GOLD DEPOSITS OF THE SEWARD-SUNRISE REGION, KENAI PENINSULA.

By BERTRAND L. JOHNSON.

INTRODUCTION.

The following paper is a preliminary report on the main features of the distribution and occurrence of gold-bearing lodes and placers in the northern part of Kenai Peninsula and the adjoining Crow Creek district. The discussion of the mineral resources is preceded by a short résumé of the principal factors bearing on their economic development. A more complete report on the mineral resources of this region is in preparation. Many of the data on which this report is based were obtained by the writer during an examination of the lode and placer prospects of the region in the summer of 1911, but free use has been made of field notes and reports of others.

The mineral resources of this district were first examined by the Geological Survey in 1895, when Becker[1] visited the placers near Hope, then recently discovered. Early in 1898 Mendenhall[2] made a hasty examination of the Mills, Canyon, and Sixmile creek placers. Six years later, in 1904, a more detailed examination of the mineral resources of the northern part of the peninsula was made by Moffit,[3] who gave particular attention to the gold placers, then the only source of gold in the district. In the fall of 1906 Paige and Knopf[4] visited the placers of Crow, Canyon, and Sixmile creeks and the East Fork. Grant and Higgins[5] have briefly described the gold lodes which were visited by them in 1908 and 1909, and Brooks[6] has made numerous summary notes on the mining industry of the region. In the work of the last season special attention was

[1] Becker, George F., Reconnaissance of the gold fields of southern Alaska, with some notes on general geology: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 1–86.

[2] Mendenhall, W. C., A reconnaissance from Resurrection Bay to the Tanana River, Alaska, in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 265–340.

[3] Moffit, F. H., The gold placers of Turnagain Arm: Bull. U. S. Geol. Survey No. 259, 1905, pp. 90–99; Gold fields of the Turnagain Arm region, in Mineral resources of Kenai Peninsula, Alaska: Bull. U. S. Geol. Survey No. 277, 1906, pp. 7–52.

[4] Paige, Sidney, and Knopf, Adolph, Reconnaissance in the Matanuska and Talkeetna basins, with notes on the placers of the adjacent region: Bull. U. S. Geol. Survey No. 314, 1907, pp. 104–125.

[5] Grant, U. S., and Higgins, D. F., jr., Notes on the geology and mineral prospects in the vicinity of Seward, Kenai Peninsula, Alaska: Bull. U. S. Geol. Survey No. 379, 1909, pp. 98–107; Preliminary report on the mineral resources of the southern part of Kenai Peninsula, Alaska: Bull. U. S. Geol. Survey No. 277, 1906, pp. 7–52.

[6] Brooks, Alfred H., Bulls. U. S. Geol. Survey Nos. 284, 314, 345, 379, 442, and 480.

given to the deposits of gold quartz, which have become increasingly important during recent years. The writer wishes to acknowledge the many courtesies shown him and the data furnished during the progress of the investigation by persons interested in the development of the mineral resources of the region.

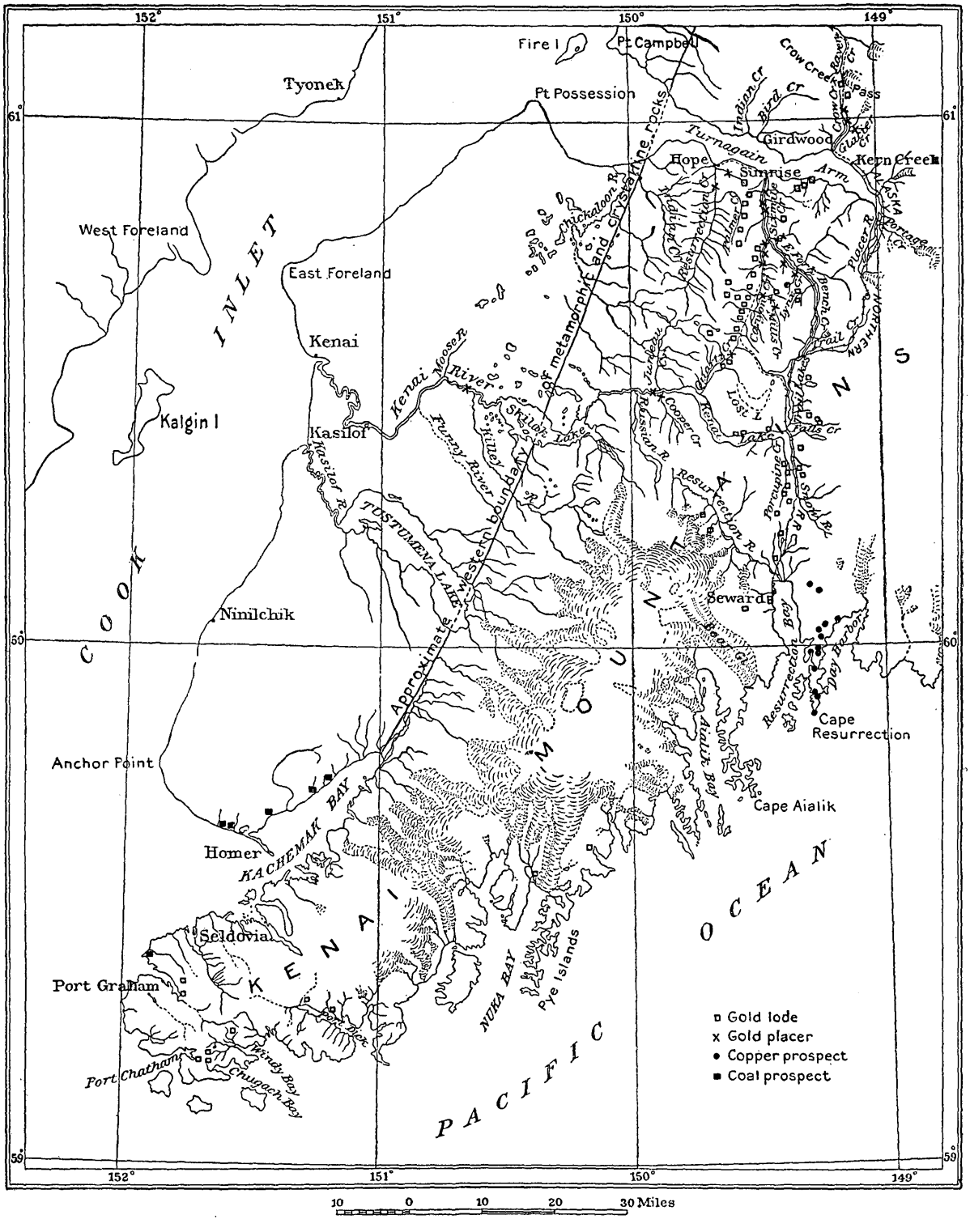
GENERAL FEATURES OF THE REGION.

GEOGRAPHY.

Kenai Peninsula, which has an area of about 9,000 square miles, lies in the northern portion of the great southward-facing bend of that part of the Pacific coast line which incloses the Gulf of Alaska. Most of the peninsula lies between meridians 148° and 152° west longitude and parallels 59° and 61° north latitude. The bounding waters are Prince William Sound, the Pacific Ocean, Cook Inlet, and Turnagain Arm. (See Pl. VII.)

The surface of the peninsula exhibits two widely different physiographic features. Mountains 5,000 to 7,000 feet high and valleys deeply cut by glacial action, remnants of the former ice sheet still remaining in the higher parts of the range, occupy the eastern, central, and southern parts of the region, covering approximately three-fourths of its area. The remaining fourth consists of a broad lowland, 25 miles wide, extending along the entire western side of the peninsula from Kachemak Bay to Turnagain Arm. The gold quartz lodes are restricted to the mountainous area, as are most of the placers, although beach placers occur at Anchor Point, on Cook Inlet, and auriferous gravels are reported to occur on the lower Kenai River.

The watershed between the Cook Inlet drainage and that of the Pacific Ocean and Prince William Sound lies close to the southeastern side of the peninsula, so that most of the drainage of the peninsula enters Cook Inlet or Turnagain Arm. Kenai River, discharging into Cook Inlet at Kenai, is the largest stream on the peninsula and drains its entire central portion, including lakes Skilak and Kenai. Kasilof River, which flows into Cook Inlet a short distance south of Kenai, drains Lake Tustumena, the largest body of fresh water on the peninsula. Lakes Skilak and Tustumena lie on the borderland between the Kenai Mountains and the Kenai lowland. Two smaller streams, Chickaloon and Big Indian rivers, drain a portion of the Kenai lowland and discharge into Chickaloon Bay near the west end of Turnagain Arm. The principal streams tributary to Turnagain Arm within the mountainous area are Placer, Portage, and Twenty-mile rivers and Resurrection, Sixmile, and Glacier creeks. The streams of the Pacific and Prince William Sound slopes are short, none of them, except Resurrection River, being over 15 miles in length. The discharge of most of the streams varies greatly in different seasons of the year because they derive a considerable part



MAP OF KENAI PENINSULA.

of their waters from glaciers and melting snows. In the mountainous area the steep gradients of many of the streams and the numerous waterfalls offer possible sources of power for use in mining.

CLIMATE.

The following table affords a means of comparing the climatic conditions on the north and south sides of the peninsula. The data were obtained from the annual reports of Alaska agricultural experiment stations for 1908, 1909, and 1910. The observations at Seward were made by W. A. McNeiley; those at Sunrise by A. Lawson. The climatic conditions at these two places are obviously somewhat different, the Turnagain Arm section having much colder winters and considerably less rainfall, although the number of days with precipitation is slightly greater. Both the recording stations are only a few feet above sea level. In the interior of the peninsula, where the elevation is considerable, the winters are much more severe.

TABLE I.—*Summary of meteorologic records at Seward and Sunrise, Alaska.*

Month.	Temperature (°F.).						Precipitation in inches.		Weather conditions.			
	Maximum.		Minimum.		Daily mean.				Clear days.		Days with precipitation.	
	Seward.	Sunrise.	Seward.	Sunrise.	Seward.	Sunrise.	Seward.	Sunrise.	Seward.	Sunrise.	Seward.	Sunrise.
1908.												
February	42	42	9	− 8	30.56	23.96	10.43	4.68	8	11	16	12
March	45	40	15	− 2	32.14	24.01	2.35	2.00	14	12	9	12
April	53	51	23	16	38.01	32.29	4.00	3.37	12	6	16	14
May	65	66	32	27	44.51	42.87	1.63	2.63	14	9	12	12
June	80	79	36	30	50.98	50.29	.45	.21	15	15	5	5
July	73	70	41	36	51.80	52.49	3.25	2.28	12	7	13	12
August	71	70	41	35	52.77	50.86	6.34	2.91	10	5	16	21
September	65	60	27	17	45.81	40.71	4.29	5.00	13	10	9	16
October	51	53	11	2	34.96	29.24	9.73	2.59	17	16	11	14
November	49	48	11	− 7	33.40	27.89	[b]20.99	4.49	9	4	19	20
December	41	42	− 1	−13	29.20	23.50	12.38	3.37	9	9	18	16
1909.												
January	43	29	− 5	−25	13.88	−1.01	.52	.54	24	22	4	6
February	44	39	2	−17	22.20	10.60	.47	1.05	18	14	2	9
March	49	49	10	− 9	31.20	24.90	3.72	2.71	14	8	12	16
April	54	51	18	11	36.50	33.10	3.03	.68	16	13	8	8
May	73	68	32	26	43.30	43.56	4.47	2.27	12	13	15	13
June	84	78	35	28	48.80	48.10	4.39	1.96	15	10	12	13
July	77	73	43	39	55.10	54.50	.72	1.79	12	11	6	13
August	75	70	40	35	55.00	52.54	3.71	3.06	15	8	14	17
September	[a]60	61	[a]45	17	[a]50.10	42.50	[a]1.41	2.64	(a)	9	[a]6	18
October	50	45	22	10	37.20	29.90	8.92	2.56	17	12	12	15
November	48	42	9	−14	27.7	13.6	.37	.40	25	21	2	5
December	40	43	4	−12	25.9	15.8	12.80	3.36	12	10	15	18
1910.												
January	37	36	− 8	−21	18.8	7.9	3.32	3.22	17	5	9	18
February	39	38	−12	−27	24.4	15.2	4.52	4.39	13	8	8	11
March	49	50	.....	−16	29.2	22.5	2.50	1.66	16	8	8	16
April	53	50	10	1	34.2	28.4	.55	1.55	20	6	4	11
May	75	73	26	24	43.6	41.7	1.43	.86	17	9	7	10
June	63	63	33	27	46.0	[c]26.4	2.59	1.44	15	7	11	15
July	80	73	40	37	55.1	52.7	2.15	1.79	18	9	8	14
August	76	68	39	35	55.1	51.1	2.45	1.74	18	10	8	12
September	84	72	35	26	51.4	45.2	7.12	2.80	14	11	14	15
October	55	53	19	8	39.2	33.4	5.72	4.34	10	3	15	20
November	45	40	12	− 8	30.1	19.9	1.55	2.29	14	13	1	11
December	.....	36	.....	−26	.....	9.2	.....	4.06	.....	15	.....	15

[a] Record for 6 days only. [b] Accuracy of this figure questioned. [c] Probably intended for 46.2.

Records were also kept at Kenai for several years, the extreme temperatures for 4 complete years and additional periods aggregating 12 months being given in the following table. The annual precipitation at this place ranges from 13.50 to 18.53 inches, being considerably less than at either Seward or Sunrise.

TABLE II.—*Summary of temperatures (°F.) at Kenai, Alaska.*

[Lengths of record, 4 complete years, 12 months.]

Month.	Maximum.	Minimum.	Months.	Maximum.	Minimum.
January	45	−40	July	82	30
February	45	−32	August	73	28
March	52	−30	September	65	16
April	58	4	October	60	−10
May	63	20	November	44	−26
June	79	26	December	45	−43

TIMBER AND VEGETATION.

Kenai Peninsula, which is heavily timbered from sea level to elevations of 1,200 to 2,000 feet, is in large part included in the Chugach National Forest. The conifers are far more abundant than the broadleaf deciduous trees, spruce predominating, although considerable hemlock grows in the Turnagain Arm region. Cottonwood, willow, poplar, birch, and alder are the principal deciduous trees. Commercial timber is reported only on Turnagain Arm and in the vicinity of Seward, but lumber adequate for many uses can be obtained at reasonable cost near most of the camps. Spruce is the best timber available for use in mining. Spruce timber from this region was tested for use in bridges on the Alaska Central Railway, and although the results obtained were not quite so good as those afforded by Washington fir, the spruce was made satisfactory by using slightly larger timbers than would have been used with fir, in order to offset the difference in the strength of the two kinds of lumber. Some scattered spruce trees near the lower end of Kenai Lake will trim to 12 inches square, but only a few will afford 18-inch pieces. Larger trees and better stands grow in the Seward and Turnagain Arm regions. The hemlock found in the Turnagain Arm region is reported to be unfit to withstand much strain. Sawmills have been erected at Seward, Hope, and Girdwood. In Seward the price of the native spruce dimension lumber in 1911 was about $25 per 1,000 feet. The better grades of lumber are brought from Seattle.

Native grasses are abundant, especially around timber line and in the upper timberless parts of the valleys, furnishing good feed for horses during the summer. Considerable hay is now being made in the peninsula, especially in the vicinity of Hope and Sunrise. Native hay in stacks in the Sunrise country brings from $10 to $12 a ton,

occasionally late in the winter going as high as $20 a ton. Near Seward, Sunrise, and Hope, where conditions are the most favorable for gardening, vegetables are raised in considerable quantities for local consumption. Cranberries, currants, blueberries, huckleberries, and a few salmonberries grow wild. An experiment station was established by the United States Department of Agriculture at Kenai in 1899 and maintained until 1908, when, on account of the isolation of the location, the work was transferred to Kodiak.

GAME.

Kenai Peninsula is well and favorably known as a big-game country. Both brown and black bear are native to the peninsula, the black bear being by far the most abundant. Fur-bearing animals other than bear include lynx, ermine, some mink, and a very few marten. Land and sea otters are found around Turnagain Arm. Foxes are scarce, wolverines are only occasionally seen, beavers are very rare, and wolves are practically extinct. Ground squirrels are fairly numerous and rabbits are beginning to reappear. Porcupines are abundant and form an easily obtainable food for the numerous dogs.

Moose are abundant in the central and western parts of the peninsula. Mountain sheep are numerous, but mountain goats are rare. Caribou are very scarce. Grouse, ptarmigan, and shore birds, as well as waterfowl, such as ducks, geese, brant, swan, snipe, and curlew, are found in most parts of the peninsula. Trout are found in many of the mountain streams, and lake trout, whitefish, and a few grayling are reported in the large lakes. In summer salmon in great numbers run up most of the streams that flow into Resurrection Bay and Cook Inlet.

POPULATION AND SETTLEMENTS.

The census of 1910 gives the population of the Kenai Peninsula as 1,692. The principal towns were Seward, 534 inhabitants; Kenai, 250 inhabitants; and Seldovia, 173 inhabitants. The population of this region, as of other parts of Alaska, fluctuates greatly during the year, being at its maximum during the summer. As the census of 1910 was taken in winter, the above figures represent probably the least number of people on the peninsula at any time during the year.

Seward is the principal distributing point for this region. Situated at the head of Resurrection Bay, it has an excellent harbor, is the terminus of the steamship lines to the States and to the Alaska Peninsula, and the coastal terminus of the Alaska Northern Railway. Seldovia is of considerable importance at present in any economic discussion of this district, as it is the transfer point of supplies from the large steamers to the numerous smaller boats (60 to 70 tons)

running on the inlet for transportation to points on Cook Inlet, Turnagain Arm, and Susitna River. Sunrise and Hope, at the mouths of Sixmile and Resurrection creeks, respectively, and Girdwood, at the mouth of Glacier Creek, are small settlements, important as distributing points for the placer and lode diggings in their vicinity. The population of these places is small, Sunrise having but 12 inhabitants in September, 1911, and Hope only 35 or 40 in the winter of 1910–11. Kern Creek, the present terminus of the Alaska Northern Railway, is a transfer point of supplies from Seward to Turnagain Arm points and Knik.

TRANSPORTATION.

WATER TRANSPORTATION.

Steamships of the Alaska Coast Co. and the Alaska Steamship Co. run regularly between Seattle and Seward throughout the year, for navigation in Resurrection Bay is never interrupted by ice. Water transportation on Cook Inlet, however, is possible only during a part of the year, for ice prevents navigation on the upper part of the inlet for about five months. During the summer of 1912 the western terminus of the Alaska Coast Co. will be at Kodiak and the steamers of this company will make several trips to Knik Anchorage, serving upper Cook Inlet points directly or by barge from Knik Anchorage instead of making the transfer of passengers and freight, as formerly, at Seldovia and Port Graham to the smaller boats plying on the inlet. The larger boats can not enter Turnagain Arm, however, and small gasoline boats, of 80 to 100 tons, which can reach the various settlements at high tide, will still have to be used between Kern Creek, Girdwood, Sunrise, and Hope and the ocean-steamer terminus in Knik Anchorage.

The Alaska Northern Railway offers a possible freight route from Seward to Turnagain Arm, but because of the high freight rates charged by the railroad most of the freight from Seattle to points on Turnagain Arm has come by water, by way of Seldovia and Cook Inlet, a rate of $8 a ton being the usual charge between Seldovia and Sunrise, Hope, or Girdwood. Water transportation on the peninsula is restricted at present to Kenai Lake, where several small gasoline launches were in operation last summer. This lake is reported to freeze over about January 1 and to open up late in May.

LAND TRANSPORTATION.

The Alaska Northern Railway Co. has built 71 miles of standard-gage track from Seward to Kern Creek, near the head of Turnagain Arm. This line was in operation in 1911, gasoline passenger cars being run almost every day during the summer. The passenger

rates in 1911 were 20 cents a mile, or 15 cents a mile on round-trip tickets. Freight trains were run only occasionally. The service was maintained on this line only during the summer and fall.

Wagon roads have been built from Sunrise to Mile 34 on the Alaska Northern Railway, from Hope for several miles up Resurrection Creek, and from Girdwood to the Nutter-Dawson placer camp on Crow Creek. Roads have also been built from the mouths of Bear and Lynx Creeks to prospects near the heads. The Alaska Road Commission has cut good trails from Hope to Sunrise and from Mile 29 on the Alaska Northern Railway through Moose Pass to Slate Creek. During the summer of 1911 the commission finished the portion of the Seward-Iditarod trail between Kern Creek and Knik, by way of Crow Creek Pass and Eagle River. A trail has also been laid out down Canyon Creek from Moose Pass to the Sunrise road.

Most people living away from the towns in the winter use their own dog teams for transportation of supplies. In the summer pack trains are run at irregular intervals from Mile 34 on the Alaska Northern Railway to Hope and Sunrise and from Mile 29 through Moose Pass to Mills Creek. The following rates, averaging approximately $0.0025 per pound per mile, were charged in 1911:

Freighting charges in Seward-Sunrise region.

	Cents per pound.
Sunrise to Hope	2½
Sunrise to Gulch Creek	2
Sunrise to Lynx Creek	4 and 5
Sunrise to Mile 34, Alaska Northern Railway	7
Gulch Creek to Mile 34, Alaska Northern Railway	5 and 6
Mile 29, Alaska Northern Railway, to Mills Creek	5

MAIL SERVICE.

Mail from the outside arrives in Seward about six times a month throughout the year. From December 1 to March 31 mail for Sunrise and Hope is carried overland twice a month, usually through Johnson Pass, but in exceptionally bad weather by way of Moose Pass. From April 15 to October 31 mail for settlements on Cook Inlet and Turnagain Arm goes to Seldovia, whence it is forwarded by small gasoline boats. During the early spring the mail deliveries at points on Turnagain Arm are infrequent on account of the poor transportation facilities.

POWER RESOURCES.

The possible sources of power for use in mining in this region are the abundant timber below 2,000 feet elevation, the steep gradient and numerous falls of many of the streams, the lignite of the Cook Inlet region, and the higher-grade coals of the Matanuska Valley.

Few power plants were in operation in 1911 in the Seward-Sunrise region. The Kenai Alaska Gold Co.'s stamp mill on Falls Creek was operated by a small steam engine with a wood-burning boiler. The California-Alaska Mining Co.'s stamp mill was run by water power furnished by a Pelton water wheel. The town of Seward was furnished with electric light and power throughout the year by a 225-kilowatt Allis-Chalmers (Bullock) alternating-current generator, driven by a Pelton water wheel operating under an effective head of 360 feet. The coal resources of this region are at present unavailable. British Columbia coal (Nanaimo coal), which alone is used, costs at Seward about $10 to $12 a ton wholesale and about $17 a ton retail.

GENERAL GEOLOGY.

SEDIMENTARY ROCKS.

The sedimentary rocks of the Seward-Sunrise region consist principally of interbedded dark-colored graywackes and black or bluish-black slates and argillites, with a few interstratified beds of conglomerate and quartzite and still fewer beds of dark-gray limestone. The thickness of the slate and graywacke beds varies from a few inches to many feet. The relative proportions of the slates, argillites, graywackes, and conglomerates differ considerably from place to place, conglomerates being the least abundant. The slates and argillites need no particular description. The graywackes are massive sedimentary rocks, composed chiefly of angular fragments of quartz and feldspar, usually orthoclase and acidic plagioclase. Flat angular fragments of slaty rock appear in many of the beds. Because of their uniform width and longitudinal extent these graywacke beds are often called "dikes" by prospectors. In local usage they are also often referred to as diorites, but the sedimentary origin is in most places readily discernible. The conglomerates contain well-rounded pebbles of argillaceous rocks, granite, quartzites, and quartz.

The general strike of the rocks on the peninsula is from north to N. 20° E., but north of Turnagain Arm more easterly strikes prevail. The dips are generally not far from vertical. In places the rocks show close folds, most of which have vertical axes, though in one place folds overturned toward the west were seen. The finer-grained sedimentary beds exhibit varying degrees of metamorphism, resulting in the development of slaty cleavage or schistose structure, in many places parallel to the stratification. Faults are numerous, but the uniform lithologic character of the rocks makes it difficult to determine the extent of the displacement.

This slate-graywacke series, called the Sunrise series by Mendenhall, forms the mass of the Kenai Mountains in central and northern Kenai

Peninsula and between Knik and Turnagain arms, and also extends along the coast from Prince William Sound to the west side of Nuka Island Passage. Considerable doubt exists as to its age. The evidence available indicates that it includes at least two formations, which are unconformable but similar in lithologic character, the younger containing fossils of Jurassic or Cretaceous age.

The unconsolidated sediments of the district are of interest because they are in places auriferous. These deposits may be classed as glacial and water-laid. Purely glacial deposits, such as moraines, are comparatively rare. Terminal moraines have been found only on Crow and Canyon creeks, but ground-morainal deposits have been seen on several creeks. Valley trains are still being formed on Placer and Snow rivers and on other streams, and remnants of earlier valley trains can be seen in the high-bench deposits along many of the streams. In numerous valleys where no glacier exists the streams have cut down through these fluvioglacial gravels and have deposited 2 to 10 feet of sands, gravels, and clays, usually poorly stratified, on top of bedrock or earlier gravels.

IGNEOUS ROCKS.

DEEP-SEATED INTRUSIVE ROCKS.

Several isolated masses of granitoid rocks, most of them coarse-grained biotite granites, are intrusive into the sedimentary rocks of the Kenai Mountains, especially in the eastern and southern parts. A large granite area, which extends from Hive and Rugged islands, in Resurrection Bay, to and beyond Aialik Bay, makes up all the adjacent islands and much of the headland on both sides of the southern half of the bay.[1] Another large granite mass forms Pye Islands and the adjacent mainland, and prospectors report a granite area in the vicinity of Russian River and Lake Skilak. At the head of Crow Creek several small, closely grouped bosses of fine-grained light-colored quartz diorite have intruded sediments of Jurassic or possibly Cretaceous age. Grant,[2] in his discussion of the igneous rocks of the Prince William Sound region, describes in detail the granites of the eastern portion of the peninsula—on Port Nellie Juan, Passage Canal, Ewan, and Eshamy bays—and concludes that "the lack of intense anamorphic changes and the occurrence of porphyritic peripheral phases of the granites, as well as the absence of the complicated aplite and pegmatite dike systems characteristic of deep-seated intrusions, indicate that these granites solidified considerably nearer the surface than is common with granitic intrusions." The

[1] Grant, U. S., and Higgins, D. F., Preliminary report on the mineral resources of the southern part of the Kenai Peninsula: Bull. U. S. Geol. Survey No. 442, 1910, p. 167.

[2] Grant, U. S., and Higgins, D. F., Reconnaissance of the mineral resources of Prince William Sound, Alaska: Bull. U. S. Geol. Survey No. 443, 1910, pp. 33–48.

only evidence available as to the age of the intrusions is that furnished by the Crow Creek locality, which places them in the middle or later part of the Mesozoic.

DIKE ROCKS.

On Crow Creek numerous light-colored acidic dike rocks of fine-grained to aphanitic texture occur as offshoots from the quartz diorite bosses, to which they are similar in composition. Similar acidic dike rocks, dioritic in composition, many of them of porphyritic texture, occur in different parts of the peninsula, as on Palmer, Bear, Porcupine, and Groundhog creeks and in the Moose Pass district. Along the shores of Turnagain Arm these dikes are easily distinguished by their light color from the dark-gray colored graywackes and black slates into which they are intruded. The dikes of Moose Pass and Palmer Creek are rather remarkable for their length and comparatively slight width. The largest, the so-called Moose Pass ledge, is a dike of much-altered, very fine-grained diorite porphyry, over 12 miles long and averaging only 8 feet wide. Knopf,[1] in describing somewhat similar dikes in southeastern Alaska, has pointed out their occurrence in a graywacke-slate formation far from known areas of diorite intrusions and their uniformity of appearance in widely separated localities. This is also true of the region under consideration, where, except in the Crow Creek section, the acidic dikes are found many miles from the nearest diorite masses and throughout the area show little variation either in their mineralogy or their texture.

ECONOMIC GEOLOGY.

GENERAL FEATURES.

Only the gold deposits are described in this report. The region contains deposits of copper, antimony, and argentiferous galena, but these are small and are of little present commercial importance, and have already been briefly described in earlier reports.

The gold produced in the district comes from both lode and placer deposits. The placers have attracted the most attention and they still lead in production, but the increasing activity of the quartz prospector and the increasing list of producing properties is steadily emphasizing the importance of the gold-quartz deposits.

Gold was first discovered in Alaska in 1848, in the gravels of streams tributary to Kenai River, by P. P. Doroschin, who was then making an examination of the mineral resources of the district for

[1] Knopf, Adolph, The Sitka mining district, Alaska: Bull. U. S. Geol. Survey No. 504, 1912, p. 17.

the Russian-American Co. The low gold content of the auriferous gravels found in that year and in 1850 discouraged prospecting and little is known of any that may have been done between 1850 and 1894, though gold is reported to have been discovered on Cooper Creek about 1884, on Resurrection Creek in 1888, and at Anchor Point in 1889. Placer discoveries were made on Bear and Palmer creeks in 1894 and on Canyon, Mills, and Lynx creeks in 1895. These discoveries were followed, in 1896, by a stampede of several thousand men to this field. Crow Creek was staked at this time but did not yield any gold until two years later. In 1898 a second rush, partly an overflow from the Klondike stampede, was made to the Turnagain Arm section. Since 1898 placer mining has been in progress on many of the creeks of the district, chiefly on Quartz and Cooper creeks and in the region adjacent to Turnagain Arm.

Practically all the richer and more accessible creek gravels that are workable at a profit by pick-and-shovel methods have been worked out and the exploitation of the bench gravels by hydraulic methods has begun. Attempts to work the gravels of Resurrection Creek by hydraulic elevator and later by dredge were not satisfactory. During all or part of the season of 1911 hydraulic work was in progress on Resurrection, Crow, Cooper, Mills, Canyon, Quartz, Gulch, Six-mile, and Silvertip creeks. The hydraulic plants on Resurrection, Silvertip, and Cooper creeks were working the creek gravels, a Ruble elevator being used on Cooper Creek. The other plants in the district were at work on bench deposits. A little pick-and-shovel work is also reported from the upper part of Mills Creek. On upper Kenai River a small dredge was installed and the installation of a larger dredge was begun; and on Kenai River near the mouth of Killey River ground was systematically drilled to determine its adaptability to dredging. Ground on Trail Creek between Kenai Lake and Lower Trail Lake was also prospected by drilling.

Gold-bearing lodes were discovered in the Turnagain Arm region soon after the placers were first worked. Gold-quartz float was found on Summit Creek, in the Moose Pass district, by John C. Gilpatrick in 1896, but the ledge was not found until 1906. Locations were made on Palmer, Bear, and Sawmill creeks in 1898, and some development work was done on these properties in that and the following year. In 1903 and 1904, after the settlement of Seward, gold-quartz veins were discovered in the hills close to the town, but were not much developed for several years. On Falls Creek gold-bearing quartz was first discovered in 1905 by F. P. Skeen and John Lechner on property now owned by the California-Alaska Mining Co. The property was bonded to C. D. Lane in October of that year, and about 110 feet of development work was done. From 1905 to 1909

no development work was in progress on the peninsula, although many prospects were located. In June, 1906, J. W. and C. E. Stephenson located the Black Butte ledge on Falls Creek, and in August of that year John C. Gilpatrick made the first locations in the Moose Pass district. The veins now being developed on the properties of the Seward Bonanza Gold Mines Co. and the Skeen-Lechner Mining Co. were located in 1907. Considerable development work was done on the Gilpatrick property in the Moose Pass district in 1909, and many new locations were made in that vicinity. New lodes were also discovered on Crow Creek and Resurrection River. Arrastres were installed on the property of the California-Alaska Mining Co. on Falls Creek and were operated for a short time during that year and the next. In 1910 development work was carried on at a few properties, notably on Crow and Falls creeks and in the Moose Pass district. During the season of 1911 the California-Alaska Mining Co. replaced the arrastres on its property by a two-stamp mill, and the Kenai-Alaska Gold Co. erected a five-stamp mill on the north side of the valley of Falls Creek. Both mills were in operation during a part of the summer. Development work was actively carried on at several properties and assessment work done on many others. A large number of prospectors visited the region in 1911, and numerous gold-bearing veins were discovered.

The auriferous area considered in this report lies within the third judicial division of the District of Alaska and includes portions of Kenai, Knik, and Valdez districts. The boundaries of these three recording districts were recently slightly changed by an order of E. E. Cushman, district judge of the third division, dated April 24, 1911, and taking effect May 1, 1911. The Crow Creek deposits are in the Knik mining district, the recording office of which is at Knik. The recorder's office of the Kenai mining district is at Seward. The revised boundary of the Kenai mining district is described as follows:

Beginning at Cape Douglas on the north shore of Shelikof Strait, running thence northeast up the center of the waters of Cook Inlet to a point opposite the center line of Turnagain Arm; thence east along the center of the waters of Turnagain Arm to the easterly extremity of said arm; thence in an easterly direction to the summit of the watershed, between the waters flowing into Turnagain Arm on the west and the waters flowing into Prince William Sound on the east; thence in a southerly direction following the summit of the watershed between the waters flowing into Prince William Sound on the east and the waters flowing into Kenai Lake on the west to the southernmost extremity of Cape Junken on the Gulf of Alaska; thence southwesterly to a point south of Cape Elizabeth, the southernmost point of the Kenai Peninsula and midway between said cape and the Barren Islands and including all islands contiguous and adjacent to the mainland of the said Kenai Peninsula; thence west to Cape Douglas and point of beginning.

GOLD LODE DEPOSITS.

DISTRIBUTION.

The gold lodes of the northern portion of Kenai Peninsula may be grouped tentatively as (1) fissure veins, (2) stringer lodes, and (3) mineralized acidic dikes. The largest number of the deposits, including those now of the greatest commercial importance, are fissure veins. Two of these rank as gold producers and others will probably soon become producers. The stringer lodes are few and have been but little developed. The mineralized dikes of the Moose Pass district attracted considerable attention in 1909–10, when extensive development work was done on one of them. The areal distribution of the fissure veins, stringer lodes, and mineralized dikes is outlined in the descriptions of these types. A linear arrangement of the lode gold prospects in parts of the area considered is indicated on the map (Pl. VII, opposite p. 132). In the Moose Pass and Palmer Creek districts this arrangement is due to the location of most of the prospects along the strike of mineralized acidic dikes. It appears probable, however, that the area between Seward and the Trail Lakes, near the main line of travel (the Alaska Northern Railway), has been more carefully prospected than other parts of the region, so that the numerous prospects show on the map a linear arrangement. However, no reason is known for the localization of the gold lodes in any one part of the mountainous region between Seward and Turnagain Arm.

FISSURE VEINS.

CHARACTER AND DISTRIBUTION.

The term fissure vein is usually applied to ore deposits, tabular in form as a whole, though commonly irregular in detail, occupying a fracture or set of fractures in the country rock. Most of them are characterized by regular and straight walls, by a fairly constant width, and by a definite direction of both strike and dip. As a rule they show no conformity to lines of structure. In form and occurrence these veins show great variety, those in the more massive and rigid rocks being generally the better developed.

Deposits referable to this general type have been found in many parts of Kenai Peninsula. The outcrops of most of the larger veins are traceable for but a few hundred feet and many of the fractures are short and gashlike. Some of the veins follow closely the structure of the country rock, but those that are now most important commercially occupy transverse fractures. Two distinct sets of fissures, approximately at right angles to each other, are conspicuous in the region examined. The strike of one set trends in general from north to a little west of north; that of most of the other set lies between

east and northeast, only a very few trending a little south of east. Both sets of fissures are, in general, ore bearing, and are probably of about the same age, although the latest movement appears to have been along the east-west set of fractures. The veins dip at angles ranging from 45° to 90°, and some individual veins show considerable variation in dip.

The ores are simple in composition. The gangue is quartz with here and there a little calcite, and the ores contain sulphides in various amounts. The principal sulphide is arsenopyrite, but galena, pyrite, and sphalerite occur in subordinate quantities. Pyrrhotite, molybdenite, and chalcopyrite are also present in some of the ores, and gold tellurides have been reported. The ores are free milling. The gold occurs free in the quartz and also in close association with the sulphides, some of it being included in the galena and arsenopyrite grains. The wall rocks show metasomatic alteration, and disseminated crystals of arsenopyrite and pyrite have been noted in the altered rocks. In the Moose Pass district the shattered diorite porphyry dikes have been sericitized by the action of ore-bearing solutions that traversed them and the associated fissures.

Brief descriptions of a few of the characteristic fissure veins of the Seward-Sunrise region will be given. There are many other prospects on deposits of this type, but they show no important differences from those here to be described, and individual descriptions of all these would result only in a duplication of examples of the type of deposit under consideration, which would be unnecessary in a preliminary report. The properties in the southern part of the area are described first and the other properties are considered in order northward. The prospects near Seward having already been briefly described by Grant[1] need only be mentioned here. Bodies of gold-bearing quartz are reported by prospectors to occur on Resurrection River, but have not been visited. Fissure veins occur also in association with the mineralized dikes in the Moose Pass region. (See p. 156.)

SEWARD BONANZA GOLD MINES CO.

The Seward Bonanza Gold Mines Co.'s property is situated on the west face of the mountain between Victor and Ptarmigan creeks. The vein was discovered in 1907 by C. E. and J. W. Stephenson, but underground development work was not begun on it until July, 1911, after the property had been taken over by the present owners. The lower tunnel was started 1,250 feet above Kenai Lake on a well-defined fissure vein striking N. 75° W. and dipping 80° S. in black slate, the cleavage of which strikes N. 17° W. On September 29 this tunnel had been driven 110 feet along the vein, whose thickness

[1] Grant, U. S., and Higgins, D. F., Notes on the geology and mineral prospects in the vicinity of Seward, Kenai Peninsula: Bull. U. S. Geol. Survey No. 379, 1909, p. 107.

ranged from 1½ to 5 feet, and averaged about 2½ feet. The vein outcrops along the bottom of a small gulch and has been uncovered for about 300 feet above the mouth of the tunnel, and at one point near its upper end it narrows to a thickness of only a few inches. It is reported to have been traced eastward up the slope for the length of five claims. At an elevation of approximately 5,000 feet above sea level a crosscut tunnel has been driven 40 feet in a northerly direction, cutting the reported continuation of this vein at its east end. The rocks near the upper workings are mostly slate with small amounts of graywacke and dark-gray limestone. The cleavage strikes N. 7° E. and dips steeply to the east at angles ranging from 55° to 80°. The strike of the bedding is indeterminate, but appears to be about north.

In an open cut above the crosscut tunnel parallel jointing occurs in the slates, the joints striking N. 59° W., dipping 55° N., and carrying narrow quartz veins. The main vein at this point is 10 inches wide and parallels the joints. A few quartz lenses also occur in the slate. Numerous parallel, approximately east-west joints, with steep dips, are characteristic of this deposit. These joints are exceedingly well developed at the open rounded head of Stevenson Gulch, but also show near the lower tunnel and at several places along the trail joining the two workings. The ore body apparently occupies one of the larger and more persistent of these fractures, along which there was considerable movement after the quartz was deposited, as is shown by the secondary banding of the vein parallel to the walls, best seen at the lower tunnel. The joint planes in the vein are in places closely spaced, but the bands range in width from 1 to 18 inches. The joints appear to be closer and more abundant along the hanging wall. The quartz is coarsely crystalline in some of the bands, but no open cavities were seen. Sulphides have been deposited along these joint planes, and the vein is more highly mineralized where the joint planes lie close together. The quartz breaks free from the walls but shows little or no gouge. The hanging wall is better defined and freer than the foot wall.

Between 75 and 90 feet from the tunnel mouth the vein grades outward on the foot-wall side into a mass of shattered slate cemented by intersecting, generally thin, quartz stringers. These stringers are irregular in length, width, and distribution, although a few thin ones follow joint cracks in the slate. The later development work reached a point where the foot wall is well defined, the vein being 16 inches wide and carrying gouge on both walls. Some quartz stringers extend out from the vein into the country rock on the foot-wall side. Numerous quartz stringers occur in the adjoining country rock, in places showing parallelism with the vein.

The owners figure on $20 to $30 a ton on the ore from this vein, although individual assays run as high as $85, and assays of ore from the vein near the upper tunnel give higher figures. The ore is free milling and contains abundant sulphides. Arsenopyrite, the dominant sulphide, occurs as crystals in the quartz along the joint planes in the veins and as disseminated crystals in the slate. Pyrite occurs principally in small stringers in the slate, with or without quartz gangue. Galena, sphalerite, and a small amount of chalcopyrite also occur. The gangue is quartz with some calcite. Gold occurs free in the quartz. It is reported fine at the lower but coarser in the upper workings, 10-cent nuggets having been found in Stevenson Gulch.

CALIFORNIA-ALASKA MINING CO.

The property owned by the California-Alaska Mining Co. on Kenai Peninsula is at the head of the canyon on Falls Creek, about 4 miles from its junction with Trail Creek. The mine workings are on the north bank of Falls Creek, the tunnel mouth being only a few feet above the creek level. Gold-bearing quartz was first discovered in the Falls Creek region on this property by F. P. Skeen and John Lechner in 1905. The property was bonded to C. D. Lane in October, 1905; but after about 90 feet of tunnel had been driven on the Betty claim and a winze, started 60 feet in from the mouth of the tunnel, had been put down to a depth of 20 feet, the bond was allowed to lapse, the property reverting to the original locators. No further development work was done until after the property had been deeded to the present owners, the California-Alaska Mining Co., in January, 1908. The winze has since been deepened to 40 feet, and from its bottom 140 feet of drifts have been run on the vein. Flooding of the lower level caused a cessation of further development work. About 30 men, principally Greeks, were employed on the property in June, 1911, but this number was much decreased later in the season. A ditch of 500 feet was put in, 600 feet of pipe line was laid, and a two-stamp mill and concentrator were installed during 1911.

But little of the country rock is exposed in the vicinity of the tunnel, the lower slopes of the valley being heavily covered except where bedrock has been exposed along Falls Creek by the erosive action of the stream. The rocks here consist of closely folded slates and graywackes striking a little east of north and dipping 75° to 90° E. A 12-foot bed of graywacke, striking N. 7° E. and dipping 75° E., occurs at the tunnel and also opposite, a little upstream. This bed carries small quantities of iron sulphides, and weathers rusty. No igneous rocks are known to occur in the vicinity of the ore body.

The vein occupies a nearly vertical fissure that strikes N. 51° E. Near the face of the tunnel the strike swings farther east and the dip changes to 75° SE. The vein varies in width from 8 inches to 4 feet. Twenty-five feet from the tunnel mouth the fissure filling is 43 inches wide, mostly gouge, but carrying quartz stringers. Six feet beyond is an 18-inch vein of quartz, which gradually widens to 46 inches, then narrows to 1 foot about 8 feet from the winze, and then widens until, directly over the winze, it is 31 inches wide, filling the entire fissure. Narrow gash quartz veins occur in the graywacke walls, which are in many places impregnated with arsenopyrite. Beyond the winze the vein fissure splits up into three small fissures, 3 to 12 inches wide, and the graywacke has been shattered and recemented with numerous small quartz veins and impregnated with considerable arsenopyrite. The lower level could not be examined, because the workings were flooded. The vein on this level, however, is reported to be well defined and to have a width of 3 to 4 feet.

The vein material is quartz, massive and clear white in most parts of the main vein. A small amount of calcite also occurs as gangue. A bluish quartz lies in narrow stringers in the mineralized fractured graywacke and is reported to occur in the main vein. No drusy cavities were noticed in either kind of quartz. Free gold occurs in the blue quartz in close association with the fine sulphides and less abundantly in intimate association with scattered sulphide groups in the white quartz. Arsenopyrite is the principal sulphide, galena being subordinate. Numerous striated crystals of arsenopyrite are embedded in the wall rocks next to the veins and narrow stringers. Gold tellurides have also been reported from this ore, but their presence in appreciable amounts has not been proved. The ore is free milling and is reported to average $30 to $40 to the ton in gold.

Two arrastres were installed in 1909 and were run for a short time in that and the following year. Early in 1911 they were dismantled and a two-stamp mill was installed. This was the first stamp mill to begin actual operations on the Kenai Peninsula, the stamps dropping for the first time early in June, 1911. The mill was run intermittently during the season and about 90 tons of ore are reported to have been treated. The present ore-dressing equipment consists of a Ford crusher, a stamp-driven automatic feeder, standard type, supplying ore to a two-stamp mill, and a Deister No. 2 concentrator. The power for the plant is furnished by a Pelton water wheel, connected by belt to the stamp mill and crusher and operating under an 80-foot head of water from Falls Creek.

KENAI-ALASKA GOLD CO.

The property of the Kenai-Alaska Gold Co. is on the north side of Falls Creek. The mill buildings are close to timber line,

approximately 1,700 feet above sea level, on a small stream tributary to Falls Creek. The mine workings, 2,825 feet above the mill, are in the west wall of a small glacial cirque 275 feet above a small glacier. The vein now being developed is on the Black Butte No. 2 claim, located by J. W. and C. E. Stevenson in June, 1906.

No development work was done until July, 1910, after an option had been taken on this and three adjoining quartz claims by T. W. Hawkins, C. E. Brown, J. R. Hayden, and John Adams. The Kenai-Alaska Gold Co., incorporated under the laws of Alaska in November, 1910, acquired the property December 16, 1910. About 200 feet of development work was done in 1910, including two crosscut tunnels 20 and 100 feet long and 80 feet of drifting. In 1911 considerable development work was done on the property. Early in the spring a road was constructed from the railroad to the mine, and a stamp mill, assay office, and several other buildings were erected. Stamps began dropping on August 25 and ceased October 1, when the mill closed down for the season, after running 276 hours actual time, and milling approximately 185 tons of ore. Work was started at the mine on July 15, a 630-foot aerial tramway being installed from the mouth of the lower tunnel to the end of the wagon road on the lateral moraine of the glacier. The underground developments to October 10, 1911, comprised a 100-foot lower crosscut tunnel, a 20-foot upper crosscut tunnel, 160 feet of drifts, one 69-foot raise connecting the upper and lower levels, and three shorter raises connecting the lower level and stopes. The ore milled was taken principally from the portion of the vein that lies east of the lower crosscut tunnel. Raises were run from the lower level toward the surface and the vein was stoped out for an area 30 feet in height and 70 feet in length. An average of 21 men and two teams were employed to October 1.

Only sedimentary rocks, slates, graywackes, and conglomerates were seen in the vicinity of the prospects on Falls Creek, but it is reported that greenstone ledges occur near its head. Conglomerate beds are found in the slate graywacke series in the cirque walls near the property of the Kenai-Alaska Gold Co. The pebbles are small, most of them less than 2 inches in diameter, well rounded, and firmly embedded in a slaty or siliceous matrix. The general tone of the rock is dark gray. The slates are very fine grained, grayish-black rocks, and the graywackes occurring with them are fine-grained gray to dark-gray rocks, weathering much lighter than the slates. On the east wall of the cirque in which the mine is located are black slates, weathering with brownish bands, interbedded with thin graywacke beds, 2 to 12 inches thick and striking N. 8° W. and dipping 70° E. The rock exposed consists predominantly of slates. On the north and west walls of the cirque the rocks have been closely folded. Some

of the folds show a decided overturning toward the west, the axis of one fold dipping 30° E. This folding has been accompanied by considerable shearing and faulting.

Three veins have been discovered on this property, the one now being developed on the Black Butte claim and two smaller ones on the Moon Anchor claim. The ore body on the Black Butte claims occupies a fissure, formed during or after the folding of the slate-graywacke series, and having a general strike of N. 70° E. with a dip ranging from 65° SE. to 90°. The strike of the fissure, as shown by the mine workings, is slightly curved, varying from N. 50° E. to N. 97° E. On the surface the vein has been traced by outcroppings and open cuts for over 1,500 feet. Considerable movement has occurred along the line of this fissure, some of which has taken place since the vein quartz was deposited, as is shown by the presence of slickensided quartz surfaces within the vein, the close jointing in the quartz, and the lenticular nature of some of the quartz masses. Slickensides are also noticeable in the slate close to the vein. The width of the shear zone is variable, ranging from 5 to 48 inches, the average width being from 20 to 30 inches. The fissure filling consists of crushed and decomposed country rock with numerous lenses and stringers of quartz which locally fill the entire fissure. The width of the quartz masses varies from 1 to 30 inches. Twenty measurements on several of the quartz lenses gave an average width of 11 inches. Larger and more continuous bodies of quartz have been opened up in the eastern end of the lower drift than in the western, and most of the development work in 1911 was done in that portion of the mine. No development work has been done on the veins on the Moon Anchor claim and but little is known regarding their size or extent. Their width varies from 1 to 2 feet and one of the veins is traceable for about 200 feet with a strike a little south of east and a vertical dip. Both veins apparently occupy fissures.

The ore has a checked appearance due to the development of roughly rhombohedral jointing in the quartz, which as a rule is massive and compact. Specimens from the Moon Anchor claim, however, show cavities containing well-developed quartz crystals. The jointing makes the ore easy to mine. The quartz is milky-white except where discolored by decomposition products of the sulphides. Many of the joint surfaces are rusty and when cleaned show considerable fine gold, left by the decomposition of the auriferous sulphides deposited on the joint surfaces. The ore is free milling. The gold is all fine and sulphides are not conspicuous, mill tests showing that it requires from 100 to 128 tons of ore to obtain 1 ton of concentrates. The gold occurs native, though in many places in close association with the sulphides, which are fine and widely disseminated.

Only galena and arsenopyrite were noted. Tellurides are reported from some of the veins in this vicinity.

No gold is reported in the country rock adjoining the vein or in the fissure filling outside of the quartz, which alone is sacked for milling. An average of several assays made by the company on the vein quartz gave slightly less than $80 a ton. This, however, included one exceptionally high assay of $718, without which the average would be about $45 a ton. Assays as high as $84, $101, and $718 have been obtained from portions of the vein. The results of the last season's run at the mill showed that the ore plated about $45 to the ton. The concentrates, of which there was approximately 0.66 ton, assayed over $400 a ton. An assumed recovery of 80 to 90 per cent would place the value of the ore at $50 or $60 a ton.

During 1911 the ore sacked at the mine was hauled on go-devils to the mill, where it was passed over a 1½-inch grizzly, the oversize going to a Blake ore crusher. It was then fed to a 5-stamp mill, the stamps dropping 114 times a minute with a 6-inch drop, the pulp being discharged through a 40-mesh screen. After passing over the amalgamating plates the pulp went to a Risdon-Johnston concentrator. The concentrates were shipped to the Tacoma smelter and the tailings were impounded pending the erection of a plant for the recovery of their contained gold.

SKEEN-LECHNER MINING CO.

The Skeen-Lechner Mining Co.'s property is on the north side of Falls Creek about 4 miles above its junction with Trail Creek. Two of the claims, the Portland and the Betty No. 1, were located by F. P. Skeen and L. F. Shaw, respectively, early in 1907. Two veins, one of which was discovered in the fall of 1911, have been uncovered on these two claims. The earlier-known (upper) vein has been opened upon the surface for 375 feet by trenches and open cuts, and the more recently found (lower) vein is reported to be traceable for 300 feet. On February 21, 1912, the underground development comprised 190 feet of crosscut tunneling and 160 feet of drifting, most of it on the upper vein.

The country rock of the ore body is principally massive graywacke. About 20 feet west of the last open cut on the upper vein there is a graywacke-slate contact, striking N. 6° E. and dipping 85° W. A small amount of slate with approximately this same strike occurs along the vein west of the small fault that offsets the upper vein. Slate, graywacke, and conglomerate bowlders are found in the talus.

The upper vein, occupying a fissure in the massive graywacke, strikes N. 15° W. and dips 45° E. About midway of its present-known length (375 feet) it is offset 40 feet on the tunnel level by a vertical fault fissure striking N. 56° E. The sheared zone along the

fault plane is 12 to 23 inches wide and is filled with crushed country rock containing fragments of vein quartz. Slickensides are visible both on this included vein quartz and on the walls of the fault fissure. In the tunnel the vein is well defined, varies in width from 20 to 45 inches, and shows 1 to 4 inches of gouge on both walls. The outcrop shows much less quartz, 28 inches being the maximum measurement recorded, and in places the vein fissure filling is a sheared pyrite-impregnated graywacke containing only a few narrow quartz stringers. The lower vein lies about 90 feet southwest of the upper vein and appears to parallel it in strike and to dip in the same direction. It measured 46 inches at the original discovery, near the mouth of the upper tunnel. This vein as exposed at present lies southeast of the fault offsetting the upper vein.

The fissure filling of the two veins is massive white quartz, somewhat shattered and jointed. A slight tendency toward secondary banding is seen in some places. Only a few small crystal-lined cavities are noticeable in the vein quartz. At the western end of the outcrop of the upper vein the quartz occurs as a network of stringers in the shattered country rock, the graywacke being considerably iron-stained. The quartz stringers here are frozen tightly to the graywacke, and narrow rusty bands, showing the former position of iron sulphides, lie along the contact. The country rock is impregnated with iron sulphides at several places along the vein.

Sulphides are somewhat more abundant in these veins than in those of the Kenai-Alaska Gold Co., but they are not nearly so plentiful as in the vein on the adjacent property of the California-Alaska Mining Co. Native gold occurs in association with arsenopyrite and galena and in one specimen gold was embedded in an arsenopyrite grain. The gold and sulphides appear as small grains, no large masses being observed in either vein. The ore in the upper vein is said to average over $35 in gold to the ton, and careful sampling and assaying on the outcrop of this vein is reported to show the presence of two distinct ore shoots. Assays of $50 a ton are reported from the lower vein.

SEWARD GOLD CO.

The property of the Seward Gold Co. is about 4,250 feet above sea level on the crest of the ridge between the forks of Groundhog Creek, a tributary to Bench Creek from the west, crossing the Government road from Sunrise 10½ miles from Mile 34 on the Alaska Northern Railway. The claims were located September 11, 1910, by R. L. Hatcher and C. A. McPherson. Between September 20 and the later part of November about 60 feet of tunneling was done on the vein. On October 20, 1910, the property was deeded to the Seward Gold Co. Development work was done during the summer of 1911,

but was brought to an end by the collapse of the tunnel. The total work done since discovery consisted of 90 feet of tunneling, 23 feet of winzes, a 12-foot crosscut, and a 15-foot shaft.

The country rock of the ore body consists of slates and some graywacke, striking a few degrees east of north and dipping eastward at an angle of about 60°. The strike and dip of the cleavage closely correspond to that of the bedding. A vertical jointing near the vein and almost parallel to it strikes N. 85° E. The joints are irregularly spaced at intervals of a foot or more. A short distance above the workings a pale-greenish porphyritic dike crosses the ridge, striking N. 28° W. and dipping vertically. The dike measures as much as 10 feet at one point, and the rock composing it is much jointed, but appears fairly fresh and unaltered, its porphyritic texture being plainly evident in most specimens. It shows little evidence of mineralization. About 150 feet northeast of this dike is another dike of similar appearance, whose northernmost end lies close to the easternmost extremity of the vein as now uncovered. The outcrop of the vein has not been traced quite to the point where it should intersect this dike, nor is this dike visible on the surface north of the vein. It is of variable width, measuring 28 inches on the first outcrop south of the vein, but in places reaching a width of at least 8 feet. It is approximately parallel to the upper dike, striking about N. 40° W. Both dikes have been fractured and the fractures have been filled with white, glassy-looking quartz, which at one place carries native gold. Arsenopyrite was found in one of the dikes.

The ore body consists of a zone of fractured slates, 5 to 6 feet wide, extending S. 80° E. between the two dikes. The fractures have been filled with quartz, much of it coarsely crystalline, which forms a network of irregular stringers, between which there is considerable crushed slate. The vein material is all more or less decomposed by surface weathering. The vein has been traced about a hundred feet, and so far as present development work shows does not extend beyond either dike. It is nearly vertical, dipping steeply to the south. A narrow streak of gouge lies along the hanging wall. In many places the vein quartz shows drusy cavities, indicating deposition in open spaces. The quartz filling varies from narrow stringers to veins over a foot in width. A small quantity of calcite occurs in the veins. The gold is free in the quartz or in close association with arsenopyrite and galena. Specimens from the outcrop show abundant free gold. Arsenopyrite occurs also in the slate wall rock and in the dikes, its appearance in those places indicating metasomatic alteration by mineralizing solutions. The vein quartz carries the gold, assays of the decomposed slate from the fractured zone showing only traces of gold.

BARNES PROPERTY.

The property of the Alaska Gold Exploration & Development Co., usually referred to locally as the Barnes property, is at the head of Crow Creek, in the Knik mining district. Glacier Creek, of which Crow Creek is the most important tributary, enters Turnagain Arm from the north 4 miles beyond the present terminus of the Alaska Northern Railway. Although the first discovery of gold-bearing quartz on this property was made in September, 1909, by Conrad Hores, little work was done to open up the vein prior to August 1, 1910. Since that date, however, underground development has been actively carried on, practically all of it on the Stella claim. Three veins had already been found at the time this property was visited, and a fourth was discovered on the Ruth claim late in the fall. The outcrops of these veins have been traced only a few hundred feet. The ore body on the Stella claim consists of two parallel veins, a little over 100 feet apart, striking eastward, and a third vein crossing these with a strike of S. 18 E. The vein on the Ruth claim is reported to strike eastward. The developments on the Stella claim to January 1, 1912, consisted of 560 feet of adit levels, 56 feet of crosscut timbering, 14 feet of drifts, and 52 feet of winzes, together with several open cuts on the different veins. These developments include three adit levels, two of which are on the southernmost vein, one 100 feet vertically above the other. This southern vein strikes S. 83 E. and dips 55° N. and varies in width from 8 to 46 inches. The upper of the two tunnels was 267 feet in length, and the lower tunnel, started late in the fall, was only 50 feet long; two winzes, 42 feet and 10 feet in depth, have been sunk on the vein in the upper tunnel. On the northern vein, which is nearly parallel to this one and about 100 feet distant from it, an adit level 243 feet in length has been driven. This northern vein varies in width from 10 inches to 3 feet, strikes N. 87° E., and dips 68° N. The third or crosscutting vein, which ranges in width from 2 to 10 inches, strikes N. 18 W. and dips 80° W. A tunnel, driven N. 47 E., crosscutting this vein 56 feet from the mouth, shows that it is a narrow-fracture zone in the country rock cemented by quartz carrying sulphides. The apex of the Ruth lode is about 860 feet above the level of this crosscut, and it is reported that very little work has been done on this vein, which is said to have a width of 6 to 8 inches.

The country rock of the ore deposits consists of dark-colored slates, banded argillites, fine-grained graywackes, and conglomerates, folded and later intruded by numerous bosses of light-colored, fine-grained granites, and fine-grained to aphanitic acidic dikes, offshoots from the granitic masses. The strike and dip of the sedimentary beds vary, but in general the strike is easterly and the dip northerly.

Fossils are not abundant. Imprints of small Inoceramus of Jurassic or Cretaceous age were found during 1911 on the bedding planes of the banded argillites in bowlders on the moraines of the Crow and Raven Creek glaciers and in place on the west side of the Raven Creek glacier. Inclusions of the banded argillites are found in some of the granite bosses with sharp contacts between the igneous and sedimentary rocks. No development of contact minerals is noticeable. The angularity of the fragments of the talus, the appearance of the weathered surfaces, and the dense character of the rocks, as well as the reddish, rusty discoloration of the sedimentary rocks of the area, suggest considerable heat action and mineralizing activity, which are further indicated by the presence of molybdenite and pyrrhotite in some of the quartz veins and by the occurrence of pyrrhotite and chalcopyrite in narrow quartz seams in the shales. Traces of contact-metamorphic action are visible along these seams. Ellipsoidal or concentric jointing by the metamorphism of some of the thicker argillite beds has also been noticed. Many of the dikes are faulted, the displacement, however, being usually only a few feet.

The predominant gangue mineral of the gold veins is quartz, but they contain also some calcite. The physical character of the vein quartz varies slightly. Secondary banding parallel to the walls is noticeable in places and sulphides have been deposited along some of the fractures. At some places joints occur in the quartz. At others the quartz is coarsely crystalline and the vein contains numerous small vugs.

Pyrite, arsenopyrite, sphalerite, and galena are the principal sulphides. Chalcopyrite also occurs in small quantities. Pyrite and arsenopyrite occur as disseminated crystals in the metasomatically altered wall rock of the veins as well as in association with the other sulphides in the vein quartz. In the open cuts galena is altered to cerusite.

The ores are free milling. Tests on some of the more highly mineralized ore are reported to have saved 80 per cent by amalgamation and 16.4 per cent in the concentrates. The gold is free and also occurs in close association with the sulphides, and is often included in galena and arsenopyrite grains. It is especially noticeable along some of the joint planes where the auriferous iron sulphides have been oxidized. Nuggets worth 63 cents have been found in the veins. The gold of Crow Creek is of rather low grade, having a value of about $15.90 an ounce.

The crosscut tunnel on the Stella claim passed through a small vein containing molybdenite, pyrrhotite, and chalcopyrite in a gangue of vitreous-looking quartz, but no visible free gold. Pyrrhotite and chalcopyrite also occur in narrow seams in the banded shales near the igneous rocks.

The ore from the two larger veins on the Stella claim is reported by the owners to average $35 to $40 a ton for the southern vein and $12 a ton for the northern vein. Much higher assays have been obtained, however, in single samples. The limits of the ore shoots are not yet defined. About midway of the upper tunnel on the southern vein a stringer runs out into the hanging wall, and at this point sulphides are said to have been much more abundant and assay values much higher than in other parts of the vein. Exceedingly high assays are reported from the crosscut vein on the Stella claim and from the vein on the Ruth claim. The wall rocks of none of the veins are said to carry gold, although the amount of pyrite and arsenopyrite would suggest the presence of at least a little.

STRINGER LODES.

Typical stringer lodes are composed of numerous nearly parallel overlapping quartz veinlets occupying irregular openings along cleavage lines or in some places cutting across the structure. Several deposits of this type, which is characteristic of slaty rocks, occur in this region, the best known of which lie in a belt extending northward from the Mile 4 property to the mouth of Porcupine Creek. They include the Mile 4, Pullen-Davis, and Schoonover properties. The Pullen-Davis lode differs somewhat from the others in that the quartz stringers form a network recementing a fractured graywacke bed. The other lodes in this belt are in slate, stand vertical, and strike in general parallel to the structure, although some of them cut the bedding at slight angles. At the Schoonover property near the upper end of Porcupine Creek a compact stringer lode 9 feet in width at the tunnel mouth and traceable for over 125 feet, contains irregular lenses and stringers of quartz from 1 inch to 15 inches in width. Assays up to $100 have been obtained on samples taken across the full width of some of the larger stringers. Other mineralized quartz stringers, 1 to 6 inches in width, are found on this property outside of the zone mentioned. The interbedded slate and graywacke strikes N. 17° W. and has a vertical dip. On the canyon walls, however, surficial creep of the beds has caused an inclination of the upper portion of the lode and country rock toward the creek and has resulted in a false dip away from the creek.

The gangue in the stringer lodes is quartz, coarsely crystalline in some of the larger stringers and showing interlocking crystals in places at the center of the veins. Some calcite occurs with the quartz as a gangue mineral. The gold occurs free in the quartz. Arsenopyrite is the most abundant sulphide; galena, sphalerite, and pyrite are subordinate.

Other occurrences of stringer lodes are known on Palmer, Cub, Groundhog, and other creeks of the district. Most of the veins are

small and comparatively short, and only where they are fairly closely spaced and well mineralized can they be considered as possible ore bodies. The small amount of development work done on deposits of this type in this region has not determined either their lateral or their longitudinal extent nor demonstrated their economic importance. Stringer lodes have proved to be of great value in some portions of the Juneau gold belt and commercially valuable stringer lodes may exist in the slate areas of Kenai Peninsula.

MINERALIZED ACIDIC DIKES.

DISTRIBUTION.

The only mineralized dikes in this district of any present economic importance are those of the Moose Pass and Palmer Creek regions. Other acidic dikes occur along Turnagain Arm, on Crow, Raven, Groundhog, Porcupine, Mile Four, Bear, and other creeks, but are so slightly mineralized that they appear of little economic value. The possible existence of other well-mineralized dikes, however, is not denied.

The characteristic feature of the Moose Pass and adjoining Palmer Creek regions is the occurrence of several nearly parallel mineralized acidic dikes striking in a general north-south direction and confined so far as known to a relatively narrow strip of country between Quartz, Canyon, and Resurrection creeks. The largest of these dikes, known locally as the "Blue Lead," is in the Moose Pass district and has been traced for approximately 12 miles from Slate Creek to Donaldson Creek with an average width of 8 feet. Near the southern end of the area several promising gold-bearing quartz veins have been opened. North of Summit Creek the mineralized quartz appears, so far as present developments show, to be confined chiefly to the fractured and mineralized dikes, although small gold quartz veins have been located at the head of Palmer Creek, and on Canyon, Juneau, and Fresno creeks. Further prospecting in this northern portion will probably reveal other gold quartz veins.

STRIKE.

The noticeable parallelism of the dikes of this district and their length is evidence of extensive parallel fissuring prior to the intrusion of the acidic igneous material now filling those former openings. These earlier fissures follow closely the dominant strike lines of the district and dip nearly vertical, as do most of the sedimentary rocks. The strike of the "Blue Lead" changes gradually from N. 12° E. in its southern portion to N. 30° E. on Donaldson Creek, where it disappears under timber cover. The Mascot ledge, near the head of Fox Creek, has a due north strike and a vertical

dip, and the Logman ledge on Palmer Creek, traceable for over 6 miles, has a north-south strike. The other dikes of this district parallel these. On Bear Creek numerous large acidic dikes outcrop and some of them have northerly strikes. Subsequent to the intrusion of the acidic dikes further fissuring took place, faulting and fracturing the dikes and opening new fissures for the deposition of gold-bearing quartz. These later fissures are vertical or nearly so. Their strikes fall into two general groups, one group having northeast-southwest strikes and the second a general northwesterly strike. Small transverse slippings are noticeable in the tunnels at the southern end of the big Moose Pass dike, but most of the offsets are small. In places the dike walls are frozen to the country rock, but generally they break clear. The dikes are badly sheared in other places and show gouge streaks and slickensides along the walls in many localities.

MINERAL CHARACTER.

The dikes are very fine grained, badly altered porphyritic rocks, light colored and greenish. Owing to the extensive alteration they have undergone their porphyritic character is discernible in few hand specimens. Under the microscope they show phenocrysts of plagioclase feldspars and a colorless silicate (probably originally biotite) embedded in a fine-grained groundmass of quartz and plagioclase feldspars. Considerable secondary muscovite (sericite) and calcite are present and also a small amount of chlorite, to which last the greenish tinge of the rocks is probably due. Sericitization of the feldspars is well advanced, and the original biotite phenocrysts are completely altered to chlorite, calcite, and sericite. The unaltered rock would best be classed as a very fine-grained diorite porphyry. Small seams of calcite occur in the more altered portions of the dikes, and calcite is present also in many of the quartz veins associated with them. Striated crystals of arsenopyrite are abundantly disseminated through the altered porphyry adjacent to quartz veins and stringers. Dendritic markings of manganese dioxide are found on many of the fractured planes of the dike rocks. In the more mineralized portions the fractured dike rock is cemented by irregular quartz stringers with a little calcite. The gold is free in the quartz gangue as well as closely associated with the sulphides. Arsenopyrite occurs both in the quartz stringers and disseminated in the altered dike rocks adjoining. Galena, sphalerite, chalcopyrite, and pyrite are also present.

The mineralization in the dikes is irregularly distributed, poorly mineralized and barren stretches occurring at irregular intervals. Low-grade mineralized zones of country rock as well as gold-bearing stringer lodes of indeterminate lateral and longitudinal extent inter-

sect the dikes, which are mineralized along the crossings, the crushing and fracturing of the dike rocks having facilitated the circulation of the mineralizing waters. The original dike rock carried practically no gold. Assays on average samples from the less altered portions range from a trace to a little over $1. In the more mineralized portions average samples are reported to assay from $1.40 to $52.80 and picked specimens to run a great deal higher. The portion of the "Blue Lead" between Summit and Colorado creeks is reported by the owners to average $19 to $20 to the ton, this result being obtained on average samples from five open cuts on the ledge between those creeks. Comparatively unmineralized portions, however, occur in this strip as in other portions of the dike, and these would lower the general average considerably. No assays from the Logman ledge on Palmer Creek are available at present save one running $100 to the ton on a picked specimen. An average figure for the value per ton of these mineralized dikes could not be given without careful sampling and assaying. Their length, the probability of their continuance with depth as borne out by their igneous origin, and their mineralization (which, though markedly irregular and in most places slight, extends over a considerable area) suggest that they warrant careful future consideration and some places may pay to work on a large scale even under present economic conditions.

Some of the associated gold quartz veins appear of greater immediate importance under existing conditions. On the Gilpatrick property, between Slate and Summit creeks, at the southern end of "Blue Lead," gold quartz veins occur in close association with the dike. One such vein follows along the west wall of the dike as exposed in the upper tunnel. A crosscut to the west at the face of this tunnel shows 5 feet 2 inches of slate and quartz separated from the dike by 3 feet of slate with small rusty quartz stringers. Within this vertical veins of quartz, 7, 16, and 18 inches wide, are visible, and the slate between these veins carries numerous small quartz stringers. A crosscut to the west about 125 feet from the mouth of this upper tunnel shows a 15-inch vein of quartz in slate 12 feet west of the dike. A crosscut in the lower tunnel does not encounter this vein and it seems probable that it occupies a later nearly parallel fissure that crosses the dike between the two tunnels. The Summit vein, on the crest of the ridge between Slate and Summit creeks east of the dike, lies in sheared graywacke, strikes northwest, stands vertical, and has a width approximating 3 feet. This vein has not been traced to its intersection with the dike. The width of the quartz ranges from 6 to 40 inches. Free gold is plainly visible to the unaided eye, as are also the sulphides, galena, and arsenopyrite. Average assays of from $30 to $68 are reported from this vein. Assays on quartz from the upper tunnel run from $0.80 to $37, although higher

results are obtainable on specimen ore. On the ridge between Slate and Boulder creeks several quartz veins have been located, assays on which are reported to run from $3 to $25.

DEVELOPMENT.

Comparatively little development other than assessment has been done on the mineralized dikes of this region. On the Gilpatrick property in Moose Pass there are three tunnels, two of which, 286 and 235 feet in length, with about 45 feet of crosscutting, were driven along the big porphyry dike, and a third, now caved, was driven 117 feet along the quartz vein on the Summit claim. On the adjoining property to the east a tunnel 204 feet in length has been driven along a shear zone striking N. 57° E. On the Logman lode, Palmer Creek drainage, a 40-foot tunnel has been driven on the south side of Cœur d'Alene Gulch. Assessment work only has been done on the other claims and has been restricted to the construction of trails to the properties and the making of a few open cuts across the dikes.

CONCLUSIONS.

The numerous gold quartz lodes and placer deposits scattered through the mountainous portion of the peninsula indicate widespread mineralization, coextensive, presumably, with the area underlain by metamorphic rocks. In the surrounding portions of Alaska, in the Iliamna region, in the Nizina, Chistochina, Yentna, and Willow Creek districts, and in southeastern Alaska, the gold deposits all appear to be genetically related to Mesozoic dioritic intrusive rocks.[1] On the Kenai Peninsula and the adjoining mainland, granitic and dioritic intrusives occur at several places and the evidence available indicates that they are of Mesozoic age. The mineralization of the area took place subsequent to the intrusion of these igneous masses and probably as an after effect of the igneous activity. In age and association, therefore, the gold quartz lodes of this region are similar to most of the auriferous lode deposits of Alaska.

The mineralogy of the gold ores of the Kenai Peninsula—pyrrhotite, molybdenite, chalcopyrite, pyrite, arsenopyrite, galena, sphalerite, gold, etc.—is characteristic of gold veins deposited by aqueous solutions under conditions of moderately high temperature and pressure, at minimum depths of several thousand feet below the surface.[2] The metasomatic alteration of the wall rocks of the ore bodies is also that effected by heated aqueous solutions under deep-seated conditions; and the present known range of auriferous vein filling, over 5,000

[1] Brooks, A. H., Geologic features of Alaskan metalliferous lodes: Bull. U. S. Geol. Survey No. 480, 1911, pp. 43–93.

[2] Lindgren, W., The relation of ore deposition to physical conditions: Econ. Geology, vol. 2, 1907, pp. 113–116.

feet, extending from practically sea level in the prospects near Seward to altitudes of 4,000 to 5,000 feet on the properties of the Kenai-Alaska Gold Co. and the Seward Bonanza Gold Mines Co., is probably a minimum estimate of the range through which the auriferous solutions were capable of depositing their contents. The deep-seated origin of the ore deposits, their probable deposition from ascending thermal waters, the character of the mineralization, and the extensive vertical range of auriferous vein-filling above sea level, all indicate the continuity of the ore deposits to a depth below the limits of profitable mining; and in general it is probable that gold quartz veins are distributed through the rocks to considerable depths, in much the same manner and form as in the rocks that lie above sea level. However, the persistence of the general mineralization with depth is no criterion as to the persistence of mineralization in individual veins.

Secondarily enriched deposits do not occur in this district, the powerful glacial erosion of comparatively recent times having removed any enriched zones that may once have existed. Neither is there a complete zone of oxidation. The original sulphide ore bodies are now exposed at the surface, and no reason exists for suspecting any marked change in depth either in the mineralogic character of the ores or in the value of the lodes as a whole. The outcrops of many of the ore bodies have been modified slightly by the postglacial oxidation of the sulphides contained in the veins, and in the more favorable places partial oxidation of the sulphides has taken place to depths of 200 to 250 feet, these being the greatest depths yet attained in the mine workings. The greater part of the contained gold appears to have been left behind in the oxidized outcrops.

GOLD PLACERS.

GENERAL FEATURES.

Colors of placer gold have been found on most, if not all, of the streams of the mountainous region of northern and central Kenai Peninsula, but in few places have deposits been found sufficiently rich to be of economic importance under present conditions. Consequently, though the present known distribution of the auriferous gravels is widespread, the list of producing creeks is small. In 1911 it included only Resurrection, Crow, Cooper, Quartz, Gulch, Mills, Canyon, Sixmile, Silvertip, Bear, and Winner creeks, and Kenai River, being much the same as it was when the region was visited by Moffit in 1904 and Paige and Knopf in 1906. About 25 claims were being worked at one time or another in 1911, and from 75 to 100 men were engaged in placer mining during the open season. The production of placer gold in 1911 from Kenai Peninsula, including

Crow and Winner creeks, is estimated at 1,540 crude ounces, valued at $26,000 for gold and $150 for silver. The value of the placer gold of this region varies from $15.86 to $17.87 per ounce. Bear and Crow creeks furnish the lower grades, the assay value per ounce (after melting) of dust from these two creeks ranging from $15.86 to $15.90. Bear Creek gold is usually taken in trade locally at $15 per ounce.

The placer deposits of this region may be grouped as (1) creek placers, (2) bench placers, (3) river-bar placers, (4) lake-bed placers, and (5) beach placers. The data regarding the principal characteristics of each of these classes, with examples of each and the methods at present used in working them, are tabulated here for convenience in reference.

Classification of gold placers of Kenai Peninsula and vicinity.

Class.	Nature and location.	Examples.	Method of working in 1911.
Creek	In, adjacent to, and at the level of small streams.	Resurrection Creek Cooper Creek	Hydraulicking. Hydraulicking over Ruble elevator.
Bench	Fluvioglacial or glacial deposits in valleys but considerably above level of present streams, usually terraced.	Lynx, Crow, Canyon, Mills, Sixmile, Gulch, Resurrection, Quartz, and Cooper creeks.	Hydraulicking.
River bar	Gravel flats, in or adjacent to beds of large streams.	Kenai River	Dredge (installed on upper Kenai River in 1911).
Lake bed	Accumulations in the beds of present or former lakes; generally formed by landslides or glacial damming.	Crow Creek Bench deposits on upper Kenai River.	Not worked.
Beach	Adjacent to the sea or to large bays to which waves have access.	Anchor Point, Cook Inlet Snipers Point, Turnagain Arm.	Rockers and sluice boxes. Not worked.

SOURCE OF THE GOLD.

Most of the placer gold of the region is undoubtedly of local origin and was probably derived from the erosion of gold veins in the slates and graywackes of the Kenai Mountains. Most of it was derived from veins within the area drained by the stream in whose valley the auriferous gravels are found. The present distribution and arrangement of the auriferous gravels results principally from the glacial and fluvioglacial activity of the recent past and from recent stream erosion. No preglacial gravels are known to occur in place in that portion of the Kenai Peninsula under consideration. Preglacial stream deposits undoubtedly existed, but probably all of them have been removed by glacial erosion and reworked by glacial streams. As the ice retreated the shifting overloaded glacial streams laid down valley trains in which the gold was necessarily widely disseminated. Later, with a decrease in load after the disappearance of the glaciers, the streams began to cut down through the valley trains, terracing

the older deposits and concentrating the gold contained therein in the creek gravels. Most of the present creek placers are the product of this concentration, although some of the placer gold of a few of them may possibly have been furnished by postglacial erosion of the lodes.

MINING METHODS.

The future of the region as a placer producer depends largely on the introduction of economical methods of handling large bodies of low-grade gravels. The channel gravels yielded most of the gold in the earlier years of placer mining in the peninsula, but the richer spots were soon worked out, and the remaining creek placers have repeatedly proved unprofitable when worked by ordinary pick-and-shovel methods. They are, moreover, in most places shallow and of small extent. Where of greatest extent, as on Cooper and Resurrection creeks, values of only 30 to 50 cents a yard are reported, and methods other than shoveling into sluice boxes must be employed to obtain a profit. As the topographic conditions and abundant water supply of the region are particularly favorable to hydraulicking, most of the placer mining in recent years has been by that method, the material worked in most places being the bench deposits. These bench placers are of much lower grade than the creek gravels; in those of glacial or fluvioglacial origin the gold is widely disseminated. On some of the lower benches where remnants of the reworked high bench deposits have been left by the down-cutting streams slightly richer deposits are found.

The handling of large bodies of low-grade gold-bearing gravels by methods other than those of ordinary hydraulic mining has been attempted at different times in the Kenai Peninsula, but thus far has not been successful. The failure of a Risdon 5-foot open-connected dredge on Resurrection Creek in 1905 is reported to have been due partly at least to the numerous large bowlders contained in the creek gravels. A small dredge, differing markedly from the usual type, was erected on upper Kenai River in 1911 but failed to yield satisfactory results; and it appears probable that nearly everywhere on Kenai River dredges designed to handle heavy wash will be required. Attempts to work the gold-bearing gravels on Resurrection and Sixmile creeks by hydraulic elevators were not successful. In general it may be said that inadequate prospecting of placer ground before a method or plant adapted to the conditions is chosen has caused most of the failures.

Many conditions favor the placer miner; the open season is longer than in either the Yukon country or on Seward Peninsula; perpetually frozen ground does not occur; compared with the interior of Alaska, the country is easier of access, and the cost of labor and supplies is

less; topographic conditions and the abundant water supply favor hydraulic methods; and timber suitable for cabins, fuel, and mine work is readily obtainable.

PRODUCTIVE CREEKS.

The general characteristics of the productive creeks have been described in considerable detail by Moffit[1] and therefore only those operations which were in progress in 1911 are here described. The placers are described in geographic order, those in the southern part of the area being placed first and the more northern ones last.

KENAI RIVER.

After the discovery in 1910, by C. D. Cunningham, of placer gold in the gravels of Kenai River about a mile below the mouth of Cooper Creek, practically all the lower ground bordering the river from the lower end of Kenai Lake to Cook Inlet was staked as possible dredging ground. Little careful prospecting, however, has as yet been done. Early in 1911 ground near the mouth of Killey River was drilled to determine its suitability for dredging and later in the season some of the claims between the upper and lower Kenai Lakes were prospected by shafts. Gold values sufficient to justify dredging are reported from parts of the lower river. Specially designed dredges would, however, be required to work these deposits on account of the occurrence of very heavy wash in many places.

Between Skilak and Kenai Lakes Kenai River flows among high rounded hills. Gravel benches flank the stream; their upper surface is at water level at the lower end of Kenai Lake, but is high above the river in the vicinity of Cooper and Juneau creeks, where the river has cut deeply into them. The 200-foot bluff at the mouth of Cooper Creek shows the structure of these high-bench deposits to be that of a typical delta, deposited in ponded waters by a stream flowing westward, as does the present river.

In recent geologic time it is probable that the trunk glacier extending down the valley now occupied by Kenai Lake and Kenai River widened and deepened the preglacial valley and impressed upon it the U-shape characteristic of glaciated valleys. Because of its greater size and erosive power this glacier cut the bottom of its valley considerably below the level of the tributaries' valleys, so that Cooper and Juneau creeks were left as hanging valleys on the retreat of the ice. The delta structure of the bench deposits indicates that a lake of considerable size formerly filled the valley, being probably produced by ice damming Kenai River in the vicinity of Skilak Lake. It appears probable that the ice front of the Kenai River

[1] Moffit, F. H., Gold fields of the Turnagain Arm region: Bull. U. S. Geol. Survey No. 277, 1906, pp. 7–52.

glacier stood near the lower end of the present Kenai Lake during the formation of the delta, which built out and filled the lake to the extent indicated by the development of the present terracing. The removal of the obstruction which gave rise to the lake was followed by the cutting of the present channel through the delta deposits, a process which is still in progress. The depth to which the Kenai River glacier eroded its channel below that of its tributaries is not known, and therefore neither the thickness of the unconsolidated glacial and fluvioglacial filling nor the depth to bedrock in this portion of the river's course is known, although it is probably considerable.

From the delta character of the bench deposits it would be expected that the contained gold would be widely disseminated and that no definite pay streaks would occur. As to the average value per cubic yard of these bench deposits no data are at hand. It is probably exceedingly small, much too small to be worked profitably under present conditions. Panning tests in the delta bluff at the mouth of Cooper Creek failed to show any colors. The fact that these delta deposits are slightly auriferous, however, is shown by the occurrence in the present stream gravels of fine flaky gold, which must have been derived, partly at least, from the concentration of the delta gravels.

Of the present river gravels that are locally considered as possible dredging ground, those in the portion of the river's course between the upper and lower lakes are the result of the reworking and re-sorting of the sands and gravels of the above-mentioned delta, as the stream cut through it down to its present level. Coarser material, derived principally from the erosion of morainic material and bedrock on the tributary streams, also occurs in the gravels of stream flat.

The thickness of these river gravels is unknown. Prospecting shafts reach only a depth from 4 to 8 feet before encountering water. The stream-flat gravels of the lower end of Cooper Creek have a thickness of only 8 to 10 feet, resting on a false bedrock of the delta deposit in which this portion of the creek valley is cut. The river gravels may be somewhat thicker.

The low gold content of the sands and gravels of the delta underlying the present river gravels has been pointed out. In the river gravels, however, colors are obtained from the surface down without any well-defined paystreak. The data available regarding the value per cubic yard of these gravels varies considerably. The Kenai Dredging Co., whose property is about a mile below the mouth of Cooper Creek, is reported to have obtained $167 from 9½ cubic yards of gravel and from 2 to 25 cents from each pan from the river bars. The results obtained from prospecting shafts 4 to 8 feet deep in

the stream flat between the upper and lower lakes are much lower. Values of 25 and 38 cents per cubic yard were obtained in two of the shafts, and placer operations on the lower portion of Cooper Creek are reported to show an average gold content for stream-flat gravels of 30 to 50 cents a cubic yard. The average gold content of all material which would have to be handled in dredging operations, as reported from a considerable number of these shallow shafts sunk during the past season, was, however, only a few cents to the cubic yard, less than the cost of dredging operations under more favorable conditions in California. It is doubtful, however, whether any of these shafts reached either the false or the solid bedrock, upon which higher values might be found.

Most of the gold in the gravels of Kenai River is very fine, light, and flaky, and has a value of about $17.58 per ounce. Coarser gold, flat but not flaky, has been introduced into the river gravels from Cooper Creek. Active operations on the upper river have thus far been confined to the original discovery, where, during 1911, the Kenai Dredging Co. erected a small dredge which, however, failed to save the values contained in the gravel worked. A larger dredge of the same type, in process of construction, had not been completed at the close of the season. Should the gravels in the upper river, after careful prospecting, warrant the installation of dredging machinery, it appears probable that dredges capable of handling rather heavy wash will be required. The further possibility that the gold-bearing gravels of the present stream in this portion of its course may be, and probably are, of comparatively slight thickness should not be overlooked.

COOPER CREEK.

Cooper Creek, 10 miles in length, enters Kenai River from the south 3 miles below Kenai Lake. Stetson Creek is its principal tributary. Cooper Creek in most of its course flows in a postglacial rock canyon cut in a broad glacial valley. Its lower half mile, however, is cut in the sands, clays, and gravels of the delta deposit of the Kenai Valley.

The auriferous deposits comprise both bench and creek gravels. The gold content of the delta bench gravels is low (see p. 164), but above the mouth of the rock canyon richer bench deposits of moraine and fluvioglacial origin, containing both coarse and fine gold, rest on the glaciated bedrock floor. The largest nugget thus far found had a value of $3.80. The larger nuggets are very much smoothed.

The creek gravels have been worked both in the canyon and on the flat at the lower end of the creek. The latest work in the canyon was done about 1903. The gravels are said to have varied much in thickness and to have been richer than most of the gravel on the

stream flat below. For several years active operations have been confined to the wide flat at the lower end of Cooper Creek, where the creek gravels, 8 to 10 feet thick, form a uniform layer over a false bedrock of fine sand and sandy clay, with some lenses of pebbly gravel. The surface of this bedrock is fairly even, with slight depressions representing temporary channels of the shifting creek as it wandered back and forth, downcutting the present flat through the old delta deposits. The creek gravels are loose and easily handled. Pebbles of dark blue-black slates and graywackes predominate, interspersed with some conglomeratic bowlders. A few bowlders of fine-grained acidic dike rocks are also found. Bowlders over 3 feet through are rare, most of them averaging 1½ to 2 feet. The larger bowlders appear principally in the lower part of the gravels. Considerable fine material forms a matrix for the bowlders, but it is gravelly and crumbles readily. No distinct stratification is noticeable, although most of the pebbles and bowlders are flattish or slabby and lie approximately flat. These stream-flat gravels are reported to average from 30 to 50 cents gold per cubic yard.

The gold is derived from three sources—partly from the delta deposits that flank the stream flat, partly from the auriferous glacial and fluvioglacial deposits in the glaciated valley of Cooper Creek, and to a slight extent, probably by postglacial erosion, from gold-bearing lodes in the bedrock of the valley. Two distinct runs of gold are reported, one a little darker than the other.

The gold is small, flat but heavy, not flaky, and has a value of about $17.60 per ounce. Nuggets up to 80 cents in value have been found, some with quartz attached. Pyrite, arsenopyrite, and magnetite are found in the concentrates from the clean-ups.

The Cooper Creek placers are the property of the Kenai Mining & Milling Co., whose claims extend from Cooper Lake to Kenai River. Hydraulic operations were in progress in 1911 on the stream flat at the lower end of the creek. On account of the low stream gradient a Ruble elevator with a 48-foot body 10 feet wide and a 12-foot extension at the lower end, has been installed. The gold-saving attachments consist of four sluice boxes, 12 feet long by 4 feet wide, set on a grade of 8 inches to the box length. The three lower boxes were set with steel-capped wooden cross riffles, 4 inches by 2 inches by 4 feet in size, 2 inches apart with 1-inch spaces between the steel straps, the dimensions of which were ¼ inch by 3 inches by 4 feet. Water for hydraulicking is obtained from Stetson, Wildhorse, and Kickinghorse creeks by an upper ditch 4 miles long, a lower ditch 1¾ miles long, and 1,300 feet of flume. Two No. 2 Hendy giants with 4-inch nozzles and two No. 4 giants with 5-inch nozzles made by a Portland firm were available, but only one giant with a 5-inch nozzle operating under a 200-foot head was in use in June, 1911. The usual

mode of operation is to strip the soil down to the gravel layer and then to wash all the gravel, down to the false bedrock, over the elevator. Most of the gold is caught in the upper boxes.

QUARTZ CREEK.

Quartz Creek, tributary to Kenai Lake from the north near its lower end, has a length of about 16 miles. In 1911 a hydraulic plant was in operation on this creek a short distance above the mouth of Devil Creek. In this portion of its course Quartz Creek winds southward in a narrow, steep-sided valley cut in the bedrock floor of a broad glaciated valley. Bedrock of interbedded slates and graywackes striking N. 17° W. and dipping 60° W. outcrops in many places in the stream course and in the valley walls. The character of the unconsolidated material covering the bedrock on the slopes is shown in the ditch which extends along the east side of the valley. It is cut in a compact clayey gravel, which contains a few rounded and striated bowlders and was evidently waterlaid in places. Small gravel-covered benches lie at different elevations on the valley sides. The creek gravels are reported to have been good pay and to have carried coarse gold. Present operations are confined to a gravel-covered rock-cut bench, the bedrock surface of which is, at the pit, about 15 feet above the present stream. The thickness of the gravel on this bench varies from 12 to 22 feet because of the unevenness of the bedrock surface. The gravels consist of fairly well rounded slate and graywacke. Large bowlders, some as much as 6 feet in diameter, are found, but most of the material is under 3 inches in diameter. An average value of 27 to 32 cents a cubic yard is reported for these gravels. The gold is coarse, pieces up to 73 cents in value having been found, and has an assay value of about $16.90 an ounce.

At the Fairman and Madson plant water is obtained from Quartz Creek, a short distance below the mouth of Johns Creek, by a ditch 1½ miles in length with a grade of one-fourth inch to the rod. The intake is situated on the west bank of the creek and the ditch follows along the west side of the valley to a point about one-half mile below the intake, where the water is carried across Quartz Creek on a 160-foot flume 65 feet above the creek. The pipe line from the penstock to the giants decreases gradually in diameter from 14 inches at the penstock to 10 inches at the giants. Two No. 2 Kendall giants with No. 3 nozzles operate under heads of 95 to 120 feet. The gold-saving apparatus consists of 10 sluice boxes, set with longitudinal pole riffles, 4 poles wide and 6 feet long, 2 sets to each box. The head box was set on a grade of 14 inches to the box length, the second box on a 12-inch grade, the third on a 10-inch grade, and the remainder on a 9-inch grade. Most of the gold is caught in the first two boxes.

Sluicing operations in 1911 began about June 25, when 10 men were at work on the property; later in the season this force was much reduced.

FALLS AND TRAIL CREEKS.

Using an Empire drill with a 4½-inch casing, the Houston Dredge Co. drilled 20 holes in 1911 in the flats along Falls Creek between Lower Trail and Kenai lakes. The unconsolidated material in the flat between the two lakes is composed partly of morainic and fluvioglacial material deposited by the former Trail Creek Glacier and partly of recent outwash-fan deposits of Falls Creek. The depth to bedrock as determined by the drill holes varied from 10 to 23 feet. The material passed through is reported as principally gravel, but contains some bowlders too large for a dredge to handle. In some of the holes prospects were found all the way from surface to bedrock, but no definite pay streak was located and, from the nature of the deposit, it would be expected that its gold would be widely disseminated.

SIXMILE CREEK DRAINAGE.

Placer mining on Sixmile Creek, a tributary of Turnagain Arm from the south at Sunrise, was in 1911, as in former years, confined to a very few small hydraulic plants, worked by individuals and operating on high-bench gravels bordering the stream. On Canyon Creek, at a small hydraulic plant installed near the mouth of the creek, only six days' sluicing was done in 1911, a No. 2 giant under 150-foot head being used on bench gravels. The remainder of the season was spent in development work preparatory to opening up an old channel in the bench gravels on the west side of the creek. Farther upstream hydraulic operations were continued on the bench gravels on the Wible property. At the lower workings about 3 miles above the "forks" a well-defined rock-cut channel about 650 feet in length, 100 feet wide, and 30 feet deep, crossing a nose in the bedrock 150 feet above the level of the present winding channel and filled with horizontally stratified water-laid gravels, has been nearly worked out. Considerable work was also done on high-bench gravels near the mouth of Pass Creek.

But little active mining was in progress on Mills Creek during the past season. A short distance above its junction with Canyon Creek a hydraulic outfit using two giants, a No. 1 and a No. 2, piped off a small low bench about 15 feet above the creek level. Four men were employed during part of the season. Operations were discontinued in the latter part of August, when the water supply from Moose Creek became insufficient for hydraulic purposes. On Mills Creek, above the junction of Juneau and Mills Creek, a few scattered placer claims were worked and some prospecting done.

On Gulch Creek, a small stream tributary to East Fork, about a mile above its junction with Canyon Creek, two hydraulic outfits were in operation in 1911. The smaller of these two outfits, in operation the entire season, was at work on a low bench, about 20 feet above the creek level, at the junction of Gulch Creek and the East Fork. The gravel, which varies from 10 to 15 feet in thickness, rests on a smooth bedrock surface. The gravels are very compact, with clayey cement and a few clayey streaks, and are roughly stratified. The pebbles and bowlders, besides the usual slate and graywacke, included an assortment of crystalline igneous rocks. The equipment consisted of an 8-inch pipe with 2½-inch nozzle. Water for the piping was collected from the sidehill drainage on the north side of Gulch Creek by a ditch 4,000 feet in length, 2 feet wide on the bottom. In the spring sufficient water is continuously available for a full pipe head, but later the supply decreases and the water is collected in a reservoir for use as required. The gravel is piped into two lead boxes and then into a string of nine 12-foot sluice boxes, 1 foot in width, set with pole riffles. The gold recovered is flat, smooth, and medium coarse to coarse, nuggets worth $70 having been found. At the upper plant, the Dunfranwald gold mines, situated a short distance above the mouth of Gulch Creek, hydraulic operations were begun on high-bench gravels early in June and discontinued about August 15. This plant was not in operation when visited. The deposit worked consisted of horizontally stratified clayey gravels, very compact in places, with beds of sandy clay, resting in an old channel cut in the interbedded slate and graywacke. Most of the bowlders appear to be under a foot in diameter. No data are at hand regarding the gold content of these gravels. Water for hydraulic operations is obtained from Gulch Creek by a large ditch about three-fourths mile in length. The gold-saving apparatus consisted of a string of 11 sluice boxes with 3-foot square cross section laid on bedrock. The two head boxes and the lowest box of all were set with steel-capped wooden cross riffles with 1½-inch spaces. The next eight boxes were set with block riffles, those in the first four boxes having a square and those in the remaining four boxes a circular cross section. One box length from the lower end an undercurrent, 6 feet wide by 12 feet long, fitted with wooden cross riffles with ¾-inch spaces, was inserted.

The shallow creek gravels, 3 to 4 feet deep, on Silvertip Creek, about one-half mile above the road crossing, were worked in 1911 by a small hydraulic outfit. The work was carried on for about six weeks by three men using 6-inch hose with a 2½-inch nozzle under a head of 60 feet. Sluicing began June 28, and ceased in August on account of insufficient water supply. The gold is reported to be sim-

ilar to that from Gulch Creek, although the nuggets found are not so large. Most of the larger nuggets had quartz attached.

RESURRECTION CREEK.

Resurrection Creek, the earliest producer and the westernmost productive stream of the Turnagain Arm region, flows northward into Turnagain Arm through a broad valley, 21 miles in length, floored with a thick deposit of gravels, in which, throughout the greater part of its course, the stream has cut a deep canyon-like channel. Near the lower end of the valley the stream flat widens and a short distance below the mouth of Palmer Creek it has a width of about 1,000 feet. High gravel benches here flank the stream flat on both sides. Slate bedrock and rimrock outcrop in but few places, the stream not yet having removed all the earlier unconsolidated deposits in its course. The gold-bearing creek gravels cover the stream flat to an average depth of 7 feet, resting on a false bedrock of earlier unconsolidated fluvioglacial deposits. At the placer workings this consists of yellowish horizontally bedded clay containing some streaks of blue clay. The auriferous gravels are loose and stream laid, with but little clayey sediment. Bowlders over 3 feet in diameter are not very numerous, although a few very large ones are found. Graywacke bowlders predominate, granite bowlders and conglomerate bowlders being much less abundant. The gravels are reported to average between 45 and 50 cents to the cubic yard. No definite pay streak exists.

During 1911 these creek gravels were being worked by hydraulic methods by the Mathison Mining Co. The property known as the Texas-Oklahoma Consolidation extends from a point 4 miles above the mouth of Resurrection Creek to within 1,500 feet of tidewater. The work of 1911 was done near the upper end of the property. Sluicing was begun on May 29 and work stopped on October 8, after 127 working days, during which approximately 16,000 cubic yards of gravel were moved. An average of seven men were employed. In August but two men were at work in the pit, on account of low water in the creeks. Three miles of new ditch, 20 inches deep and 36 inches wide, was built, tapping Bedrock and Rimrock creeks and Gold Gulch for water supply, the water running through the ditch for the first time about September 10. Two miles of the ditch were constructed on a grade of one-half inch to the rod and 1 mile on a grade of 1 inch to the rod. Prior to the construction of this ditch the water supply had all been obtained from Bedrock Creek. Approximately 3,000 feet of pipe-line, ranging in diameter from 16 inches down to 11 inches, is used to lead the water from the ditch to two No. 2 Hendy ball-bearing giants with 4-inch nozzles and one No. 1 giant

with a 3-inch nozzle, all operating under 315-foot heads. Occasionally a 4½-inch nozzle is used on one of the No. 2 giants. Two of these giants are used in the face of the workings and the third stacks the tailings from the sluice boxes. Only three 15-foot sluice boxes can be used, because of the low stream gradient. These are 3 feet in width and are set on an average grade of 9 inches to the box length. Pole riffles are used in the head box, where most of the gold is caught, and Hungarian vacuum riffles in the remaining two boxes. All of the gold-bearing gravel is driven into the boxes by the giants. Small bowlders are handled by a derrick and stone boat and the larger ones chained.

Near the above plant E. E. Carson has installed a small hydraulic plant on a bench on the west side of Resurrection Creek. Water is obtained from Wildhorse Creek through a ditch 1½ miles in length. The equipment is reported to consist of a No. 1 giant with a 3-inch nozzle operating under a 60-foot head of water. The gravels are similar to the creek gravels; they are horizontally bedded and rest on a clay bench. In 1911 a shortage in the water supply permitted only a short working season on these bench gravels.

CROW CREEK.

At present Crow Creek is the only important gold-producing stream on the north side of Turnagain Arm. It is 4 to 5 miles in length, heading against Raven Creek of the Eagle River drainage in a broad pass (Crow Creek Pass) 3,540 (aneroid) feet above sea level and entering Glacier Creek from the northwest, 5 miles from Turnagain Arm. A considerable part of its water is derived from several small glaciers occupying cirques in the mountains surrounding the head of the valley. From the pass the creek flows southward in a narrow U-shaped valley, bottomed with glacial till in which the stream has cut a small V-shaped gorge, to a point within about 3 miles of its mouth, where it swings sharply to the southeast, the valley broadening suddenly to a gravel-filled basin three-fourths mile long. Below this basin the creek drops into a narrow gravel-walled flat-bottomed valley, in which it flows for a considerable distance. In the remaining half mile of its course the stream flows through a narrow rock canyon in a series of rapids and falls to its junction with Glacier Creek.

Placer operations in recent years have been confined to the moraine-dammed gravel-filled basin in the upper part of the valley, and to an old buried channel at the head of the rock canyon about one-half mile from the mouth of the creek. Hydraulic plants have been installed in both places. During the past season work at the upper plant was suspended to avoid covering unworked gold-bearing gravels

with tailings. The recent geologic conditions at this property have been described in detail by Moffit[1] and Paige and Knopf[2] and need not be repeated here.

Near the middle of the rock canyon of the present stream mining operations in 1904 disclosed an earlier well-developed gravel-filled channel, cut in bedrock, crossed by the present channel and apparently headed toward the gravel flat at the upper end of the present rock canyon. Most of the later development work has been confined to the removal of the unconsolidated deposits filling this channel. The property has changed hands several times. The present owners, the Nutter-Dawson Mining Co., completed in 1911, after several seasons' work, a cut through the high-bench deposits from the original point of discovery of the channel in the canyon to the gravel flat at its head. This cut, 1,800 feet in length, with a maximum depth of about 225 feet, follows the course of the old channel. The filling of this channel, up to the level of the bedrock surface at the head of the present canyon, consists chiefly of firmly cemented water-laid pebbly clays, horizontally bedded, with a few scattered bowlders in the lower portions near the rim and on bedrock along the sides and bottom of the channel. Wash gravel of variable thickness is also reported in portions of the channel. Overlying these pebbly clays is 60 feet or more of yellowish irregularly stratified sandy and gravelly beds. These high-level unconsolidated deposits, which extend for some distance up Crow Creek, have been trenched by the present stream to a considerable depth contemporaneously with the development of the rock canyon. Near the head of the present rock canyon the stream flat has an average width of 250 to 300 feet and lies about 100 feet below the top of the high-bench deposits, which here have an elevation of approximately 1,000 feet above sea level. The thickness of the stream-flat gravels is not known. A shaft 70 feet in depth is reported to have been sunk at the lower end of the flat without reaching bedrock. No record of the material passed through is available, but it appears probable that most of the section must be similar to that exposed in the cut and must have about the same gold content, and that the thickness of the stream gravels does not exceed a few feet. The completion of the big cut has demonstrated the low gold content of these high-bench fluvioglacial deposits. Exact figures are not available, but it appears that 1½ cents per cubic yard would be an exceedingly liberal estimate of the gold they contain. The higher gold content of the gravels of the stream flat is due to the concentration of the gold of the bench deposits by the

[1] Moffit, F. H., Gold fields of the Turnagain Arm region: Bull. U. S. Geol. Survey No. 277, 1906, pp. 41–43.

[2] Paige, Sidney, and Knopf, Adolph, Reconnaissance in the Matanuska and Talkeetna basins, with notes on the placers of the adjacent region: Bull. U. S. Geol. Survey No. 314, 1907, pp. 121–122.

present stream in the development of its present channel. Moffit states that the results of mining operations in 1904 in the flat above the canyon gave an average of 44 cents in gold per cubic yard of dirt moved. No further data are available.

The recent geologic history of this deposit is probably as follows: During the general retreat of the ice following the intense glaciation of the region the Crow and Glacier Creek glaciers separated. The Crow Creek Glacier retreated the more rapidly because of its smaller area of ice supply, but the Glacier Creek Glacier retreated sufficiently to allow the escape of the Crow Creek waters, which cut a gorge of considerable depth in the bedrock. A later advance of the Glacier Creek Glacier, accompanied probably by a slight advance of the Crow Creek Glacier, ponded the Crow Creek waters with a resultant deposition of their load and the filling of the gorge and of part of the valley with waterlaid sediments. With the final retreat of the glaciers to their present position Crow Creek cut a new channel through the fluvioglacial deposits, deviating somewhat from its former channel and exposing the latter where the channels cross.

Water for the present hydraulic plant is taken from Crow Creek by a ditch 5,700 feet in length, 6 feet wide at the top, 4 feet wide at the bottom, and 4 feet deep. A pipe line 3,000 feet in length, 24 inches in diameter at the intake and 15 inches at the giants, carries the water to three No. 7 Hendy giants, with 7 and 8-inch nozzles, operating under heads varying from 300 to 350 feet according to their position in the cut. The gold-saving apparatus consists of a bedrock sluice 600 feet in length, set in the bottom of the old channel, with boxes 5 feet wide by 4 feet deep placed on a grade of 9 inches to the box length. Twelve-inch cube hemlock block riffles are used in the boxes. Two box lengths from the lower end of the sluice two parallel 6-foot undercurrents have been installed. The tailings are dumped into the rock canyon of the present stream at the intersection of the two channels. Fifteen to twenty men were employed on the property during 1911.