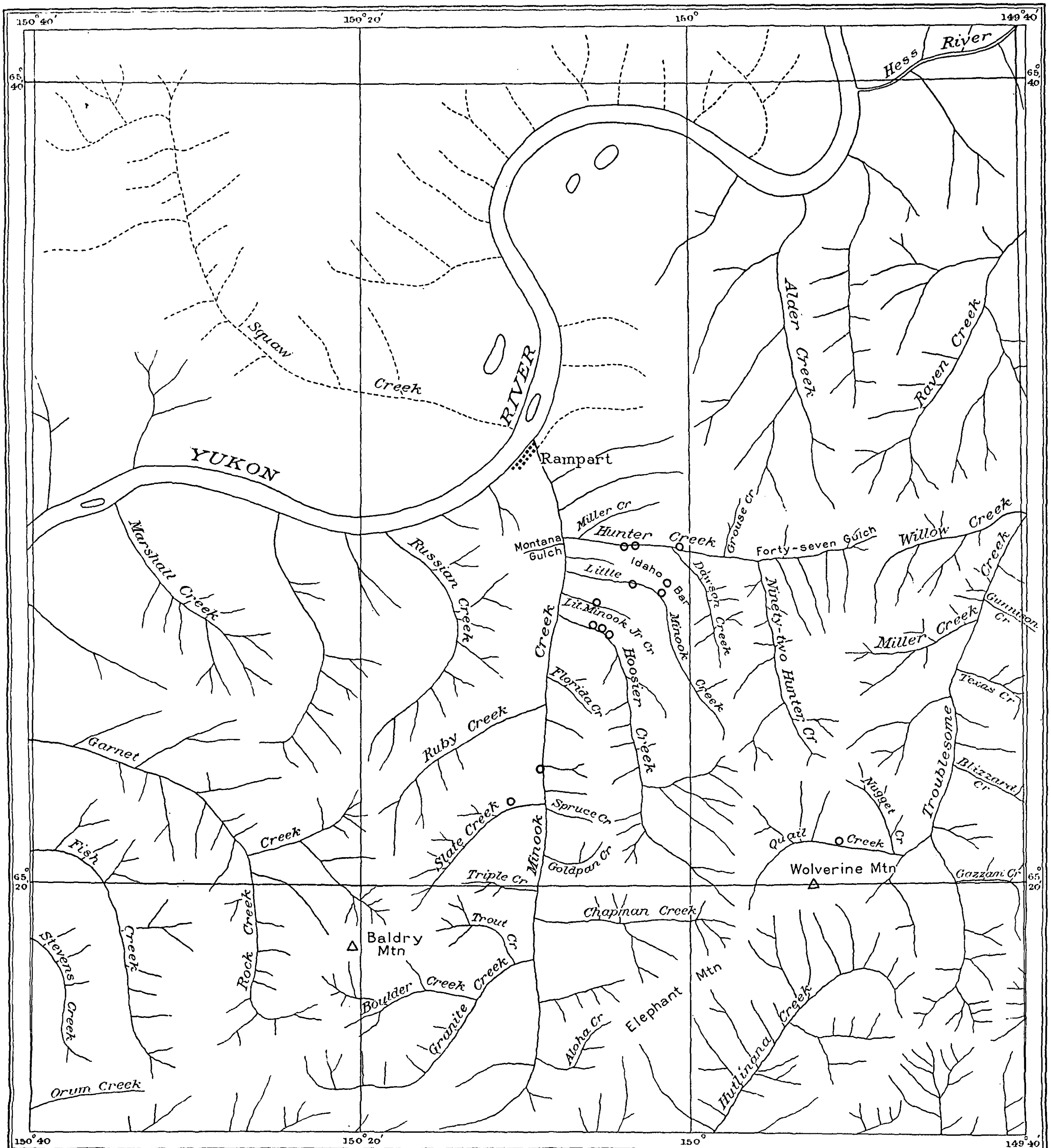
Gold placers are mined in three general areas in the Rampart and Hot Springs districts, which may be designated the Rampart district and the Eureka and Tofty areas. The drainage of these three areas and the localities where placer mining is being carried on are shown, respectively, in plates 3, 4, and 5.

The Rampart district includes Minook Creek and its tributaries and also the valley of Troublesome Creek, where gold placers are being worked on Quail Creek. The Eureka area centers around Eureka Creek and its tributaries, about 20 miles northeast of Hot Springs. The Tofty area comprises the headwater tributaries of Patterson Creek—Woodchopper, Sullivan, and Cache Creeks—but also extends westward and northward to include American and Boulder Creeks.

RAMPART DISTRICT

MINOOK CREEK

Minook Creek is a stream about 25 miles in length that heads against the Baker Creek drainage basin and flows almost due north to the Yukon River. It drains an area of about 200 square miles. On its east side Minook Creek receives four large tributaries—Hunter,



Gold placer mine

1/250000

5 0 5 Miles

SKETCH MAP OF THE RAMPART DISTRICT, SHOWING LOCATION OF GOLD PLACER MINING OPERATIONS.

Little Minook, Hoosier, and Chapman Creeks, named in order upstream. It also has several smaller tributaries from the east, of which only two, Little Minook Junior Creek and Florida Creek, have any economic importance. Little Minook Junior Creek lies between Little Minook and Hoosier Creeks, and Florida Creek enters Minook Creek about 2 miles south of Hoosier Creek. On its west side Minook Creek has three large tributaries, which in order upstream are Ruby, Slate, and Granite Creeks. (See pl. 3.)

Minook Creek is deeply incised in a narrow, V-shaped valley, which is prominently benched on its east side, particularly in the lower valley. Between the mouths of Hunter and Little Minook Creeks the following terraces between the top of the ridge and the level of Minook Creek were identified:

960 feet above Minook Creek. Terrace sloping gently toward Minook Creek, with an elevation of 860 feet at rim. Bedrock at rim but gravel farther back.

480 feet above Minook Creek. Prominent bedrock terrace, same as the upper terrace of Hunter Creek.

255 feet above Minook Creek. Imperfectly developed terrace.

190 feet above Minook Creek. Imperfectly developed terrace.

155 feet above Minook Creek. Imperfectly developed terrace.

90 feet above Minook Creek. Well-developed alluvial terrace, composed of gravel and silt.

10 feet above Minook Creek. Alluvial bench, rising gently 20 feet to valley floor, with here and there indications of intermediate erosion levels.

Other measurements north of the mouth of Hunter Creek and between Little Minook Junior and Hoosier Creeks give much the same results, although differing somewhat in details. In general, four well-developed terraces and several less well developed are present. The highest of the four prominent ones is the alluvial terrace about 1,000 feet above the present level of Minook Creek, which is the site of the Pliocene (?) deposits previously mentioned. Below this terrace, about 500 feet above the present level of Minook Creek, is another well-developed terrace, and still lower, 90 feet above the creek level, is an extensive gravel bench. The fourth level is the valley floor, into which Minook Creek is incised from 10 to 20 feet.

The 90-foot terrace, hereafter referred to as the low gravel bench, is covered with gravel and silt and is the best developed of the older erosion levels. About half a mile below the mouth of Hunter Creek alluvial bluffs from 35 to 50 feet high begin and continue upstream. These bluffs are the eroded remnants of the low gravel bench and slope upward and backward from the creek to that level. Downstream the bedrock base of the low gravel bench may be seen at intervals in greenstone bluffs, at places covered with a thin veneer of gravel. Between Slate and Chapman Creeks the low gravel bench coalesces with the valley floor of Minook Creek, and the alluvial deposits of Minook are rather thick, owing to the fact that the present Minook Creek has a higher gradient in its lower valley than the ancient stream that produced the low gravel bench. Below Slate Creek the alluvial deposits consist of 10 to 20 feet of gravel, overlain by a few feet of carbonaceous silt.

A short distance below Slate Creek the valley floor widens appreciably, and a sheet of "aufeis" develops here in winter and often remains until late summer. Such deposits of ice result from repeated overflows and freezing in winter, forming a considerable thickness of ice by spring. Such aufeis deposits start in open places in a valley floor and tend to be self-perpetuating, for in the spring break-up water is forced against the valley walls, causing lateral erosion that would not otherwise take place. Thus the width of such an ice sheet tends to increase in the course of time.

In its upper valley Minook Creek for a short distance flows northeast, and within this stretch it is markedly asymmetric in cross section, the northwest wall having a long gentle slope, whereas the southeast wall is steep, and the creek follows closely along the southeast side of its valley. Similar asymmetry is also developed in the headwater tributaries of Baker Creek, whose valleys have the same general elongation. This feature is probably due in part to differential rock erosion and in part to the effects of the sun's rays in promoting soil flow on southward-facing slopes.

The gradient of Minook Creek, from Slate Creek to the Yukon, is about 40 feet to the mile, but this gradient increases gradually above Slate Creek. According to Ellsworth and Davenport,[19] the average daily discharge of Minook Creek, as observed on a gage a short distance above Little Minook Creek over a period of 133 days in the summers of 1908 and 1909, was 255 second-feet, to which should be added about 80 second-feet for the water received from tributaries below the gaging station, including Little Minook and Hunter Creeks. During these 2 years the precipitation at Rampart was close to normal, and this figure may therefore be taken as a fair average of the discharge. It should be noted, however, that this average is based in part on the heavy run-off from melting snow in May and June. The average daily discharge for July, August, and September above Little Minook Creek is only about 50 second-feet, or 2,000 California miner's inches. This amount of water equals 20 to 67 sluice heads, according to the varying definitions of the term.

The gravel of Minook Creek is not sufficiently high grade to be worked by small-scale methods, and little mining has therefore been done. Most of the gold in the basin of Minook Creek and its tributaries came originally from bedrock sources in the lower rather than

[19] Ellsworth, C. E., and Davenport, R. W., Surface water supply of the Yukon-Tanana region, Alaska: U.S. Geol. Survey Water-Supply Paper 342, pp. 225–227, 1915.

the upper part of its valley, and it is therefore improbable that much placer gold exists above the mouth of Slate Creek. Below the mouth of Slate Creek Minook Creek has received gold both from the erosion of the older bench gravel and from bedrock sources, but the valley is wide and the pay is scattered. According to Hess,[20] colors of gold were found in the gravel of a bench on the west side of Minook Creek, a few feet above the present stream. Hess also records the fact that the two small areas of gravel between Ruby and Slate Creeks were worked in 1904, giving returns of $3 a square yard, and another small area in the same locality yielded $4 a square yard and produced nuggets worth as much as $90.

During the summer of 1931 two men were engaged in small-scale placer mining along the west side of Minook Creek, about 1½ miles below the mouth of Slate Creek. At one locality three box lengths were worked out in the spring in a low rim a few feet above the river level. At this place 4 to 5 feet of well-washed gravel overlies a chert bedrock, and old tailings show that earlier work was done in the same vicinity. About 100 yards farther downstream another cut, about 100 feet long and 10 to 12 feet wide, was being worked in the late summer. Here 3 feet of gravel is overlain by 3 to 5 feet of muck, and the bedrock is phyllite. Water for sluicing was being obtained from a small gulch along the west wall of the valley, and mining could be carried on only during the spring run-off or during and shortly after periods of rainfall.

Several projects have been organized for working the gravel of Minook Creek on a large scale, but so far none have materialized. In 1904 a company was formed to hydraulic a portion of the creek, and pipe, lumber, and other supplies were imported, but apparently the project was not successful. At the time of the writer's visit in 1922 the Rampart Gold Mining Co. of Des Moines, Iowa, had been formed with the intention of dredging parts of Minook Creek. This company did assessment work on its holdings for several years, but the dredge was never installed.

Minook Creek is worthy of prospecting for large-scale placer mining. A constant and large supply of water is available for hydraulic operations, and with the relatively shallow gravel this might be a more practical method of operation than dredging. It is probable, however, that only parts of the lower valley could be worked at a profit, and therefore the gravel should be thoroughly prospected before mining operations are begun.

HUNTER CREEK

Hunter Creek is the lowest tributary of Minook Creek, entering that stream about 3 miles above its confluence with the Yukon. The

[20] Prindle, L. M., and Hess, F. L., The Rampart gold placer region, Alaska: U.S. Geol. Survey Bull. 280, p. 30, 1906.

main creek is 9 miles long and flows almost due west. About 6 miles from its mouth it receives a large southern tributary 6 miles long, known as 92 Hunter Creek. The upper part of Hunter Creek, above the mouth of 92 Hunter Creek, is called 47 Gulch. Dawson Creek, another large tributary of Hunter Creek, enters from the southeast about 2½ miles below 92 Hunter Creek. On the north side are two small tributaries called Grouse and Miller Creeks. Grouse Creek enters Hunter Creek about half way between 92 Hunter Creek and Dawson Creek, and Miller Creek comes in almost at the mouth of Hunter Creek.

Hunter Creek flows in a narrow, V-shaped valley throughout its course. In its lower valley remnants of the low gravel bench of Minook Creek are visible on both sides of the creek, but owing to the fact that the gradient of this bench is lower than that of the present creek, the elevation of the bench decreases upstream, and at the mouth of Dawson Creek it is only 30 feet above the creek. From 47 Gulch to its mouth Hunter Creek has a gradient of 80 feet to the mile and follows close to the north wall of its valley, except at one place, 4 miles above the mouth, where it runs along the south side for a short distance.

No good data are available regarding the water supply of Hunter Creek. A partial summer record of the stream flow at claim 17 above Discovery from August 11 to September 12, 1908, shows an average daily discharge of 8.7 second-feet at that point. This record, however, does not include the water from Miller Creek. Better data are available for Hoosier Creek, which is comparable in size with Hunter Creek, and by comparing the discharge of these two creeks for a 28-day period, from August 16 to September 12, 1908, a ratio has been obtained which indicates that the run-off of Hunter Creek may be a little less than that of Hoosier Creek. The average daily summer discharge rate for Hunter Creek, from the middle of May to the middle of September, at a short distance below the mouth of Dawson Creek, is thus estimated to be about 77 second-feet, but this is of course only an approximation and not the true run-off.

Gold was discovered in 1896 on Hunter Creek by William Hunter, for whom the creek was named. Its placers have not proved to be as rich as those of Little Minook Creek, but it nevertheless continues to be a producer of placer gold. The mining claims on Hunter and the other creeks of the Rampart district were staked for the most part under the old mining law, and therefore most of them are 500 feet in length. Discovery claim on Hunter Creek is about 8,000 feet above the mouth, claim 20 above Discovery lies about opposite the mouth of Dawson Creek, and claim 47 above Discovery is at the junction of 92 Hunter Creek and 47 Gulch. During the season of 1931 mining was in progress only on claims 3 and 24 above Discovery and claim 1 below Discovery, but earlier records give some idea of conditions on other claims.

When Hess [21] visited this district in 1904, miners were shoveling in at Discovery claim, on a left-limit bench about 16 feet above the level of Hunter Creek. The overburden on this bench consisted of 5 to 6 feet of gravel covered by 1 to 4 feet of muck. Many large boulders of quartzite 3 feet or less in diameter were present in the gravel. The bedrock consisted partly of diabase and partly of a much deformed cherty shale, and the gold was found mainly in the upper 18 inches of this fractured bedrock. The gold was mostly a fine variety described as "pumpkin seed" gold, though nuggets worth as much as $20 were also recovered. Barite and hematite were recorded among the concentrates recovered with the gold.

A hydraulic plant was also installed in 1904 on claim 17 above Discovery. The section here consisted of 2 to 12 feet, on the average 6 feet, of gravel, overlain by 1 to 40 feet of muck. The maximum thickness of overburden was found at the mouth of a small tributary gulch. Both the gravel and the muck were frozen, and the gravel contained many lenses and dikes of ground ice. The bedrock was largely diabase, with some thin-bedded quartzite. The gold here occurred in the lower 3 feet of gravel and in the underlying fractured bedrock, and for the most part was bright and smooth, although a small amount of rougher gold was also found. The gold was reported to have a value of $19 an ounce. Nuggets as large as 10 ounces were recovered.

In 1931 two men had leases on parts of claim 3 above Discovery. One of these men was mining on the south bench, the bedrock rim of which is about 20 feet above the level of the creek. Above the bedrock lies 5 to 6 feet of gravel, covered by 12 to 15 feet of carbonaceous silt or muck. The bedrock is a fractured olive-drab greenstone. The gravel is well rounded, and some boulders as large as 3 feet in diameter are present. No giant is used in working the 20 feet of overburden, but water from a ditch is allowed to run down the face of the cut, thus slowly thawing and sluicing the frozen overburden to a condition where the operator is able to shovel the gravel into sluice boxes. About 16 inches of bedrock is also removed in the subsequent operation of shoveling in. Water is obtained from a ditch with an intake about three quarters of a mile upstream. Parallel cuts normal to the creek are worked, each cut three box lengths (36 feet) long and 16 feet wide, and it was expected that two such cuts, or about 1,200 square feet, would be shoveled in during the summer of 1931. Pieces of gold weighing as much as half an ounce are recovered. The value

[21] Prindle, L. M., and Hess, F. L., op. cit., p. 33, 1906.

of the gold is not known, but it passes commercially at Rampart for $18 an ounce.

The other lessee on claim 3 above Discovery was planning to dam and divert Hunter Creek to the north side of the valley floor and to work the creek placers directly below the bench operations above recorded.

Claims 14 to 28 above Discovery are now held by one operator, who also holds two claims on lower Dawson Creek. In the past the bench ground from Dawson Creek downstream for several claim lengths has been worked, and the present operations are on the bench above the mouth of Dawson Creek, on claim 24 above Discovery. At and below Dawson Creek the mining operations in the bench have shown a thickness of 8 to 10 feet of gravel, overlain by 20 to 30 feet of muck. At the upper workings the gravel is 12 feet thick, and there is little or no overlying muck. The gravel is well rounded but rather poorly sorted and has an average size of about 3 inches, though many boulders 2 feet in diameter and a few 5 feet in diameter are present. The material of the gravel is mainly greenstone but also includes much slate, chert, quartzite, and quartzite schist, derived from the Paleozoic and Mesozoic rocks farther upstream. The muck, particularly at the older workings opposite Dawson Creek, has numerous ice lenses, and both the muck and gravel are usually frozen. The bedrock consists of a greatly shattered olive-drab greenstone, into which the placer gold penetrates so deeply that 4 feet of this material has to be removed in mining operations. The gold is rather fine at the upper workings and occurs almost entirely either on or in bedrock. The assay value is said to be $18.40 an ounce. At the older workings opposite Dawson Creek the gold is coarser and a little higher in grade, averaging $18.60 an ounce. The pay streak at both upper and lower workings is about 300 feet wide, and the tenor of the placers is less at the present workings above Dawson Creek, but this ground is shallower and cheaper to work. The tenor of the gold-bearing gravel is said to range from 7 to 25 cents to the square foot of bedrock.

A sample of the concentrates from Hunter Creek, opposite the mouth of Dawson Creek, was found to contain magnetite, ilmenite, hematite, barite, pyrite, picotite, cinnabar, galena, and cassiterite, named roughly in order of abundance. A few grains of native copper were also detected. Another sample of concentrates, from claims 14 to 16 above Discovery, was found to contain hematite, barite, ilmenite, magnetite, pyrite, cinnabar, picotite, and cassiterite.

The mining in the vicinity of Dawson Creek is done by hydraulic methods. Water is conveyed by hydraulic pipe, flume, and ditch from an intake about 2 miles upstream and is delivered at the plant under a head of 175 feet. Three giants with 3-inch nozzles are employed, one of which is used for stacking tailings. As the ground is frozen, the giants have to work alternately on different places in the cut, to allow time for natural thawing. A line of 12 sluice boxes is used, with block riffles interspaced with iron rails. With one hired man and a season of 3½ months, beginning June 4, the operator expected, under favorable conditions, to clean 30,000 square feet of bedrock during the summer season of 1931.

Winter drifting was also done on the bench ground of claim 1 below Discovery from January 1 to March 1, 1931. In this work 1,200 square feet of bedrock was cleaned.

LITTLE MINOOK CREEK

Little Minook Creek is a stream about 8 miles in length that empties into Minook Creek from the east about 5 miles from the Yukon. Its course is north-northwest in its upper 5 miles and west in its lower 3 miles. The valley is V-shaped and at its lower end is almost a gorge with walls rising 500 to 700 feet, but at the lower end remnants of the old 500-foot bench are still preserved, though the low gravel bench has been entirely eroded away. Above the bend the valley of Little Minook Creek is more mature and open. Little Minook Creek has no large tributaries, and therefore its drainage basin is small, being less than 6 square miles. The water supply is accordingly scant. A composite record of 126 days, made partly in 1908 and partly in 1909, shows an average discharge of about 14 second-feet, or 560 California miner's inches, but during midsummer, particularly when rain is scarce, the discharge may drop to less than 1 second-foot. The grade of Little Minook Creek, for the lower 3 miles of its course, is 130 feet to the mile.

Little Minook Creek has been the largest producer of placer gold in the Rampart district. Its placers were first discovered by John Minook, a Russian half-breed, in 1893, but apparently the first organized mining was done by F. S. Langford in 1896, since when the creek has been worked continuously. Discovery claim was located about 7,000 feet from the mouth of the creek, but claim 8 above Discovery is said to have had the richest placers, its production to date being estimated at $1,000,000.

Little Minook Creek heads in country rock of the same type as Hunter Creek, and its gravel is therefore about the same in lithologic character. Unlike Hunter Creek, however, it has no bench placers, and all the gold is found in gravel that lies at the present level of the creek. Formerly most of the claims were worked by drifting in winter, but now all mining is of the open-cut type, mainly by manual methods. During the summer of 1931 two plants were operated, one on claims 1 and 2 below Discovery and the other on claim 8 above Discovery, the old site of the rich placers.

The pay streak on claims 1 and 2 below Discovery is 100 to 125 feet wide and is worked by successive open cuts parallel to the creek. The gravel is 5 to 6 feet thick, with little or no covering of muck in the center of the pay streak and only 2 or 3 feet at the edges. The gravel is well rounded and has an average size of 4 to 5 inches, though large numbers of cobbles as much as a foot in diameter are present, and some boulders as large as 3 feet in diameter occur. The gold is found mostly on bedrock, and in some places where the bedrock is much shattered a foot or two of it must be removed to obtain a good recovery of the gold. There are several indications of concentration of the placers from the east side. Curious narrow troughs in the bedrock lead from the east wall diagonally downstream, and the stumps of old trees with the same orientation are also common in the gravel along this same side.

The gold is generally coarse and flattened but not flaky. It is also smooth and shows much abrasion. In the three years 1929–31 the largest piece found weighed 1 ounce, but larger nuggets are said to have been found in earlier mining. One assay on 54 ounces, made in 1929, gave a fineness of 0.917 gold and 0.079 silver, which, with silver at 53 cents an ounce, corresponds to an assay value after melting of $18.99 an ounce. Another assay, on gold produced in 1931, showed a fineness of 0.920½ gold and 0.075 silver, which, with silver at 29 cents, corresponds to a value of $19.05 an ounce. This is high-grade gold.

The concentrates recovered with the gold on claims 1 and 2 below Discovery include native copper, hematite, barite, pyrite, galena (altering to cerusite), and chromite. Copper nuggets are common, and one of these, presented to the writer by the operators, was an inch in greatest diameter. Some native sulphur was also recovered from the concentrates, but possibly it had some foreign source. Another sample of concentrates from claim 1 above Discovery, collected by R. M. Overbeck in 1918, contained hematite, ilmenite, pyrite, magnetite, barite, tetradymite, galena, native copper, picotite, argentite, and scheelite.

Mining at this property is done by groundsluicing and shoveling in. The water of Little Minook Creek is impounded above the workings, and an open cut 900 feet long was being opened by groundsluicing with successive splashes from an automatic dam. When all or nearly all the overburden has been thus removed, the lower foot or two of gravel and loose bedrock is shoveled into sluice boxes. In a cut 18 feet wide about 12 linear feet a day can thus be shoveled in, after the groundsluicing is completed. Two men were engaged in these operations in the summer of 1931, over a period of 4½ months, beginning May 10, and cleaned up 10,000 square feet of ground.

The second plant on Little Minook Creek is on claim 8 above Discovery. Here open-cut mining is being carried on in rather deep ground along the north bank of the creek, where drifting had formerly been done. The pay streak at its widest is 150 feet wide. Along the south side of the pay streak only 9 feet of gravel had to be handled in earlier open-cut operations, but the bank on the north side, where mining is now being done, is 30 to 40 feet high. The overburden consists of muck and poorly assorted subangular gravel in irregular stratification. Old tunnels are now filled with ice. No large boulders are present, and this material has apparently been derived in considerable measure from Idaho Bar, to the north.

The gold is coarse and high grade, averaging $19 an ounce or better after melting. The largest piece found by the present owners was a $50 nugget, but some years ago a $360 nugget was found on this claim. Two samples of concentrates, from claims 6 and 8 above Discovery, show that the heavy minerals are hematite, barite, ilmenite, magnetite, argentite, galena, pyrite, picotite, native copper, and cinnabar (?).

Mining is done in the same way as above described—by sapping away the bank of the cut with water from a splash dam. The muck and gravel after thawing caves into the cut and is groundsluiced by the running water, the gold being thus concentrated near bedrock. The present operators had just taken over this property and were at a disadvantage because they were obliged to spend considerable time in straightening their cut. They expected to shovel in only 12 box lengths, 16 feet wide, or about 2,300 square feet in all, in 1931 but a larger block of ground in 1932.

IDAHO BAR

Idaho Bar is a deposit of high gravel that forms the top of the ridge between the bend of Little Minook Creek and the junction of Dawson and Hunter Creeks. Similar deposits that lie on the top of the ridges southeast of Little Minook and Hoosier Creeks are known respectively as California and Florida Bars. These gravel deposits are believed by the writer to be of Pliocene (?) age and are without doubt the proximate source of much of the gold in Hunter, Little Minook, Little Minook Junior, and Hoosier Creeks.

Idaho Bar is about 1,600 feet above sea level and about 1,000 feet higher than the mouth of Little Minook Creek. Little Minook Creek, however, has a high gradient, so that the elevation of Idaho Bar above Little Minook Creek at the bend is only 600 to 800 feet. Little information is available concerning the character of this deposit, for it is nowhere well exposed, and no logs have been kept of the old shafts that were driven through it. One shaft at the crest of the ridge, however, is said to have been sunk 100 feet to bedrock, and this probably indicates the maximum thickness of the deposit in this vicinity.

A favored locality for prospecting and mining the gravel of Idaho Bar is along the south side of the deposit at the head of a gulch about 600 feet above the level of Little Minook Creek. A short tunnel has recently been driven on bedrock at this place, and 1,500 square feet of bedrock was cleaned during the winter of 1930–31. The bedrock in the tunnel is an impure chert, and the overlying gravel is well rounded and fairly uniform in size, though boulders as large as 2 feet in diameter are also found. The gravel consists mainly of chert, diabase, quartzite, vein quartz, and a variety of metamorphic rocks. The large boulders are mainly quartzite and are derived from the Lower Cretaceous rocks that crop out farther up Little Minook Creek. The gold occurs mainly in the lower foot or two of gravel and also in the decomposed bedrock, but a little gold is also found in the gravel at the top of the tunnel. At favorable localities this placer is said to carry as much as $1 to the square foot of bedrock.

No assays of gold are available, but it is of high grade and is said by the present operators to have an assay value of $18.75 or more an ounce. The gold is coarse, shotty, and rather uniform in size, with no large nuggets. The heavy minerals of the concentrates are chiefly ilmenite, hematite, and magnetite.

Lack of water prevents the economical development of this gold placer. At present only a winter dump can be taken out, which is sluiced in spring by the water from melting snow on the top and sides of the hill. The scope of these operations might be expanded somewhat by the use of snow fences, which could be built up during the winter to a considerable height, thus capturing more snow and increasing the water supply in spring. This method has been used to advantage at the head of Flat Creek, in the Iditarod district and elsewhere in Alaska. Otherwise, the problem of obtaining water is an almost insuperable one. The placer would not pay for pumping water to this height, and the nearest creek that could supply water on a ditch grade is Quail Creek, but such a project would be difficult of construction and expensive both in original outlay and in upkeep.

LITTLE MINOOK JUNIOR CREEK

Little Minook Junior Creek is about 2½ miles long and lies between Little Minook and Hoosier Creeks. Its course is a little north of west, and its headwaters do not extend above the zone marked by the Pliocene (?) gravel of Idaho, California, and Florida Bars. The valley is narrow, with steep walls, and in its lower 2,000 feet becomes almost a canyon. Barometer readings for a distance of about 9,000 feet upstream from the mouth show a gradient of 385 feet to the mile. The water supply is very meager, and the creek is usually dry during the summer.

Discovery claim on Little Minook Junior Creek is at the mouth of the creek, and claim 25 above Discovery is at the junction of the two gulches that form its head. The claims were originally staked 500 feet long, but some of them have subsequently been restaked as 1,320-foot claims. The placers are mainly creek placers, but in places where the stream cuts over against one wall of the valley the gravel extends for a considerable distance up the opposite slope, and at least two bedrock terraces have been recognized under the alluvial cover.

In the lower part of the creek bedrock appears at the surface and little gravel is present. Both open-cut work and drifting have been done, but the present mining is of the open-cut type.

One miner was at work on Little Minook Junior Creek in 1931, on the lower end of claim 18, above Discovery. The gravel at this claim is coarse and fairly well rounded and ranges in size from pebbles to boulders more than 3 feet in diameter. It consists of quartzite, greenstone, slate, chert, quartz, and a hard cherty quartzite conglomerate. The gravel deposit averages 4 to 5 feet in thickness and carries little gold, the gold being found mostly in the upper 1½ feet of bedrock. The gravel is usually frozen. Above the gravel lies an overburden of frozen muck and slide rock, about 18 to 25 feet thick, which contains much vegetal material and mammal remains. The bedrock is chiefly greenstone, and its surface is very uneven. The pay streak has a maximum width of 40 feet in the valley bottom but at places extends up the slopes for some distance.

The gold is flattened and rounded but not flaky, the grains averaging perhaps less than 0.1 inch in size. The largest piece of gold known to have been recovered was a $200 nugget, found on claim 24 above Discovery. The gold is of about the same fineness as that found on Little Minook Creek, but the product of these operations is sold at Rampart at the commercial rate of $18 an ounce. The concentrates recovered with the gold include the heavy minerals pyrite, hematite, ilmenite, barite, magnetite, and galena.

Various methods of mining have been tried on Little Minook Junior Creek. The present operator at one time did a little hydraulic mining on claim 20 above Discovery with water obtained from an 1,800-foot flume, but this was later destroyed by fire. Winter drifting has also been done by several men but is difficult on account of the presence of water in the drifts. At present an automatic dam is used, and, as elsewhere in this district, the overburden is groundsluiced off and the pay gravel and broken bedrock is shoveled into sluice boxes. The present cut is 300 feet long and 6 to 7 feet wide. A line of seven or eight sluice boxes is used, and 1,300 square feet of bedrock was cleaned during the early summer of 1931. After the creek dries up a rocker is used at favorable localities until October.

HOOSIER CREEK

Hoosier Creek is about 11 miles long and enters Minook Creek from the east about 5½ miles from the Yukon. It has few tributaries in its lower 6 miles, but above that stretch several tributaries give rise to a wide upper basin. Although its drainage basin is smaller than that of Hunter Creek, the run-off appears to be slightly greater, owing to the fact that the headwaters of Hoosier Creek drain higher country, where the precipitation, both in summer and winter, may be somewhat greater. Stream measurements by Ellsworth and Davenport [22] over a period of 132 days in the summers of 1908 and 1909 show an average summer discharge for Hoosier Creek of 84 second-feet, though naturally the discharge in midsummer is much less than the average.

The valley of Hoosier Creek is broader and more open than the valleys of Hunter and Little Minook Creeks, and the stream gradient is appreciably lower than that of Hunter Creek. The alluvial deposits of the present valley floor contain the pay streak and consist of 1 to 9 feet of gravel, averaging perhaps 6 feet, overlain by 1 to 10 feet of carbonaceous silt, or muck. The pay streak is rather ill defined but is believed to range from 100 to 150 feet in width.

The claims on Hoosier Creek are 500 feet in length, and Discovery claim is about 200 feet above the mouth. The total overburden is only 7 to 16 feet, and therefore the placers may be regarded as shallow. There is adequate water for hydraulic mining, but the grade of the creek is too low for sluice boxes, and in an attempt in 1904 to do this type of mining a hydraulic elevator was used to dispose of the tailings, but the water supply in midsummer is inadequate for an elevator. Much of the present mining is therefore carried on as winter drifting. In this work wood fires are used to thaw the ground in sinking a shaft, and from the bottom of the shaft the gravel is thawed in an expanding circle by the same method. Steam points are not used either here or elsewhere in the Rampart district. It is possible that a consolidation of holdings in Hoosier Creek might make it possible to work the creek as a unit, utilizing all available water for a single open-cut hydraulic plant and diverting enough water to stack tailings with one giant.

Claims 13 to 14 above Discovery have been and probably still are the best on the creek but are estimated to have produced only $50,000. The pay streak on these two claims is said to have a maximum width of 150 feet. Drift mining was continued on these claims by three men during the winter of 1930–31. The gold is said to be coarse, and one piece worth $250 has been recovered. This gold is of unusually high grade. One assay based on production in 1926 gave a fineness of 0.941½ gold and 0.053 silver. With silver at the then

[22] Ellsworth, C. E., and Davenport, R. W., op. cit., pp. 227–228.

current price of 63 cents an ounce the resulting value of the gold is $19.49 an ounce.

Another operator, who holds the claims from Discovery to 2 above Discovery and also claims 17 to 25 above Discovery, worked an open cut on claim 25 above Discovery during the summer of 1930; and he again did open-cut mining on claims 21 and 22 above Discovery, during the summer of 1931, cleaning 1,200 square feet of bedrock. Still others have holdings on Hoosier Creek, and considerable winter prospecting and small-scale mining is done every year.

A sample of the concentrates recovered with the gold on claims 13 and 14 above Discovery was collected by R. M. Overbeck in 1918. The heavy minerals of this sample consisted mainly of hematite, ilmenite, barite, magnetite, pyrite, picotite, scheelite, native copper, and cinnabar.

SLATE CREEK

Slate Creek enters Minook Creek from the west about 11 miles above its mouth. It is about 4 miles long and flows in a general northeasterly direction. Its valley is narrow and V shaped in the lower part but somewhat more open in the headwater region. The gradient of Slate Creek in the lower part of its valley is about 150 feet to the mile.

The gold in Slate Creek is found in both creek and bench placers, but the old creek workings have been largely filled in by gravel subsequently deposited by the creek. The bench gravel now being worked is confined to the northwest side of the creek, and the character of the alluvium suggests that much of the gold may have come from this northwest slope of the valley. The bedrock in the creek consists of sheared or schistose chert, black, maroon, and green slate and phyllite, and, in the lower valley, limestone. The gravel consists of the same types of rock, with the addition of considerable vein quartz and a small percentage of several varieties of schist, including some dark-green epidote-chlorite schist, probably derived from the metamorphism of basic intrusive rocks. The country rock in general is considerably metamorphosed. The vein quartz, which is present in both bedrock and gravel, is probably the source of the gold.

Discovery claim on Slate Creek is about 4,000 feet from the mouth, and 500-foot claims were staked upstream as far as claim 12 above Discovery. The early mining on Slate Creek was done in the creek placers, but those have now been worked out, and present mining is confined to the benches. No data are available on the character of the creek placers, except the statement by Hess [23] in 1904 that most of the work at that time had been done nearly 2 miles above the mouth

[23] Prindle, L. M., and Hess, F. L., op. cit., p. 38.

by winter drifting in gravel 26 feet thick. Much subsequent open-cut work, however, has evidently been done in the creek itself farther downstream. The pay streak in these upper placers was said by Hess to be 50 feet wide, and the gold was reported to occur in the lower 3 feet of gravel and the upper 1½ feet of fractured bedrock. A piece of gold worth $8 was the largest then reported, but placer silver also occurred with the gold, and one silver nugget weighing 8 ounces was recorded.

The present mining is being done along the northwest bench on claim 2 below Discovery. An open cut about 15 to 20 feet above the level of the creek is being opened up. The placer consists of about 5 feet of well-worn gravel and boulders, overlain by 10 to 12 feet of muck. The fractured bedrock is mingled with considerable clayey material, some of which is yellowish brown from iron staining and is probably mineralized. The gold is coarse, and some nuggets worth as much as $100 have been found. The average fineness of the gold is said by the operator to be 0.915, and this, without counting the silver, makes the gold worth $18.91 an ounce. No concentrates are available from these operations, but much barite was observed as good-sized cobbles in the gravel, and placer silver is of common occurrence.

This mining is done largely by a unique application of groundsluicing methods. A ditch 1,200 feet long brings a sluice head of water to the upper part of the cut, where it is ponded and allowed to splash periodically down over the face of the cut. No nozzle is used, and no sluice boxes are employed. The operator merely visits the cut when the overburden has been groundsluiced away and picks up the nuggets.

RUBY CREEK

Ruby Creek enters Minook Creek from the west about 8 miles from the Yukon. This stream is about 7 miles long and flows northeast, nearly parallel to Slate Creek. A number of small tributaries enter Ruby Creek from the southeast but practically none from the northwest. The lower part of the valley is broadly V-shaped, with steeply sloping sides, and the upper part is more open. According to Hess,[24] the gradient of the lower valley is 150 feet to the mile, and the stream carries 300 to 500 California miner's inches, or about 10 second-feet of water, but this is merely an estimate that was not based on actual measurement. No mining was in progress on Ruby Creek in 1931, and this creek was not visited by the writer.

Ruby Creek heads in the area of highly metamorphosed Paleozoic rocks that include quartz-mica schist, quartzite schist, quartzite, garnet-staurolite schist, phyllite, hornblende schist, and chert schist, and such rocks apparently extend well down the valley of Ruby

[24] Prindle, L. M., and Hess, F. L., op. cit., pp. 37-38.

Creek. According to Hess,[25] the alluvial deposits of the lower valley are 300 to 500 feet wide and are composed of 5 to 7 feet of gravel overlain by 1 to 4 feet of muck. The gravel is composed of the same material as the varieties of bedrock above mentioned, with the addition of some gneiss. It is of medium size but contains a few boulders a foot or more in diameter. Hess mentions in particular the absence of the heavy quartzite boulders that are present on Minook Creek and its eastern tributaries, but as the Lower Cretaceous quartzite is now known to be absent on the west side of Minook Creek, this is easily understood. The gold is found on bedrock and is distributed across the entire width of the present gravel deposits. The gold from a point half a mile above Minook Creek is described as iron-stained and in general a little rougher than the gold from Little Minook and Hunter Creeks. The larger pieces, however, were very smooth. Nuggets weighing as much as 2 ounces were recovered. The concentrates include a large quantity of garnet, some crystals attaining 1 inch in diameter. In fact, the garnet crystals were so numerous that they interfered seriously with placer mining and made it necessary to clean the riffles once or twice a day. Some barite was also said to be present, and placer silver also was found; one nugget of the silver weighed 2 ounces.

QUAIL CREEK

Quail Creek is one of the headwater tributaries of Troublesome Creek, which in turn flows into the Hess River. It is about 6 miles long, and its main branch drains the north and west sides of Wolverine Mountain, heading against the upper drainage basin of Hoosier Creek. The drainage and topography in the vicinity of Wolverine Mountain are not well indicated on the published map,[26] and not all the tributaries of Quail Creek are shown. About a mile above the junction with Troublesome Creek, Quail Creek divides into two branches. The main creek heads westward, and the other branch, known as the South Fork of Quail Creek, heads southward against Hutlinana Creek. A short distance above the forks a small tributary, known as Nugget Creek, enters Quail Creek from the north. For 3 miles above the forks the main branch of Quail Creek flows a little south of east, and in this stretch receives several small tributaries both from the north and from the south, the southern tributaries draining the north side of Wolverine Mountain.

In its upper part the main valley of Quail Creek is wide and open, even to the very summit, between Wolverine and Elephant Mountains. At the lower end of this part, however, the walls of the valley close in and the valley floor narrows to a few hundred feet. In the east-west or central section the valley is still fairly constrict-

[25] Prindle, L. M., and Hess, F. L., op. cit., pp. 37-38, 1906.
[26] Prindle, L. M., A geologic reconnaissance of the Fairbanks quadrangle, Alaska: U.S. Geol. Survey Bull. 525, pl. 1, 1913.

ed but not so much so as Hunter or Little Minook Creeks. A well-defined bench about 150 feet above the creek appears on the north side of this section of Quail Creek all the way to Troublesome Creek. Above this bench, at an elevation of about 400 feet above the creek, the ends of the spurs are noticeably flat and spatulate, suggesting a still older stream channel at that elevation. In fact, this old channel level shows as a terrace on the spur between the main branch and the south fork of Quail Creek. Colors of gold are reported to have been found on this terrace, and workable placers have been found on the lower bench.

The gradient of a part of Quail Creek has been determined by barometric readings from the forks upstream for 3 miles to be about 160 feet to the mile. This gradient seems rather high, but the contours on the map indicate about the same amount. No complete summer record of the water supply is available, but the average discharge of Quail Creek just above Troublesome Creek for a period of 98 days, from June 7 to September 12, 1909, is computed from the records of Ellsworth and Davenport [27] to have been 363 second-feet. The heavy run-off in May is not included in this amount, and the average summer discharge is therefore considerably greater.

Claims were first staked on Quail Creek in 1898, but no very high-grade placers have been found in its valley, and the creek has not been a large producer of gold. It has a large and constant supply of water, however, and may therefore have possibilities for hydraulic mining. Claim 9 below Discovery is just above the mouth of the creek, and Discovery claim, on the assumption that the original claims were staked 500 feet long, must be nearly a mile upstream. The total production up to 1904 is reported by Hess [28] to have been about $3,300. Since that date mining has been carried on intermittently. The present operators on McCaskey Bar, in the Eureka area, mined for several years prior to 1922 in the upper stretch of Quail Creek. When the writer visited Quail Creek in 1922, two men were operating a small hydraulic plant on the lower bench on the north side of Quail Creek, just below the mouth of Nugget Creek. These low bench placers are reported by the present operator on Quail Creek to have a tenor of about 40 cents to the square foot of bedrock, which is higher than the tenor of the creek placers. The small supply of water available from Nugget Creek limited the scope of these operations. A good ditch, with an intake well upstream, together with adequate equipment, might result in a large recovery of gold from this bench ground. At the present time one man is working an open cut on claim 8 above Discovery, with the usual equipment of an automatic dam and sluice boxes. A cut 12 box lengths (or 144 feet) long is

[27] Ellsworth, C. E., and Davenport, R. W., op. cit., p. 221, 1915.
[28] Prindle, L. M., and Hess, F. L., op. cit., p. 48.

projected, and it is planned to shovel in a width of 12 to 16 feet. The pay streak in the creek placers is said to be about 300 feet wide, but the tenor is low. The placer consists of about 5 feet of gravel, overlying the bedrock. The gold is said to be of not quite as high grade as that from the creeks close to Rampart but passes commercially in Rampart at $18 an ounce.

A sample of the concentrates from claim 8 above Discovery on Quail Creek was found to contain the heavy minerals picotite, cassiterite, barite, scheelite, pyrite, and a single grain of cinnabar. The presence of cassiterite on Quail Creek is specially noteworthy, as it tends to relate this placer with those in the Tofty area.

OTHER CREEKS

Gold placers are known on other creeks in the Rampart district, but most of these are either worked out or are too low in grade to be mined under present conditions. Prospecting is also in progress on other creeks. One of these is Florida Creek, a small stream that enters Minook Creek from the east about 2 miles above Hoosier Creek.

Florida Creek has a narrow valley and a high gradient. The stream is dry in midsummer. According to Hess,[29] the alluvial deposits are narrow but in places have a depth of 15 to 20 feet. The bedrock is a diabase of greenstone habit. Little is known of past mining operations, but the placers in general are probably similar to those on Hoosier and Little Minook Creeks. No mining is now being done on Florida Creek, and this locality was not visited by the writer.

Another creek close to Rampart that has been much prospected is Alder Creek, which heads against Hunter Creek and flows north to the Yukon River. A line joining the centers of the gravel deposits of Idaho, California, and Florida Bars trends northeastward toward the basin of Alder Creek, and for this reason attempts have been made on some of the headwater tributaries of Alder Creek to find placers like those of Hunter, Little Minook, and Hoosier Creeks, which have been concentrated from the old Pliocene (?) placers. Such an extension of this zone of placer deposits seems at first sight reasonable, but workable placers have not been found. A fact that has been discovered by recent prospecting may throw some light on the absence of such placers. It has been reported to the writer that a bedrock of coal was found in the bottom of one shaft that was sunk in the gravel of one of the upper tributaries of Alder Creek. This may mean that much of the old valley of Alder Creek was covered by the Tertiary coal-bearing formation at the time when the gravel of Idaho Bar was deposited. The gold in the Pliocene (?) gravel is believed to have had a local source in the underlying Carboniferous rocks of the Rampart group;

[29] Prindle, L. M., and Hess, F. L., op. cit., p. 36.

and if these gold-bearing rocks were covered by Tertiary sediments at the time when the old gold placers were accumulated, as appears to be the case, it is easy to see that no gold placers would be formed in Alder Creek. The same conditions probably prevail also on MacDermitt and Raven Creeks.

Indications of prospecting were also seen on Garnet and Russian Creeks, and north of the Yukon considerable prospecting and some placer mining have been done on Morelock Creek and its tributaries, but no recent data on these activities are available. Prospecting has also been done on Bear Creek, another tributary of the Yukon from the north, which enters the main river a short distance above the "Ramparts", or rapids of the Yukon. Bear Creek lies east and Morelock Creek west of the large body of Tertiary monzonite or quartz monzonite that forms the bedrock at the "Ramparts", and conditions of mineralization are probably similar on these creeks to those in the vicinity of Tofty. In fact, cassiterite is also known from this area. A sample of the concentrates from Bonanza Creek, a tributary of Bear Creek, was presented to the writer by Mr. Joe Egler, of Rampart. The principal heavy minerals of these concentrates were magnetite, cassiterite, and ilmenite.

In the Quail Creek country some prospecting and mining has also been reported from Troublesome Creek, but no such work is now in progress. A sample of concentrates, however, from Troublesome Creek, just below the mouth of Union Creek, was collected by R. M. Overbeck in 1918. The heavy minerals of this sample were found to be barite, hematite, magnetite, ilmenite, picotite, pyrite, cinnabar, and cassiterite. Placer mining was also done for several years on Gunnison Creek, a tributary of Troublesome Creek, which drains much of the northwest slopes of Sawtooth (Lynx) Mountains. No record of this work has been made, but a sample of the concentrates submitted by J. Burrington, a former placer miner on Gunnison Creek, contained the heavy minerals magnetite, ilmenite, picotite, scheelite, and pyrite.

EUREKA AREA

The Eureka area comprises chiefly Eureka Creek and its tributaries but also includes certain adjacent tributaries of Baker Creek, such as Hutlinana Creek and its tributaries, and McKinley, Omega, and Thanksgiving Creeks. The placer-mining activity centers mainly about Eureka Creek and its tributaries. (See pl. 4.)

EUREKA CREEK

Eureka Creek is about 12 miles long and heads in the hills southwest of Elephant Mountain. In the upper third of its course it flows southwest but then turns abruptly south and flows in that direction in the southern two thirds of its course. Boston Creek enters Eureka Creek at the point where its course changes from southwest to south and might be considered the true head of Eureka Creek. At 1½ miles below the mouth of Boston Creek Eureka Creek is joined by Pioneer Creek, a large tributary from the northeast, which flows nearly parallel to the upper valley of Eureka Creek. At 3½ miles below Boston Creek another tributary, called Rhode Island Creek, enters from the northwest, and 3½ miles below the mouth of Rhode Island Creek Eureka Creek joins Baker Creek.

On Eureka Creek and its tributaries one fairly well defined old erosion level is recognized about 250 feet above the present creek. Another less well defined erosion level occurs at 50 to 70 feet above Eureka Creek; and several others, which are not apparent at the surface, show where the bedrock is bared by mining operations. The oldest of these old erosion levels is the best known, for it is the site of gravel-covered terraces that have been mined at numerous places in the Eureka Creek area. Perhaps the best known of these is What Cheer Bar, which is on the northwest side of Pioneer Creek just below Doric Creek and about 250 feet above the level of Pioneer Creek. These older alluvial deposits continue up Pioneer Creek and occur here and there between small tributaries of Pioneer Creek. Similar bench gravel is found along the northeast side of upper Eureka Creek, from the confluence with Boston Creek upstream. Another well-known site of these older deposits is McCaskey Bar, on a bench on the east side of Eureka Creek, west of Alameda Creek. This has about the same elevation above the creek as What Cheer Bar. Between Eureka and Rhode Island Creeks is a broad, gently sloping spur, which is covered by these older alluvial deposits. This is the site of Shirley Bar, one of the benches that was formerly mined and from which gold was concentrated in the present gulches draining this bench to form high-grade gold placers.

The valley of Eureka Creek above Boston Creek is narrow and markedly asymmetric in cross section. The creek follows the southeast wall, which is steep and in places precipitous, and no tributaries enter from this side. The northwest side of the valley has a gentle slope, and two tributaries enter from this side. The first creek above Boston Creek is called Unanimous Creek, and the second is called American Creek. The ridge southeast of upper Eureka Creek rises 400 to 600 feet above its valley floor and is composed largely of Lower Cretaceous quartzite, which is highly resistant to erosion. The Lower Cretaceous rocks in this vicinity strike southwest, and upper Eureka Creek therefore occupies a strike valley. The asymmetry of this valley is due largely to the superior resistance to erosion offered by the quartzite that forms the south wall, but a great deal of erosion in this region is accomplished by processes of soil flow that are materially aided by exposure to the sun's rays. Such processes in the upper valley of Eureka Creek have probably accentuated the asymmetry that was begun by differential erosion. Below the mouth of Boston Creek the valley of Eureka Creek widens rapidly, and below the mouth of Pioneer Creek it merges gradually with the flats of Baker Creek. According to the topographic map,[30] the gradient of Eureka Creek between points 1½ miles below and 3 miles above Boston Creek is about 100 feet to the mile, but the gradient of the lower valley is much less. Above Boston Creek the water supply of Eureka Creek is small and during an average summer is hardly adequate for sluicing.

Discovery claim on Eureka Creek is just below the mouth of Boston Creek. The creek claims from claim 2 below to the upper end of claim 1 above Discovery have in past years been worked by drifting, by open cutting, and by scraper plants, and the high-grade placers have been well worked out. Nevertheless two men have been engaged from 1929 to 1931 in shoveling in thrice-worked gravel on Discovery claim, but they were removing several feet of bedrock and were recovering thereby considerable gold that had been overlooked in earlier operations. Twelve box lengths 16 feet wide, or about 2,300 square feet, was shoveled in here during the summer of 1931. On Discovery claim the pay streak ranges in width from 25 to 70 feet, and so far as known the high-grade placers were limited to the four claims above enumerated. The gravel is 10 to 18 feet deep and in places has a covering of 8 feet of muck. The bedrock is composed of sheared grits and argillaceous rocks of the Lower Cretaceous series, and where the bedrock is quartzite it is fractured and blocky, so that the gold penetrates deeply into the cracks. The gold is bright and rather chunky, and many good-sized nuggets have been found. Considerable vein quartz adheres to the coarser gold. No assays of the gold from Discovery claim are available, but the commercial value of this gold is $15.50 an ounce. Among several assays of the gold from Eureka Creek, however, the lowest known to the writer is gold 0.780¼, silver 0.213; and this with silver at 29 cents an ounce gives a minimum value of $16.19 an ounce.

Above Discovery claim, on the east side of Eureka Creek, is a well-defined bench about 75 feet above the level of the creek. This bench is about 200 feet wide and 600 feet long and is said to have carried some low-grade placers. Armstrong Bar, on the spur between Boston and upper Eureka Creeks, is the upstream continuation of this terrace. This bar has been prospected, but its placers have not so far been found to be of workable grade.

About 2 miles above the mouth of Boston Creek considerable mining has been done on bench ground along the northwest side of the head of Eureka Creek. The bedrock of phyllite and slate upon which these placers rest is not planated as a horizontal terrace but slopes gently

[30] Eakin, H. M., A geologic reconnaissance of a part of the Rampart quadrangle, Alaska: U.S. Geol. Survey Bull. 539, pl. 1, 1913.

toward the creek. Some of the best of the gravel lay on this gently sloping bedrock surface, about 70 feet above the creek. The pay streak is not continuous, and the spotted character of the placers, together with the angular to subangular character of the gravel, indicates that the gold has been concentrated almost in place, as a hillside placer deposit. The depth of the gravel ranges from 8 to 20 feet.

These older bench-mining operations were carried on by hydraulic methods. A high ditch, which tapped the headwaters of Eureka Creek, was used in this older work but is now in bad shape and has been abandoned. At the time of the writer's visit in 1931 another open cut had been started on this bench ground, opposite claim 7 above Discovery, but water was scarce and hydraulic mining had temporarily been discontinued. Two men, however, were engaged in putting into shape a low ditch that was to be utilized for piping the tailings. A higher ditch, which obtains its water from American Creek and gives a head of 25 feet at the cut, will be used for the main hydraulic mining. These operations will be limited largely to spring, when the snow is melting, and to occasional periods of summer rains, for American Creek is nearly dry during most of the summer.

PIONEER CREEK

Pioneer Creek heads in the southwest flanks of Elephant Mountain and flows in a general southwesterly direction for 9 miles to join Eureka Creek. It is nearly parallel to the upper part of Eureka Creek throughout most of its course. Like the headwater portion of Eureka Creek, and for the same reasons, the cross section of Pioneer Creek is unsymmetrical, for the south wall is steep, and the stream follows that side of the valley. All the tributaries of Pioneer Creek enter from the northwest. These tributaries, named in order upstream, are Doric, Boothby, Seattle Junior, Skookum, and Joe Bush Creeks and the North Fork of Pioneer Creek. Pioneer Creek itself, above the North Fork, is called Deadwood Creek.

The northwest slope of the valley of Pioneer Creek is characterized by a gentle slope, on which at several places are gravel-covered terraces. The most prominent of these is a terrace about 250 feet above the level of the creek, in the lower valley. Southwest of Doric Creek this terrace is known as What Cheer Bar and has been the site of placer-mining operations. This terrace may be traced upstream for 3 or 4 miles. Farther upstream other less well-defined benches, both above and below the elevation of What Cheer Bar, are also present, and the general impression of this northwest wall of Pioneer Creek is that it consists of several benches at different elevations which mark various stages in the erosional history of the creek.

Pioneer Creek is larger than the headwater portion of Eureka Creek and ordinarily gives a fair supply of water for one large hydraulic plant but usually not enough for several. Stream measurements by Ellsworth and Davenport [31] over a period of 118 days in 1908 and 1909, from May 26 to September 20, show an average discharge of 7.6 second-feet, or 304 miner's inches. These measurements were made at a gage established at a point called the What Cheer Bar intake, about 4 miles above What Cheer Bar. It should be recognized that this average includes some of the high water of spring. The measurements in July and August show an average discharge of only 2 to 3 second-feet. The gradient of Pioneer Creek, from the mouth of its North Fork to its junction with Eureka Creek, a distance of 5 miles, is about 80 feet to the mile.

Placer mining on Pioneer Creek has been confined to the benches along the northwest side of the valley. One of the best known of these bench workings was at What Cheer Bar, below Doric Creek, but this was worked out years ago. According to the description given by Hess,[32] What Cheer Bar lies 2,000 feet from Pioneer Creek and is 250 feet vertically above it. The bedrock, where exposed by placer mining, is greatly jointed and broken and is also affected by later creep, so that the eroded ends of the strata bend over and lean downhill, blending with the overlying gravel. The overburden, from top to bottom, consists of 1 to 1½ feet of muck, 3 feet of rather fine wash, 5 feet of medium-sized yellowish gravel, and 3 to 4 feet of rather heavy wash, including some boulders of vein quartz 2 feet or more in diameter. Most of the gold was found in the lower part of the gravel and the upper 2 feet of bedrock. The gold was well worn and light-colored and had a commercial value of $15.50 an ounce.

Another early site of mining was on Seattle Bar, between Seattle Junior and Skookum Creeks. This bench ground is about the same distance from Pioneer Creek as What Cheer Bar and at about the same elevation above the creek. The gravel here is 9 feet thick and very similar to that on What Cheer Bar. The gold is bright and varies in shape from chunky to flat but is not flaky.

The benches have been pretty well prospected and worked at many places along the northwest side of the valley, and the creeks cutting the benches have also been mined. A typical example of this bench mining was at a plant about 2 miles upstream from Eureka Creek, visited by the writer in 1922. Here the pay streak was from 300 to 1,000 feet wide, and the gravel was 3 to 8 feet thick, with an average thickness of about 5½ feet. The gravel here, as elsewhere on these benches, is subangular to angular and of medium size. No large boulders occur, but numerous cobbles a foot or less in diameter were found, many of which are quartzite and quartzite conglomerate,

[31] Ellsworth, C. E., and Davenport, R. W., Surface water supply of the Yukon-Tanana region, Alaska: U.S. Geol. Survey Water-Supply Paper 342, pp. 316-317, 1915.

[32] Prindle, L. M., and Hess, F. L., op. cit., p. 41.

derived from the Lower Cretaceous country rock. The bedrock, which is sheared sandstone and slate that strikes N. 75° E. and dips 75° N., is notably pyritized and iron-stained and is cut here and there by quartz stringers, which are undoubtedly the source of this gold. The concentrates recovered with the gold at this plant included the heavy minerals picotite, ilmenite, pyrite, barite, scheelite, magnetite, and cinnabar. Several miles of ground similar to this extended upstream from this plant, and much of it has now been worked.

Present operations in this vicinity are on and near Doric Creek. In 1931 a block of 10,000 square feet was worked in the creek placers of Doric Creek. The pay streak here is only 50 feet wide, and the present work was the upper 200 feet of a 700-foot cut that was started a year or two ago. This was originally very rich ground, averaging $4 to the square foot of bedrock, but was drifted 20 years ago. In the present operations this ground is being worked by open cuts, and for this type of mining it still yields good returns. The gravel is about 15 feet thick and consists of slate and phyllite, principally the latter, and a few large boulders of dark-gray quartzite. Most of the gravel is under 10 inches in size, and all of it is angular. Little or no muck overlies this deposit. The bedrock here is mainly phyllite that strikes N. 50° E. and dips 75° NW. In places heavy beds of massive dark-gray quartzite form reefs in the bedrock. One of these beds is closely folded, and another is cut by a quartz vein 8 inches thick, which was subsequently faulted, with a displacement of 3 inches. Here and there are quartz reefs in the bedrock, and vein quartz also forms a notable part of the gravel. The gold is said to assay a little over $16 an ounce. During the present operations two nuggets, worth $70 and $45, were found. Evidently this deposit resulted from the concentration of gold from the surrounding bench gravel.

This deposit was mined by giants under a hydraulic head of 150 feet. The water is supplied by a good-sized ditch with an intake 4 miles upstream. A long line of sluice boxes are used, the upper one set to a grade of 7 inches per box length, and the lower ones to a grade of 5 inches. Most of the gold is recovered in the upper five or six boxes, and the lower ones have false bottoms rather than riffles and are used mainly to move the tailings farther down the cut. Seven people were engaged in this work, 5 in the day shift and 2 at night. After this work was completed, a new cut was begun on Seattle Junior Creek, but the results of this work are not known to the writer.

Farther up Pioneer Creek another plant was operated between Seattle Junior and Skookum Creeks, on a piece of ground called Last Bench. This bench is 200 feet above the level of Pioneer Creek and has a pay streak about 250 feet wide. At its upper end the bench is dissected by Skookum Creek, and above Skookum Creek no bedrock benches with a gravel covering are known on the northwest side of Pioneer Creek. The gravel at the upper side of Last Bench is 12 feet thick but on the down-slope side is but 4 feet thick. The gravel, which consists of quartzite, phyllite, and conglomerate, is rather fine, averaging 3 to 4 inches in size, and includes only a few boulders and these are not large. The dominant strike of the bedrock is N. 60° E. and the dip 80° NW. The bedrock is slate and sandy phyllite and is greatly iron-stained, but not much vein quartz was observed in it. The gold penetrates deeply into the bedrock, and in places it is necessary to remove 5 to 6 feet of bedrock in order to get a good recovery. This renders necessary a long bedrock drain in order to dispose of tailings. The gold is said to have a fineness of a little over 0.800, which would give it a value of more than $16.50 an ounce. The largest piece of gold so far found was worth $20. The principal heavy minerals of the concentrates are picotite, ilmenite, magnetite, limonite, and scheelite.

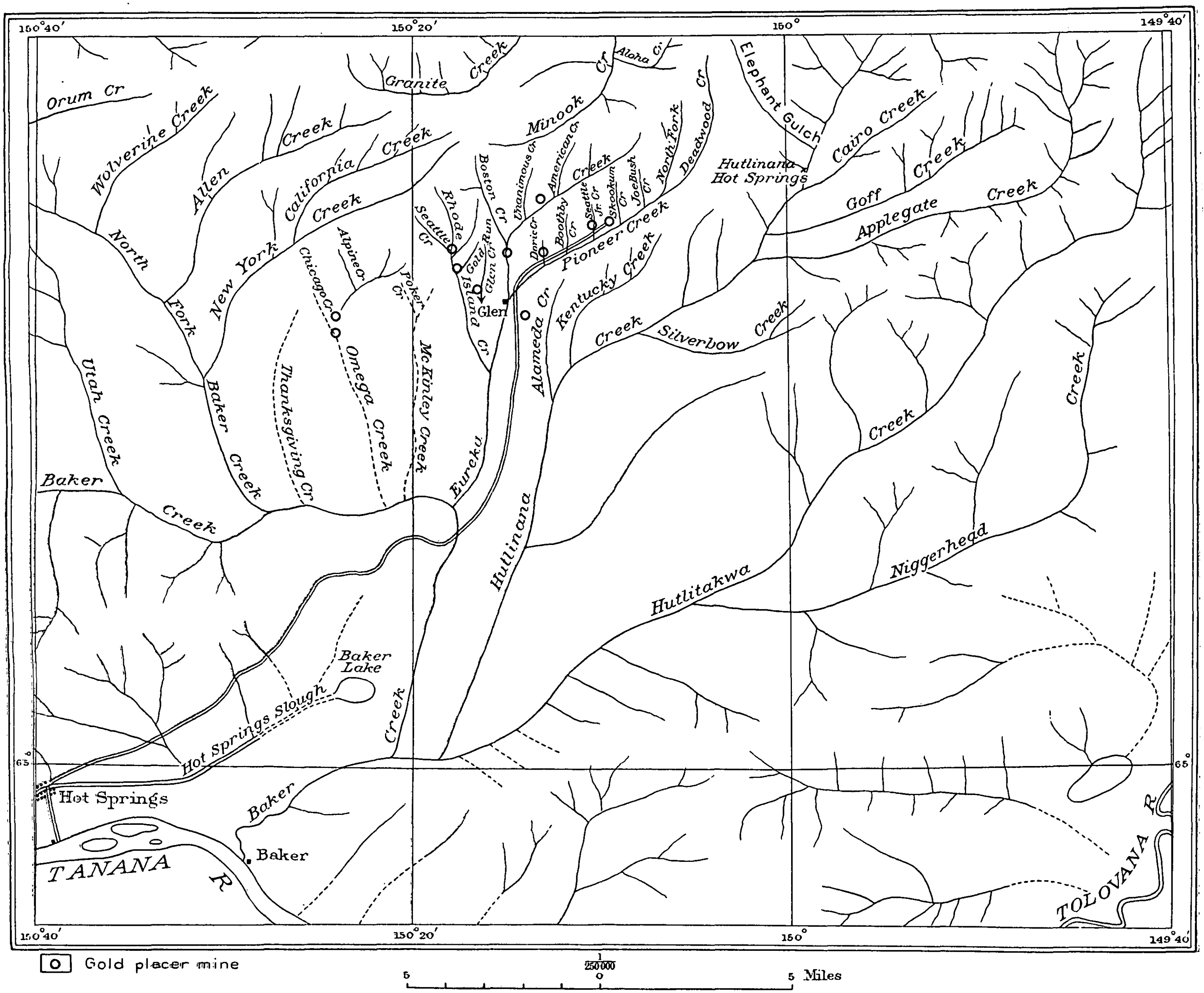
The southwest end of Last Bench grades downward into a lower bench, 50 feet below, called Jordan Bar. The tenor of the placers on Jordan Bar is lower than on Last Bench. Pioneer Creek also has auriferous gravel, but opposite Last Bench and Jordan Bar the gravel is 40 feet deep, frozen, and too low in grade to pay for drifting operations. The same is true of the stream gravel of upper Eureka Creek.

The gravel deposits of Last Bench, considered as material for open-cut mining, are high-grade placers, but the operators are greatly handicapped by lack of water, for the big ditch that supplies the hydraulic plant farther down Pioneer Creek takes most of the water available. A short ditch has been built from Last Bench around into Skookum Creek and is being extended to Joe Bush Creek, but this supply of water is inadequate except in the spring and in times of heavy rainfall during the late summer.

Two parallel cuts were being opened on Last Bench at the time of the writer's visit in 1931. In the upper cut 2,000 square feet of bedrock was cleaned from May 18 to June 10, but most of the cut had yet to be worked, and several men were employed there. Another man was prospecting on the North Fork of Pioneer Creek.

McCASKEY BAR

Another large placer-mining plant was operating in 1931 on McCaskey Bar, at the end of the spur between Pioneer and Kentucky Creeks. This ground was opened up in 1924 and has been mined continuously since that time. This is a low-grade placer, and its successful exploitation has been accomplished by good management, which enables the moving of a large amount of gravel. The width of the pay streak is not accurately determined, but the present operations



SKETCH MAP OF THE EUREKA AREA, SHOWING LOCATION OF GOLD PLACER MINING OPERATIONS.

are at the lower and southeast side of a long cut, in a zone 100 feet wide. At this locality the overburden is 15 to 18 feet thick and is solidly frozen. The gravel consists largely of subangular quartzite in a brown clay. The quartzite is derived from the ridge of quartzite that follows the southeast side of Pioneer Creek, and some of the gravel contains imperfect remains of a fossilized sea shell known as *Aucella crassicollis* Keyserling. Most of the gravel ranges in size from 6 inches to 2 feet, but a few boulders as large as 4 feet in diameter are found. The fossiliferous quartzite cobbles are porous, with numerous elongate openings, from which the sea shells have been dissolved. The massive nonfossiliferous quartzite has a curious spheroidal fracture, which on weathered surfaces simulates sections of shells and crinoids. The bedrock is mainly phyllite and argillite in a highly altered condition. It is everywhere stained brown and is so thoroughly softened by alteration that no hard fresh rock can be found. One dike cuts the country rock, but this, too, was so badly decayed that its character was indeterminate. Quartz veins also form a part of the bedrock, and these are greatly fractured and iron-stained. One quartz vein, 4 inches thick, was faulted off at both ends. The decomposed condition of the bedrock suggests that much residual alteration had taken place at this locality before the gold placers were deposited. A little gold is found throughout the gravel, but most of it occurs in a foot or two just above bedrock. One assay of this gold, made in 1929, was as follows: Gold, 0.802¾; silver, 0.191. With silver at 53 cents an ounce, as in 1929, this gives a value of $16.69 an ounce for this gold. The largest nugget so far found on McCaskey Bar was worth about $8. The concentrates contain the heavy minerals ilmenite, picotite, cinnabar, and magnetite. The presence of cinnabar, both here and at the lower end of Shirley Bar, is interpreted as evidence of the Tertiary age of the mineralization.

As the gravel is frozen, it is the practice to hydraulic off the overlying muck and to allow the ground to thaw naturally in the summer sun. Water for hydraulic operations is obtained from a ditch that taps both Alameda and Kentucky Creeks, but in midsummer the supply of water is inadequate for continuous hydraulicking, and the work is done intermittently for periods of 15 minutes or less until the ditch is emptied. A giant with a 4-inch nozzle is used. This plant has opened and mined 300,000 square feet of ground since 1924, and 70,000 square feet was mined in the summer of 1930, when water was plentiful. The plant is operated by two partners and a crew of three men.

RHODE ISLAND CREEK

Rhode Island Creek is a stream about 5 miles long that heads between Boston and New York Creeks and flows into Eureka Creek. The upper half of its course is nearly due south, but in its lower half the course veers to southeast. It has two tributaries from the east, of which the lower, known as "Gold Run", has been the site of considerable placer mining. A headwater tributary from the northwest is called Seattle Creek. Unlike Pioneer and upper Eureka Creeks, Rhode Island Creek flows across the strike of the Lower Cretaceous rocks, and the shape of the main valley is therefore little dependent on the control of rock structure. The upper valley is open and fairly symmetrical, but in the lower valley the stream follows closely the west wall, which is rather steep. Omega Creek lies west of Rhode Island Creek, and between these two streams is a gravel-covered bench, about 300 feet above the level of Rhode Island Creek. East of Rhode Island Creek is another bench at about the same elevation, known as "Shirley Bar", which is likewise gravel-covered and has been the site of extensive placer-mining operations in earlier years. No discharge measurements have been made on Rhode Island Creek, but the water supply is probably as great as that of the headwater part of Eureka Creek, or a little greater. The gradient has not been accurately determined, but placer mining is being carried on; it may be from 80 to 100 feet to the mile.

Placer mining has been in progress on Rhode Island Creek for many years, but no complete record of this work has been preserved. It is known, however, that both stream placers and bench placers have been worked, the former by open-cut mining and by drifting and the latter by hydraulic methods. The only published record pertains to Seattle Creek, where, according to Hess,[33] the bedrock is a graphitic schistose arkose, which is overlain by 8 to 30 feet of relatively fine gravel, consisting of quartzite, vein quartz, and graphitic slate. This gravel is covered by 1 to 3 feet of muck, and the entire overburden is solidly frozen. With the exception of a small open cut, which was worked intermittently, no mining was in progress on Seattle Creek during the summer of 1931. Some winter drifting, however, was done on Rhode Island Creek just above the mouth of Seattle Creek during the winter of 1930–31.

The principal placer mining on Rhode Island Creek in 1931 was done by a hydraulic plant on the east side of the creek, on claim 2 above Discovery, just above the mouth of Gold Run. The operator of this plant holds the claims from Discovery to 5 above Discovery on Rhode Island Creek and also claims 3 below to 10 below Discovery on lower Eureka Creek. The present workings are on a bench about 50 feet above the level of Rhode Island Creek. The pay streak is about 70 feet wide. The overburden is 18 feet thick at the upper end of the cut and 10 feet at the lower side and consists largely of a carbonaceous silt containing in places layers of fine gravel, but in other places no gravel at all is present from top to bottom of the overbur-

[33] Prindle, L. M., and Hess, F. L., op. cit., p. 44, 1906.

den. Remains of mammoth, bison, and other vertebrates are common in this material. At one end of the cut there is a body of coarse gravel 3 feet thick, which lies upon bedrock and is overlain by silt, but this is quite exceptional at this locality. Where gravel is present it is subangular, and cobbles 10 inches in diameter are the largest materials observed. The bedrock is phyllite, but quartz stringers trending northeast are common here and elsewhere in this vicinity. The gold lies on and in bedrock, and several feet of the bedrock is commonly removed in order to obtain all the gold. The largest nugget so far found in this bench was worth $18.

This deposit is worked by means of a giant with a 2½-inch nozzle, using water under a head of 50 feet. Water is obtained from a ditch with an intake on Rhode Island Creek, about a mile upstream, with a branch tapping also the water of Seattle Creek. In midsummer water is scarce, and the nozzle can operate only by occasional splashes of about 12 minutes' duration.

Gold Run was once a site of gold placer mining but is now entirely worked out and abandoned. From conversations with the operators on Rhode Island Creek, and from the observations recorded by Hess,[34] however, the general history of this mining is known. Gold Run is a small gulch about a mile in length whose valley is shallow and open. It cuts through the gold-bearing gravel of Shirley Bar, and therefore, as on Doric Creek, the gold has been reconcentrated to form a rich placer. The pay streak was said to be 150 feet wide and about 1,500 feet long. The bedrock is a graphitic schistose arkose, in part slaty. The gravel is fairly well rounded and consists of slate, quartzite, and grit. The overburden consisted of 15 to 18 feet of gravel overlain by 2 feet of muck and was only partly frozen, so that water was present in underground workings, and timbering was necessary. The pay was found in the lower part of the gravel and in the upper 3 to 4 feet of bedrock. The gold is said to have been light colored, shotty, and somewhat worn, although the crystal outline was observable on some pieces. Mining was begun on Gold Run in the winter of 1900–1901, and the pay streak was drifted from one end to the other. The total production of this creek is said to have been $200,000.

SHIRLEY BAR

The gently sloping spur between Rhode Island Creek and lower Eureka Creek is covered by a shallow deposit of gravel, which in places is gold-bearing. The gravel is subangular and has not moved a great distance from its bedrock source, so that the placers of this type are believed to be semiresidual or eluvial. Between Rhode Island Creek and Glen Creek the gravel constituted a commercial placer, and this part of the bench is known as Shirley Bar. The

[34] Prindle, L. M., and Hess, F. L., op. cit., pp. 43–44, 1906.

gravel ranged in thickness from 2 to 10 feet and consisted of the same material as the neighboring bedrock. Many ditches and the remains of old plants show that a good deal of mining has been done on Shirley Bar, but the history of its development is not available. Even today, however, several men manage to eke out a living by taking out a little gold on and about Shirley Bar by simple hand-mining methods.

Down the hill from Shirley Bar proper the surface of the bedrock slopes steeply downward and is deeply covered by a body of muck. Upon this muck the same type of subangular gravel that is found on Shirley Bar has been deposited, forming a downhill continuation of the Shirley Bar pay streak. On this ground the principal placer-mining plant in this vicinity is now operating. The present operators began work here in 1918, near Rhode Island Creek, and have gradually worked eastward to the present site near Glen Creek. At the present cut it is 40 to 60 feet from the surface to bedrock, but only the upper 6 feet of fine subangular gravel is removed in mining. Here and there a boulder of quartzite is found among this finer detritus. Just uphill from the present cut, at the lower end of Shirley Bar, the overburden consists of only 4 feet of fine gravel resting directly on bedrock. The gold is fine and shotty, and the largest piece found in the present cut weighed three quarters of an ounce, though a nugget found in 1930 weighed 2¾ ounces. Two assays of the gold were as follows: 1929: Gold, 0.791¾; silver, 0.203, at 53 cents an ounce. 1930: Gold, 0.792; silver, 0.204, at 38 cents an ounce. With the values of silver above given, this gold is worth about $16.45 an ounce. A sample of the placer concentrates collected by the writer in 1922 shows the presence of the heavy minerals pyrite, cinnabar, picotite, barite, galena, ilmenite, and limonite.

This ground is worked by a hydraulic plant, consisting of two 2½-inch giants that are supplied by water having a head of 100 feet. The water is brought by a ditch with an intake on Rhode Island Creek near the mouth of Gold Run. The present cut is 90 by 225 feet and has an area of about 20,000 square feet. With plenty of water four or five times this much ground could be worked in a season, but water is scarce in midsummer, and in late July 1931 the giants were operating only for 15-minute periods every 2 hours. More gold could be recovered if the operators could strip off the overburden clear to bedrock, but this is impossible on account of the low gradient of the spur south of the plant. Even to mine as at present, the first five riffle boxes can have a maximum gradient of only 5 inches to the box length, and the long line of boxes that follow the riffle boxes, for carrying off the tailings, have a gradient of only 3 inches in 12 feet. With the decreasing gradient toward the lower valley, an excessively long string of sluice boxes would be necessary in order to strip to bedrock.

GLEN CREEK

Between Rhode Island Creek and Eureka Creek a small stream called Glen Creek drains southward across Shirley Bar. Glen Creek is about 3 miles long and has a shallow open valley, not unlike Gold Run. The creek itself is probably less than 50 feet below the level of the bench and is dry during most of the summer.

The gold placers of Glen Creek were discovered in 1901 and are now entirely worked out. According to local information, the pay streak was 150 feet wide and about a mile long and the overburden ranged in thickness from 7 to 10 feet. The gravel consists of subangular to angular debris, derived from the neighboring Lower Cretaceous rocks. Geologic conditions in general are almost identical with those existing on Gold Run—that is, a rich placer streak was developed by stream concentration from the poorer bench placers. This placer was mined by drifting from one end to the other and was then sold for $50,000 and worked by open-cut methods, yielding, according to report, 48 cents to the square foot of bedrock to the open-cut operator. The total production of Glen Creek is said to have been more than $1,000,000.

OMEGA CREEK

The next large creek west of Rhode Island Creek is known as Omega Creek. This stream has a length of about 7 miles, for the upper 2 miles of which the course is southwest, whereas in the lower 5 miles it is south. The upper valley is more or less parallel to the strike of the country rock and has the same unsymmetrical cross section as the valleys of Pioneer and the head of Eureka Creeks, with gravel-covered quartzite forming the southeast wall. Omega Creek has two principal tributaries from the northwest, of which the uppermost is called Alpha Creek and the next downstream Chicago Creek. Most of the course of Omega Creek lies in the flats north of Baker Creek and therefore the headwater portion, where mining has been carried on, is short, and the water supply is correspondingly small.

Omega Creek was first worked in 1901, though gold had been found on it 2 years earlier. The creek has been worked intermittently in a small way and may be described as having fairly good spots in a more or less continuous pay streak. The placers so far worked are either stream gravel or gravel very close to the creek. The country rock is largely black fissile slate of the Lower Cretaceous series, which strikes about N. 70° E. and dips steeply north. The gravel where present consists largely of slaty rock with some larger cobbles and a few boulders of quartzite, and ranges in thickness from 5 to 10 feet, with a variable cover of muck.

Claim 8 above Discovery on Omega Creek is at the mouth of Alpha Creek, and claim 5 above Discovery is at the mouth of Chicago Creek. During 1931 two open cuts were operated on Omega Creek, of which the upper one was on claim 6 above Discovery. This cut was on the northwest side of the creek, on a bedrock rim about 5 or 6 feet above the level of the stream. The pay streak here is of undetermined width but apparently trends diagonally, or southward, toward the creek. The overburden is 10 feet thick at the uphill side of the cut and only 5 feet thick on the side toward the creek. This overburden is largely silt, with little or no gravel but with a few boulders of vein quartz and quartzite 2 feet or less in diameter. The largest nugget so far found here was worth $38.

This work is being done by groundsluicing and shoveling into 12 sluice boxes. The cut is 25 by 120 feet, or 3,000 square feet, but in the lower half of the cut mining operations did not extend to bedrock, because the operators do not own the claim below their cut and therefore cannot start their bedrock drain sufficiently far downstream to bare the bedrock in their cut. Water is taken in a ditch from Omega Creek some distance above the cut. Two partners were the operators at this property.

Farther down Omega Creek, at the mouth of Chicago Creek, two men were operating another open cut. Here the overburden is composed largely of about 10 feet of black silt with numerous layers of small gravel, or "chicken feed," but at some places, as near the head of the cut, a body of gravel 2 feet thick lies on bedrock and is covered by the silt. Cobbles and boulders are scarce, but a few as large as a foot in diameter were noted. The gravel also contains much vuggy iron-stained vein quartz and some basic intrusive rocks. The bedrock is a sandy phyllite. The largest nugget found in this cut was worth $48. A sample of the concentrates shows that the heavy minerals are principally pyrite, ilmenite, picotite, scheelite, and cinnabar.

This cut is 60 by 100 feet, or 6,000 square feet, and is worked partly by groundsluicing and partly by hydraulicking. Water is supplied by a ditch 600 feet long, with an intake on Chicago Creek. Before reaching the cut the water is divided into two streams, which are used to groundsluice simultaneously both sides of the cut. Another portion of the water is diverted to a giant with a 2½-inch nozzle in the bottom of the cut, where it is applied under a head of 20 to 30 feet.

OTHER CREEKS

Prospecting and intermittent mining is also done on other creeks in the Eureka area, but little activity on these creeks was in evidence in 1931. Chief among these is Thanksgiving Creek, which is the next tributary of Baker Creek west of Omega Creek. This creek has a shallow, open valley about 5 miles long, which lies mainly in the flats of Baker Creek. It is essentially a gulch in the broad left bench north of Baker Creek and is essentially similar in general character to Glen Creek, though farther from the hills.

According to Hess,[35] the bedrock on Thanksgiving Creek is a yellowish, somewhat sheared arkose, and the overburden consists of 6 to 18 feet of gravel, overlain by 1 to 4 feet of muck. The gravel consists of subangular pieces of quartzite, schistose arkose, vein quartz, slate, and a small amount of monzonitic rock and is mixed with clay and ground ice. The gold occurs in the lower 1½ to 9 feet of this mixture, and the pay streak is said to be 25 to 100 feet wide. The assay value of the gold is given as $15.64 an ounce. It is reported locally that the pay streak extended up and down the creek for seven claim lengths, and the placers were worked for this distance.

Another creek in this vicinity that is being prospected is McKinley Creek, a small gulch between Rhode Island and Omega Creeks. This stream is about as long as Thanksgiving Creek and of the same general character. The placers that are being prospected are in a small western headwater tributary known as Poker Creek.

Hutlinana Creek, which lies at the east side of the Eureka area, has been much prospected but little mined. It is one of the large tributaries of Baker Creek and drains the country south and southeast of Wolverine and Elephant Mountains. Some gold has been found on most of its northwest tributaries, but no good pay streak has been located. It is the consensus of local opinion that the headwater portions of Hutlinana Creek may have a pay streak, but the ground is deep and unfrozen and cannot be worked economically on a small scale.

TOFTY AREA

The Tofty area comprises several creeks northwest of Hot Springs where placer mining is in progress. (See pl. 5.) For the purpose of description, this area may be divided broadly into two units, as follows:

1. A mineralized belt that lies mainly in the valleys of Woodchopper, Sullivan, and Cache Creeks but also extends northeastward into the headwaters of Baker Creek. This belt bears little relation to the courses of the larger streams above named and is best treated as a unit, which is here designated the tin belt.
2. Sundry other placers that lie north of the tin belt, in the valleys of American, Boulder, and Quartz Creeks.

TIN BELT

The valley of Patterson Creek is the main site of the tin belt. Patterson Creek is nearly 30 miles long and is formed by the union of three large streams. The lowest of these is Woodchopper Creek, which enters Patterson Creek about 14 miles from its mouth. The general course of Woodchopper Creek is south, but its headwater tributaries tend to run southwest, following the strike of the country

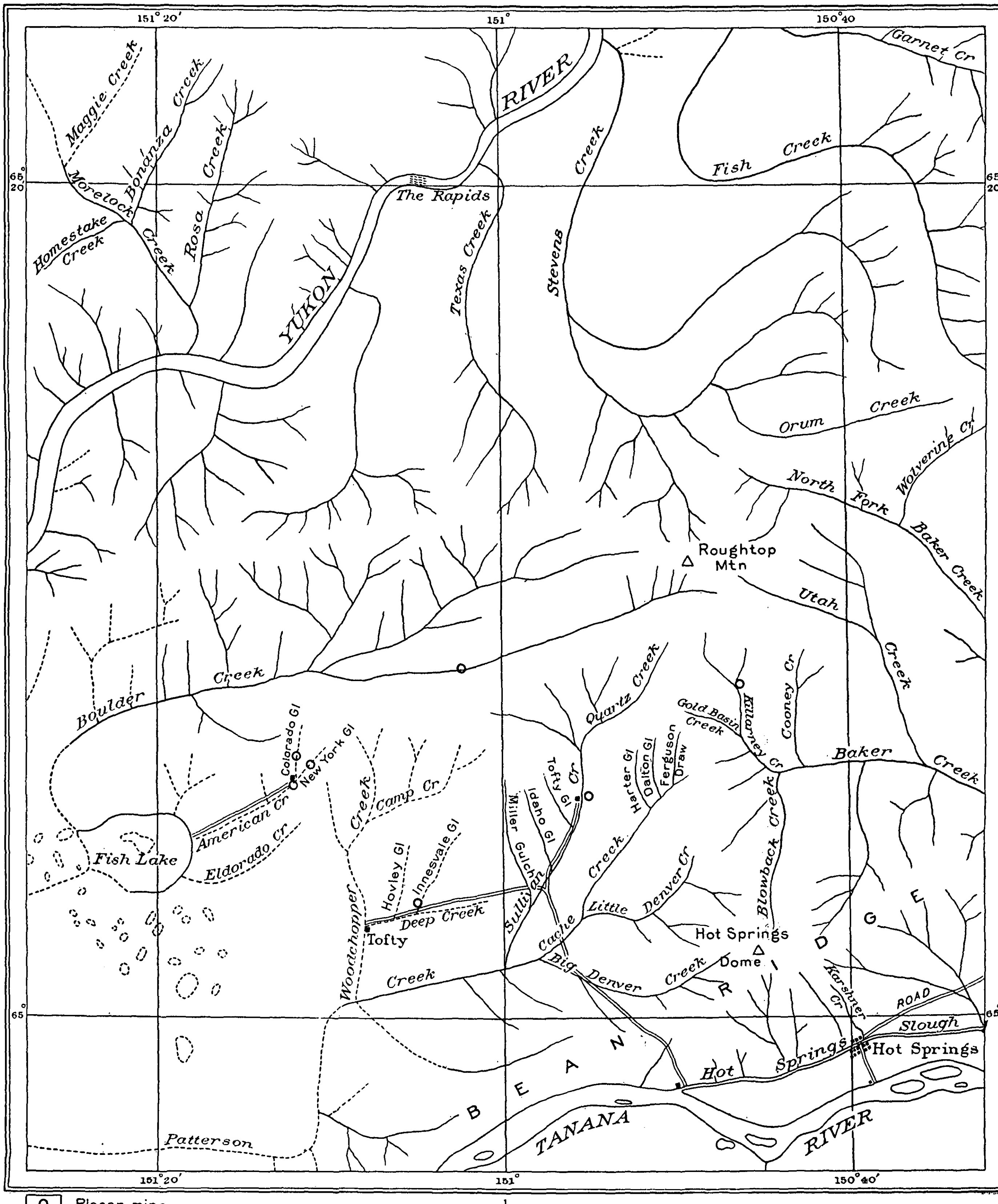
[35] Prindle, L. M., and Hess, F. L., op. cit., pp. 92–93.

rock. The most easterly of these tributaries is Camp Creek. A small tributary called Deep Creek enters Woodchopper Creek from the east about 3 miles above its mouth. Deep Creek, though a small stream, is notable because it drains a considerable part of the tin belt. Two tributaries of Deep Creek from the north, known as Hovley and Innesvale Gulches, cut directly across the tin belt.

About 5 miles above the mouth of Woodchopper Creek Patterson Creek splits into its two headwater streams, which are known as Sullivan and Cache Creeks. The general course of Sullivan Creek is southwest and, like Woodchopper Creek, it has several headwater tributaries, the most easterly of which is called Quartz Creek. Several small tributaries that enter Sullivan Creek from the west, farther down the valley, are known as Tofty Gulch, Idaho Gulch, and Miller Gulch, named in order downstream. These three gulches also cut across the tin belt.

Cache Creek, the third branch of Patterson Creek, lies east of Sullivan Creek, to which it is parallel and from which it is separated by a low and narrow alluvial divide. The headwater tributaries of Cache Creek, named from west to east, are Harter and Dalton Gulches and Ferguson Draw, all three of which likewise cut the tin belt. Cache Creek has two other tributaries, which enter from the east farther down the valley. These, named in order downstream, are Little Denver and Big Denver Creeks, but both of them lie south of the mineralized zone and are not known to have any economic importance.

Patterson Creek and its tributaries occupy a wide valley that is deeply filled with alluvium and that is disproportionately large in comparison with the size of the streams that now occupy it. The length of Patterson Creek, together with its longest headwater tributary, Sullivan Creek, is nearly 30 miles. Patterson Creek with little doubt has been developed on an alluvial fill without any regard to the underlying slope of bedrock. In its lower course it is superposed on bedrock along the north side of Bean Ridge, showing in a striking way its lack of adjustment to the old bedrock configuration. Baker Creek likewise flows over an old alluvial fill throughout most of its course and passes around the east end of Bean Ridge, impinging upon the bedrock wall of the valley instead of flowing over the central part of the deep alluvial fill. These facts, at first sight, suggest that the Baker-Patterson Creek depression may have been the site of an ancient valley, occupied by a stream of considerable size. A shaft, however, which was sunk on the divide between the head of Cache Creek and Gold Basin, shows a depth to bedrock of only 45 feet, so that a bedrock divide, about 850 feet in elevation, separates the headwaters of Baker Creek from those of Patterson Creek. Moreover, the deep alluvial fill at and on both sides of this divide is essentially silt



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SKETCH MAP OF THE TOFTY AREA, SHOWING LOCATION OF GOLD PLACER MINING OPERATIONS.

and not normal fluviatile material, and the bedrock gradient from the divide downstream for 10 miles, as revealed by placer-mining operations on Woodchopper Creek, is too steep to have been the bottom of a large stream. An ancient stream of major size may indeed have once occupied the site of the Baker-Patterson Creek depression, but the present elevation of the divide between these two streams indicates that such a stream must have existed, if at all, at some time during the Tertiary period. The existence of such an ancient valley, however, particularly if it was of considerable width, may help to account for the width of the depression, the center of which was later filled with silt.

The valleys of Patterson and Baker Creeks are therefore interpreted as normal stream valleys that were deeply incised in early Pleistocene time and in the glacial age were extensively filled with alluvium. This filling resulted in part from an elevation of the baselevel of the Tanana River, due to aggradation by outwash deposits from the south and in part from causes unknown. This alluvium has not only effectively concealed the configuration of the underlying bedrock surface but has also buried the normal stream detritus that was laid down at the time when these valleys were first eroded. The present alluvial surface gives no clue to the position, size, and thickness of such older gravel, and all that is known has been learned by drilling and underground mining.

The outstanding feature of the valley of Patterson Creek is the existence of a relatively narrow belt containing deeply buried gold-tin placers that extends from Killarney Creek, a headwater tributary of Baker Creek, for at least 12 miles to Woodchopper Creek. The direction of this belt is about S. 70° W., or roughly parallel to the dominant structure of the country rock, and the width in general is about 1,000 feet, though in places, as on Sullivan Creek where this stream emerges from the hills, the width increases to as much as 2,000 feet. The country rock along this belt is probably more or less continuously mineralized, but no continuous pay streak has been formed. Instead, a number of small discontinuous pay streaks are present whose major directions are normal to the zone of mineralization. The sites of these pay streaks are the gulches that drain from the hills to the north or, more commonly, the ground lying along the sides of such gulches. In general, cassiterite and gold occur together in the placers, and where the cassiterite becomes scarce or absent the gold content also drops. The sharpness of the cut-off of these small pay streaks, as they are followed north to the hills, is amazing. The limit of the placer is suddenly reached, and north of this limiting line no tin and little gold can be found. The south line is less exactly defined, because the ancient gulches draining southward had a tendency to distribute the gold and tin downstream from the mineralized zone, as in the deposit on Sullivan Creek.

The gravel that forms the pay streak in the tin belt is poorly sorted and either subangular or not well rounded, and evidently most of this material has not been transported any great distance from its bedrock source. The cassiterite, on the other hand, though as hard and as resistant to erosion as quartz, is well rounded and must therefore have undergone considerable erosion. But the gold-tin placer is not continuous, and the sections of it that are missing lie between the tributary gulches from the north. Therefore, these blank sections cannot be attributed to lateral erosion that subsequently destroyed sections of the placer. Instead, the rich spots are along the edges of these tributary gulches. Hence the rounding of the cassiterite cannot be due to a prolonged downstream movement of this material from some hypothetical source at the head of Baker Creek.

An additional line of evidence is the sharp cut-off of the cassiterite in these tributary gulches that drain from the north. This condition indicates that the mineralization of bedrock did not extend beyond the cut-off points in these gulches, for otherwise some traces of tin could still be found above these cut-off points. Therefore, the cassiterite pebbles and cobbles cannot have acquired their rounded outline by a downstream migration from a bedrock source to the north. The only hypothesis that seems to explain these conditions is that the cassiterite has accumulated essentially in place horizontally, and that the rounding of the pebbles is due to long-continued residual erosion. This history in turn implies that these gulches, though headwater streams, had relatively low gradients, and this in turn suggests that a relatively low regional relief existed at the time when the placers were deposited.

Some observers have considered that the Tofty gold-tin placers are of beach origin, but there seems to be little basis for this interpretation. The placers are not horizontal, for their elevation above sea level decreases continuously from the head of Patterson Creek westward. Moreover, the placers are not continuous, as they well might be if they had been beach deposits. Finally, they are not symmetrically disposed on both sides of the tributary gulches, as they would be if these gulches had emptied into an inland body of water. Instead, the pay streaks in general are on one side or the other of the tributary gulches but seldom on both. The origin is clear. A relatively narrow zone in the country rock was originally mineralized with gold and tin. Where this belt was cut by streams, the gold and tin were eroded and concentrated by fluviatile action to form commercial placers, and subsequently these old gravel deposits were deeply buried by silt. The later history of these placers is less clear, for the history of the silt filling in the valley of Patterson Creek is not entirely understood. If this filling took place during a single geomorphic cycle the gold-tin placers have suffered little erosion from the present streams, which were subsequently established upon the old alluvial surface. But if, as seems more probable, this filling took place in more than one stage, older superposed streams may have removed much of the silt and some of the gravel before the latest silt was deposited. The spotted character of these placers is more easily accounted for by this hypothesis.

A great deal of prospecting and mining has been done in the Tofty area in the 25 years since these placers were discovered. The original discovery was made on Tofty Gulch in the winter of 1906–7, and with the finding of rich placers a stampede started in 1907. Little by little the deeply buried gravel was prospected and located, and mining proceeded. Scores of deep drill holes have been sunk to locate these placers, and if a record of the elevations of the tops and bottoms of all these holes were available, together with their surface distribution, a very fair contour map of the surface of bedrock over much of the mineralized zone might be drawn. Unfortunately this information has not been accurately recorded and is lost forever, and all that can now be learned of the character and configuration of bedrock is what may be seen in underground workings or in old open cuts, where bedrock is more or less silted over.

At the present time only two plants of any size are being operated in the Tofty area. On the east bench of Sullivan Creek, just above the old town site of Tofty, an open cut has been worked for many years. This property at one time belonged to Howell & Cleveland, then passed into the hands of an English company, and is now owned by Tilleson & L'Heureux, together with a group of claims extending southwest to Miller Gulch. The cut is now more or less irregular in shape but must be at least 1,500 feet long and 500 feet wide. The gold is not evenly distributed throughout the pay streak, but from the experience of past years the tenor is believed to range from 30 to 50 cents a square foot of bedrock. The overburden is 55 feet thick and consists of 3 to 12 feet of gravel, averaging 6 feet, at the base, overlain by carbonaceous silt or muck. Both the muck and the gravel are frozen and have to be thawed before they can be sluiced. The muck is particularly rich in remains of extinct vertebrates, such as the mammoth, bison, and horse, and also includes a great deal of vegetal material. The gravel consists mainly of quartzite but includes also considerable vein quartz and more or less phyllite. The bedrock is phyllite and slate, greatly decomposed and also much mineralized by pyrite. Many quartz stringers also cut the bedrock. The gold is not distributed vertically throughout the gravel but is found largely near, on, and, in bedrock. About a foot of decomposed bedrock is removed to obtain a good recovery of gold. Two assays of the gold are as follows: Gold, 0.807¼ and 0.821; silver, 0.174 and 0.169. At the current price of silver, 29 cents an ounce, the average value of this gold is therefore $16.88 an ounce. The largest nugget so far found by the present owners was worth about $11.

The concentrates at the property contain the heavy minerals cassiterite, pyrite, ilmenite, picotite, magnetite, and native copper. Cassiterite is very plentiful, and it is estimated that there is about 0.2 pound of this mineral to the square foot of bedrock. In mining, the cassiterite is sorted by hand from the concentrates, and when enough is available it is shipped to Singapore for smelting. This material, according to a return in 1929, consisted of 57.9 percent of tin and had a gross value in Singapore of £123 a ton, but the net proceeds to the shipper at Tofty are about $400 a ton.

Mining is done by hydraulic methods. Water is supplied by a ditch about 7 miles long, with intakes on Sullivan and Quartz Creeks, and is delivered with a head of 100 feet at the bottom of the cut. Part of the water is allowed to run down over the face, in order to thaw and groundsluice the muck; another part is used in a giant with a 2-inch nozzle, which is directed against the face; and a considerable part is required to operate a hydraulic elevator, by means of which the thawed gravel is conveyed to the dump box and thence into sluice boxes. The plant is operated by the two owners and a crew of three or four men.

One large drift mine was operated in 1931 by Hansen & Allbright on the west side of Innesvale Gulch. The pay streak here, as elsewhere in this area, has its major elongation normal to the zone of mineralization. The overburden consists of 5 or 6 feet of gravel on bedrock, overlain by 60 feet of muck containing here and there layers of fine gravel, which in turn is overlain by 30 feet of pure black muck. The deposit is frozen. The gravel is composed mainly of quartzite, phyllite, and slate but also includes vein quartz, much of which is vuggy and iron-stained. In places cavities may be seen from which pyrite has been dissolved. The gravel is subangular to poorly rounded and is not in general heavy, being composed of cobbles a foot or less in diameter. But here and there in the drift are very large boulders, commonly quartz, and one such boulder of pure vein quartz 6 feet in diameter was observed, underlain by 2 feet of small gravel and cobbles. Also in places great slabs of country rock are found, underlain by gravel. Such conditions indicate that the concentration of the gold occurred almost in place, neither the gold nor the vein quartz having been transported any great distance. The gold occurs in the lower 2 feet of the gravel and the upper foot of the bedrock. The surface of bedrock is very irregular and in places rises abruptly as much as 20 feet. On such slopes gravel is usually absent and the muck rests directly upon bedrock. The best parts of the pay streak are on the tops of such high bedrock reefs, and the next best places are in the low saddles between the reefs. Little or no gold is found on the slopes. The bedrock itself is a much weathered phyllite but in places is slate.

The pieces of gold will average in weight about a grain or a little more, but nuggets worth as much as $20 have been recovered. Three assays of this gold are as follows: Gold, 0.839¾, 0.841¾, 0.856¼; silver, 0.154, 0.155, 0.138. With silver at 29 cents an ounce these assays give an average value for this gold of $17.52 an ounce. Large amounts of cassiterite are also recovered in the concentrates. This material is well rounded and occurs in all sizes from small grains half the size of a small pea up to pieces 6 inches or more in diameter. These larger pieces are usually of low grade—that is, the cassiterite is intimately mixed with vein quartz and country rock. A cut and polished specimen of one of these pieces of tin ore shows that the vein quartz was extensively fractured and that the cassiterite was then introduced into the cracks and crevices thus made. There is little evidence of replacement of the quartz by the cassiterite. The concentrates also include a variety of other heavy minerals, of which the most common are ilmenite, pyrite, picotite, and magnetite. A small amount of wood tin, or amorphous cassiterite, is also present.

Mining at this plant is done by drifting. A shaft 95 feet deep and 7 feet wide in the clear has been sunk to bedrock, and from the bottom of the shaft underground drifts lead off in four directions. Excellent timbering has been done in the shaft and drifts. The gravel is thawed by 10-foot steam points, set 3 feet apart. The pay dirt is then transported in barrows to the shaft, where it is dumped into a bucket with a capacity of 1,500 pounds and elevated to the surface. From the top of the shaft the bucket is conveyed by an overhead tram to an automatic tipple, where it is dumped against shear boards into an elevated dump box. The upper sluice boxes of the line have a grade of 14 inches and the lower ones 12 inches to the box length. This unusual pitch is said to be rendered necessary by large amounts of cassiterite, which require that a heavy current be used to clean out the lighter material, in order to make room in the boxes for the cassiterite. This bed of cassiterite in turn makes a good settling place for the gold. Most of the gold is said to be recovered in the upper three or four boxes. Water for sluicing is obtained through a small ditch from Innesvale Gulch and is very scarce, so that it is necessary not only to pump water to the elevated dump box but also to impound the water from the sluice boxes and use it over and over again. The power plant consists of two 30-horsepower boilers, in which wood is used for fuel. This wood, mainly birch, is hauled by caterpillar tractor from upper Woodchopper Creek. The other equipment consists of the usual hoist and water pumps. The commercial freight rate from Hot Springs to Innesvale Gulch is 3½ cents a pound. The present shaft was begun on March 10, 1931, and by the middle of July two or three clean-ups had already been made. The plant employs a crew of 11 men, including the cook.

In earlier years plants similar to the one above described have been worked at other points between Innesvale Gulch and Woodchopper Creek, and also to the east, in the vicinity of Miller, Idaho, and Tofty Gulches, but much of this ground has now been worked out. When the writer visited this camp in 1922 a deep mine was being operated by Hansen & Linberg a short distance east of Woodchopper Creek. The section of the overburden there was somewhat different from that at the present plant. The bottom stratum consisted of 20 feet of gravel, above which was 20 feet of muck with some gravel, then 40 feet of gravel, and finally on top 40 feet of pure muck. The concentrates recovered with the gold at this property contained cassiterite, ilmenite, picotite, pyrite, and magnetite. The total thickness of the sediments overlying bedrock, it will be observed, is 120 feet, and the top of the shaft was lower than the shaft at Innesvale Gulch. The intervening distance is perhaps 1½ miles, and this gives an idea of the diversity of the placer deposit and of its lack of horizontality. South of the line connecting these plants drill holes have shown that the depth to bedrock becomes much greater, and evidently the ancient master stream that occupied the Patterson Creek depression flowed some distance to the south of present mining operations.

Another plant visited by the writer in 1922 is also of interest because of the character of the gravel that constitutes the placer and of its bearing upon the local geology. This plant was located on a bench on the east side of upper Cache Creek. The depth to bedrock at this locality was 55 feet, of which the lower 10 feet was gravel and the upper 45 feet muck. The gravel was largely composed of phyllite and slate but also included some crystalline limestone and some diabase of greenstone habit. The bedrock was phyllite and slate, presumably of Lower Cretaceous age. The concentrates recovered with the gold included the heavy minerals magnetite, pyrite, ilmenite, barite, and picotite, but cassiterite was absent. In another sample of concentrates from upper Cache Creek, however, collected by A. E. Waters, Jr., cassiterite also was found. The limestone and greenstone gravel is probably of Paleozoic age, and its presence at this one locality in an area where both the bedrock and the stream gravel consist of phyllite and slate of Lower Cretaceous age indicates that the underlying Paleozoic rocks in this vicinity are covered only by a thin veneer of the Lower Cretaceous rocks, through which in places the stream has penetrated.

Some placer gold has also been mined on Quartz Creek, a headwater tributary of Sullivan Creek, but the details of this work are not known. It is known, however, that little or no cassiterite was present in these placers, and it is very likely that one or more mineralized belts lie north of the tin belt, from which the placers of Quartz, American, and Boulder Creeks have been concentrated.

AMERICAN CREEK

American Creek is about 5 miles long, heads against Woodchopper Creek, and drains southwest into Fish Lake. Near its head it flows south, but a somewhat smaller headwater tributary, called New York Gulch, has the general course of lower American Creek. New York Gulch must not be confused with the large stream, called New York Creek, that flows into the North Fork of Baker Creek. About a mile below the mouth of New York Gulch another small tributary of American Creek, called Colorado Gulch, enters from the north. American Creek flows nearly parallel to the strike of the country rock and, like similar streams in this district, is therefore unsymmetrical in cross section, the south wall being the steep side of the valley.

The gold placers of American Creek were discovered in 1911, and mining has been in progress since that time, but complete records of these activities are not available. It is known, however, that the placers of American Creek were worked for 15 years or more by shoveling in, drifting, and by means of a scraper plant. The scraper work appears to have been the principal mining activity. Eakin [36] states that the ground on most of the claims was only 12 to 15 feet deep.

In 1917 the American Creek Dredging Co. took over most of the claims on lower American Creek and installed a dredge, which has operated intermittently to the present time. The dredge in 1931 was located on the lower part of a block of ground called the Hillside Association, about 400 feet downstream from the mouth of Colorado Gulch. The pay streak on the Hillside Association is said to have been 300 feet wide, with the best material along the north side of the pay streak. The ground above the present location of the dredge has in earlier years been worked by open-cut operations, and the ground below the dredge along the north side of the pay streak has been drifted in earlier operations. The operators of the dredge plan to neglect this drifted ground and to work downstream, mainly along the south side of the pay streak, which is virgin ground, though of lower grade. The gravel at the present site of the dredge is 7 to 8 feet thick and is overlain by 5 to 7 feet of muck. The lower 4 feet of gravel is more than ordinarily coarse and carries gold throughout its thickness. The dredge also digs up 2 to 3 feet of bedrock to recover all the gold. This ground is frozen, and the overlying muck has to be groundsluiced off well in advance of the dredge, so that the ground

[36] Eakin, H. M., A geologic reconnaissance of a part of the Rampart quadrangle, Alaska: U.S. Geol. Survey Bull. 535, p. 37, 1913.

can thaw naturally, as the gold tenor of the gravel is not high enough to warrant the expense of artificial thawing. No data are available on the fineness of the gold, but a sample of the concentrates was found to consist mainly of magnetite, pyrite, ilmenite, barite, chromite, and hematite.

The dredge is of the Yuba flume type, operated by two 60-horsepower Fairbanks-Morse Diesel engines, one of which is used for pumping water to the flume and the other supplies power to the dredge itself. The dredge is operated by a head line and two spuds amidships and has a rated capacity of 1,700 cubic yards per 24-hour day. The bucket line consists of 56 buckets of 2½ cubic feet capacity and by actual timing digs at the rate of 29 buckets a minute. The fuel consumption is about 100 gallons of oil per 24-hour day. Water for stripping the ground in advance of the dredge is obtained from a ditch leading from upper American Creek, but at the time of the writer's visit water was so scarce that only enough was available to operate a giant with a 1½-inch nozzle. An area 1,000 feet long by 125 feet wide, downstream from the dredge, had already been stripped and was in process of thawing in mid-July 1931.

The present dredge operated for 1 month in 1927, the whole season of 1928, and 2 months in 1929 and was idle in 1930. It was put into operation again on July 11, 1931, but 4 days later struck frozen ground and was shut down for the remainder of the season. The operators claim that the production of the dredge to date has been $102,000 and that about $600,000 was recovered from the placers of American Creek before the dredge was built.

Three small open cuts were also operated by shoveling into sluice boxes during the summer of 1931. The work on one of these cuts, on New York Gulch, which was continued from May 26 to September 28, was essentially prospecting. The other two were worked at the head of American Creek, but details of the operations are lacking. A sample of the concentrates from New York Gulch, however, was found to contain the heavy minerals magnetite, barite, ilmenite, and picotite.

BOULDER CREEK

Boulder Creek is a large stream that heads in Roughtop (Moose) Mountain, flows a little south of west to the end of the hilly country, and then turns abruptly south to empty into Fish Lake. This stream is 20 miles long and has three large headwater tributaries which come together at nearly the same point in the valley and several smaller tributaries from both sides farther downstream. This creek was not visited by the writer, but a report from one operator indicates that in 1931 a hydraulic plant was operated from May 15 to September 19 and that 7,000 square feet of bedrock was cleaned. This placer body is on a bench of Boulder Creek. The gold is reported to have an assay value of $16.90 an ounce. A sample of the concentrates recovered in earlier mining operations on Boulder Creek has been found to contain the heavy minerals magnetite and ilmenite.

LODE DEPOSITS

No lode mining has yet been done in the Rampart or Hot Springs districts, but the character of the heavy minerals in the placer concentrates shows that not only gold but also other metals are present in the neighborhood of the placers, though the commercial value of such deposits is not known.

The placers in the Rampart and Hot Springs districts, like many of the other placer deposits of interior Alaska, are found among relatively low hills, where rock croppings are poor and scarce, and in the Hot Springs district, where the chances for profitable lodes seem best, the country is particularly low and lacking in outcrops. Such conditions make prospecting for lodes difficult and of doubtful return. No gold lodes have yet been found in the vicinity of the placers. On Hot Springs Dome, however, a mineralized belt has been known for many years, but the available ore seems to be too low in grade to mine under present economic conditions. The country rock at this locality consists of metamorphosed sediments that strike N. 45° E. and dip about 60° SE. Just to the south is a large body of biotite granite that forms the south slopes of Hot Springs Dome and has a northwest and southeast extension of about 10 miles. The sediments along the northwest side of this granite body appear to be sheared in narrow zones that trend about east. The attitude of the shear planes is nearly vertical. At least six zones of gold-silver mineralization have been localized along such shear zones in this vicinity. At the summit of the mountain is the zone that has been most prospected. Three similar zones of mineralization, at least 750 feet apart, are also known to the south of the main lode and two others to the north. Very little underground work has been done, and only a few open cuts have been made at the surface, and these are slumped, so that little can be learned of the true character of the vein material and ores.

The Barrett prospect, on the summit of Hot Springs Dome, ranges in width from 35 feet on the east side to 20 feet on the west side, and is said by the owner to have been traced for more than 2,000 feet. One short tunnel, one 40-foot shaft, and several open cuts have been made on this lode, but all these openings are now caved. The surface ores are essentially galena and limonite, the former in veins and the latter in pockets. So far as surface indications show, little quartz is present in the lode system, but with the limonite are some siderite and hematite and possibly also some manganese ore. Galena is the chief sulphide, but small quantities of chalcopyrite, pyrrhotite, and pyrite are also present, with here and there a little malachite or azurite. Chalcocite has also been reported from this deposit, but none was seen by the writer. In one open cut on this lode erythrite or pink cobalt bloom was observed, both in quartz stringers and without quartz in crevices in the schistose country rock. This is the only known occurrence of cobalt in Alaska. In a basalt dike south of the Barrett lode nickel is also reported to have been identified in a pyrrhotized basalt dike, but this occurrence has not been verified. Native sulphur in small white balls, which burn readily on ignition, is also evident at the surface of this lode. Sampling of the Barrett lode has not been carefully done by the owners, but the available information indicates a possible content of $1 to $2 in gold and 5 to 8 ounces in silver to the ton. These assays have been made on surface material that is clearly oxidized. The Donnelly prospect, which is on the next mineralized zone south of the Barrett prospect, is of essentially the same type as the Barrett, but hardly any exploratory work has been done on it.

The second zone to the north of the Barrett prospect lies in the drainage of Big Denver Creek. It is of the same general type but appears to strike N. 75° E. and it differs in having at one place a considerable amount of vein calcite. It is said by the owners that this mineralized zone has been traced 3,000 feet from Big Denver Creek to Blowback Creek, but more than one system of veins may be represented.

Next to gold, cassiterite has the greatest possibilities in this district, if its bedrock sources could be located. The placer operators have been fully aware of the potential value of cassiterite lodes, and the bedrock in the placer diggings has been carefully examined at many places. Moreover, a considerable amount of prospecting for tin has been done along the nearby hill slopes. Much vein quartz has been found in the bedrock under the placers, and pyrite, the second mineral in volume among the concentrates, has been observed at many places in the vein quartz, but not a trace of cassiterite in place has been found. What is the source of the cassiterite that is the most plentiful mineral of the concentrates? It is a well-known fact that certain types of metalliferous deposits are formed only in restricted shoots, where the conditions of temperature and pressure, the cavity space, and the chemical nature of the bedrock are favorable for the deposition of the ores. The quartz-cassiterite veins in the tin belt may have been formed under such delicately balanced conditions, at a considerable distance above the apical zone of a deeply buried intrusive body of granitic rocks, and therefore, though widely distributed linearly, they may have been sharply restricted vertically. In short, the tin lodes, which were certainly formed under deep cover but well above the elevation of the present surface, may have been completely destroyed by erosion as they were progressively denuded. It has already been suggested that the tributary gulches that cut the tin belt had relatively low gradients, and under such conditions neither the gold nor the cassiterite, whose specific gravity is about half that of gold, would be moved far downstream. The result under such conditions would be that the gold and tin, though repeatedly moved and abraded, would tend to accumulate almost as residual deposits. This hypothesis would also explain the rounded character of the cassiterite pebbles, as compared with the imperfectly rounded character of the surrounding gravel. It is therefore possible that the tin lodes, from which the stream tin was derived, are no longer in existence.

No other lodes of commercial size are known at present in the Rampart and Hot Springs districts. It is of interest, however, to record the fact, reported to the writer by M. S. Gill, of Eureka Creek, that several years ago a lead-silver deposit was found by a prospector in the headwaters of either Eureka or Pioneer Creek. Two assays of the sulphides are said to have shown 100 ounces of silver to the ton and 70 percent of lead. Another occurrence of sulphides in place, though not of commercial importance, is a deposit of stibnite that was found by the Geological Survey party of 1931 along the top of the ridge between Granite Creek and upper Minook Creek. Scattered pieces of partly oxidized stibnite were observed at the surface, and shallow trenches were dug to discover the bedrock source of this material, but the cover of residual debris was too great to permit the vein to be exposed with a geologic pick.

MINERALIZATION

The gold placers of the Rampart and Hot Springs districts differ from one another in several noteworthy respects, which in turn suggest differences in the genesis and age of the lodes from which they were derived. In the Rampart district the placers in the eastern tributaries of Minook Creek, and perhaps a part of those in the western tributaries, have been derived in large part from older placers of Pliocene (?) age that lie along the ridge tops. These older placers in turn lie in a belt that strikes northeast and were probably concentrated by streams tributary to a master stream that flowed in that direction. The course of this ancient valley also probably coincided roughly with a belt of gold mineralization that extended from the heads of Ruby and Slate Creeks northeastward for 10 miles or more, and the Pliocene (?) placers were probably derived from this mineralized belt. The mineralized bedrock from which these placers were derived can no longer be studied, for most of it has been destroyed by erosion, and the remainder is covered by alluvium. At the head of Ruby Creek, at the southwest end of this mineralized belt, strong contact metamorphism is visible in the country rock, and the writer is inclined to believe that a large intrusive body, perhaps of granitic rock, lies at no great distance below the surface at that locality. The deeply incised valley of Minook Creek, however, shows no exposures of granitic rocks, and it is therefore evident that if the original mineralization was connected genetically with granitic intrusive rocks the gold-bearing solutions must have worked upward at least 1,000 feet, and probably much more than that, before the mineral contents were precipitated. In other words, the genetic connection of these placers with granitic rocks is remote and not demonstrable.

The contact metamorphism at the head of Ruby Creek is entirely different in character from that which has been observed in the vicinity of any of the Tertiary granitic intrusive rocks, either in the Hot Springs district or in southwestern Alaska. Most of the Tertiary granitic rocks have come fairly close to the surface during their intrusion, and the contact-metamorphic effects are of the type that might be expected in such an upper zone. Some of the Mesozoic granitic intrusive rocks may also have approached close to the surface during their intrusion, but these apical zones, if ever present, have subsequently been eroded away, and where such intrusive bodies are now exposed, it is usually the deeper portions that are visible. The contact metamorphism of the country rock in the vicinity of Ruby Creek suggests strongly the similar effects seen elsewhere in the Yukon-Tanana region around the peripheries of the Mesozoic batholiths. Hence, if any of the gold in the Rampart district has been derived from the rocks at the head of Ruby Creek it is probable that Mesozoic mineralization is represented in this area.

In the Tofty area the tin belt lies in a well-developed zone of shearing that trends N. 70° E., and the country rock also strikes in the same direction. The country rock not only shows the effects of movement but is notably impregnated with pyrite and is cut by numerous quartz veins, which also contain pyrite. A body of pyroxene monzonite lies 4 or 5 miles north of the tin belt at Roughtop Mountain, and a body of biotite granite lies 5 or 6 miles to the southeast, at Hot Springs Dome. The bedding and cleavage in the tin belt therefore do not strike in the direction of either of these intrusive bodies, so that the natural solution channels in the country rock could not be expected to communicate with them. The northern intrusive body is drained on its west side by Boulder Creek, but the placer concentrates of Boulder Creek contain no cassiterite. Considerable prospecting has been done on both the north and the south sides of Hot Springs Dome, but no tin and little gold have been found in the creeks draining this intrusive body. Therefore the mineralization of the tin belt has not been proved to have a genetic relation to any granitic rocks that appear at the surface in the Hot Springs district. On the other hand, the quartz veins that contained the tin, as revealed by fragments of this material in the placer concentrates, contain much tourmaline, which suggests their derivation from a deeper-seated granitic body. These veins are not of the more common pneumatolytic type that are so characteristic of tin deposits at many other places in the world, for minerals like topaz, fluorite, axinite, and others that contain volatile constituents are either lacking or very scarce. These data indicate that the cassiterite and probably also the gold of the tin belt were deposited by mineral solutions in the upper rather than the lower zone of high-temperature mineralization.

The age of the deep-seated granitic rocks that acted as a source of the mineral solutions in the tin belt is hard to determine. The ore-bearing solutions that emanated from them invaded the Lower Cretaceous rocks, and the underlying granitic body is therefore younger than Lower Cretaceous. The Tertiary age of the granitic rocks of the Rampart and Hot Springs districts that are visible at the surface has been established mainly by their petrographic similarity to other granitic rocks whose Tertiary age is well established. As the granitic rocks that acted as a source for the mineral solutions in the tin belt are concealed, such petrographic evidence cannot be obtained here. Therefore, the mineralization in the tin belt cannot be definitely proved to be of Tertiary age, but this is believed to be very probable. Even the Tertiary granitic rocks of this area, however, are not regarded as strictly correlative with one another, for they show petrographic differences that suggest a long epoch of igneous activity, during which granitic intrusion took place in several stages.

Little is known regarding the mineralization that produced the placers of American, Boulder, and Quartz Creeks. It has not been determined, for example, whether these placers have been derived from one or more mineral belts, but it does seem assured that the sites of the original lodes were different from those of the Tofty tin belt. The general geographic distribution of these creeks suggests a relation of the placers to the pyroxene monzonite of Roughtop (Moose) Mountain, very similar to that existing between the Eureka mineralization and the monzonite of Elephant Mountain, but insufficient data are available on the quality of the gold and the nature of the concentrates to carry the analogy any further.

In the Eureka area the country rock is mineralized along a zone of shearing, and in fact if this zone were projected southwestward along its strike it would connect directly with the tin belt. The flats of Baker Creek, however, conceal the country rock that lies between the Eureka mineralized area and the tin belt. Many quartz veins and stringers are found in the bedrock of Pioneer and upper Eureka Creeks, but the mineralization was different from that of the tin belt, in that the quartz veins contain no cassiterite or tourmaline. Pyrite, however, is plentiful. The available evidence indicates that the gold was derived from such quartz veins at no great distance from the site of the present placers. A large body of monzonite lies to the northeast of Eureka and Pioneer Creeks, at Elephant Mountain, but granitic rocks are absent in the gravel of these two creeks. Therefore the direct genetic relation of the gold mineralization to the Tertiary granitic rocks of Elephant Mountain is doubtful. On the other hand, this mineralized area lies in a shear zone that strikes directly into Elephant Mountain, so that some kind of a relation between the centers of mineralization and intrusion is suggested. In all probability, as in the Tofty area, the mineralization is related to more deeply buried granite rocks. West of Eureka Creek, however, particularly in the placers of Shirley Bar and vicinity, the minerals found in the concentrates suggest a more direct relationship between the mineralization and the body of monzonitic rocks at the heads of Rhode Island and Omega Creeks.

The character of the gold and the nature of the concentrates recovered with the gold also have a value in the study of the regional mineralization. At Rampart the grade of the gold is notably high. The available assays show fineness ranging from 0.915 to 0.941, with an average near 0.923, which, exclusive of the silver, gives a value of more than $19 an ounce. This compares closely with the gold from the Tolovana district,[37] which on the basis of four assays shows a fineness of 0.915. The grade of the gold from the Tofty and Eureka areas is considerably lower. As the placers of the tributaries of Minook Creek have in large measure been reconcentrated from older placers, the fineness might naturally have been increased by this process. But the older placers of Idaho Bar, as previously shown, have an assay value of $18.75 an ounce or more. Therefore, if it is assumed that the gold in the Pliocene (?) placers suffered no greater abrasion than the gold in the younger and partly reconcentrated placers of the Tofty and Hot Springs areas, it follows that the high-grade character of the Rampart gold was an original characteristic rather than one acquired by the later elimination of alloyed silver.

The Eureka gold, on the basis of five assays, has an average fineness of 0.793, whereas the Tofty gold, on the same number of assays, has a fineness of 0.833; and the highest-grade gold of the Eureka area is lower in grade than the lowest-grade gold of the Tofty area. It has been shown, however, that the cassiterite and also probably the gold in the placers of the tin belt have undergone much concentration, whereas most of the placers in the Eureka area have not been so greatly reworked. The difference in fineness between the Tofty and Eureka gold may perhaps be attributed to this cause; but the Rampart gold appears to be essentially different in grade and may therefore represent a different epoch or stage of mineralization.

[37] Mertie, J. B., Jr., The gold placers of the Tolovana district: U.S. Geol. Survey Bull. 662, p. 264, 1918.

The concentrates from all the placers of the Rampart and Hot Springs districts are now being studied by Waters (see pp. 227–246), in the hope of obtaining additional information regarding the nature and sequence of mineralization in the lodes from which the placers have been derived. This work is as yet incomplete, and no general conclusions can now be made. Certain facts, however, that are already known suggest some tentative correlations and conclusions. In an earlier paper [38] the writer has called attention to the almost universal occurrence of cinnabar in those gold placers of southwestern Alaska that have been derived from Tertiary quartz veins. Cinnabar is present in the concentrates from at least four localities in the Eureka area and has also been identified in small amounts in the concentrates from Hunter, Hoosier, Troublesome, and Quail Creeks, in the Rampart area. The placers of Hunter Creek are believed to have been reconcentrated in part from the older placers of Idaho Bar, but it is a significant fact that cinnabar is not present in the placer concentrates from Idaho Bar. This distribution of cinnabar suggests that Tertiary mineralization occurred in both the Eureka and the Rampart areas, but earlier mineralization may also have occurred in the Rampart area.

The cassiterite of the concentrates merits some consideration. This mineral has been found not only in the tin belt at Tofty but also in the concentrates on Quail, Hunter, and Troublesome Creeks. Cassiterite has now been recognized at several localities in Alaska and probably has a wider distribution than is commonly believed. The following occurrences are known to the writer:

York district, Seward Peninsula.
Hot Springs district, including certain localities north of the Yukon.
Quail, Troublesome, and Hunter Creeks, Rampart district.
Grant Creek, Gold Hill district, west of Tanana.
Wade Creek, Fortymile district.
Deadwood Creek, Circle district.
Several creeks in the Fairbanks district.
Boob Creek, Tolstoi district.
Several creeks in the Ruby district.
Nearly every placer-producing creek in the Yentna district.

In the Hot Springs and Yentna districts the nearest granitic rocks to which the cassiterite may be genetically related intrude Upper Cretaceous rocks, and the cassiterite veins are therefore probably of Tertiary age. On Boob Creek, in the Tolstoi district; on Wade Creek, in the Fortymile district; and on Quail, Troublesome, and Hunter Creeks, in the Rampart district, cassiterite and cinnabar occur together in the placer concentrates; but the Tertiary age of the cinnabar does not prove that the cassiterite is also of the same age, for

[38] Mertie, J. B., Jr., The occurrence of metalliferous deposits in the Yukon and Kuskokwim regions: U.S. Geol. Survey Bull. 739, pp. 156–158, 1923.

it may have been deposited in an earlier period of mineralization. In the York, Gold Hill, Circle, Fairbanks, and Ruby districts insufficient stratigraphic or metallographic data are available to decide the age of the cassiterite mineralization, but several investigators, including the writer, have stated that the cassiterite at most of these localities probably originated in Mesozoic time. From these data it seems rather likely that cassiterite veins have been formed in Alaska both in a Mesozoic and in a Tertiary epoch of mineralization. Cassiterite alone is therefore not a reliable index of the age of an epoch of mineralization. At Hot Springs the cassiterite is considered to be of Tertiary age on other grounds, but in the Rampart district its age is indeterminate.

Another interesting mineral associated with the gold placers is chrome spinel (picotite), which is found in nearly all the concentrates from the Rampart and Hot Springs districts. The writer [39] has previously called attention to the similar widespread occurrence of picotite in the Livengood district. In that area chromite was found in place associated with ultrabasic rocks of Devonian age, and the picotite was believed to have the same origin. It is logical to assume a similar origin for the mineral in the Rampart district, but in the Hot Springs district the Paleozoic rocks are in large measure concealed by an overlying mantle of Cretaceous rocks. The universal presence of picotite, together with the occurrence of limestone and greenstone in the gravel of upper Cache Creek, may indicate that this mantle of Cretaceous sediments is rather thin and has been penetrated at numerous places by the present streams. Another explanation, however, is that basic differentiates of the Tertiary granitic rocks have also been the source of chromiferous solutions.

The facts and deductions therefrom given above lead to the following conclusions:

1. The mineralization in the Rampart and Hot Springs districts is believed to have a genetic relationship with granitic rocks that lie below the surface, but no such relationship with the granitic rocks at the surface has been proved.

2. The granitic rocks that produced the mineralization in the Tofty and Eureka areas and in the valley of Troublesome Creek and its tributaries are of Tertiary age, and the mineralization in those areas is likewise believed to be of Tertiary age.

3. The absence of cinnabar in placers containing considerable amounts of cassiterite, and the absence or scarcity of cassiterite in placers containing considerable cinnabar, lead to the belief that these two minerals were deposited in different stages of mineralization.

[39] Mertie, J. B., Jr., Gold placers of the Tolovana district: U.S. Geol. Survey Bull. 662, p. 265, 1918.

4. It appears probable that the mineralization of the Rampart and Hot Springs districts took place in at least three stages, as follows:

(*a*) An early stage of mineralization, possibly of Mesozoic age, characterized by the deposition of gold, silver-lead, and copper ores, which was effective mainly in the valley of Minook Creek and its tributaries, in the Rampart district.

(*b*) An early stage of Tertiary mineralization, characterized by the deposition of gold, often with but at some localities without the deposition of cinnabar. The Eureka area is the type locality for the deposition of gold and cinnabar, but the presence of small amounts of cinnabar on Hunter and Hoosier Creeks indicates that this stage of Tertiary mineralization was also effective in some measure in that part of the Rampart district. The mineralization on American, Boulder, and Quartz Creeks, which yielded no cinnabar, and that on Quail and Troublesome Creeks, which yielded little cinnabar, were probably phases of this same general stage of mineralization.

(*c*) A late stage of Tertiary mineralization, characterized by the deposition of gold and cassiterite. The Tofty area is the type locality. The small amounts of cassiterite on Quail, Troublesome, and Hunter Creeks have little significance, for cassiterite has also been found elsewhere in the Yukon-Tanana region in association with gold of Mesozoic age. The lode deposits at Hot Springs Dome may also have been formed during this late period of Tertiary mineralization.

COAL

The Tertiary rocks in the vicinity of Rampart contain coal beds of workable size, which at some places were once mined. Thus, along the northwest side of the Yukon River, opposite the mouth of the Hess River, a prospector named O. C. Miller drove a prospect tunnel to explore these coals in 1895 or 1896. This opening was then called the Miller mine but subsequently came to be known as the Pioneer mine and still later as the Drew mine. Coal beds have also been prospected at the mouth of Hunter Creek and along the south bank of the Yukon, about 2 miles below Rampart.

Collier,[40] in 1902, examined the coal-bearing rocks opposite the mouth of the Hess River and concluded that at least seven coal seams are present there, unless unrecognized duplication of beds has taken place. Of these, the largest coal seam is the sixth from the bottom, which at the Drew mine contains two workable beds of coal. Collier's section at the Drew mine is as follows:

[40] Collier, A. J., The coal resources of the Yukon, Alaska: U.S. Geol. Survey Bull. 218, pp. 38-43, 1903

Section at Drew mine, Alaska

	Ft.	in.
Yellow shaly sandstone, top of section.		
Bone and black shale	1	8
Coal (analysis 138)	2	1
Black shale and bone	4	
Coal (analysis 137)	1	1
Black shale or bone coal	2	
Coal		2
Black shale	4	
Bony coal	4	

Another coal seam (analysis 312), which was thought by Collier to represent the fifth bed from the bottom, was exposed about 100 yards north of the main workings of the Drew mine. This seam ranged in thickness from 4 to 7 feet and consisted of crushed coal, with considerable fossil resin, or amber. The coal at the junction of Hunter and Minook Creeks (analysis 310) was said to be a glossy lignite. Analysis 160 was made of the coal 2 miles downstream from Rampart. Another analysis of a sample of coal from the Drew mine, collected by Spurr in 1896, is also included with these analyses.

Analyses of coal from Rampart district, Alaska

	Spurr, 2	137	138	160	310	312
Water	7.29	9.58	9.54	16.43	11.21	14.44
Volatile matter	37.38	36.87	40.09	41.09	44.32	47.15
Fixed carbon	36.91	39.83	37.35	35.22	38.64	33.77
Ash	18.42	13.72	13.02	7.26	5.83	4.64

These analyses indicate that the Tertiary coal near Rampart is a black lignite.

MINERAL WATERS

Reference has already been made to the hot springs near the town of Hot Springs and in the valley of Hutlinana Creek. The first have been called the Baker Hot Springs but are better known locally as the Manley Hot Springs. The second are known as the Hutlinana Hot Springs.

The Manley Hot Springs issue from two vents, about 50 yards apart, and the hot water runs into Karshner Creek, a small stream that enters the Hot Springs Slough about 1,000 feet northeast of the town. According to Waring,[41] the temperature of the water issuing from the western of these two springs is 136° F. and that of the eastern spring 125°, and the respective discharges are 35 and 110 gallons a minute. The water issues directly from the biotite granite that forms the Hot

[41] Waring, G. A., Mineral springs of Alaska: U.S. Geol. Survey Water-Supply Paper 418, pp. 60–62, 1917.

Springs Dome, to the north, but the croppings at the springs are poor, consisting of residual material derived from the decomposition of the granite.

The following description of the water is taken from Waring's report:

> The water has no noticeable odor or taste. There is a small amount of bubbling, probably of carbon dioxide, and thin coatings of a white, brittle substance, probably lime carbonate, are deposited on stones along the run-off channels. The water is said to eat up iron vessels rapidly. The original iron pipe from the springs was so much corroded that it was taken out and replaced by galvanized pipe. This corrosion is probably due to the rather high proportion of chloride in the water, which is shown in the analysis of water from the largest eastern spring. The analysis shows, however, that the water carries only a moderate amount of mineral matter in solution, other constituents being present in minor amounts relative to sodium and chloride.

Warm springs with a temperature between 80° and 100° F. also issue at the head of a small gulch called Ohio Creek, which enters the Hot Springs Slough on the same side as Karshner Creek but directly across the slough from Hot Springs.

The Hutlinana Hot Springs are on the northwest side of Hutlinana Creek, about half a mile upstream from the mouth of Cairo Creek. The creek at this point swings in against a rock bluff about 75 feet high, and the water issues from the downstream end of this bluff. The country rock is a hard dark-gray quartzite, of Lower Cretaceous age, which is extensively fractured and filled with small quartz veins and stringers. The strike is N. 28° E., and the beds are vertical.

The water does not issue from a single fissure but from cracks in the country rock, some of which are in the creek itself. A continuous stream of bubbles issues from several of the cracks, and a faint sulphurous odor is noticeable. A very slight sulphurous taste may also be detected. No incrustation of mineral salts is visible about the spring. According to Waring,[42] the temperature of the water is 114° F. and the discharge about 50 gallons a minute. A sample of the water was taken in 1931, and the analysis, as shown below, compares closely with the sample taken by Waring in 1915.

[42] Waring, G. A., op. cit., p. 59.

Mineral analyses of water from hot springs in Hot Springs district, Alaska

[Parts per million]

	1	2	3
Silica (SiO_2)	59	44	34
Iron (Fe), Aluminum (Al)	[a] .80	.09	.11
Calcium (Ca)	9.1	22	22
Magnesium (Mg)	.9	6.0	8.1
Sodium (Na)	121	[b] 208 (Na+K)	[b] 204 (Na+K)
Potassium (K)	8.2		
Bicarbonate (HCO_3)	86	494	500
Sulphate (SO_4)	48	67	66
Chloride (Cl)	120	38	37
Nitrate (NO_3)	----------	----------	([c])
Total dissolved solids	417	634	615

[a] $Fe_2O_3+Al_2O_3$.
[b] Na_2O+K_2O (calculated).
[c] Less than 0.2.

1. Manley Hot Springs; western of two principal springs. Collected Aug. 5, 1915, by G. A. Waring; analyzed by R. B. Dole and Alfred A. Chambers.
2. Hutlinana Hot Springs. Collected Aug. 6, 1915, by G. A. Waring; analyzed by R. B. Dole and Alfred A. Chambers.
3. Hutlinana Hot Springs. Collected Aug. 16, 1931, by party of J. B. Mertie, Jr.; analyzed by C. S. Howard.

PLACER CONCENTRATES OF THE RAMPART AND HOT SPRINGS DISTRICTS

By A. E. Waters, Jr.

INTRODUCTION

The Rampart and Hot Springs districts are described by Mertie in the preceding paper and shown on figure 4 and plates 3, 4, and 5.

During the field season of 1931 the writer visited most of this area in company with Mr. Mertie and was thus enabled to observe the occurrence of the gold placers. In the Tofty area of the Hot Springs district cassiterite occurs in the gold placers in sufficient quantity to be considered a commercial byproduct of mining. Although these placers have been mined and prospected for many years, the bedrock source of this cassiterite has not been located. The placer concentrates, however, that are recovered with the gold, contain other heavy minerals besides cassiterite and also a variety of rock-forming minerals, and it was thought that a study of these concentrates might possibly yield additional information regarding the source and mode of origin of the tin ore. At the same time, it was realized that it would also be desirable to examine carefully other samples of placer concentrates from contiguous areas where cassiterite was not known to occur, in order that comparative data might be available. Accordingly, a study of all the placer concentrates from the Rampart and Hot Springs districts was undertaken, and the results of this study are given in the following pages.

In the execution of this plan 10 days was spent by the writer in the Tofty area, at the end of the regular field season, in order that additional collections and supplementary field data might be obtained. Fourteen samples of concentrates were collected by the writer from the Tofty area, and 26 other samples were contributed from the Rampart and Hot Springs districts by the Geological Survey. The writer takes this opportunity to thank Philip S. Smith, chief Alaskan geologist, for permission to use the Geological Survey collections and for helpful cooperation in completing this work. He is also indebted to J. B. Mertie, Jr., of the Geological Survey, for assistance in the field and for the use of unpublished maps, manuscripts, and notes.

The laboratory work was done at the Johns Hopkins University, and in this connection the writer also wishes to acknowledge gratefully the helpful criticism and advice given by Dr. E. B. Mathews and Dr. J. T. Singewald, Jr., of the geological department of that university. He is also indebted to Charles Milton, of the Geological Survey, for the determination of several minerals in the placer concentrates; and he wishes to express his appreciation of the hospitality and cooperation shown him by Messrs. Hans Tilleson and Arthur L'Heureux, of Hot Springs, at whose camp he was a guest during a part of the field work.

GEOGRAPHY AND GEOLOGY

The geography and geology of this region have been described in the preceding paper by Mertie and also in papers by other writers.[1]

In the following description of the placer concentrates the Rampart mining district is divided into two units, known as the Rampart area and the Troublesome Creek area. The Rampart area includes Minook Creek and its tributaries, particularly Hunter, Little Minook, Little Minook Junior, and Hoosier Creeks, also Idaho Bar, an ancient gravel deposit athwart the ridge between Little Minook and Hunter Creeks. The Troublesome Creek area includes Troublesome Creek and its tributaries, lying between Wolverine and Sawtooth Mountains.

The Hot Springs district is also divided for descriptive purposes into two units, known as the Tofty and Eureka areas. The Tofty area lies in the alluvial depression between Roughtop Mountain and Hot Springs Dome, on the upper tributaries of Patterson Creek, particularly on Woodchopper, Sullivan, and Cache Creeks. Boulder Creek, which flows westward from Roughtop Mountain, and American Creek, between Woodchopper and Boulder Creeks, are also included in the Tofty area. The Eureka area lies southwest of Elephant Mountain and is drained by several creeks, of which the largest are Pioneer, Eureka, Rhode Island, McKinley, Omega, and Thanksgiving Creeks.

The Tertiary granitic rocks of the Rampart and Hot Springs districts are of particular importance in the present study, because they are believed to be connected genetically with the mineralization of this region and thus to have been the ultimate source of most of the heavy minerals of the concentrates. Masses of such rocks of considerable size occur at Hot Springs Dome, Roughtop Mountain, Elephant Mountain, Wolverine Mountain, the Sawtooth Mountains, and along the Yukon River below Stevens Creek. Smaller bodies lie northwest and southeast of Wolverine Mountain and at the heads of Rhode Island and Omega Creeks.

[1] Prindle, L. M., and Hess, F. L., The Fairbanks and Rampart quadrangles, Yukon-Tanana region, Alaska: U.S. Geol. Survey Bull. 337, 1908. Eakin, H. M., A geologic reconnaissance of a part of the Rampart quadrangle, Alaska: U.S. Geol. Survey Bull. 535, 1913.

The intrusive mass exposed at Hot Springs Dome is unique. Its surface exposure, starting at a point half a mile north of the mouth of Hot Springs Slough, extends N. 65° E. for about 10 miles. Over a large part of its length it averages about 2 miles in width, and in the central portion it reaches a maximum of 3 miles. Its northern contact, which is the highest point of the intrusive mass, follows in a general way the crest of Bean Ridge. Its southern contact is nearly vertical metamorphosed thin-bedded Cretaceous sandstone and shale. The outline of this area from Hot Springs southwest to its extremity and then back again along the crest of Bean Ridge to the low saddle 4 miles northeast of the summit is fairly easy to trace, but from that point on around the northeast end of the igneous body and back to Hot Springs the granite is largely covered by residual debris. In general the contact appears to be vertical or dipping very steeply outward. However, at several places along the northern contact, especially at the highest portions of Hot Springs Dome, the contact seems to flatten out and the sediments to lap over the top of the intrusive body like the crest of a wave about to break. The elongation of this body conforms to the regional strike of the area, and the contacts appear to be generally concordant.

The intrusive mass at Hot Springs Dome shows little variation in mineral composition and consists essentially of quartz, potash feldspar, basic oligoclase, and biotite, with accessory iron ores, zircon, muscovite, and tourmaline. The potash feldspar is partly orthoclase and partly microcline, but some of the orthoclase is perthitically intergrown with albite. This rock is a biotite granite but lies near the dividing line between the granites and quartz monzonites, as those terms are defined by Lindgren.[2] The results of marked thermal and dynamic metamorphism of the country rock are apparent along the borders of this intrusive mass.

Associated with and cutting the granite of Hot Springs Dome are dikes from 3 inches to 4 feet thick, which are thought to represent the last stage of the Hot Springs Dome intrusion. Most of these dike rocks contain tourmaline, in proportions ranging from less than 1 percent to 15 percent; and in one specimen monazite also was identified. The tourmaline is similar in every respect to the tourmaline found in the tin ore and in the quartz-tourmaline boulders occurring in the tin placers. Some of the tourmaline in these dikes is later than both potash feldspar and plagioclase, but it is earlier than some of the quartz.

The intrusive mass at Roughtop Mountain crops out in an oval area, the long direction of which strikes east. Its contact with the country rock lies well below the summit of the mountain and was

[2] Lindgren, Waldemar, Granodiorites and other intermediate rocks: Am. Jour. Sci., 4th ser., vol. 9, p. 279, 1900.

nowhere seen, but on the south side of the mountain it appears to dip away from the igneous body at a low angle. The adjoining sediments have suffered considerable thermal metamorphism, but the contact-metamorphic effects are much less intense than those in the rocks adjacent to the granitic rocks at Hot Springs Dome.

The main intrusive mass at Roughtop Mountain is a monzonite, which, however, grades into syenite and olivine monzonite. The monzonite proper consists essentially of acidic plagioclase, orthoclase, augite, hornblende, and biotite, with accessory quartz, apatite, titanite, iron ores, and zircon. The average ratio of plagioclase to orthoclase is 3 to 2. In addition to this rock and its variants, a considerable number of dikes also cut the main intrusive mass. These range from fine-grained rocks in dikes a few inches thick to granular rocks in dikes as thick as 50 feet.

The granitic rock at Elephant Mountain occurs as an elongated mass, about 2 miles wide and 5 miles long, of which the major axis is parallel to the regional strike. This rock is similar in general character to the monzonite at Roughtop Mountain but is more uniform and contains a somewhat greater proportion of quartz, though scarcely enough to warrant the designation quartz monzonite. The intrusive mass that forms the core of the Sawtooth Mountains is strikingly similar to the monzonite at Roughtop Mountain. The granitic rocks at Wolverine Mountain and the two smaller bodies of such rocks northwest and southeast of Wolverine Mountain differ from those above described in containing about 15 percent of quartz, so that they are more properly described as quartz monzonites.

The sedimentary rocks of the Hot Springs district are cut by numerous quartz veins ranging in width from less than an inch to at least 1 foot and probably several feet, to judge by some of the quartz boulders seen. Most of these veins show no sign of metallization and consist of a whitish glassy quartz. However, several exceptions were noted.

On the left side of Sullivan Creek about 2 miles upstream from old Tofty and 500 yards east of the creek was found a sharply angular block of iron-stained whitish glassy quartz to which pieces of highly sheared slate were adhering. On a fresh break this quartz showed abundant pyrite.

Many of the quartz stringers exposed in the phyllite bedrock of the open cut on the property of Tilleson & L'Heureux, on the east side of Sullivan Creek, were greatly honeycombed, and several specimens were found in which the openings were filled with calcite.

On the west side of Sullivan Creek about 1 mile upstream from old Tofty and 100 feet above the valley floor are several shallow prospect pits at the bottom of which was found a much sheared and contorted slate containing masses of crumbly and honeycombed white quartz. This quartz was iron-stained and enclosed irregular patches of slate ranging from less than one sixteenth of an inch to at least 1 inch in diameter. These slate inclusions were in places almost completely altered to sericite. About 100 yards downstream from these pits is a massive gray quartzite which is cut by an intricate network of iron-stained whitish glassy quartz stringers. The quartzite bordering some of these stringers has undergone intensive silicification, and a few arsenopyrite crystals were found—not in the quartz stringers but in the quartzite about 1 inch from them.

All the above described occurrences of vein quartz were found either in the placer-tin belt or just north of it on the upstream side. However, no pegmatitic veins or bodies were seen, nor any trace of tourmalinization. The slate and phyllite of this belt and of several other portions of this area are impregnated with pyrite, usually in well-formed cubes.

On the summit of Hot Springs Dome is a mineralized belt that parallels the north side of the granite for almost a mile. This belt is made up of several nearly parallel lodes or composite veins in almost vertical fracture zones in the metamorphosed Cretaceous slates. The mineralization appears to have consisted largely of the deposition of the iron carbonate, siderite, with here and there pockets of galena and small amounts of chalcopyrite, pyrrhotite, and pyrite. The pink cobalt bloom, erythrite, also azurite and malachite were seen in several places. In all the surface exposures the iron carbonate has been largely altered to limonite. The ore is reported to contain small amounts of gold and silver. No trace of tourmalinization or tin was found, although the deposits are thought to be genetically connected with the nearby granitic intrusion.

PLACER CONCENTRATES

Thirty-eight samples of placer concentrates from the Rampart and Hot Springs districts were examined. Most of these are well-concentrated mixtures of ore minerals, but they also include a representative selection of rock-forming minerals. Some of the samples, however, were poorly concentrated, so that the heavy minerals had first to be separated by means of bromoform, before examination. Both the ore minerals and the rock-forming minerals were identified, and in the following pages all minerals are listed in their approximate order of abundance in each sample. The localities at which these samples were collected and their mineral composition are set forth below.

RAMPART AREA

Nine samples of placer concentrates from the Rampart area were examined.

2. Hunter Creek, claims 14 to 16 above Discovery, about 3 miles from mouth of creek. Donor, Charles Swanson, 1922. Sample 2 is well washed and well concentrated and is free from rock particles and other light constituents. The color is speckled black and white, with a brownish tinge. The individual minerals range from a fraction of a millimeter to several millimeters in diameter. Free gold is plainly visible with the naked eye. The sample contains the following minerals:

Hematite—well-rounded to subangular, dark reddish black to steel-gray with high luster.
Barite—well-rounded to angular, extremely fine grained to coarsely crystalline, colorless to white.
Ilmenite—angular and platy fragments and few euhedral grains.
Magnetite—octahedrons and angular fragments.
Pyrite—irregular massive grains and cubes.
Gold—well-worn and much flattened nuggets, many of which are iron-stained; also some very irregular nuggets showing less wear, many of which are intergrown with nearly colorless quartz.
Quartz—angular, iron-stained, colorless to milky-white vein quartz.
Cinnabar—subangular, bright-red to mottled dark-red grains.
Diopside—very small, subangular, pale yellowish-green to greenish-gray grains.
Limonite—pseudomorphous after pyrite cubes.
Zircon—well-worn pink pleochroic grains, less than 1 millimeter in greatest dimension.
Picotite—somewhat rounded octahedrons.
Cassiterite—dark amber, somewhat worn crystal fragments. Also dark-brown to yellowish, laminated rounded fragments of wood tin. Both kinds are present only in a few very small grains.
Epidote—few very small greenish-yellow crystals.

3 (31AMt4). Hunter Creek at mouth of Dawson Creek, about half a mile upstream from sample 2. Collector, J. B. Mertie, Jr., 1931. Sample 3 is well washed, free from rock particles and other lighter constituents, and in general appearance is similar to sample 2 except that the percentage of very fine black sand is much greater and the gold is not as easily seen. This very fine black sand is largely magnetite. The following minerals were identified:

Magnetite—small octahedrons and angular grains; makes up 40 percent of the sample.
Ilmenite—angular, platy, and partly euhedral grains.
Hematite—large, rounded to subangular, reddish-black to steel-gray grains.
Barite—white, brownish, and gray; translucent to nearly transparent; fine-grained to coarsely crystalline; angular cleavage fragments to well-rounded grains.
Pyrite—irregular massive grains and unworn cubes; usually iron stained.
Gold—well-worn and much flattened nuggets, many of them iron-stained or partly coated with a brownish material. Also a few very irregular nuggets, paler in color, showing much less wear, and containing some quartz.
Garnet—small, clear, angular, wine-red to yellowish-amber pink fragments, also a few euhedral yellow crystals.
Picotite—very small octahedrons and larger rounded grains.
Zircon—well-worn small pleochroic pink grains; color ranges from deep purplish red to very pale pink.
Diopside—small, angular, pale yellowish-green grains.
Cinnabar—small angular crystalline fragments; dark mottled red with an almost metallic luster.
Copper—much flattened and well worn nuggets, 1 millimeter in greatest dimension; usually coated with black oxide.
Galena—angular cleavage fragments; also some rounded grains coated with cerusite.
Epidote—very small clear-yellow crystals.
Cassiterite—small angular to slightly worn crystal fragments; color ranges from very dark amber to clear golden-yellow, often in the same grain. Pleochroism is brown to yellow. One grain was pink, nearly colorless, and yellow in different parts. Very rare but more abundant than in sample 2. No wood tin was found.

5 (18AOC6). Little Minook Creek, claim 1 above Discovery. Collector, R. M. Overbeck, 1918. Sample 5 is well washed and fairly well concentrated, with only a small proportion of rock particles. The grain size ranges from a fraction of a

millimeter to several millimeters. Particles of phyllite, hematite, and barite make up most of the coarser grains. It contains the following minerals:

Hematite—subangular to rounded, dark reddish black to iron-gray with high luster. Grains vary in size; 4 millimeters in greatest dimension.
Ilmenite—angular to subangular fragments and subhedral crystals.
Pyrite—angular to rounded massive grains, also cubes and pyritohedrons.
Magnetite—small octahedrons and angular fragments.
Barite—angular to rounded white grains.
Tetradymite—rounded grains showing almost micaceous cleavage. Largest piece seen measured 2.6 millimeters in greatest dimension.
Galena—rounded to angular cleavage blocks, many of them coated with cerusite.
Gold—well-worn, flattened and chunky nuggets, many of which are iron-stained and coated with a brown substance; also some very irregular nuggets showing little or no wear, brighter in color, and commonly containing quartz.
Clinozoisite—angular, slightly yellowish-white grains.
Zoisite—angular white grains.
Copper—rounded and much flattened nuggets coated with black oxide.
Garnet—somewhat worn grains ranging in color from dirty white to a light amber; also one pale-green isotropic euhedral crystal.
Picotite—small rounded octahedrons.
Argentite—rounded grains, many of them coated with an orange-colored substance; soft and sectile.
Zircon—irregular colorless fragments averaging 0.3 millimeter in diameter; rare.
Scheelite—only one small grain.

6 (18AOC5) and 8 (31AMt18). Little Minook Creek, claim 8 above Discovery, about 3 miles upstream from mouth. Collectors, R. M. Overbeck, 1918; and J. B. Mertie, Jr., 1931. Samples 6 and 8 are well concentrated and very similar to one another. Sample 8, however, contains much foreign matter, such as lead shot, pieces of solder, nails, pins, and pick points. Some of the gold is amalgamated with mercury. The minerals in these two samples are practically identical and are listed below:

Hematite—large well-worn grains, mostly brownish black; also a few iron-gray grains with high luster.
Barite—angular to well-rounded grains, white, yellowish, and gray; clear to translucent.
Ilmenite—angular fragments to subhedral crystals.
Quartz—angular to slightly worn milky-white fragments.
Magnetite—small octahedrons and angular fragments.
Hornblende—ragged and fibrous green to brown fragments.
Argentite—irregular to rounded grains, many of them coated with an orange-colored substance; soft and sectile.
Galena—small cleavage fragments, locally coated with cerusite.
Clinozoisite—angular yellowish-white grains.
Zoisite—angular white grains, some of them striated.
Gold—well-worn rounded to flattened nuggets; also some very irregular pieces intergrown with quartz and showing practically no wear.
Pyrite—irregular massive to crystalline grains.
Picotite—small black angular fragments.
Epidote—small yellowish pleochroic grains.
Titanite—a few small clear, slightly yellowish grains. Most of it, however, is largely altered to brownish, nearly opaque, somewhat rounded grains.
Garnet—pale yellowish-white to amber-colored rounded grains.
Copper—well-worn flattened nuggets coated with black oxide. Only a few were seen, and these were less than 1 millimeter in greatest dimension.
Zircon—few small well-rounded pink grains.
Cinnabar (?)—two or three extremely small red grains with high luster.

7. Little Minook Creek, claims 1 and 2 below Discovery. Donors, John Cunningham and Peter Larkin, 1931. Sample 7 consists of hand-picked mineral grains an eighth of an inch in diameter or larger and therefore is not strictly comparable with the other samples from Little Minook Creek. It contains the following minerals:

Copper—irregular but well-worn nuggets, the largest of which measured 1 inch in greatest dimension.
Hematite—well-worn reddish-brown to almost black pieces, bluish gray on fresh break; largest piece measures half an inch in greatest dimension.

Garnet—somewhat rounded fragments; color a deep wine-red; largest fragment measures seven sixteenths of an inch.
Barite—rounded fine-grained pieces ranging in color from white to brownish gray; largest piece measures nine sixteenths of an inch in greatest dimension.
Pyrite—subangular massive fragments; largest piece measures half an inch in greatest dimension.
Galena—rounded cleavage fragments coated with cerusite; largest piece measures a quarter of an inch in greatest diameter.
Chromite—one rounded finely crystalline grain a quarter of an inch in diameter.

9 (31AMt35a). Little Minook Junior Creek, about 1½ miles from mouth. Donor, Thomas Antonsen, 1931. Sample 9 is well washed and highly concentrated. It ranges from extremely fine grains to pieces of pyrite nearly half an inch in greatest dimension. It is a mottled brown with slight brassy tinge and contains the following minerals:

Pyrite—irregular massive grains and subhedral crystals.
Hematite—rounded reddish-brown to almost black grains.
Ilmenite—angular to slightly worn fragments and subhedral crystals; a few grains are partly coated with leucoxene.
Barite—clear colorless angular cleavage fragments and rounded white to brownish-gray fine-grained pieces.
Magnetite—angular fragments and octahedrons.
Quartz—colorless to white angular fragments.
Clinozoisite—angular yellowish grains.
Zoisite—angular whitish grains, many of them striated.
Garnet—angular to worn pale yellowish-white to clear amber-colored grains, also a few worn, badly altered opaque grains.
Epidote—slightly rounded yellowish to greenish grains.
Hornblende—ragged brown grains embedded in a brownish-white amorphous alteration product.
Titanite—clear, slightly brownish angular grains, also some brown nearly opaque rounded pieces; probably altered.
Zircon—small, well-worn pink grains.
Galena—rounded cleavage fragments, usually coated with cerusite.
Gold—a few small well-worn nuggets, chunky but slightly flattened.

10 (18AOC3). Hoosier Creek, exact locality unknown. Donor, W. W. Crockett, 1918. Sample 10 is clean and well concentrated; it ranges from very fine grains to well-worn particles of hematite nearly half an inch in greatest dimension. Its color is a very dark brown mottled with white. It contains the following minerals:

Hematite—well-worn to subangular brownish to black grains, half an inch or less in size.
Ilmenite—angular to somewhat rounded grains.
Barite—clear, nearly colorless cleavage fragments and white to grayish-brown well-worn fine-grained pieces measuring as much as a quarter of an inch.
Magnetite—small octahedrons and angular fragments.
Pyrite—cubes and irregular masses.
Gold—flat to chunky well-worn nuggets, many of them badly iron stained or coated with brown substance. A few are intergrown with quartz, and one or two show very little wear.
Garnet—pale yellowish-white to amber-colored fragments and euhedral crystals. Some show a little wear.
Clinozoisite—angular, slightly yellowish-white grains.
Picotite—corroded octahedrons and angular glassy black fragments.
Scheelite—angular to slightly rounded whitish to very pale yellow grains.
Zoisite—angular whitish grains, commonly striated.
Zircon—well-worn pale to deep pink grains, also a few colorless prismatic crystals showing practically no wear.
Copper—small well-worn flattened nuggets, usually coated with black oxide.
Cinnabar—a few very small grains.

4 (31AMt20). South side of Idaho Bar, opposite the sharp bend in the valley of Little Minook Creek. Collector, J. B. Mertie, Jr., 1931. Sample 4 is poorly washed and practically unconcentrated and ranges from clay to pebbles nearly an inch in greatest diameter. Its color is a mottled yellowish gray. The heavy minerals, which make up only a small percentage of the sample and had to be separated out by means of bromoform before they could be seen, are listed below.

Ilmenite—angular and platy grains many of which are partly coated with leucoxene.
Hematite—somewhat rounded reddish-brown massive grains.
Hornblende—brown, strongly pleochroic grains, usually embedded in a whitish-brown amorphous decomposition product.
Clinozoisite—pale-yellowish to milky-white grains, commonly showing striations.
Magnetite—thin crystalline plates.
Apatite—somewhat rounded white prismatic grains.
Zircon—well-rounded pale to very deep pink grains.
Epidote—angular green to nearly colorless pleochroic grains.
Garnet—partly altered and dirty-brown fragments.
Gold—one small well-worn chunky nugget.

TROUBLESOME CREEK AREA

Three samples of placer concentrates from the Troublesome Creek area were examined.

12 (31AMt163). Quail Creek, claim 8 above Discovery, about 2 miles above the junction of Quail and Troublesome Creeks. Collector, J. B. Mertie, Jr., 1931. Sample 12 is well washed and concentrated. Its color is a brownish black mottled with white. The grain size is fine and uniform, few particles exceeding 1 millimeter in diameter and most of them averaging less than 0.5 millimeter. It contains the following minerals:

Picotite—angular glassy black fragments and octahedrons.
Cassiterite—chiefly angular fragments ranging from nearly colorless to a very dark amber, also some imperfect crystals and some grains showing rounding. Color varies in some grains, and the deeper-colored pieces show a slight pleochroism. The largest piece was a broken fragment from a somewhat rounded grain and measured 1.5 by 2.1 by 3.6 millimeters.
Barite—colorless to white angular grains.
Scheelite—colorless to white, slightly rounded grains.
Garnet—euhedral crystals and angular fragments ranging from clear reddish brown to cloudy yellowish brown.
Quartz—angular fragments of milky-white vein quartz and very fine grained aggregates.
Zircon—colorless to slightly brownish euhedral prismatic grains; contain abundant microscopic inclusions and are highly fractured internally. Also some extremely well rounded pink pleochroic grains, a few of which show a biaxial figure with very small positive optic angle.
Augite—angular brown grains; some are pinkish brown and are probably titaniferous.
Gold—irregular but well-worn nuggets; all are amalgamated with mercury.
Diopside—angular glassy green fragments.
Titanite—yellowish-brown to nearly colorless angular grains.
Hornblende—ragged green grains showing pleochroic halos around microscopic inclusions.
Pyrite—very small cubes.
Plagioclase—angular fragments.
Biotite—very few brown flakes.
Rutile—one small prismatic grain.
Dolomite—one rounded fragment.
Cinnabar—only one angular grain.

13. Gunnison Creek, exact locality unknown. Donor, J. Burrington, 1918. Sample 13 is well washed but not highly concentrated. Numerous particles of rock are present. These are mostly gray and brown phyllite, and they give the sample a mottled brownish-gray color. The grain size is medium to fine, there being few pieces over 2 millimeters in greatest diameter. The coarser portion is limited to the rock particles, and the bulk of the sample is made up of a black sand whose component minerals average less than 0.5 millimeter in diameter. This black sand was found to consist of the following minerals:

Magnetite—octahedrons and angular fragments; constitutes about 30 percent of sample.
Ilmenite—angular and slaty fragments.
Picotite—angular fragments and corroded octahedrons.
Augite—large ragged brown grains containing inclusion of biotite; some grains are titaniferous.
Zircon—colorless to slightly brownish short euhedral crystals and broken fragments.
Scheelite—somewhat rounded fragments.
Orthoclase—large cleavage fragments.

Quartz—few angular fragments, mostly fine-grained aggregate.
Epidote—strongly iron-stained yellowish angular grains.
Biotite—large dark-brown flakes.
Diopside—pale yellowish-green grains with patches of brown; probably grade into diopsidic augite.
Hypersthene—strongly pleochroic angular grains, reddish to greenish.
Garnet—angular reddish-brown fragments.
Hornblende—ragged grains, strongly pleochroic in shades of green and brown.
Gold—small irregular nuggets showing some rounding.
Pyrite—small cubes.
Apatite—colorless, somewhat rounded prismatic grains.
Uvarovite (?)—glossy deep-green isotropic grains giving test for chromium.
Rutile—small broken prisms.

1 (18AOC8). Troublesome Creek, just below mouth of Union Creek. Collector, R. M. Overbeck, 1918. Sample 1 is well washed and concentrated, with a maximum grain size of 2 millimeters. Its color is a mottled black and white, tinged with brown. In addition to the other minerals, about 75 pieces of brown, yellow, and reddish-brown mammillary wood tin were found, which ranged from 0.5 millimeter to 1.0 centimeter in greatest dimension. These pieces all show slight rounding of sharp edges, and some are worn quite smooth. This sample contains the following minerals:

Barite—Angular cleavage fragments and somewhat rounded grains, from colorless to white with a few of yellowish or grayish tinge. One piece appears to have come from a ⅛-inch veinlet in red shale.
Hematite—slightly to well rounded steel-gray to reddish-black grains.
Magnetite—octahedrons and angular fragments.
Ilmenite—angular and platy grains.
Picotite—angular fragments and corroded octahedrons.
Pyrite—chiefly irregular grains of massive pyrite; some grains intergrown with quartz; some pyritohedrons and a few small cubes.
Diopside—angular dirty to clear, slightly yellowish-green grains.
Quartz—angular milky-white fragments.
Cinnabar—somewhat rounded grains, bright red to a mottled red and black.
Gold—chiefly well-worn and flattened nuggets; some irregular nuggets showing very little wear and a few inclosing a piece of slightly milky quartz.
Garnet—pink to reddish-brown euhedral crystals and angular fragments.
Plagioclase—small cloudy fragments.
Galena—rounded crystalline grains.
Zircon—two well-rounded pink pleochroic grains.
Cassiterite (crystalline)—dark-brown slightly worn crystal fragment.
Suderite—angular brownish fragment.

EUREKA AREA

Five samples of placer concentrates from the Eureka area were examined.

16 (22AMt67). Pioneer Creek, from bench along northwest side about 2 miles above mouth. Collector, J. B. Mertie, Jr., 1922. Sample 16 is well washed, and the grains are less than 1 millimeter in greatest diameter, but it is not concentrated, and by far the larger part of the sample is composed of flat particles of phyllite and carbonaceous schist, which give the sample a dull-grayish color and largely mask the heavy minerals. The latter were separated by means of bromoform and found to be as follows:

Picotite—angular glassy black grains and octahedrons.
Ilmenite—angular and slaty grains.
Augite—ragged "motheaten" grains. Many contain numerous small inclusions of biotite. Most of the grains are brown, but some are pinkish, show strong pleochroism, and hence are probably titaniferous.
Pyrite—cubes and irregular massive grains. Many grains are intergrown with phyllite.
Zircon—colorless short prismatic crystals, also some well-rounded pink pleochroic grains.
Gold—irregular but water-worn nuggets; also a few extremely irregular nuggets showing practically no rounding, some of which are intergrown with milky-white quartz and all are brighter and lighter in color than the abraded nuggets.

Barite—colorless, white, and gray angular fragments.
Diopside—clear blue-green grains similar to those found on Quail Creek. Also some dull yellowish-green grains similar to those found on Gunnison Creek. A few grains are green in one part of the fragment and brown in the other part. These probably grade into augite.
Titanite—reddish-brown to pale-yellow opaque grains, probably altered.
Scheelite—slightly rounded translucent white grains.
Apatite—colorless partly rounded prismatic grains.
Magnetite—very few irregular grains and octahedrons.
Cinnabar—several rounded grains.
Quartz and feldspar are abundant constituents of this sample but were floated off with the rock particles.

17 (31AMt135). Pioneer Creek, from bench along northwest side a short distance east of Skookum Creek. Collector, J. B. Mertie, Jr., 1931. Sample 17, from "Last Bench," probably represents the upstream continuation of the same gravel that yielded sample 16, described above. Megascopically this sample is identical with sample 16. It contains the following minerals:

Quartz—colorless and milky-white vein quartz.
Picotite—glassy black fragments and octahedrons.
Ilmenite—angular and platy fragments.
Augite—large ragged brown grains most of which contain numerous inclusions of biotite. Some are titaniferous.
Diopside—large angular pale yellowish-green grains, some of which grade into a brownish diopsidic augite.
Chlorite—pale grass-green, slightly pleochroic flakes ranging from uniaxial to slightly biaxial; birefringence extremely low; shows the ultrablue interference color characteristic of penninite.
Zircon—colorless and slightly yellow short prismatic crystals, also some well-rounded pink pleochroic grains.
Titanite—ranges from clear, slightly brownish grains showing faint pleochroism to reddish-brown nearly opaque grains that are probably partly altered.
Gold—well-worn chunky nuggets; also irregular pieces showing little or no wear, which are brighter and lighter in color than the well-worn nuggets and some are intergrown with quartz. One nugget was intimately intergrown with carbonaceous schist.
Orthoclase—milky-white cleavage fragments.
Garnet—small equidimensional pink to brownish-red grains.
Apatite—colorless, slightly rounded prismatic grains.
Hornblende—well-rounded grains, strongly pleochroic in shades of green.
Biotite—reddish-brown flakes.
Magnetite—a few very small octahedrons and almost perfect spheres about 0.1 millimeter in diameter.
Limonite—pseudomorphous after pyrite cubes.
Tourmaline—brownish-black striated prismatic grains, very rare.
Scheelite—only one slightly rounded grain.

15 (31AMt132). McCaskey Bar, on east side of Eureka Creek below the mouth of Pioneer Creek. Collector, J. B. Mertie, Jr., 1931. Sample 15 in megascopic character is very similar to the two preceding ones except that its gray color shows a strong brownish tinge. Flat brownish-gray particles of phyllite and schist and angular pieces of milky-white quartz constitute about 60 percent by volume of the sample. The heavy minerals, separated out by means of bromoform, are as follows:

Ilmenite—angular and platy fragments.
Picotite—glassy black fragments and octahedrons.
Garnet—clear reddish-brown to red angular fragments, isotropic, also dirty-yellow to black euhedral crystals showing slight birefringence.
Zircon—colorless to yellowish prismatic crystals, also well-rounded colorless to deep-pink pleochroic grains.
Gold—well-worn chunky and also slightly flattened nuggets; a few very irregular nuggets showing no wear and a brighter color than the worn nuggets.
Apatite—colorless, slightly rounded prismatic grains.
Augite—a few ragged grains from brown to pinkish brown, the latter probably titaniferous.
Cinnabar—mottled pink rounded grains.
Magnetite—a few small octahedrons.
Tourmaline—short prismatic grains, brown in transmitted light, very rare.

18 (22AMt66). Lower end of Shirley Bar, close to Rhode Island Creek. Collector, J. B. Mertie, Jr., 1922. Sample 18 is well washed but poorly concentrated and consists chiefly of flat particles of schistose, carbonaceous, and quartzose rock which gives the sample a dull brownish-gray color. These particles average

between 1 and 3 millimeters in greatest dimension and constitute the bulk of the sample. Quartz and a little orthoclase are present. The heavy minerals were separated out by means of bromoform and are listed below.

Pyrite—striated cubes and massive grains; constitutes about 50 percent of heavy minerals present.
Augite—large ragged brown grains; only a few are titaniferous.
Cinnabar—well-rounded to subangular massive to finely crystalline grains.
Picotite—large irregular glassy black grains and octahedrons.
Barite—large well-worn white grains.
Galena—cleavage fragments showing little or no alteration to cerusite.
Ilmenite—a few large platy grains.
Gold—much worn and commonly much flattened iron-stained nuggets; some are intergrown with quartz and show less wear.
Garnet—clear amber-colored euhedral crystals; many show various stages of alteration to opaque iron-stained rounded grains.
Limonite—pseudomorphous after pyrite cubes.
Muscovite—a few colorless flakes.
Biotite—reddish-brown flakes.
Titanite—light-brown opaque grains.

19 (31AMt137). Omega Creek at the mouth of Chicago Creek. Collector, J. B. Mertie, Jr., 1931. Sample 19 differs from the others obtained from the Eureka area in being highly concentrated and very fine in grain size. The individual minerals average about 0.3 millimeter in diameter. The sample is brass-colored mottled with black. It contains the following minerals:

Pyrite—small striated cubes and irregular grains; makes up 40 percent of sample.
Ilmenite—irregular fragments and a few partly euhedral crystals.
Hypersthene—angular, strongly pleochroic grains.
Zircon—colorless to yellowish short prismatic crystals and fragments, also well-rounded pink pleochroic grains.
Quartz—milky-white to colorless angular fragments.
Orthoclase—unaltered cleavage fragments.
Gold—small well-worn chunky nuggets, many of them iron-stained; also some showing very little wear.
Diopside—clear, very pale green angular grains; some show brownish areas in parts of the grain. Probably a diopsidic augite.
Plagioclase—cloudy white fragments.
Apatite—colorless stout prismatic grains showing some rounding.
Picotite—a few glassy black octahedrons.
Garnet—pale yellowish-gray euhedral grains full of carbonaceous inclusions, slightly birefringent.
Scheelite—one octahedron and several angular grains.
Cinnabar—only one small angular grain.

TOFTY AREA

Certain creeks within the Tofty area lie within the tin belt, and all the placer concentrates from these streams contain stream tin. Samples 23 to 36 were collected in the tin belt; samples 20, 21, 22, 37, and 38 came from streams north of the tin belt, and samples 39 and 40 from streams south of the tin belt.

23 (22AMt42). North side of Deep Creek, just east of Woodchopper Creek. Collector, J. B. Mertie, Jr., 1922.

24. Old tailing piles near site of sample 23. Donor, Fred Hansen, 1932.

Samples 23 and 24 contain coarse particles as well as fine, and in sample 23 particles of cassiterite, quartz, and phyllite, half an inch in greatest diameter, are present. Sample 24 contains much less cassiterite than the other and very little gold. Their mineral content is listed below:

Cassiterite—rounded to subangular pieces of ore.
Ilmenite—subangular and platy fragments, also subhedral crystals showing some rounding.
Picotite—glassy black angular to well-rounded fragments and octahedrons.
Zircon—angular to subangular colorless to brownish fragments and crystals. Most of the crystals are extremely short bipyramids with the prism faces nearly lacking, maximum size half an inch. Also a few very small pink water-worn grains.

Quartz—angular milky-white fragments; a few grains show some rounding.
Pyrite—angular fragments and cubes.
Magnetite—very small angular grains.
Aeschynite (?) (niobate and titanate, chiefly of cerium metals)—angular to slightly rounded brownish-black striated fragments.
Gold—a few well-worn nuggets.

25 (31AMt122) and 26 (31AMt121). Old workings along north side of Deep Creek, about 2 miles east of Woodchopper Creek. Donor, A. Bock, 1931.

27 (31AMt624) and 28 (31AMt743). North side of Deep Creek about 2 miles east of Woodchopper Creek. Collector, A. E. Waters, Jr., 1931.

Samples 25 and 26 contain only coarse concentrates ranging from one-sixteenth of an inch to 1½ inches in greatest diameter. Samples 27 and 28 came from the drift mine of Fred Hansen and represent both fine concentrates obtained in the clean-up and hand-picked minerals. The minerals found in these samples are listed below:

Cassiterite—rounded pebbles of ore and a few angular brown crystal fragments. One piece of nearly amorphous "wood tin" in sample 25.
Ilmenite—angular to slightly rounded fragments and crystals three quarters of an inch in greatest dimension.
Zircon—angular to subangular colorless to brownish fragments and crystals; largest fragment measured a quarter of an inch in greatest dimension. Prism faces poorly developed. Also a few well-rounded very small pink grains.
Pyrite—angular to somewhat rounded fragments and cubes.
Quartz—angular to subangular milky-white fragments.
Picotite—angular to somewhat rounded glassy black grains and a few octahedrons.
Magnetite—angular fragments and octahedrons. Some pieces reach a diameter of about a quarter of an inch, are somewhat rounded, and show some alteration to hematite.
Aeschynite (?)—subangular to rounded brownish-black, commonly striated fragments.
Monazite (phosphate of cerium metals)—very well rounded fine-grained light-buff pebble measuring three quarters of an inch in greatest dimension.
Gold—well-worn and somewhat flattened nuggets.

Samples 29 (22AMt36) and 30 (22AMt37). East bench of Sullivan Creek, just north of old site of Tofty. Collector, J. B. Mertie, Jr., 1922.

Samples 31, 32, and 33. Same locality as samples 29 and 30. Collector, A. E. Waters, Jr., 1931.

The minerals found in these five samples of concentrates are listed below:

Cassiterite—well-rounded pieces of ore.
Pyrite—rounded to angular fragments and cubes.
Ilmenite—angular to somewhat rounded fragments and subhedral crystals.
Picotite—angular to rounded glassy black fragments and a few octahedrons; also large well-rounded masses as much as 1½ inches in diameter. Probably grades into chromite.
Magnetite—angular to slightly rounded fragments, some altering to hematite.
Zircon—angular to slightly worn colorless to brownish fragments and crystals in which the prism faces are poorly developed; maximum size at least a quarter of an inch. Also a few small well-rounded pink grains.
Quartz—angular to subangular milky-white fragments.
Monazite—well-rounded light-buff very fine grained pebbles 1 inch in greatest dimension.
Aeschynite (?)—angular to rounded brownish-black pieces composed of prismatic crystals; largest piece measures seven eighths of an inch in greatest dimension.
Xenotime—somewhat rounded yellowish grains.
Orthoclase—small subangular cloudy grains.
Plagioclase—small subangular cloudy grains.
Gold—well-worn irregular to slightly flattened nuggets; also a few small very irregular pieces showing practically no wear. Some nuggets intergrown with quartz.
Copper—a few very small well-rounded and flattened pieces coated with black oxide.
Apatite—a few somewhat rounded grains.
Epidote—small angular fragments.
Brookite—small whitish grains.
Anatase—one small bipyramidal blue crystal.

34 (31AMt742). Prospect ditch on Sullivan Creek 2 miles above old Tofty. Collector, A. E. Waters, Jr., 1931. Just above the old site of Tofty Sullivan Creek flows through a fairly narrow gap in the ridge north of the tin belt, and on the north side of this gap it divides into a number of small headwater tributaries that drain a somewhat semicircular basin about 5 miles wide. In this upper basin are shallow gravel deposits that have yielded a fair amount of gold but little or no tin. Unfortunately concentrates are not available from these gold workings. Sample 34, however, of unconcentrated sand was obtained from bedrock in a shallow prospect pit on one of the tributaries about 2 miles upstream from old Tofty and just above the north end of the gap. In addition to the fine particles of slate, phyllite, and quartzite, which make up the bulk of this sample, it contains the following minerals:

Quartz—clear to milky-white angular fragments.
Ilmenite—small angular fragments.
Diopside—pale-green ragged grains.
Augite—ragged brown grains.
Hypersthene—strongly pleochroic grains.
Apatite—somewhat rounded prismatic crystals and fragments.
Pyrite—cubes and irregular masses.
Orthoclase—a few cloudy fragments.
Zircon—well-rounded pink grains, one of which was embedded in a fragment composed of very small well rounded quartz grains. Also angular colorless fragments and prismatic crystals.
Gold—irregular but well-worn nuggets.
Xenotime—a few slightly rounded yellowish grains.
Cassiterite—a few small angular clear-brown grains.
Tourmaline—two small prismatic grains, reddish-brown to greenish-black in pleochroism.
Brookite—one angular slightly brownish grain.

35 and 36. Upper valley of Cache Creek, about three quarters of a mile west of the divide between Cache Creek and the headwaters of Baker Creek. Donor, Otto Hovley, in 1922 and 1931, respectively. In general appearance, sample 36 is similar to sample 35 but is not quite as well concentrated and contains particles of slate and phyllite. In mineral content they are the same, except that sample 36 contains a few well-rounded grains of tin ore similar to that found throughout the tin belt. No trace of cassiterite, however, was found in sample 35. In addition to the cassiterite in this sample of concentrates a few pebbles of the ore measuring about an inch in diameter were seen by the writer. However, this mineral is much less plentiful here than elsewhere in the tin belt.

Magnetite—angular to subangular grains, some of which are altering to hematite; makes up nearly 50 percent of sample.
Pyrite—angular to slightly rounded massive fragments and some imperfect cubes.
Ilmenite—angular to subangular fragments and platy grains.
Zircon—colorless to brownish angular to subangular fragments and large crystals with the prism faces usually poorly developed, also a few well-rounded pink grains.
Quartz—angular to subangular clear to milky-white fragments.
Orthoclase—subangular white fragments.
Barite—subangular white fragments, also one well-rounded pebble nearly an inch in diameter.
Cassiterite—well-rounded pieces of ore as much as a sixteenth of an inch in diameter, also a few angular to subangular crystal fragments.
Garnet—angular to slightly worn pink and amber-colored fragments.
Titanite—angular dusky-brown fragments.
Andalusite—a few pleochroic clear grains.
Picotite—rounded to angular glassy black fragments and a few octahedrons.
Apatite—somewhat rounded prismatic grains.
Hornblende—slightly ragged deep-green fragments.
Hypersthene—slightly rounded to angular strongly pleochroic grains.
Aeschynite—angular to slightly rounded brownish-black striated fragments.
Plagioclase—angular cloudy-white fragments.
Epidote—small angular yellowish-green grains.
Calcite—a few angular grains.
Gold—a few irregular but well-worn nuggets.

In addition to the concentrates above described, the writer found in one of the old tailing piles of Cache Creek a subangular, only slightly rounded stone composed of orthoclase, microcline, and quartz in sharp contact with a band of quartz and tourmaline.

37. Boulder Creek, locality and donor unknown. Received by U.S. Geological Survey in 1922. Sample 37 is well washed and has been well concentrated, for rock particles and other light constituents are practically absent. It is nearly black and nearly uniform in grain size, which averages 0.5 millimeter or less. It contains the following minerals:

Magnetite—small octahedrons and irregular grains; constitutes about 70 percent of sample.
Ilmenite—angular, platy, and partly euhedral grains.
Zircon—colorless to yellowish angular fragments and prismatic crystals.
Apatite—colorless broken prisms, somewhat rounded.
Orthoclase—milky-white subangular fragments.
Quartz—colorless to whitish angular fragments.
Gold—Well-worn, somewhat flattened nuggets.
Rutile—small broken prismatic grains.
Garnet—slightly reddish brown euhedral crystals.
Epidote—angular greenish-yellow grains.
Augite—a few small ragged brown grains.

38 (31AMt594). Sand from present stream bed of Boulder Creek, about 1 mile from head of south fork, just within the monzonite body that forms Roughtop Mountain. Collector, A. E. Waters, Jr., 1931. The sand of sample 38 ranges in size from silt to particles a quarter of an inch in diameter. The coarser material consists largely of angular fragments of bluish-gray orthoclase and a whitish plagioclase, with numerous flakes of bleached biotite. The heavy minerals were separated by means of bromoform and are listed below:

Augite—angular grains ranging from slightly greenish brown to pinkish brown, the latter probably titaniferous. Megascopically these grains are black.
Hornblende—ragged prismatic grains, strongly pleochroic in shades of green and brown.
Hypersthene—ragged grains, strongly pleochroic in shades of green and pink.
Apatite—large (0.5 by 0.3 millimeters) euhedral to slightly rounded colorless grains.
Titanite—angular dusky-brown grains.
Zircon—colorless euhedral prisms and angular fragments.
Quartz was found in small amounts in the "light-weight" minerals.

20. American Creek below mouth of Colorado Gulch. Collector, P. S. Smith, 1927.

21 (31AMt777). American Creek about 400 feet below mouth of Colorado Gulch. Collector, A. E. Waters, Jr., 1931.

Samples 20 and 21 contain coarse and fine concentrates and are dark in color. The minerals found in them are listed below:

Magnetite—small angular fragments and octahedrons.
Pyrite—angular fragments and cubes.
Ilmenite—angular to subangular grains and large pieces.
Barite—small well-rounded gray to white fine-grained pebbles and smaller angular fragments.
Chromite—dull-black rounded fragments and octahedrons. Rounding probably original and not because of abrasion. Grades into picotite.
Hematite—rounded reddish-brown grains, apparently after magnetite.
Quartz—angular milky-white fragments.
Garnet—reddish-brown, slightly rounded grains and crystals.
Epidote—angular greenish-yellow grains.
Zoisite—a few angular slightly yellowish-white grains.
Actinolite—very pale greenish fibrous grains.
Gold—a few small well-worn nuggets.
Hornblende—a few ragged green grains.
Tourmaline—one very small black prismatic grain.

22 (31AMt120a). New York Gulch, a tributary of American Creek. Donor, Anthony Styckex, 1931. Sample 22 is composed of fine mineral grains and is generally similar in mineralogic character to samples 20 and 21, but, unlike those samples, it contains no pyrite.

39. Sand from present stream bed of Big Denver Creek, about midway between its mouth and its extreme head. Collector, A. E. Waters, Jr., 1931. Sample 39 is the only sample from the south side of the Patterson Creek drainage basin. This sand is composed largely of small fragments of quartz schist and phyllite from the metamorphosed Cretaceous rocks over which the stream flows above this point, and contains neither cassiterite nor gold. This, however, is only negative evidence as to their presence or absence on this creek, as both these heavy minerals would tend to work their way downward through the gravel and might be present on bedrock without showing, except rarely, in the surface sand. The minerals found in this sample show clearly the metamorphosed and recrystallized nature of the rocks over which this stream flows and, when compared with the mineral content of sample 40, suggest that neither the granite at Hot Springs Dome nor its associated tourmaline-bearing dikes are cut in any appreciable amount by Big Denver Creek.

Quartz—angular fragments and granular aggregates.
Biotite—small deep reddish-brown flakes.
Chiastolite—large irregular grains, almost opaque from carbonaceous inclusions.
Hypersthene—small weakly pleochroic, somewhat rounded grains.
Hornblende—small rounded to angular prismatic deep-green to brownish-green grains.
Chlorite—nearly isotropic grass-green cleavage flakes.
Garnet—small nearly colorless to reddish angular to slightly rounded grains.
Zoisite—small colorless fragments showing strong ultrablue interference color.
Apatite—very small colorless rounded grains.
Titanite—small somewhat rounded colorless to pale-yellow grains; deeper-colored grains are slightly pleochroic.
Muscovite—a few colorless cleavage flakes.
Calcite—a few large angular grains.

40. Sand from present stream bed of Karshner Creek, about 100 yards from the Hot Springs Slough. Collector, A. E. Waters, Jr., 1931. Sample 40 is the only available sample from a stream that drains the body of granite at Hot Springs Dome. The sand is composed dominantly of minerals derived from the disintegration of the granite, but the presence of andalusite and well-rounded crystals of pink zircon suggests that patches, at least, of the intruded Cretaceous sediments are included in the drainage basin of this stream. Although tourmaline was second in abundance among the "heavy" minerals, no cassiterite was found. The presence of brookite and monazite is of interest, as this is the only place in this region, outside of the vicinity of the tin placers, where these two minerals were found. The mineral content of this sample is listed below:

Quartz—angular clear fragments, also a few prismatic crystals.
Orthoclase—angular slightly milky-white fragments.
Plagioclase—angular dull-white fragments.
Biotite—large deep-brown flakes; some show various degrees of bleaching.
Tourmaline—large black prismatic to angular fragments; pleochroism, colorless to greenish-brown.
Magnetite—angular fragments and thin plates.
Apatite—colorless to yellowish somewhat rounded grains.
Andalusite—ragged pale-pink pleochroic grains.
Brookite—angular slightly brownish-gray grains with an almost metallic luster, commonly striated.
Zircon—very small slender prismatic crystals, which were originally inclusions in biotite; also a few well-rounded pink grains.
Muscovite—a few colorless flakes.
Monazite—a few somewhat rounded yellowish grains.

TIN ORE

The bedrock source of the stream tin in the Tofty area has not been discovered, but good-sized cobbles of tin ore are of common occurrence in the placer concentrates, so that some idea of the occurrence of this material can be obtained. The areal limits of the tin belt are fairly well known, but the distribution of cassiterite within the tin belt has not been determined. Some of the placer miners think that the ore is coarser and of lower grade at the west end of the belt, but this belief has no quantitative basis and cannot be verified. It is nevertheless true that the largest cobble of tin ore seen by the writer was recovered at the west end of the tin belt; and this cobble contained much vein quartz and was therefore of low grade. The larger cobbles, however, are normally of lower grade than the smaller pebbles.

The tin ore occurs as well-rounded to slightly subangular gravel and ranges in size from crystal fragments hardly visible to the naked eye to cobbles at least 6 inches in greatest diameter. The bulk of the ore recovered ranges from one eighth of an inch to 1 inch in diameter and consists largely of fine-grained cassiterite with a little interstitial quartz and tourmaline. It is well worn and ranges from a very dark to a very light gray, with only rarely a brownish tinge.

Most of the tin ore is dense and very fine grained, but in some specimens it is coarser grained and has vuggy cavities lined with euhedral prismatic crystals of brown cassiterite and colorless quartz. In one specimen from Deep Creek, supplied by Fred Hansen, the cassiterite measured about 1 millimeter in average diameter and was a yellowish brown instead of the usual gray or brownish gray. This piece contained several large fragments of white quartz but very little tourmaline. It measured about 2 inches in greatest dimension and was decidedly subangular, showing less rounding than usual.

The most abundant gangue mineral is a milky-white vein quartz. It occurs as irregular masses but more commonly as angular fractured pieces. The fragments show very little evidence of replacement, and some of them clearly show a border of later quartz that is contemporaneous with or even later than some of the cassiterite. Some of the fractures in the white quartz have been filled with tourmaline and quartz, and others with tourmaline, cassiterite, and later quartz, thus showing that the milky-white quartz is earlier than the tourmaline and cassiterite and was highly fractured and brecciated prior to their deposition.

The tin ore contains, in addition to vein quartz, fragments of what are thought to have been a sedimentary rock. Most of these fragments are angular and contain many fractures along which tourmaline and cassiterite have been deposited. Under the microscope some of these fragments are seen to consist of quartz and tourmaline. The quartz occurs in very small more or less equant grains with sutured boundaries and is similar to that seen in some of the Cretaceous quartzites. The tourmaline is a fine-grained brownish variety and occurs in narrow parallel bands which traverse the fragment and suggest that the tourmaline has replaced certain sedimentary layers.

Fine-grained quartzitic sandstones containing such thin, closely spaced sedimentary layers composed of chloritic and carbonaceous matter are found in the thin-bedded Cretaceous rocks on the flanks of Hot Springs Dome and probably occur elsewhere in this area. The tin ore also contains fragments of fine-grained quartz and still others of tourmaline.

The material that acts as the matrix between these fragments and makes up most of the higher-grade ore consists chiefly of granular to subhedral cassiterite grains with some interstitial quartz and prismatic brownish to bluish tourmaline. A few small patches of yellow fluorite were also recognized, but no topaz was seen in any of the thin sections. The grain size of this material varies considerably but usually averages less than 0.1 millimeter. Most of the tourmaline appears to be earlier than the cassiterite, but some of it is contemporaneous. Most of the second-generation quartz, on the other hand, is later than the cassiterite. The fluorite is of later origin than the cassiterite, but its relation to the later quartz could not be determined.

No mammillary "wood tin" like that found on Troublesome Creek is present in any of the samples from this area. However, one very smooth light-gray cassiterite pebble in sample 25, from Deep Creek, was so extremely fine grained and free from impurities as to suggest "wood tin," but the structure was uniform throughout without a trace of banding.

ORIGIN OF THE TIN ORE

In considering the origin and bedrock source of the cassiterite in the Hot Springs district, three questions stand out. Where did the ore-bearing solutions originate? Where and in what manner did they deposit the tin? How did the ore get where it now is? Contemporaneous tourmaline and later fluorite and the coarsely crystalline character of the cassiterite at some localities give clear evidence that the cassiterite from which the placer material came was of deep-seated origin and was deposited from solutions or emanations of direct magmatic origin. Hence an igneous intrusive must be sought as a source for the tin-bearing solutions.

Near the tin placers of the Tofty area there are now exposed two bodies of granitic rocks—namely, the granite at Hot Springs Dome and the monzonite at Roughtop Mountain. No cassiterite has been found in the streams now directly draining either of these bodies, nor has it been found in the dike rocks associated with them. Hence it is not possible directly to connect the cassiterite with either intrusion. However, the facts derived from the study of these two igneous masses throw considerable light on this question.

On the 41 tin deposits listed by Ferguson and Bateman [3] from all over the world, the only one that does not occur in association with

[3] Ferguson, H. G., and Bateman, A. M., The geologic features of tin deposits: Econ. Geology, vol. 7, pp. 209–262, 1912.

granites or their surface equivalents is a deposit in Japan which is reported to be associated with dikes of augite andesite. In the article cited 14 analyses of granites and quartz porphyries from tin-producing regions are given. None of these show less than 70 percent of SiO_2, and all occur in either rang 1 or 2 of the quantitative classification, thus showing they are rich in alkalies. The analysis of the monzonite of Roughtop Mountain shows that it differs considerably from these typical tin granites. The granite at Hot Springs Dome, however, is not only similar in chemical composition to those granites, but it falls in exactly the same position in the quantitative classification as the granite from the Altenberg tin district in Saxony. Hence the chemical composition of these two bodies points to the Hot Springs Dome intrusive as the more likely source of the tin-bearing solutions. It must also be admitted, however, that some of the larger dikes, which invade the monzonite of Roughtop Mountain, approach rather closely the tin-bearing granites in composition.

The occurrence of tourmaline also has a significant bearing upon the origin of the tin ore. Tourmaline is abundant in the tin ore and is a common constituent of the dike rocks of Hot Springs Dome and sparingly present in the main granitic intrusive. The monzonite of Roughtop Mountain, on the other hand, and also the dike rocks associated with it are practically free of tourmaline or other minerals containing boron. Hence the distribution of tourmaline suggests that the granite of Hot Springs Dome, or some similar intrusive body, is likely to be the source of the tin-bearing solutions.

It has also been shown that angular fragments of quartz are very numerous in the ore and that fragments of altered sedimentary rocks are probably present. This strongly suggests that the tin ore was deposited in brecciated quartz veins or pockets in the thin-bedded Cretaceous sandstones and slates after these strata had been intruded by granitic rocks. This idea is further strengthened by the absence of pegmatitic minerals and the lack of evidence of granitic texture in the ore, the presence of which would be expected if the ore had been deposited in bodies of pegmatitic granite. The evidence as to the form of these deposits is very meager, and nothing can be said except that in some places they must have been at least 6 inches thick.

Mertie has suggested (pp. 207–208) that the cassiterite was deposited in a zone coinciding with the present tin-placer belt but that the tin lodes have been completely removed by erosion, and because of the high specific gravity of the cassiterite and the low gradient of the streams the ore has accumulated almost in place. This theory accounts for the reported sharp boundary of all the placers on the northern or uphill side of the belt, for the localizing of the pay streaks opposite the gulches cutting this belt, for their elongation at right angles to it, and for the absence of angular and unworn pieces of ore.

This hypothesis is based in part upon the distribution of cassiterite in the gravel and in part upon the exposures of bedrock, which show that the tin belt is a zone of movement and injection of numerous quartz veins and stringers. It is where this belt crosses the valley of Sullivan Creek that arsenopyrite and other evidences of mineralization and shearing were found. Hence, although this belt at its closest point is 5 miles from the surface exposure of the granite at Hot Springs Dome, it is possible that the tin-bearing solutions may have risen through this zone of shearing and fracture from a northward extension of the granite magma, which has not yet been bared by erosion.

Another hypothesis that also has much in its favor is that the lodes were not localized along the present tin belt but originated nearer to Hot Springs Dome and that the present placers are the result of a reworking of older tin-bearing gravel laid down by an ancient stream that once flowed parallel to the present site of the tin placers but at a higher level. The chief objections to this hypothesis are that cassiterite has so far been found only in the vicinity of the present placers; that these placers are separated by barren stretches which lie between the gulches cutting the tin belt; and that no trace of these older deposits has been found. The last two of these three objections can be met by postulating exactly the same process that, under the first hypothesis, is necessary to account for the rounding of the ore and the complete erosion of lode deposits—namely, considerable erosion and rehandling of the cassiterite by the streams flowing out of the hills north of the present placers. The first of these objections, however, that cassiterite has not been found outside of the tin belt, cannot be so easily explained. All that can be said is that it may occur at other points, as the gravel south of the present tin belt is deeply buried, and cassiterite, unless present in considerable quantity or in large pieces, would probably be overlooked by the average prospector. Moreover, most of the prospecting for tin has been done in the vicinity of the placers and in the areas north of them, especially on the slopes of Roughtop Mountain.

The main points in favor of the second hypothesis are that it accounts for the presence of rounded grains of monazite, aeschynite, and large zircons in all the gravel deposits of the tin belt. These minerals are apparently derived from a pegmatitic facies of a syenitic or granitic mass and may have become originally either from the intrusive at Roughtop Mountain or from the granite of Hot Springs Dome, or possibly from both. This explanation does not require the deposition of tin lodes at a considerable distance from any known magmatic source.

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