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CONTENTS.

THE JUNEAU GOLD BELT, ALASKA.

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INTRODUCTION.

In the summer of 1903 the writer and Mr. Charles W. Wright made a detailed study of the geology and mineral resources of a limited area, including the Alaska-Treadwell and associated mines near Juneau, Alaska. In addition to this work, visits were made to nearly all the mining camps of the mainland portion of southeastern Alaska, between Windham Bay, about 75 miles southeast of Juneau, and the Porcupine placer district, in the Klehini and Salmon river basins of the Chilkat River drainage, about 120 miles to the northwest.

The Juneau gold belt resembles the gold belt of California in several ways. Not only are the various rocks which occur in this part of southeastern Alaska similar in character and partly equivalent in age to those forming the country rock of the Mother Lode district, but there is as well a definite linear distribution of some of the gold-bearing veins parallel with the general strike of the bed-rock formations, though, as in the neighborhood of the noted systems of veins in the California gold belt, there are many independent deposits lying outside the main complex of lodes.

Prospecting has been in progress in different parts of this belt since 1876, but the main incentive to vigorous exploration came with the discovery of the Gold Creek placers and the founding of Juneau in 1880. Several early attempts to work gold veins occurring adjacent to the productive placers in the Silver Bow Basin, at the head of Gold Creek, were unsuccessful, the first mine to be put upon a productive basis being the Alaska-Treadwell, on Douglas Island, about 2 miles

southwest of Juneau. This property was opened in 1881, and it continued to grow in importance for several years, so that by 1889 it had reached its present rating as one of the great mines of the world.

The success of this enterprise was an incentive to prospectors, the region had become favorably and somewhat widely known, and capital appeared to be ready to prove the value of several properties when, in 1896, the discovery of the Klondike gave a great impetus to prospecting in the interior of British Columbia and Alaska and caused the mineral region tributary to Juneau to be temporarily abandoned as a field for investment. The gold fields of the interior turned out to be of more than passing value and the exploitation of their rich placers has naturally held the main interest of both investors and promoters, to the great disadvantage of the longer known, though less rich, coastal region, the development of which would have involved greater outlay and slower returns. It may be said that only now, after seven years, has the district regained the position which it appears to have held in 1896.

At present a growing interest in the gold belt here under consideration is apparent from the number of properties which have recently changed hands, from the number of experienced engineers making examinations in the field with a view to acquiring property for their clients, as well as from the demand for experienced miners, which is continually bringing new men into the Territory.

The number of miners and laborers at present engaged in the region is estimated as follows:

Number of miners estimated to be engaged in Juneau region, Alaska.

Independent prospectors	140
Douglas Island mines	900
Mainland mines south of Juneau	80
Mainland mines near Juneau	80
Mainland mines north of Juneau	90
On other islands, mining and prospecting	50
Placers	100
Total	1,440

About 30 per cent of the miners in the region were engaged in prospecting and preliminary development during the year, and indications are that the exploration of properties recently purchased by outside parties will materially increase the proportion of men engaged in work not immediately productive.

In 1903 there were seven productive mines in the district in addition to the placers of Porcupine and adjacent creeks. These were the Alaska-Treadwell, Alaska-Mexican, and Ready Bullion, on Douglas Island; the Silver Queen, on the mainland opposite; the Sumdum Chief, 60 miles to the south, now worked out and abandoned; and the Alaska-Juneau and Ebner mines, in Gold Creek, both of which will soon be

opened on a large scale. The product of these mines for the year is estimated at $2,400,000, while the total output of the belt to the end of 1903 has been more than $20,000,000.

Several properties which were formerly worked are not now producing bullion, either because they have been worked out or because the conditions of further development would involve too great an increase in mining costs.

The examinations which have been made indicate that the known prospects in the belt tributary to Juneau are of sufficient promise to warrant all the work now in progress and the expenditure of still more capital in development work. There is still room in this field for development companies with adequate capital for acquiring control of promising properties to be explored and sold to operators when their value has been proved. The participation of new interests, which seems about to begin, will undoubtedly bring about a rapid quickening of the mining industry, but the development of the field has reached a critical stage, and owners of unproved or partially explored claims should remember that, though experienced operators are willing to pay good prices for properties of determined value, it can not be expected that they will make the heavy cash payments often demanded for the privilege of risking larger sums in developing mere prospects. It is commonly reported that overreaching in this direction has already done much to retard the progress of mining operations in the Juneau belt.

GEOLOGY.

The observations of the summer were confined almost entirely to the mainland opposite Stephens Passage and Lynn Canal, where a belt nearly 200 miles in length was examined with sufficient care for the determination of its main geologic features. The results of this work will be published in a report dealing with the geology and mineral deposits of the district, which will contain a topographic and geologic map of the mainland from Windham Bay to the head of Lynn Canal and the Porcupine district.

Structure.—In the mainland belt northward from Windham Bay the bedded or sedimentary formations all strike northwest and southeast, and dip, almost without exception, toward the northeast into the mountains. The igneous rocks closely follow the structure of the sediments, as a rule, so that viewed either in detail or in their general relations the rocks are found to occur in bands parallel with the general trend of the coast.

Division of the rocks.—The rocks may be grouped into three series, which are named in the order of their occurrence from southwest to northeast: (1) Black slates and black limestones alternating with green-

stones, and more or less metamorphosed; (2) highly metamorphic schists; (3) intrusive dioritic rocks, forming the main mass or core of the Coast Range.

The average width of the sedimentary belt on the mainland is about 6 miles, while the diorite zone is from 50 to 80 miles across, and therefore extends into Canadian territory.

Black-slate-greenstone series.—The series composed mainly of black slates and greenstones, with some beds of limestone, occurs all along the shores of Stephens Passage and Lynn Canal up to the crossing of the great mass of dioritic rocks about 30 miles below Skagway. It occurs also on many of the adjacent islands of the Alexander Archipelago, but its westward extent has not been determined. The slates have been derived from fine-grained carbonaceous shales, their slaty cleavage being a secondary structure produced by pressure metamorphism which accompanied folding and upturning of the rocks of the region. Carbonaceous matter, which occurred in the original shales, has been converted almost entirely into graphite, which is disseminated throughout the slates and is encountered in large amounts in some of the mines. The limestones sometimes contain graphite, but as a rule their carbonaceous matter has not been crystallized by metamorphic action, and freshly broken fragments usually give a strong odor resembling that of petroleum, which indicates the presence of hydrocarbons. Fossils of Paleozoic age have been found in the limestones belonging to the series at Taku Harbor, 20 miles south of Juneau, and lower Carboniferous forms occur in the Porcupine district, 120 miles to the northwest, but near Juneau organic remains have not been found.

The greenstones interbedded with the slates are mostly volcanic rocks, which flowed out over the surface at different periods during the deposition of the sedimentary strata in which they occur.

Schist series.—East of the slate-greenstone series, and sharply defined from it, there is a series of highly metamorphic schists, characterized by hornblende, mica, and garnet. A few bands of quartzite and limestone are intercalated in the schists, which, in connection with existing strata-like alternations in the composition of the schists, prove the sedimentary origin of the series. The schists occupy a belt about 3 miles wide opposite Juneau, but their area of outcrop narrows in both directions along the strike, and they are not found beyond 30 miles northwest of Juneau, being gradually cut out by Coast Range diorites.

Coast Range intrusives.—Beyond the schists, when these are present, but elsewhere occurring next to the slate-greenstone series, coarse granular rocks having the appearance of granite occur. These form the great mass of the Coast Range, not only opposite Stephens Passage and Lynn Canal, but throughout the corresponding mountains which border Pacific Ocean southward nearly to the boundary between

British Columbia and the State of Washington. The intrusive rocks of this zone have been grouped by Dawson under the name of Coast Range granite, and they have been described in general terms as hornblende-granites. With our present knowledge this designation can not be followed consistently, because in the portion of the belt which has been examined with more or less care by the geologists of the Survey, dioritic rocks are the rule and granites the exception.

In the Juneau district the diorites show a considerable variation not only in the main mass which bounds the sedimentary rocks, but also in the outlying arms and stocks which are intrusive in the schists and black slates. Some of the masses are normal hornblende-diorites or quartz-diorites, others are granodiorites, while an extreme variety is the albite-syenite, occurring in the Treadwell mines. In general, the rocks are closely related and similar in appearance to the granular intrusives of the Sierra Nevada.

The diorite masses generally follow the stratification of the older rocks. Locally there is a certain amount of crosscutting, and in the case of the main contact the amount of transection is measured by the varying width of the schist band, which is noted above.

The main mineralization of the Juneau belt occurred subsequent to the intrusion of the diorite, in which respect the deposits correspond in general with those of the gold belt of California.

THE GOLD VEINS.

The principal geologic features of the Juneau region have been described in the foregoing paragraphs. It seems appropriate to speak of the mainland strip which is accessible from the waters of the inland passage as the Juneau gold belt, for the reason that gold is found very generally distributed throughout the area in which the crystalline schists and the slate-greenstone series outcrop. In the former band, however, and in the main diorite of the mountains back of the coast, but little promise has been found of valuable mineralization, such veins as exist being mostly mere stringers, showing little tendency toward segregation into workable lode systems.

All of the promising prospects, working lode mines, and placers of the Juneau belt occur in the outer part of the mainland strip or on Douglas Island adjacent, either in the slate-greenstone band or in intrusive masses of diorite which lie outside of the main core of the Coast Range. In the aggregate gold-bearing quartz veins or other forms of mineralization are distributed throughout the whole exposed width of this band between its inner boundary next to the crystalline schists and the channels which separate the mainland from the adjacent islands. Although only their large geologic features are known, many of these islands contain mineral veins, and Admiralty Island, which parallels the coast for 70 miles opposite the Juneau belt, affords

indications which have warranted considerable prospecting each year. The rocks are in part lithologically similar to the slates of the Juneau belt, and the island is separated from Douglas Island by a channel in places less than 2 miles wide. The distance between known areas of mineralization on the two islands is much less than the width of the Juneau belt, and it seems that, though practically separate, the island and mainland belts are two parts of a wide zone of mineralization, divided longitudinally by Stephens Passage.

The Admiralty belt has not been studied with care, but many of its features conform with those of the Juneau belt. In both belts many of the veins and composite lode systems follow the strike of the country rocks, frequently holding to the vicinity of contacts between beds of different character, such as slate and greenstone. Composite lode systems, such as Becker has called stringer leads, are perhaps a characteristic type for the region at large, but in the Juneau belt there are many crosscutting veins which are sometimes well defined for long distances when contained in massive rocks, such as diorite, or greenstone which has not received schistose structure. In the slates crosscutting veins are seldom found, because these rocks are too flexible to break with extensive continuous fractures.

Toward the northwest both the Admiralty and the Juneau belts should appear on the west shore of Lynn Canal, the course of which is slightly diagonal to the strike of the formations. Reports of the comparatively small amount of prospecting which has been done in this region suggest that the veins occurring in the vicinity of James Bay and Endicott River correspond in a general way with the Admiralty belt, while mineralization existing on Sullivan Island lies directly in line with an extension of the Juneau belt beyond the Berners Bay district. Measured across the strike of the rocks the distance between the known deposits of the two belts is practically the same as that already noted between deposits on Douglas and Admiralty islands, and it is believed that future work in the region west of Lynn Canal along the shores of Chilkat Inlet will demonstrate intervening mineralization.

The data collected during the season have been sufficient to bear out the previously suggested existence of a main-lode system, which is now known to follow a definite geologic horizon for a long distance on the mainland. The observed facts do not warrant the further suggestion that there are other narrow bands conforming to divisions in the bedrock formations, in which profitable mineralization is to be expected throughout great distances along the strike. It seems, on the other hand, that outside of the main-lode system mineralization has been widely and irregularly distributed. Gold veins or vein complexes may follow or recur along certain beds for several miles, but no zones of limited width can be designated as specially suited for their occurrence and, therefore, as eminently favorable for prospecting. At the

same time, in the neighborhood of known mineralization further search along the strike is the most logical procedure.

The main-lode system.—The most prominent feature of the Juneau gold belt is a system of stringer leads, which resembles the mother lode of California. It occupies a band of variable width in black slates lying northeast of, that is, stratigraphically above, a thick group of greenstone beds, which includes the highest of the basaltic flows of the slate-greenstone series. This group of slates and the underlying greenstones have been traced throughout the entire length of the Juneau belt from Windham Bay almost to Berners Bay, where they are cut out by the transverse contact of the main diorite of the Coast Range, and at many points throughout this distance a great deal of veining and mineralization is found.

The greenstones are locally schistose, and where they have this structure they are sometimes impregnated along surfaces of particularly intense sheeting with sulphides locally accompanied by gold. In such cases quartz is seldom present. Elsewhere when the rocks are unaffected by secondary structure they contain stringers, or even fairly well-defined veins of quartz, which sometimes carry the same values as the veins in the main lode system.

The slates in which the quartz veins of the main lode are found bear a general similarity to those occuring throughout the stratigraphic band of which they form a part. They are highly metamorphosed, and having been originally carbonaceous now contain large amounts of graphite, which, with other secondary platy minerals, is arranged in conformity with the slaty structure of the rock. As a whole the slates are but little plicated, and their secondary cleavage follows the original bedding, which in turn is parallel with the greenstone contact. Locally, as in the Gold Creek mines, where dikes are intruded into them, there is some intricate folding, and when this feature is present the secondary structures do not conform to the original bedding, but keep their normal attitude parallel to the average position of the stratigraphic planes.

The quartz veins which compose the lode are not continuous for long distances, but occur as independent lenses, or in series of interrupted overlapping veins closely following the structure of the slates within a zone which may often attain a width of 100 feet, or again in the form of stringers filling gashes slightly oblique to the main structure, but ranged in sets along some particular horizon. Often the large lenses or stringers are joined by networks of minor veinlets which follow secondary joints arranged with more or less regularity.

MINES OF THE DISTRICT.

Gold Creek mines.—The lode system, which has been described in general terms, is most strongly developed in the vicinity of Juneau,

where the Gold Creek placers, which first called attention to the region, were derived from it, and where several lode mines are now being developed. Here mineralization is rather irregularly distributed through the black slates in a zone averaging somewhat more than 800 feet in width, running parallel with the easily recognized outcrop of the greenstone, which forms the effective foot wall of the vein system. This vein complex is well defined from the middle slope of Juneau Mountain, where recent prospecting has been in progress, through the Ebner, Humboldt, Alaska-Juneau, and Alaska-Perseverance properties to Sheep Creek divide and thence southeastward across the basin of Sheep Creek, a total distance of about 5 miles.

In the northwest half of the portion of this zone which lies in Gold Creek an important feature is the occurrence of several dikes of highly altered and sometimes mineralized rock, commonly known as diorite or brown rock. The original character seems to have been gabbro, but the rock has suffered so complete metasomatic alteration that its original nature is seldom observable.

When these dikes are present the quartz occurs mostly in the form of oblique gash stringers, which often recur along the contacts between the dikes and the slates. Locally auriferous sulphides, mostly pyrrhotite, impregnate the body of the igneous rock between the veinlets of quartz, but the values are principally in the veins. The free-milling ores, which are confined to the northwestern mines of the lode system in Gold Creek, are said to contain only small amounts of silver, the bullion sometimes running as low as 4 dollars of silver in 1,000.

In the southeastern part of Gold Creek the brown diorite dikes are smaller and more irregular, and while many cross-cutting stringers are present in the slate, a large part of the veining takes the form of interleaved stringers and irregular bunches following the slaty cleavage. Here only a small amount of pyrrhotite is found, the sulphides being principally galena and sphalerite, with a small amount of chalcopyrite. The proportion of silver varies from three to six times the gold by weight.

Formerly in working the deposits of Gold Creek the quartz was picked out and milled by itself, but this was not found profitable, and it is now realized that the only possibility of economic operation lies in the direction of mining and milling a large tonnage of unsorted material.

The average values of the ores mined in a large way and unsorted is very low, but the strength and persistence of the lode system leads to the belief that both mineralization and values will continue to any depth likely to be reached in mining.

The estimated output of Gold Creek lode mines and placers to date is $1,500,000.

Sheep Creek mines.—The lode system of Gold Creek extends without interruption southward across the Sheep Creek divide, though its physical character and its metallic contents are somewhat different. Strong and fairly continuous veins of quartz occur in the black slates for a distance of from 400 to 500 feet from the greenstone contact, and these veins, almost without exception, follow the slaty structure. Veining is prominent at four horizons, though but two of these have been systematically explored and worked. The main operations have been in the Glacier and Silver Queen mines, which have produced in the neighborhood of $500,000. The sulphides are the same as those in the adjacent part of Gold Creek, but the silver values are very much higher, and the ores are really silver ores.

Farther to the southeast, though still undeveloped, the four veins are well marked and locally mineralized, as far as the Regan group of claims, beyond which they are covered by rocky débris and vegetation in the bottom of the gulch. Where they reappear in the ridge between Sheep Creek and Grindstone Creek they are much less prominent, and probably too small and too much interrupted to be of value. This lode system does not seem to attain any importance on the opposite side of the ridge in the basin of Grindstone Creek nor upon the shore of Taku Inlet beyond.

Mines south of Juneau.—Most of the veins which have been discovered and worked south of Juneau lie on or near the line joining the mines of Gold Creek with those near the head of Windham Bay. This line trends about N. 40° E., nearly parallel with Stephens Passage, and follows approximately the extension of the contact between the upper greenstone and the overlying shales.

Southeastward from Sheep Creek no important veining is known near the contact until the vicinity of Port Snettisham is reached. On the south side of this long inlet, near Snettisham post-office, about 3 miles from Stephens Passage, there has been considerable prospecting, and one mine has already produced a few thousand dollars. Again, at Sumdum, on Endicott Arm, 20 miles farther down the coast, the black shales carry veins from which approximately $450,000 have been extracted. From these properties mineralization is fairly continuous across the intervening mountains to the head of Windham Bay.

Placers located on the streams tributary to Windham Bay were worked in a small way with more or less profit at various times between their discovery, in 1869, and 1888. In 1888 a hydraulic plant was installed to work deposits of gravel near the mouth of Spruce Creek, about one-fourth mile from the head of the bay. About the same time an attempt was also made to work a higher basin on the same creek, but these large-scale operations failed, presumably because of inexperienced management, since the possibility of making wages

with a shovel and pan along the edges of the deposits has been demonstrated.

Shuck River, the main affluent of Windham Bay, also contains good-sized gravel deposits, some of which have yielded more or less profitable returns to sluice-box mining. It is reported that a proposition is now afoot to install a dredge on this river.

The lode mines of the district have received a great deal of attention, but with discouraging results. Two sorts of deposits have been prospected—quartz veins and mineralized bands in the slates. The former are usually crosscutting, containing various sulphides and free gold, but they are extremely irregular and unreliable and are often mere stringers or bunches, as has been demonstrated in several places. There are several bands of mineralized slate that contain a large amount of disseminated pyrite which carries some gold, but these bodies have not been found sufficiently valuable to constitute even low-grade ores.

No points beyond Windham Bay were visited, but prospecting is known to be in progress in the vicinity of Hobart Bay, and it is regarded as probable that a connection will yet be established between the Juneau gold belt and some portion of the Ketchikan district, throughout which mineralization is so widely distributed.

Mines north of Juneau.—At present more attention is being directed to the northern portion of the mainland belt than to the region south of Juneau. During the summer of 1903 considerable development work was done and some promising leads were discovered, and still greater activity is promised for 1904.

Northward from Juneau the upper greenstone contact can be traced nearly as far as Berners Bay, though from Mendenhall River, 10 miles beyond Juneau, its outcrop trends less to the west than in the lower part of the belt. Between Juneau and Mendenhall River no important discoveries have been made along the line, but farther north there are important placers in McGinnis, Montana, and Windfall creeks, and the black slates next to the upper greenstones contain many quartz stringers, both in the creeks named and northward in the tributaries of Cowee Creek. In the drainage of this last stream, a few miles from Berners Bay, the greenstone and slate beds are cut off by the transverse contact of the Coast Range diorite.

Hydraulic plants were installed in McGinnis Creek and Windfall Creek early in the season of 1903, but the exceptionally dry season made it impossible to operate them and doubtless mining will begin early in the coming summer.

On the landward side of the well-defined lode system there is in the aggregate a large amount of mineralization, though present development has revealed no workable deposits. Stringers of quartz, often carrying sulphide and gold, are to be found throughout the area of

schist between the black slates and the main intrusive mass of the Coast Range, and these intrusives are also known to be mineralized locally, so that it is not improbable that workable deposits may yet be discovered.

On the seaward side of the slate-greenstone contact the number and importance of the gold veins in the northern belt is quite as great as in the principal lode system. In this region the bands of greenstone are relatively narrower than farther south, but they are more numerous, and the slate-greenstone series is therefore less homogeneous. The many contacts between the greenstone beds and the slates are frequently marked by veins which resemble the stringer leads of the main system, though they are not traceable through the same distance. Many of them are, however, well marked and practically continuous for several miles. Besides these, there are also many veins following well-defined fissures transverse to the structure of the rocks. Such cross veins are ordinarily confined to massive portions of the greenstone beds and seldom, if ever, cross the contacts with the slates, which are not massive, and therefore ill adapted for supporting continuous fissures.

Only a portion of the slate-greenstone band occurs north of Berners Bay, the upper or inland portion being cut out by masses of diorite. A broad band of this intrusive rock, separated from the main mass which forms the Coast Range by a narrow band of slate and greenstone, is present south of the bay, and, reappearing on the north side, cuts diagonally across the peninsula between Berners Bay and Lynn Canal. In this region no mineralization has been discovered in the black slates, which form the prevailing rock of the end of the peninsula. Most of the veins which have been opened within the drainage of Johnson Creek and Sherman Creek occur in the outlying band of intrusive diorites. The Jualin, Comet, Eureka, Kensington, and other properties, are all situated in this formation, most of them on veins which fill strong fissures belonging to two systems. The Greek Boy property, however, is a strong stringer lead, which occurs in the slate belt near its contact with the main diorite at the head of Berners Bay.

The combined output of the Berners Bay mines to date is estimated at about $1,100,000.

The Juneau belt can not be definitely recognized beyond the Berners Bay Peninsula, which it crosses diagonally and beyond which it strikes into Lynn Canal. Copper deposits which are reported at Sullivan Island, near the west side of the canal, nearly opposite Davidson Glacier, may represent a continuation of the belt, but the nature of the rocks and their stratigraphic position relative to the strata of the mainland toward the southeast is not known. The next known gold deposits toward the northwest are in the Porcupine district of the Chilkat drainage, 50 miles distant. The gravels which are being profitably worked on several creeks in this district are regarded as of local

origin, from the facts of their occurrence, though the actual source of their gold has not been discovered. The country rocks are mainly black slate, containing some limestone, in which Carboniferous fossils occur, but there are no massive flows of greenstone like those of the Juneau belt, and no sufficiently detailed studies have been made to warrant correlating these rocks with the slates in the southern districts. The region lies several miles from the main contact of the dioritic rocks which form a continuation of the Coast Range intrusives, and as these invading rocks are crosscutting toward the west in the vicinity of Berners Bay, it is probable that the rocks of the Porcupine field belong to the formations which carry mineral veins on Admiralty Island and on the west side of Lynn Canal, at James Bay, and on Endicott River.

Treadwell mines.—The main feature of interest on Douglas Island is the Treadwell group of mines, consisting of the Alaska-Treadwell, 700-foot, Alaska-Mexican, and Ready Bullion properties. The mines are advantageously located on the inner or mainland side of the island, close to tide water. The ore, which is of low grade, averaging about $2 in value, occurs in a series of ore bodies lying between a mass of greenstone on the hanging wall and black slate on the foot wall. The strike of the deposits and of the country rock is about N. 45° W., slightly diagonal to the shore of Gastineau Channel, which trends about N. 40° W., and the average dip toward the northeast is about 50°.

The ore bodies are brecciated masses of intrusive syenite, filled with a network of quartz and calcite veinlets, and impregnated with pyrite, which occurs both in the veinlets and in the rock itself. The gold occurs both in association with the pyrite and native, and a large, though variable, proportion of the values are saved by amalgamation. Visible specks of the metal are sometimes, though rarely, found.

The following associated minerals have been observed: Pyrrhotite and magnetite are always present, and molybdenite is of common occurrence; native arsenic, realgar, and orpiment have been noted, and arsenic is commonly found by the assayer, probably indicating the presence of arsenopyrite; stibnite occurs in small amounts with the quartz. Bullion assays indicate only small amounts of silver.

The syenite bodies which have been worked occur as somewhat irregular dikes. In the Alaska-Treadwell property two of these dikes are mined, each having a width of about 200 feet. Between them there is a band of barren slate perhaps 50 feet across, and there are some minor masses of the country rock included in the ore bodies. The south or foot-wall dike has a known length along the strike of 800 feet, and from the lenticular outline of its horizontal cross section the entire extent can not be much in excess of this figure. The hanging-wall dike has been mined continuously for a distance of nearly 2,000 feet through the Treadwell and 700-foot workings, but beyond this

toward the southeast there are several separate ore bodies of lenticular cross section, which occupy the same position under the greenstone, as is shown in the Alaska-Mexican and Ready Bullion mines. Toward the northwest only narrow dikes are present where the base of the greenstone has been prospected.

The distribution of values is irregular, as in nearly all gold deposits, but there is no suggestion of impoverishment in the deepest workings, which are nearly 1,000 feet below the sea.

While only the hanging-wall bodies of the syenite have thus far been found productive, many other dikes of the rock occur for a distance of about 3,000 feet across the strike of the black slates, toward the southwest. They are almost entirely confined to this side of the greenstone, though a few are found between it and the channel, and a large mass forms an island about one-fourth mile offshore. Along the strike the dikes extend for a distance of 3 miles, mainly northwestward from the vicinity of the mines, and the greenstone may be traced for a much longer distance in this direction.

OTHER DEPOSITS ON DOUGLAS ISLAND.

Aside from the deposits of altered syenite, the black slates are locally found to contain systems of quartz stringers or sometimes veins of fair size. One of these systems of stringers forms an extension of the Treadwell deposits, and is traceable for several miles along the mainland side of Douglas Island, and though it has been prospected to a certain extent no mines have been discovered.

Several other areas of strong mineralization are found on Douglas Island, two of which occur in the massive basaltic greenstone which forms the outer two-thirds of the island and may prove of future value. One of these is situated on Nevada Creek, about 3½ miles southwest of the Alaska-Treadwell mine, where an area of bleached rock impregnated with small cubes of iron pyrites extends about 1 mile along the creek below the main divide of the island and for a distance of about 1½ miles along the strike of the rocks. Parts of the altered and mineralized greenstone give fairly good assay, but no well-defined ore bodies have been discovered. Locally there are narrow, irregular veinlets which carry galena and sphalerite, and these are richer both in gold and silver than the main mass of the rock. A few irregular quartz veins occur, but as a rule the sulphides are not accompanied by this mineral.

The second case of mineralization mentioned above is a zone in the greenstone occurring about 1 mile west of the Treadwell deposit. The mineralized band follows the structure of the rocks and varies in width from perhaps 100 to 300 feet. It is traceable for more than a mile by the altered and bleached condition of the greenstone, through which pyrite is distributed in the form of small cubes similar to those

occurring in the Nevada Creek deposit. It is reported that gold occurs throughout large parts of the mineralized mass in amounts somewhat less than $1. Here also, as in Nevada Creek, there are occasional narrow stringers of high-grade sulphides. Several hundred feet of prospecting by means of a shaft on the Yakima group of claims has, however, developed no deposit of workable ore.

POWER PROBLEM.

Throughout the Juneau belt, and in southeast Alaska in general, the water powers now utilized are available for not over seven months in the year. Winter precipitation is almost entirely as snow, and melting is at a minimum between December 1 and May 1, so that during this period the effective run-off in most of the streams is very small or nil. Consequently auxiliary steam plants have been employed where continuous power has been needed throughout the year, and double installations must always be planned where mining and milling operations are to be carried on without interruption. However, sufficient water power for even extensive development work is seldom wanting.

The streams now used have been naturally selected because they were easily accessible, and it has thus come about that only creeks of steep grade and small drainage area are furnishing power. Many large and constant rivers exist, but the length of the ditches required and the difficulty of keeping them open in winter have thus far prevented, and probably always will prevent, the utilization of streams of low grades.

It seems at present that plants large enough to furnish power throughout the year can be installed only where favorably situated natural lakes can be turned to account for winter storage, and to tide over seasons of exceptional dryness, such as was experienced in the summer of 1903. One project of this sort now under advisement by the engineers connected with the Alaska-Treadwell and associated interests will, if successfully inaugurated, greatly reduce the already low cost of working the large bodies of low-grade ores controlled by these companies. The problem of transmission for long distances and across the deep fjords which abound throughout the region will be an important factor in deciding the practicability of any large water-power plant.

The necessity of reducing power costs, if possible, is evident from the price of coal, which is reported by the Treadwell management to be not less than $6 per ton under favorable return cargo conditions.

The existence of coal beds at several points on Admiralty and Kuiu islands has been known for many years, and early, though unsuccessful attempts were made by the Navy Department to locate workable deposits. The proximity of these localities to Juneau and the possi-

bility of establishing a coaling station, if good coal could be found and worked to advantage, has led to a great deal of private prospecting in recent years, but no minable deposits have been found. At Killisnoo it is reported that the seams are too thin to be mined economically, while at Murder Cove the coal and the rocks in which it occurs are said to be too much broken to be of value. At present, therefore, these occurrences do not promise any reduction in the cost of fuel, though a comprehensive examination of the areas in which the coal-bearing rocks occur may yet lead to valuable discoveries. The reason for this belief is that the amount of folding, faulting, and crushing in these rocks seems to vary from place to place, and if regions only slightly disturbed exist, they may contain workable coals.

Peat deposits which exist in many parts of Alaska may locally become a factor in the power problem. The fuel value of peat is of course comparatively low, but under favorable conditions it can be cut at small cost and used for making steam or, possibly with greater economy, to produce fuel gas for gas engines.

On the inner side of Douglas Island a broad bench at an elevation of about 400 feet is covered by large areas of peat, and though the material has never been prospected or tested, it apparently exists in unlimited amount and could undoubtedly be used for fuel in either of the ways suggested.

PLACER MINING IN ALASKA IN 1903.

By Alfred H. Brooks.

INTRODUCTION.

Though the development of lode mining of gold, silver, and copper is progressing rapidly, yet over six-sevenths of the value of Alaska's mineral output comes from the gold placers. No great increase of production can be expected until the mining plants now being installed are ready to begin operations. The activities of the past year have been devoted to the introduction of better equipment and to more energetic development in the larger mining camps. While no new districts have been discovered within the calendar year, the prospecting of some which had been previously only very superficially examined has placed them among those of commercial importance. In this category belong the Fairbanks district, on the Tanana; the Good Hope district of Seward Peninsula; and possibly also the Kowak placers, as they may eventually prove to be of commercial importance.

Of vital interest to placer mining, as well as to other Alaskan industries, are the improvements made in the means of communication. The completion of the military telegraph line, which now extends from Valdes to Eagle, on the Yukon, and down that river to the mouth of the Tanana, from which point one line connects with the new Fairbanks district and another with St. Michael, on the Bering Sea, is of the greatest possible importance. It is hoped that the installation of the wireless system will connect St. Michael with Nome. This, by using the Canadian line from Dawson to Skagway, and the United States military cable to Seattle, will give a complete system from Nome to the outside world. A short cable connects Juneau with Skagway. It is possible, therefore, to telegraph to many of the important mining camps in Alaska. It is to be hoped that the War Department may be able to extend this system, as it plans to do, by a cable to Valdez and another to Ketchikan.

The transportation facilities also have shown some improvement, but are still far behind the requirements of the miners. The ocean steamers now sometimes give a six-and-a-half-day service between Seattle and

Nome, but even this could be improved. It costs probably $5 per ton to land freight from the steamer at Nome—one-third of the entire expense of sending it from Seattle to the Nome beach. Last season about 60,000 tons were landed at an expense of $300,000, which can be regarded as a direct tax on the mining industry. Moreover, this is not all, for the delays incidental to stormy weather, or a late season, much increases this tax. Plans are under consideration for the construction of a pier at Nome which shall extend out to deep water. If such a pier could be built, it would be a great boon to the region. The ordinary difficulties of engineering such a structure are very much enhanced in this northern region, because it would have to be built strong enough to withstand the tremendous ice floes which pile up on the Nome beach, sometimes to a height of 100 feet.

The handling of freight at Nome is done fairly expeditiously during the good weather of early spring and summer, but is very uncertain after the stormy weather of fall begins. Freight for other points on the coast of Seward Peninsula is frequently transferred to small steamers at Nome, a very costly and time-consuming system.

The uncertainties of Yukon River traffic were well illustrated by the conditions in the summer of 1903, when low water delayed many steamers until midsummer, and, as a result, many of the supplies and equipments did not reach their destination. While there is not likely to be actual suffering because of these interruptions to traffic, yet, as a result, provisions will be overexpensive in several camps and many mining operations will be blocked. Until the Yukon placer fields are reached by a railway from the coast a repetition of such a state of affairs may be expected every year. Two railway projects have been under consideration: (1) From Resurrection Bay to the Tanana, crossing the Alaskan Range at Caribou Pass (elevation, about 2,000 feet); (2) from Valdes across the Chugach Mountains at Thompson Pass (elevation, 2,200 feet), and across the Mentasta Mountains through Mentasta Pass (elevation, 2,400 feet). Neither route presents any serious engineering difficulties, and both are known through the reconnaissance maps made by the United States Geological Survey. There are also several projects for reaching the Yukon placer fields by railways through Canadian territory.

In southeastern Alaska the transportation question is a simple one. The principal mining camps can be reached by comfortable steamer from Seattle in two to five days.

KOWAK[a] REGION.

The Kowak[b] placers, which received some attention in the summer of 1903, have produced a few thousand dollars, and the reports have

[a] The river from which this name is derived is known locally as the Kobuk.

[b] A general account of this region will be found in "A Reconnaissance from Fort Hamlin to Kotzebue Sound," by Walter C. Mendenhall, Prof. Paper U. S. Geol. Survey No. 10, 1902.

been sufficiently encouraging to cause a considerable movement of prospectors from Nome and from points on the Yukon to this far-away region. The placer gold has been found in the basin of Shingnek Creek, a small northerly tributary of the Kowak, which can be reached by a steamboat journey of 225 miles from the sea. So far as known the gold has its source in a complex of metamorphic schists, limestone, quartzites, and greenstones, which find an extensive development in the Kowak Valley. As early as 1899 gold was found on some of the creeks of this district, but it was only during the last season that actual values have been developed. It is of interest to note that placer gold was discovered some years ago on one of the tributaries of the upper Noatak, and this locality seems to lie in the strike of the formation of Shingnek Creek. The facts at least suggest that gold may have a wider distribution in this region than has been generally supposed, and lead to the hope that valuable placers may yet be discovered.

The district is not easy of access, and the workable placers must give a very large yield during the three months of open season. The summer journey from Nome to Hotham Inlet is made by ocean steamer, which must be of shallow draft, and thence by river steamer to Shingnek Creek, from which point the creeks are reached overland. As the Arctic Ocean is seldom clear of ice before the middle of July, it will hardly be possible to reach the diggings before the 1st of August. Many prospectors will reach the new camp by winter journeys with dog teams.

The valley floors and slopes are clothed with spruce, poplars, and birches up to an altitude of 2,000 feet above the sea. The miner will have to transport all his supplies with him, for game is very scarce, though there is considerable fish.

These isolated camps offer a field to the individual miner, especially if he be of that restless class which seldom remains in a district after its development has begun on a commercial scale, yet they have little effect on the gold output of the Territory. Some of these districts, like the Koyukuk, have produced gold for nearly a decade, and will continue to yield grub stakes, with an occasional small fortune. It is, however, to the larger and more accessible camps that we must look for Alaska's wealth of placer gold. These attract the engineer and the capitalist, without whose services large mining plants capable of materially increasing the output can not be installed. It is the influx of capital and experienced mining men which makes the future outlook of Alaska's development so bright.

SOUTHEASTERN ALASKA.

Southeastern Alaska is essentially a field of lode mining. The pre-Glacial gravels, which were undoubtedly more or less auriferous, were in a large measure removed during the invasion of the ice. The

gravel terranes laid down during, in, and after the glaciation, were often deposited in the deep fiords, into which the drainage channels discharge. There are, however, some post-Glacial auriferous gravels which have been, and are being, mined at a profit.

The Juneau placers had yielded large returns long before a stamp had fallen on any of its lode ores. In the Silver Bow basin is the oldest placer mine of the region, which has not been abandoned, but it was not in operation during the calendar year. A comprehensive scheme has been in course of development during the past three years to hydraulic the gravels of the Last Chance placer mine. This property includes a gravel-filled basin on Gold Creek, 1 mile from Juneau. A tunnel has been driven for half a mile, through which it is proposed to hydraulic the placers. As yet but little sluicing has been done, difficulty having been experienced in getting rid of a large mass of bowlders at the upper end of the tunnel.

Extensive hydraulic plants have been installed at McGinnis and Windfall creeks, northwest of Juneau. Some hydraulic operations are also being carried on at Lemon Creek, 10 miles northwest, and at Windham Bay, 75 miles southeast of Juneau.

The Porcupine is the largest of the placer districts of southeastern Alaska. As it lies close to the International Boundary its development has been retarded by the uncertainties of control of a part of its area. It is expected that with the settlement of this difficulty it will now take a new lease of life. A description of this district by Mr. Wright will be found elsewhere in this report.

YAKUTAT BAY REGION.

This region would not here be worthy of mention were it not for the current reports of the discovery of new placer fields. The latest report accredited Yaktag River with gold-bearing gravels, and the rumors have been sufficiently definite to attract some prospectors. It has not been learned, however, that these prospects are of any commercial importance. The fact that gold has been found in the beach placers at Yakutat and Lituya bays, where it apparently has been concentrated from glacial material by wave action, points to the conclusion that there are gold-bearing formations somewhere in the St. Elias Range. It is known that metamorphic and crystalline rocks do occur in this range, and this is suggestive of the conclusion that some of the auriferous formations of southeastern Alaska find their extension in these high mountains. Additional weight is given to this point of view by the fact that the western extension of these mountains is found to be gold bearing, to a limited extent at least, along the lower reaches of the Copper River Valley and its tributaries. The writer does not wish to convey the impression that this range will necessarily become a locus of commercial placers, for the following facts would argue

against such a conclusion: (1) Though considerable prospecting has been done in this region, especially along Alsek River, whose valley crosscuts the range, gold has been found only in small quantities; this evidence is, however, purely negative; (2) the extensive glacial erosion and the great deposits of glacial drift, as well as the presence of many large glaciers, would not seem to present favorable conditions for the concentration of gold in placers.

COPPER RIVER BASIN.

Unconsolidated Pleistocene[a] gravels and sands are extensively developed in the Copper River basin, and many of these are auriferous. In relatively few of these deposits has the gold been sufficiently concentrated to be of commercial importance. The Chistochina district, in the northern part of the basin, where developments have been going on steadily during the past year, is the only one which has produced any considerable amount of gold. What would seem to be the eastern extension of the gold-bearing series has been found in the headwaters of the Tanana, but it has not yet been proved to carry commercial values. Gold has also been found to the west of the district, but up to the past summer not in commercial quantities. Rumors of important discoveries on White and Slate creeks, which are said to lie in the upper Sushitna basin reached Valdes late in the summer, and parties are said to be now en route to these diggings with dog teams. These placers are reported to be drained by streams flowing into East Fork of the Sushitna, and to lie 200 miles from tidewater. What is known concerning them is too vague to permit of speculation in reference to their importance, but their position would indicate that they lie in a zone which elsewhere has been found to be auriferous.

Little has been heard of the placer fields in the southern part of the Copper River basin. These, which embrace Nizina River, the Tiekel, and the Tonsina, while they have given sufficient indications to attract mining men, as far as known have not yielded gold in commercial quantities during the last year.

COOK INLET REGION.

The Turnagain Arm placers, which have been exploited since 1895, lie in the drainage basins of streams which empty into the head of Cook Inlet both from the north and the south. The district may be reached by a ten-days' ocean journey to Tyonok or Homer, and thence by small steamer to Sunrise. Most of the placers are within 10 to 20 miles of tidewater. There is little to add to the statements concerning this district in last year's report.[b] The improvements have been of a

[a] Mendenhall, W. C., and Schrader, F. C., The mineral resources of the Mount Wrangell district, Alaska: Prof. Paper U. S. Geol. Survey No. 15, 1903.

[b] Brooks, A. H., Placer gold mining in Alaska in 1902: Bull. U. S. Geol. Survey No. 213, 1903, p. 48.

character requiring heavy investments of capital. Several hydraulic plants have been, or are being, installed.

A large deposit of gold-bearing gravels is reported at the upper end of Tustumena Lake, in the central part of Kenai Peninsula, the promontory which separates Cook Inlet from the Pacific. These placers, which are from 20 to 30 miles inland, are said to be of sufficiently high grade to be workable by hydraulic methods, and a plant was installed during the past summer.

KUSKOKWIM AND MOUNT McKINLEY REGION.

The large area which is blocked out by Cook Inlet on the east, the Tanana and Yukon on the north and west, and Bering Sea on the south, and which is drained chiefly by Kuskokwim River, has been but little explored. It has been traversed by a few of the parties of the Geological Survey,[a] but much of it is practically unknown. Spurr reported evidence of mineralization in the Tordrillo Mountains and colors of gold in streams which head in these mountains. Prospectors, too, have entered this region, and now and again come reports of the discovery of rich placers, but up to the present time these have not been verified. Gold has long been known to occur on the upper waters of Mulchatna River, and the easterly fork of Nushagak River, emptying into Bristol Bay, but has not yet been found in workable quantities. These placers are said to yield $4 to $5 a day to the man, but their inaccessibility makes them of no commercial value. In 1900 the news of the discovery of gold near the lower Kuskokwim caused a small stampede from Nome. The scene of the find, which proved to be of no importance, was on one of the small streams which flow into Kuskokwim Bay from the east.

The latest reports of placers in this field locate them in the vicinity of Mount McKinley. Several parties of prospectors ascended Kantishna River, a southwestern tributary of the Tanana about 100 miles from the Yukon. These men report the presence of auriferous placers in the Kantishna Basin, near the foot of the mountains. The writer, who traversed this region in the summer of 1902, is unable to substantiate this report. Of the streams which flow into the Kuskokwim from the Alaskan Range few, if any, even carried colors. In some of the streams of the Kantishna drainage system, however, some colors were found, and there was other evidence of mineralization. It seems at least possible that this field may yet produce placer gold.

SEWARD PENINSULA.

Seward Peninsula, from the standpoint of production and of early increase of production, is still the focal point of Alaskan mining inter-

[a] Spurr, J. E., A reconnaissance in southwestern Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1901, pp. 31–264. Brooks, A. H., A reconnaissance in the Mount McKinley region (in preparation).

ests. In 1902 the output of all the camps of the peninsula was about $4,500,000, and was probably about the same in 1903, but the statistics have not yet been compiled. This will bring up the value of the entire gold production of the peninsula since 1899 to over $20,000,000.

Though placers are widely distributed in Seward Peninsula, yet probably somewhat over four-fifths of the gold mined has come from two districts, the one lying immediately adjacent to Nome, and the other tributary to Council City. These facts must be taken as evidence rather of the greater developments in these two camps than of the greater richness of their placers. Though there are probably few placers in the peninsula in which the gold is as concentrated as in those of Nome and Ophir Creek, yet there are many undeveloped or little-developed prospects which give promise of yielding very large returns. It is certain that the field is far from having reached its maximum output, for in relatively few of the districts have mining methods been introduced which would give large returns. During the excitement of the years 1899 and 1900, the pick and shovel, with the rocker and short sluice box, held sway, and these primitive methods are still in use on the majority of the creeks. With their aid many a broken-down miner and prospector has retrieved his fortune, but capital is often chary of entering a field where such methods are in use, because they are suggestive of pocket mining, and large enterprises are in many cases delayed. Then, too, the general public has so often undergone losses in this field through ill-planned or downright swindling mining schemes, that it looks with well-merited suspicion on new ventures. With the successful execution of some extensive mining operations this conservatism is being rapidly overcome, and mining men of experience and reputation are finding it less difficult to secure backing for legitimate undertakings.

Mine operators are now thoroughly alive to the fact that an abundant and reliable water supply is the first requisite to large mining operations. The experience of the past three years has settled the question of depending on local and periodic supplies of water. To the experienced hydraulic miners of other regions it may seem strange that this lesson had to be learned again at Nome. It should be remembered, however, that Nome was first developed by men who were trained in the early days of the Klondike, when gold was taken out by the crudest methods. There were many who believed that it would be impossible to build and maintain ditches at anything but a ruinous cost, but this has been disproved. There are now nearly 100 miles of ditches in successful operation on the peninsula, and an equal mileage has been surveyed and is partly under construction. Experience has shown that, except for the difference in wages, the construction and maintenance of ditches is not more expensive in the Nome region than in many more favorably located districts. The original

cost can be roughly approximated at from $1,000 to $2,500 per mile. It has been proved that, at the present high cost of fuel, it is usually cheaper to obtain water by ditches than by pumping.

The fuel problem is a serious one, as coal at Nome still commands about $25 a ton, and is never below $20. Gasoline and petroleum engines are extensively used. Gasoline retails at about 25 cents a gallon. During the last season petroleum tanks were built at Nome which were filled directly from tank steamers and were connected by a pipe line with some of the placer camps of the vicinity. This introduction of petroleum, handled in a large way, may revolutionize the fuel question. Another proposition is to convert into fuel the thick mat of vegetation which covers the surface of the tundra. This material, which is a form of peat, burns readily when dried, but its utilization as fuel has not been attempted on a commercial scale. On the north slope of the peninsula a small body of lignitic coal has been developed which, though not of high grade, has found ready market in the neighboring mining camps.

The deeply scoured glacial valleys of the Kigluaik Mountains, which lie about 40 miles north of Nome, afford an abundant water supply, which has been and will be an important factor in the development of placers both north and south of the mountains. Several ditches have already been built to these mountains. The same highland belt also contains much undeveloped water power, and plans have been formulated to convert this into electric energy and to supply camps all over the southern part of the peninsula with both light and power. The promoters of this enterprise believe that they can thus, by the use of pumps, successfully compete with the water-supply ditches.

The idea that hydraulicking gravels in this northern region was not practical from a commercial standpoint has been effectually dispelled. Even where the gravel was frozen solid, which is not by any means universally true, it is possible, by using sufficient head, to break up the frozen alluvium. Moreover, after the thick coating of muck and vegetation, which is nonconductive, is removed, thawing takes place rapidly during the long days of the arctic summer.

While hydraulic mining in this northern latitude contends with many difficulties, these are by no means so great as is ordinarily believed. Wages are $5 a day with board, the halcyon days for the pick and shovel men of $1 to $1.50 an hour having long since passed. Freight rates to Nome last spring were $15 a ton, including lighterage. Later in the season a combination was formed among the ocean vessels, and the rate was doubled. During the season of 1903 there were 26 steam vessels, small and large, and 7 schooners, which carried about 75,000 tons of cargo to Seward Peninsula ports.

The cost of water transportation between coastal points fluctuates greatly. The figures secured from half a dozen sources indicate a rate

of from $7 to $15 a ton per 100 miles by steamer, with an average of about $10. Freight is carried at much lower figures by small gasoline sloops and schooners, and these are particularly well adapted to this work because they can anchor close to the beach and can enter the mouths of the larger rivers. During the past season there were four small steamers with 50 to 200 tons capacity and half a dozen gasoline sloops and schooners of from 5 to 15 tons burden engaged in the coastal transportation.

Overland transportation with horses is very expensive, but varies greatly. According to best reports it varies from $10 to $16 per ton a mile, and will average $13. The railways carry small lots of freight for about $3 per ton a mile.

Navigation opens in the spring between May 25 and June 15. Surface mining operations can usually be carried on through the months of June, July, August, and often until the first of October. It is fair to assume that three months of sluicing can be counted on if a reliable supply of water is available. It should be borne in mind that this season is not so very much shorter than in many a placer camp in western United States. Taken all in all the conditions of mining are not so unfavorable as is often represented.

Reference has been made to the transportation facilities on the peninsula, which are still far from adequate for the mining industry. The only important improvement made during the past season was the construction of the Solomon and Council City Railway. About 10 miles of this well built standard-gauge road has been completed, together with terminal facilities, and plans are under way to push the construction next season. The road to Council will have a length of about 50 miles, and extensions are planned by the same company. This is really the first attempt to permanently solve the transportation problem. The Wild Goose Railway, which is narrow gauge, extends from Nome to the head of Dexter Creek, by way of Anvil Creek Valley, and has benefited the mining interests very much. Some wagon roads have been constructed on the peninsula, but most of the teaming is done across country or along the beach and stream bottoms, and, as has been shown, is enormously expensive.

The question is often asked, What minimum limit of value can profitably be exploited in this northern field? There are so many factors which have to be considered that no categorical answer can be given to this query. A placer which is close to tide water can be mined much more economically than one at a distance, where it costs $10 to $15 per ton a mile to transport equipment overland. Again, a low-grade gravel can often be worked, if it is near a bonanza, because the same ditch may supply water to both properties. After ditches have once been constructed and paid for by the yield from very rich ground, the water they supply may be utilized profitably to exploit deposits of

lower grade. Statements in print are not infrequent from which it would be inferred that only bonanzas can profitably be exploited in the Nome region. Pay streaks which have yielded $30 to $40 and even $100 per cubic yard are not uncommon, but these do not form any considerable percentage of the auriferous gravels which carry values. Much profitable mining is done in gravels which will not average over $3 and $4, and if the facts were known it would be found that probably much ground of lower grade is even now being worked. The cost of mining is being rapidly reduced, and it is fair to presume that eventually values of $1 and possibly 50 cents per cubic yard can be mined with profit.

Some plants have been installed for dredging with bucket dredge or with steam shovel, but these enterprises have not yet yielded any considerable amount of gold. Probably the most successful of these plants so far are those which have been operated on rich portions of the beach, where the material handled was entirely loose and no difficulty was experienced in disposing of the tailings. Beach mining is still carried on, but is almost a thing of the past. The gravel plain, or tundra placers, which lie within a few miles of Nome, have not received the attention which their importance is believed to warrant. Extensive prospecting with churn drills has demonstrated the presence of gold in these deposits, a conclusion which had previously been arrived at from purely geologic lines of reasoning, based on the investigations of the United States Geological Survey.[a] In the reports of 1899 and 1900 it was pointed out that old beach deposits would probably be found in this tundra belt, and this theory has since been substantiated by the discovery of an old beach deposit which has been mined at a profit. It was also shown that auriferous gravels would most likely be found at other points in the tundra, which while of lower grade might profitably be exploited. These latter deposits have been mined along the courses of some of the streams with the aid of steam shovels and dredges, but in general it can be said that entirely successful methods of exploitation have not yet been elaborated.

Underground or drifting operations form another phase of mining at Nome, which has yielded large returns. This has been carried on to a limited extent in the tundra belt, but only during the winter, when operations were not hampered by the surface drainage. The more important drifting has been on the high-bench gravels in the divide between Anvil, Dexter, and Dry creeks. Attention was called to these high gravels in the Preliminary Report of 1899,[b] but they were not exploited until 1900, and have since then yielded large returns. The

[a] Compare Schrader, F. C., and Brooks, A. H., Preliminary Report on the Cape Nome Gold Region: Special Reports on Alaska, U. S. Geol. Survey, 1900; and Brooks, A. H., Richardson, G. B., Collier, A. J., and Mendenhall, W. C., A Reconnaissance of the Nome and Adjacent Gold Fields in the Seward Peninsula in 1900: Special Reports on Alaska, U. S. Geol. Survey, 1901.

[b] Schrader, F. C., and Brooks, A. H., op. cit.

gravels are from 40 to 200 feet thick, and are usually frozen, so that neither shafts or drifts require any timbering. There are some 20 shafts and several miles of underground workings in the gravels. The pay streaks, of which there are frequently two or more, one above the other, usually run in narrow channels, so that no great amount of stoping is required. The sinking and drifting in the frozen ground is all done with the aid of steam thawers, and many of the mines are provided with steam hoists. Pumping has not been found necessary, as the workings in the frozen ground are practically dry. This mining can be carried on throughout the year, but the operations are often confined to winter months, when miners wages are 50 per cent lower than in summer. The winter accumulation of gravel is washed out in the spring, when water is plentiful. Some of the high-bench placers have proved very rich, and as no large investment is required for plants they are very profitable. Similar high-bench gravels occur at other localities, and some of these are known to be auriferous, so it is fair to assume that other high-bench placers will be discovered.

Briefly considering the results of the past year in the peninsula, it is found that the extensive developments were confined to the Nome and Council City districts, and consisted chiefly in the introduction of mine machinery and equipment. Hydraulic lifts have been installed on Glacier and Anvil creeks in the Nome district, and many claims are being worked by hydraulic sluicing. Water for these operations is furnished by the Miocene and some smaller ditches, as well as by two large pumping plants. The coming season will witness the construction of a number of additional ditches in the Nome district, some of which have already been begun. One of these, to supply the placers on Hastings Creek, will be built to Flambeau River, a distance of about 15 miles. Another is planned to furnish water to the Cripple River mines. The drift mining on the high benches, already described, has been actively pushed. In the Eldorado basin some mining is being done on Venetia Creek, and across the divide to the north Iron Creek and other tributaries of the Kruzgamepa have become important gold producers.

The Council City or Ophir Creek district is second only to Nome in importance. A narrow-gauge railway connects the camp with navigable waters on Niukluk River. Several ditches are in operation, and the equipments include three hydraulic elevators, several inclines, and derricks. One steam shovel and one dredge were in operation on the bars of Niukluk River. The Koksuktapaga Basin includes many promising placers, but their exploitation has not been commensurate with their importance because of the lack of transportation facilities.

Two steam dredges were operated last season in the gravels of Solomon River, and sluicing was done on a number of tributary streams. A ditch has been projected, while the building of the Solomon and

Council City Railway promises to be of the utmost importance for the region. At Topkok the completion of the 12-mile ditch has renewed the mining activities, which have lain dormant while it was in construction. This will furnish water for sluicing a large amount of gravel, not only in the Daniel Creek basin, the immediate objective point, but also in adjacent creeks.

In the Kugruk basin Harris, Homestake, Northfork, and Dahl creeks, as well as the main river bed, were worked in the past season, but operations are not so extensive as they would be if the region were more accessible. The Kotzebue region, lying to the northeast, is the subject of a paper by Mr. Moffit which is printed elsewhere in this volume.

The streams flowing into Grantley Harbor from the north have long been known to be gold bearing, but as the gravels are not of very high grade their exploitation has been dependent on the installation of a hydraulic plant. Surveys for a ditch have been completed, and it is expected that a plant will be installed during the coming season.

In the Bluestone region Gold Run, Alder, and Bering creeks were worked. Several small ditches, the longest 2 miles in length, supply the diggings on the Alder and the Bluestone. The high benches have been exploited with promising results in some instances, and a large ditch from the Kigluaik Mountains to provide hydraulic power for the whole region is projected.

QUARTZ MINING IN SEWARD PENINSULA.

While it is no part of the purpose of this paper to discuss the auriferous quartz ledges, yet, in view of the great interest in this matter it seems worth while to add a note on these. Quartz veins which carry from a trace to $8 or $10 in gold are not uncommon in the peninsula, but only very few have been found whose values are high enough to give promise of profitable exploitation under the present economic conditions. In the Solomon River country a 10-stamp mill has been installed to work a free-gold quartz from a lode which has been opened up. The lode, which includes three distinct veins, has been developed sufficiently to insure ample ore for running the mill, and the enterprise seems assured of success. Other quartz veins of a similar character in this region are being prospected, and some carry values and give promise of being at least as valuable as the one already developed.

In the Nome region proper many ledges have been staked and a few trenches and a pit sunk, but no attempt has been made to systematically and properly prospect any ore body. Samples have often been gathered at haphazard, so that the assay returns do not necessarily carry conviction. In the Ophir Creek region also many quartz veins have been located, but, as in the Nome region, no systematic prospecting has been done.

During the placer mining, large surfaces of bed rock are often stripped, disclosing at several localities the presence of a large number of small quartz veins which on assay are found to carry values. These veins are found both following and crosscutting the foliation. In some instances observed by the writer well-defined fissure veins crosscut the country rock and sent out offshoots which penetrate the walls along lines of cleavage to a distance of several yards from the main vein. These offshoots the prospectors term "blanket veins," and entirely overlook their subordinate character.

In one class of veins the gangue is chiefly quartz and in another largely calcite. In veins of the second class, the gold seems to be free, while the first promises to run into a base ore below the surface weathering. The first class of ore carries considerable arsenopyrite. It seems entirely possible that deposits may yet be found where a zone of country rock has been so permeated by these veins that the entire belt may be regarded as an ore. The values would, however, have to be much higher than in most of those now known to make an ore of commercial value. Large quartz veins, mineralized with pyrite and often auriferous, are not uncommon in Seward Peninsula, but few of these carry commercial values.

On the whole, it can be said that the outlook for quartz mining in Seward Peninsula is far more hopeful, now that more ground has been stripped, than it was a few years ago. It is well worth while to make careful search for lodes, but the greatest conservatism should be exercised when such lodes have been found. A vein must be well opened and thoroughly tested before any equipment is installed, and only after ore enough has been exposed to pay for the mill is it time to think of establishing a milling plant.

The excitement last fall at Nome about quartz mining promised the usual harvest of ill-advised, to say nothing of stock-jobbing, enterprises. The staking of many of the quartz claims has been of such a character that, where veins of value are opened, nearly every claim will run the gauntlet of law suits, and must be expected to pay the usual tribute to experts and attorneys.

THE YUKON BASIN.

Placer mining was carried on in all of the old camps of the Yukon and its tributaries during 1903, and the Fairbanks district on the Tanana has been added to those of commercial importance. An account of the Fairbanks district by Mr. Prindle will be found elsewhere in this bulletin. In but few creeks have any large enterprises been inaugurated, but in many there has been considerable improvement in mining methods. The annual output of the Alaskan Yukon can be estimated at between $800,000 and $1,000,000, which is likely to be materially increased with the opening up of the new Fairbanks district

and the more systematic exploitation of the older ones. This output is chiefly distributed in small amounts, running from a bare grub stake of $1,000 to $20,000. Few attempts have been made to work groups of claims by improved methods.

The general backwardness of the Yukon field compared with that of Nome is, of course, in a large measure due to the differences in values, but must also be assigned to the isolation of the region. So long as developments are dependent on the present inadequate transportation facilities the region will be handicapped. With the uncertainties of the river-steamboat service, the entire absence of roads, and the scarcity of trails, the placer miners of the Yukon district have had to face conditions which would have utterly disheartened less resolute men.

Freight rates from Seattle to Yukon River points are from about $40 to $65 per ton, and the first up-river steamer from Bering Sea can not be counted upon before the 1st of August. The cost of the summer freighting from the banks of the Yukon to the mining camps, which is all done by pack horses, can be roughly estimated at $10 per ton a mile; while the winter rates, when the traffic is carried on by means of horse and dog sleds, are from $2 to $3 per ton a mile. It must be remembered that some of the placer camps are from 40 to 50 miles distant from water transportation, and that this haulage greatly increases the necessary outlay of time and money for installing a mining plant. There are scores of creeks, if not hundreds, in the Yukon country, which will be worked when the transportation problem is solved.

The construction of roads is properly a function of a territorial government, but as Alaska has no representative government, and is administered to all intents and purposes as a colony, its mining interests must look to Congress for legislation, and probably appropriations, for road construction. Their cost could, however, be met by a tax on the properties which they would benefit. It has been suggested that the yearly assessment work required by law on each claim could well be commuted in part to a money tax, to be spent on roads. It is estimated that roads could be built in the Yukon country at an average cost of $1,000 to $1,500 per mile. Many a mining camp in the region has already spent on the transportation of its supplies more money than the cost of a wagon road. It is roughly estimated that 700 miles of wagon roads in the Yukon and Copper River regions would put nearly every placer camp within reach of reasonable transportation facilities. A million dollars might well be spent in such a manner, for there would be a certainty of an increase of the gold output sufficient to warrant such an expenditure. The building of roads in the Klondike district by the Canadian government has much accelerated the development of the placer mines in that district.

The writer would make the following provisional suggestions for the location of Government roads to develop the placer fields as they are now known: (1) A road from Eagle to the Tanana, the Chistochina, and to Valdes, on the coast, a distance of approximately 400 miles. This probably should follow the present well-established trail, which is used as winter and summer mail route. The most important part of the road would be that between Eagle and the camps of the Fortymile region. An alternate route would be to Fairbanks, on the Tanana, from Copper River by way of the Delta River Valley, a distance of about 300 miles. (2) A road to extend from Circle, on the Yukon, through the Birch Creek and Fairbanks district to the Tanana, a distance of about 150 miles. (3) Rampart, on the Yukon, to be connected with the mouth of Baker Creek, on the Tanana, by a road which would open up the Minook and Baker districts, a distance of less than 50 miles. (4) A hundred miles or so of road to be built in the Koyukuk region to connect the gold-bearing creeks with the head of steamboat navigation on Koyukuk River. It is believed that these roads would form a system of main arteries by which most of the placer fields could easily be reached, and that the production of the mines would thereby be so much increased as to fully justify the expense. In case a railway were built to the Yukon, this plan should be somewhat modified, but there would still remain an urgent need of roads.

During the year 1903 work steadily progressed in the Fortymile district, though the dry season made the output less than it would have been had there been ample water supply. On Chicken Creek, one of the oldest of the district, work was extended to an examination of the benches and was rewarded by finding good pay gravel 275 feet above the water level. Much work is being done by drifting with steam thawers in the frozen ground, a method now carried on throughout the year. Use is being made of both steam and horse hoists. On Wade Creek a steam hoist is in operation, and bed-rock drains have been put down on several claims to enable working by the open-cut system rather than by drifting. On Walker Fork a steam scraper and bucket conveyor are being used on one claim. Most of the claims are worked by open cuts. Some winter work is being done on the bar at the mouth of Franklin Gulch. At the so-called "Kink," an ox bow meander of the North Fork of Fortymile, and about 50 miles in an air line from the Yukon, a strong company is engaged in turning the course of the river, so as to leave exposed about 2¾ miles of its bed. This it is proposed to mine with a steam shovel.

On American Creek a large plant has been installed, including a flume, giving a 150-foot head and power to work two hydraulic elevators. Scarcity of water prevented the extensive operation of this plant. On Seventymile River two hydraulic companies were prospecting in the past season, but no sluicing has been done. A small hydraulic

outfit was operating at the falls on Seventymile, and a little grub-stake mining was done on this stream, as well as on Woodchopper, a few miles to the northwest, where a steam thawer was used.

In the Birch Creek district, where there was ample water, Miller Creek was worked in a small way, as was Eagle Creek, which carries the purest gold of the district. On Deadwood Creek, where ground sluicing has been resorted to, the bed is largely worked out, but good values have been found on the benches. On Mammoth Creek a steam shovel is being used, while on the Mastodon some experimenting is being done with machinery and the benches here are beginning to receive attention. There were about 500 men in the entire Birch Creek region in the summer of 1903.

The Rampart region includes several creeks where operations are being carried on. A small hydraulic plant has been installed on Hunter Creek and others are in process of erection. On the Hunter the pay gravel is said to be on a bench 20 feet above the creek and is covered by 20 feet of muck. The gravels are frozen, but when a face is exposed it thaws out at the rate of a foot in 24 hours. When stripped the sun's rays thaw it to a depth of 10 feet in two weeks.

The dozen creeks which were worked in the Koyukuk diggings have done well during the past season, having produced upward of $300,000. The heavy rains interfered greatly with the work on some of the creeks, especially Hammond River. Provisions and equipment are still very expensive. The transportation charges are $100 per ton from Seattle to Coldfoot, which is nearly 100 miles from some of the placers. There were about 300 men in the district, many of whom came out in the fall. Wages are from $8 to $10 a day.

As this article goes to press, well-authenticated news comes from Alaska of a "stampede" to the White River region. It probably will take a year to find out whether this is based on the actual discovery of placer gold, or is simply another one of those wild scrambles which are perennial in the northland. The new placer field is reported to lie partly on the Alaskan, partly on the Canadian, side of the boundary, but has not been more definitely located. The writer, who explored the Tanana and White River basins in 1898 and 1899, found evidence of the presence of mineralized zones in a belt of schists which should cross the White River Valley about 100 miles from its mouth. Traces or gold were found[a] both in the bed rock and the stream gravels, but not in commercial quantities. It seems altogether possible that somewhere along this belt workable placers may be found. In the fall of 1903 the discovery of gold placers in the Tanana basin was reported to the writer by prospectors who had been examining the region in which these mineralized schists form the bed rock.

[a] Brooks, A. H., A reconnaissance in the Tanana and White River basins, Alaska, in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 485–483.

This discovery, so far as the writer is able to determine its position, must lie near the district to which the stampeders are now directed. So far as anything is known of the region, there is at least some basis for the opinion that placer gold may be found in it.

White River is navigable only for small boats, and then only with great difficulty. A small launch could be used on the Tanana above the Fortymile trail crossing. The region can be conveniently reached with pack horses from Dawson, Fortymile, or Eagle, but there are no trails. Grass is usually abundant in the summer months. White River would be exceedingly difficult to cross with horses, except close to its source.

THE PORCUPINE PLACER MINING DISTRICT, ALASKA.

By CHARLES W. WRIGHT.

GENERAL DESCRIPTION.

The placers of Porcupine Creek and vicinity, discoverd in 1898, are now coming into prominence as gold producers. Porcupine Creek, a stream about 5 miles in length, enters Klehini River from the south 12 miles above its junction with the Chilkat. Geographically it lies just north of the fifty-ninth parallel of latitude and approximately at 136° 20′ west longitude. The camp is situated at the mouth of the creek, 35 miles in a straight line northwest of Haines Mission, on Lynn Canal, but by the river route the actual traveling distance is about 45 miles.

The surrounding region may be described as a high plateau, dissected by numerous deep and narrow valleys, so that its general aspect is rugged and mountainous. The average elevation of the summits is about 5,000 feet above sea level, the mountain slopes being rounded and glaciated, with no abrupt benches or terraces. The valley of the Klehini is a flat-bottomed gravel flat, averaging one-fourth mile in width. The creeks, such as the Porcupine, are characteristic mountain streams, cutting deep canyons into the hillsides, and many of them are fed by glaciers.

Of the creeks tributary to Klehini River, Porcupine Basin contains the only deposits of gravel which have proved remunerative up to the present time, though prospects have been found on Glacier Creek, 3 miles to the west, on the Canadian side of the provisional boundary. The recent boundary decision throws Glacier Creek into Alaskan territory, and this will probably lead to the early development of its placers by the United States citizens who have claimed the ground for several years.

This gold field was formerly reached by the Dalton trail, but this is now seldom used. Most of the freight is taken up the Chilkat in Indian canoes to a cache opposite Wells, at the mouth of the Klehini, and thence by wagon to Porcupine City, a distance of 10 miles.

GENERAL GEOLOGY.

A few miles north of Klehini River is the edge of a belt of intrusive rocks 80 miles or more in width, striking northwest, and composed principally of diorite. Adjacent to this on the south is a zone 8 miles in width occupied mainly by folded and metamorphosed black shales and limestone, which trend parallel with the general northwest-southeast course of the diorite contact. Fossils of lower Carboniferous age were found in a stratum of limestone on Porcupine Creek. The upper part of the Porcupine cuts into a belt of quartz-diorite 2 to 4 miles in width, also striking northwest-southeast, parallel with the Klehini Valley, beyond which toward the southwest no observations were made. This intrusive mass extends eastward to Cottonwood Creek on Salmon River, where it disappears. Several greenstone dikes were observed crosscutting the slate country rock, but the relative age of these and the diorite could not be determined, as the two were not found near the contact. An interrupted zone of mineralization carrying large amounts of iron sulphide and intersected by narrow veins of quartz and calcite, also mineralized, occurs in the sedimentary series, and from this zone the placer gold has probably been derived.

SOURCE OF THE PLACER GOLD.

It has been generally believed by the discoverers and operators of Porcupine and Nugget creeks that the gold contained in their gravels has been transported from some region outside the district. The supposed necessity of this view is urged from the coarseness and worn condition of the nuggets and from the failure to find coarse gold or more than small amounts of the free metal in any of the local veins.

The distribution of the placers is, however, distinctly against this view and favorable to a local origin. If the occurrence of gold in the gravels is due to glacial or water transportation there is no reason apparent for its concentration in one stream and its absence from adjacent gulches. This localization and the fact that pay gravels are not found in the upper portions of the gold-bearing creeks, beyond the area of mineralization or where they enter the diorite intrusive belt, strongly suggests that the gold has been derived from the surrounding country rock.

Besides the creek gravels, there are important auriferous bench deposits filling abandoned channels a few hundred feet above the present creek bottoms. These not only furnish workable placers, but have also contributed some of their nuggets to the gulch gravels through the tributary streams which have cut into the deposits and effected a reconcentration of their gold. This suggests an explanation for the occurrence of rich deposits in potholes and the irregular distribution

of gold in the gravel beds. These high benches will be more fully discussed in the complete report on this placer district.

DEVELOPMENT.

The Porcupine placer diggings date from the summer of 1898, when they were discovered by three prospectors en route to the interior over the Dalton trail. After the rush to this creek in 1898 and 1899 there was but little development until 1900, when several of the claim holders bonded or leased their properties, while others formed companies in order to obtain means to operate on a large scale. The peculiarities of occurrence here require a still further combination of interests for economic exploitation, and negotiations are now being made to bring the entire creek under a single management. The only claims being developed at present are the Cranston and Discovery, on Porcupine Creek, and the Chisholm and Woodin claims on McKinley Creek. To work the creek gravels it is first necessary to divert the stream into a flume built to one side of the channel, then to install a derrick to remove the large granite bowlders, some of which weigh several tons and have to be blasted. After this a hydraulic plant must be built.

On the lower claims very little work has been done owing to the depth of the bed rock. The first property worked was the Cranston claim, about 1 mile above the mouth of the creek. Here a bench deposit, which is said to carry good values, is being hydraulicked into a sump cut into the bed rock 40 feet below the surface, from which a bucket elevator, operated by water power, lifts the gravel to the sluice boxes above. At the Discovery claim the gravel deposit is about 12 feet deep and is reported to carry high values. The creek has been turned through a large flume and at present an elevator is used to lift the creek gravels, but eventually they will be worked through ground sluices.

On McKinley Creek, an eastern branch of the Porcupine, which flows in a canyon-like valley, the beds of stream gravel are very narrow. On the Chisholm claim, not far from the mouth of the creek, the placers are being worked by the ground-sluicing method. A long flume has been built along the side of the creek, and is so regulated that the water can be turned back into the creek channel from time to time and the smaller gravels washed downstream, thus removing the upper wash and concentrating the gold in a shallow deposit on bed rock from which it is easily recovered.

The operators of the Woodin claim, one-half mile above the Chisholm claim, are hydraulicking a bench deposit of a channel 150 feet above the creek. One troublesome factor here is the occurrence of a capping of gravel cement 3 feet thick. This can not be disintegrated by the hydraulic nozzle, which throws a 200-foot stream of water,

and it is difficult to break it even with hammer and pick. The occurrence of a bed of glacial mud also entails the loss of much fine gold in the sluice boxes.

Placer gold is found in workable deposits from the mouth of Porcupine Creek to McKinley Creek, its eastern tributary, a distance of 3 miles, and from this point for a mile or more up McKinley Creek. The total production of the Porcupine basin since its discovery is estimated to be $450,000.

Beyond the divide at the head of McKinley Creek lies Salmon River, fed by numerous glaciers. In character its valley corresponds to the Klehini, with its vast gravel bed over one-half mile in width. The gold discoveries here are of more recent date than those of the Porcupine, and actual development work was first attempted during the summer of 1902. Fine colors may be panned from almost any place along Salmon River, but the coarse gold is all found in a few of the tributary streams on the north bank. Nugget Creek, 20 miles from the mouth of Salmon River, is the center of placer digging, and, on the creek, Discovery, two claims above the mouth, is the only holding which has received much attention. The gravels on this stream are worked by the same method that is used on the Porcupine, though the creek is much smaller and less difficult to control. On the north side of Salmon River between Nugget and Cottonwood creeks, a distance of nearly 2 miles, there is a wide bench deposit 50 feet above the present river, on which eight claims have been staked. From several pits an average of 25 cents per cubic yard is reported. Plans are being made to mine this extensive gravel bank and also to install large dredges to work the bed of Salmon River. It is believed that these deposits will yield favorable returns.

On Bear Creek, a west fork of the Chilkat, is a third placer camp, 40 miles north of Chilkat Inlet. Since its discovery in 1900 the camp has been almost abandoned, largely through difficulties arising from American ownership of claims along the creek, which is situated on the Canadian side of the provisional boundary. As it is now in Alaskan territory, claims have again been staked and operations will begin in the spring.

Further prospecting and investigation of the surrounding region may reveal other valuable placers, and possibly quartz ledges as well. If it can be assumed that the Porcupine mineral zone is a continuation of that extending along the coast from Windham Bay to Berners Bay the belt should cross Lynn Canal diagonally from Seward City to the vicinity of Davidson Glacier, so that the west shore of Lynn Canal, opposite Sullivan Island and northward, would appear to offer favorable ground for prospecting.

GOLD PLACERS OF THE FAIRBANKS DISTRICT, ALASKA.[a]

By L. M. PRINDLE.

INTRODUCTION.

In the report of the Peters and Brooks expedition of 1898,[b] the conditions in the Tanana country were described and prospectors were advised to investigate the streams tributary to the Tanana from the north and heading opposite the gold-producing creeks of the Fortymile and Birch Creek regions.

In July, 1902, gold was discovered on a tributary of one of these streams by Felix Pedro, and the creek was named after him. The neighboring creeks were staked during the fall and following winter, and some development work was done. Stampeders came in over the ice from Dawson and other points on Yukon River, but the momentum with which they came carried them beyond and out of the country with only an unfavorable impression of it. Some were caught by the springtime on the Goodpaster, were obliged to wait till the breaking up of the ice, and finally reached the region by water. During the summer of 1903 prospectors were coming and going, and about 200 men were working on the various creeks, most of them handicapped by the high prices of all supplies and the lack of money for the development of their claims. Notwithstanding the unfavorable conditions, this district produced from $30,000 to $35,000 during the summer of 1903.

GEOGRAPHIC POSITION.

On its way to the Yukon the Tanana receives several tributaries from the north. The most important of these from east to west are Volkmar, Goodpaster, Chena, and Tolovana rivers, and Baker Creek. They all head far back in the Yukon-Tanana divide, and flow in westerly and southwesterly courses. The area to be considered lies between Chena and Tolovana rivers and is drained by their tributaries. It is 140 miles southwest from Circle, 200 miles in a straight line west from Eagle, and perhaps 200 miles above the mouth of Tanana River. This region forms a portion of what is known as

[a] Abstract of a more complete report in preparation.

[b] Brooks, Alfred H., A reconnaissance in the Tanana and White river basins, Alaska, in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, p. 488.

the Fairbanks district, and present interest is directed mainly to the valleys of a few small streams, which head close to one another just

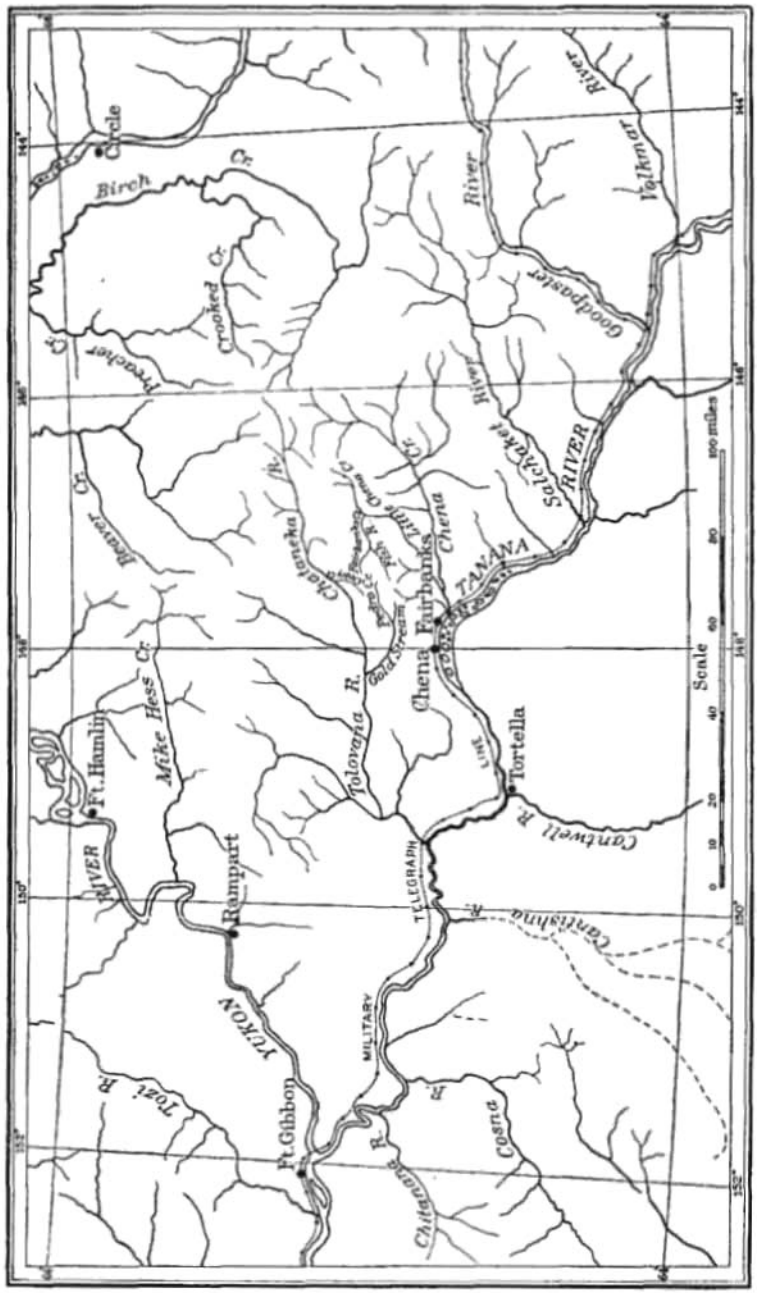

FIG. 1.—Sketch map of the Fairbanks district, Alaska.

within the hill country, about 12 miles north of Tanana River. Their geographic position is indicated on the accompanying map (fig. 1).

ROUTES OF APPROACH AND SOURCES OF SUPPLY.

The district can be reached by trail from Eagle and Circle, or by Yukon and Tanana rivers to Chena or Fairbanks, and thence by trail to the diggings. The distance from Circle to the Tanana is about 150 miles, and this is the shorter and better trail from the Yukon, and is generally preferred to that from Eagle by way of the Goodpaster. It can be traversed by pack train in the summer and by dog team during the winter months.

Fairbanks, situated on a slough of the Tanana, and Chena, about 9 miles below Fairbanks, are the nearest sources of supply, both places possessing stores. Fairbanks is accessible only by the smaller steamers like the *Koyukuk*, a boat 120 feet long by 24 feet in width, with an average draft of 22 inches. Chena is on the main river and can be reached by the larger steamers. The total population of both places, together with that of the creeks during the present winter (1903–4), is probably about 800. Both are connected by trail with the diggings. The distance from Fairbanks to the nearest creek where mining is in progress is about 10 miles, and the trail is said to be somewhat shorter and drier than that from Chena. Freight may be shipped by way of Yukon and Tanana rivers to either place. Passenger rates from Seattle to Chena or Fairbanks by way of St. Michael, Yukon and Tanana rivers, during the past season, were $150 first class and $100 second class; freight rates, $80 a ton. The rates from the Tanana to the creeks vary from a few cents a pound in the winter to about 25 cents a pound during the summer season. A telegraph office has been established by the Government about half a mile above Chena, and telegraphic communication thus is made possible with other portions of Alaska and the outside world. It is probable that in the near future an office will be established at Fairbanks.

There is very little timber large enough for mining purposes on the creeks, but a sufficient quantity is to be found a few miles away in the lower valleys of the larger streams and in the valley of the Tanana itself. Three sawmills are located at Fairbanks and have a total daily capacity of about 50,000 feet.

Feed is good in portions of the main valley and on the timbered slopes. Grass was found growing luxuriantly along the trail from Fairbanks to the creeks, and as late as the 11th of September had been untouched by frosts. On the creeks where work is being done there is but little horse feed.

GENERAL DESCRIPTION.

The Fairbanks district lies within the area of the Yukon Plateau, which extends from the northern base of the St. Elias and Alaskan ranges to the base of the Rocky Mountains, far north of Yukon River, and its characteristics are those of the great province of which it is a part.

The country is composed of ridges and valleys. The broad-backed ridges have an altitude of about 2,500 feet above sea level, and to an observer at this height all seem to attain about the same general level with the exception of isolated dome-like elevations of somewhat greater height. They slope gradually toward the Tanana and break off more or less abruptly to the extensive lowland of the latter stream. This southern edge of the Yukon-Tanana block of the plateau is much dissected by numerous minor streams, whose valleys are sunk to a depth of 1,200 to 1,600 feet below the comparatively even sky line of the ridges. The narrow V-shaped gulches of their headwaters widen to open valleys, often bounded on the one side by precipitous slopes and on the other by long, gently sloping spurs from the main ridge to the stream valleys.

The moss-covered surface of the highest divides gives place to that of the dwarf birch and alder on the lower ridges, and the growth of small spruce on the slopes and stream bottoms is abruptly terminated by the willow-covered strip which follows the waterway. Along the upper slopes and spurs are scattering poplar and birch, which lower down cover the hillsides bounding the Tanana Valley.

GENERAL GEOLOGY.

As this region in its surface features closely resembles that on the Yukon side of the divide, so the rocks are similar in character and form a part of the series already proved to be of economic importance there.

The bed rock of the gold-placer diggings of the Birch Creek mining district is composed of an essentially schistose series of metamorphosed sedimentary rocks, varying from a comparatively massive quartzite to a quartzite-schist and mica-schist. These have been cut by intrusive rocks, most of which are of a granitic character. This same series of more or less completely schistose quartzites and mica-schists was found to extend southward from the Birch Creek region to the diggings of the Fairbanks mining district. Associated with these schists in the Fairbanks region are hornblende-schists, gneiss, and granitic rocks of probably intrusive character. The distribution of the igneous rocks has not yet been determined.

The area from the Yukon to the Tanana is closely folded and the rocks often exhibit beautiful illustrations of overthrust folds in a nearly horizontal position. The apparent dips are generally low and give the rocks the appearance of gently folded strata.

The strike is variable, but the general structure seems to run northeast-southwest. Quartz stringers occur in the schists, but the proportion of quartz in the gravels, as in the Birch Creek district, is small.

CREEKS AND DEVELOPMENT.

The creeks of present economic importance are Pedro, called Gold Stream below the point where Gilmore enters it, and Twin Creek, a tributary of Pedro; Cleary Creek, with its tributaries, Chatham and Wolf; and Fairbanks Creek. They are but a few miles apart, separated by broad divides, 1,000 feet or more above them, and flow in divergent courses—Pedro toward the southwest and west, Cleary toward the northwest, Fairbanks toward the east. Pedro and Cleary belong to the drainage system of the Chatanika, which lower down is called the Tolovana, and Fairbanks Creek flows into Fish Creek, a tributary of the Little Chena. Cleary and Fairbanks creeks are easily reached by comparatively good trails from Pedro Creek. The distance is about 6 miles from the mouth of Twin on Pedro to Discovery Claim on Cleary Creek, and it is about the same to the head of Fairbanks Creek.

Claims include 20 acres, are a quarter of a mile long, and, with a few exceptions, are staked lengthwise of the creeks.

Pedro Creek and its tributaries.—Pedro Creek flows in an open valley. It is limited on the east by a rather abrupt slope, and on the west by broad, rounded spurs, sloping gradually from the divide to the stream bottom, and occasionally showing a bench-like character in the vicinity of the stream. Toward the headwaters and along the tributaries the sides approach until the valley becomes sharply V-shaped. The stream flat or valley floor varies in width up to a maximum of about 1,000 feet, and the grade in the portion where work is in progress is about 100 feet to the mile. The stream itself carries perhaps 3 to 4 sluice heads of water, or about 200 miner's inches, in its meandering course over the willow-covered flat. The sides of the valley are clothed with a light growth of spruce, sufficient only for wood and cabin material. The tributaries are small and flow in narrow valleys. On the west are Deadwood, Twin, and Steamboat creeks; on the east, Nugget Gulch, California Gulch, and Gilmore Creek. The continuation of Pedro below Gilmore has, unfortunately, received another name and is known as Gold Stream.

The area of present interest includes the lower portion of Twin Creek, the 3 miles of Pedro from Twin to Gilmore, and 2 to 3 miles on Gold Stream.

Twin Creek heads in the triangular divide between the Fairbanks, Cleary, and Pedro drainage areas. It is about 3 miles in length and flows in a narrow V-shaped valley over the bed rock, composed, so far as known, of quartzite-schist and porphyritic granite. The creek was staked in September, 1902. Work has been done at the mouth and at a point about one-half mile above the mouth.

There is about 12 feet of material on the bed rock, half of it muck

and coarse rock fragments, and the other six feet a mixture of more or less angular flattened fragments of quartzite-schist, mica-schist, granite, and occasional large pieces of vein quartz up to 200 pounds in weight. The pay dirt varies from 2 feet to over 4 feet in thickness. It is somewhat finer grained than the material above it and contains a sediment composed of sand and a large proportion of yellow clay, which makes panning rather difficult. The dirt is said to average about 4 cents to the pan, and to run from $5 to an ounce a day to the shovel. The gold is generally flat, and occasional pieces are found up to a half inch or more in diameter, worth from 50 cents to $2.50. Sufficient work has not yet been done to give definite information in regard to the average value and distribution of the pay dirt.

Pedro Creek for 2 or 3 miles below Twin keeps for the most part close to the rather steep slope bounding the unsymmetrical valley on the east. The stream bottom widens on the west and merges into the spruce-covered hillside, which rises gradually to the divide between Pedro and Cleary creeks.

The bed rock, so far as seen in this part of the creek, was found to be a quartzite-schist. This is mantled over with 10 to 25 feet of muck and gravel. The muck averages, perhaps, 4 feet in thickness and is underlain by gravel to bed rock. The gravel is composed mostly of flattened fragments of schist, with occasional pieces of gneiss, granite, and vein quartz. The gravel containing the gold varies from 2 to 7 feet in thickness, and gold is also found in the bed rock to a depth of about 2½ feet. The pay dirt is characterized by a yellow color, due to a considerable quantity of the fine yellowish sticky clay, and ranges from 5 to 20 cents to the pan, with occasional pans of much higher value. The gold is of a bright color and occurs generally in small, flattened pieces. Very fine gold is sometimes present, and coarse, lumpy pieces up to a value of $14 have been found. Garnet and rutile are frequently associated with the gold.

Prospect holes have been sunk during the winter, but most of the developments were made in the summer. The claims are worked by open cuts, and the low grade of the creek has necessitated the construction of bed-rock drains up to about 800 feet in length. Ground sluicing is commenced by May 20 and shoveling in by June 22. Work can be continued till about the middle of September. Ground is prepared by draining and stripping off the 4 feet or more of muck, after which the gravel becomes thawed and is ready for shoveling in.

During the past season wages were in some cases as high as $1 an hour for a man and $25 a day for a team. The expense of working probably absorbed from 50 to 60 per cent of the production.

Gold Stream, the continuation of Pedro below Gilmore Creek, was not visited. From the information available, however, it would seem that the conditions there are similar to those on Pedro Creek except

that there is more ground to be worked by drifting methods. So far as could be learned, less development work had been done than on Pedro Creek.

Cleary Creek and its tributaries.—Cleary Creek flows in a northeasterly and finally northerly direction to the Chatanika. Its general characters are similar to those of Pedro Creek. It flows in an unsymmetrical valley bounded on the east by a rather steep, wooded slope. On the other side a bench a quarter of a mile or more in width rises gradually from an elevation of 15 to 20 feet above the creek flat to the foot of the wooded slope on the left.

The tributaries of importance are Chatham and Wolf creeks. Chatham is about a mile in length, heads in the divide opposite Twin Creek, and flows in a northerly direction in a narrow valley, which has a stream flat about 300 feet in width at its mouth.

The headwaters of Wolf Creek have formed an amphitheatral depression in the divide between it and Fairbanks Creek. The main creek is about 1½ miles in length, and flows in a rather open valley, which expands to a flat a quarter of a mile in width, merging with that of Cleary about a mile below the mouth of Chatham.

Below the mouth of Wolf Creek the valley of Cleary widens, rather steep, wooded ridges approach it closely on the west, the stream flat on the east becomes more thickly wooded, and rises gradually until at a distance of about a mile from the stream it merges into the base of the wooded ridges. Cleary Creek, 6 miles below Wolf, flows into the Chatanika.

The bed rock is mostly mica-schist and quartzite-schist; hornblende-schists occur, and a granitic rock of apparently intrusive character is found near the head of Chatham.

Work is in progress on Chatham, Wolf, and the portion of Cleary from Chatham to a point a half mile or more below the mouth of Wolf. Claims are being prospected along Chatham, and, at the mouth, mining is carried on by the open-cut method. Sufficient work has not been done to determine the average thickness of the gravels or the average value and extent of the pay dirt. The material on bed rock varies from 4 to 20 feet in thickness, and the covering of muck constitutes in some cases a considerable proportion of this. The gravel is composed mostly of schist, and has been found to yield values ranging from 1½ cents to, in exceptional cases, 40 cents to the pan. The gold is generally fine, but nuggets have been found up to a value of $5. The gold near the head of the stream is rough.

On Wolf Creek the covering on bed rock is from 4 to 10 or more feet thick. The gravels are composed of quartzite-schist and this is the rock which outcrops on the rim of the amphitheater at the head of the creek. The open-cut method is used and very little ground is found to be frozen. The gold is generally in the lower portion of the gravel

and down to 2 feet in the bed rock. It is mostly of a bright color, and that found at the head of the creek is very rough and angular, and feels gritty in the handling. It has the appearance of having traveled but a short distance.

On the main creek considerable work has been done. The depth to the bed rock of mica-schist and quartzite-schist varies from 18 to 40 feet, including from 4 to 30 feet of muck, "chicken feed" gravel, and pay dirt. The pay dirt here, as in the other localities, contains the yellowish clay which often has to be scraped from the rock fragments in order to save the pay. Nuggets have been found up to a value of $19. Some of these have considerable quartz attached and some are black in color. Most of the development thus far has been on the west side of Cleary, opposite the mouth of Wolf Creek. The method employed here is drifting, and a plant has been installed consisting of a 6-horsepower boiler and accessories, capable of thawing by 5 steam points about 300 eight-pan buckets in ten hours, and at least one sluice head of water, or about 50 miner's inches is required for sluicing. During the past summer, for a few days, the stream was running less than that. In the early part of September from 3 to 4 sluice heads were available.

The bench to the left of Cleary is being prospected, but the depth to bed rock of over 30 feet renders this a slow process.

Fairbanks Creek.—The valley of Fairbanks Creek lies just over the divide to the east of Wolf Creek. Its upper portion lies between the drainage areas of Pedro and Cleary creeks. It flows in an easterly and southeasterly direction, a distance of about 9 miles to Fish Creek, a tributary of the Little Chena. In its upper portion it is narrow and V-shaped; lower down its unsymmetrical valley is bounded on the south by a steep slope with short, abrupt spurs, and on the north by broad spurs a mile and a half in length, sloping gradually from the ridge 1,400 feet above the valley to the creek bottom. The creek is small, carrying only a few sluice heads of water, and flows through a willow-covered flat 100 to 300 feet in width, with a grade of about 100 feet to the mile. For the last two or three miles it meanders across a broad flat to Fish Creek. The spurs to the north are thickly covered with a growth of small spruce and some poplar. A very small proportion of the spruce is large enough to saw into 8-inch boards.

Moose, Crane, Alder, Walnut, and Deep creeks are the main tributaries from the north. They are about 1½ to 2 miles in length and are separated by the broad spurs from the main divide. Those from the south are short and flow in narrow canyons.

Fairbanks Creek is still in the prospecting stage of development. Some work has been done and pay has been found over several miles of its course. The bed rock, so far as known, is mica-schist, quartzite-schist, and gneiss. These are covered with a thickness of 14 to

over 40 feet of muck and gravel. Muck may constitute a half of this, and is underlain generally by a light wash, and this by a sediment-bearing gravel in which the gold is found. The gravel is composed mostly of quartzite-schist, some mica-schist, gneiss, and occasional large pieces of vein quartz up to a foot or more in diameter.

The pay dirt is said to run from 2 to 7 feet in thickness and to contain values averaging from 2 to 15 cents to the pan. The gold is generally bright and occurs in granular or flattened pieces, some of which have been found worth $1.50.

As the ground is deep and frozen, prospecting is a time-consuming task. Holes are sunk by the use of wood fires, hot rocks, and hot water. Sometimes a combination is used, and where there is danger of thawing the walls too rapidly, hot water is preferred. It is difficult to thaw much more than 2 feet a day by any of these methods, and their use means an expenditure of energy far in excess of the results attained, yet many miners are forced by lack of capital to work by these methods, and much patient work under adverse conditions is being accomplished. One boiler with steam points was in operation; another had just reached the creek, and a third was met on the way, both of which were expected to be in operation within forty-eight hours.

With the advent of the boiler, work can be done more easily and quickly, and a brief description of the method may not be out of place. Boilers at present in use on the creeks vary from 2 to 6 horsepower, and are capable of supplying steam to 4 or 5 points. Steam is generated by the boiler, passes through an ordinary steam pipe, and is delivered to the points. These points are pipes from 4 to 5 feet in length, attachable at one end to the steam pipe and at the other end provided with a small opening through which the steam rushes with greatly increased penetrative force. They correspond to the nozzle attached to fire hose, and the whole system is similar, with the exception that the thawing machine is adapted to the transmission of steam rather than of water. The blunt ends of the points are placed in position against the frozen surface and the steam turned on. Shafts may rapidly be sunk to bed rock by this method and the ground then drifted out laterally. Care must be exercised to prevent the too extensive thawing of the ground with the consequent "sloughing" or falling in of material from the walls.

SUMMARY.

The creeks above described are the only ones in the Fairbanks district which up to the present time have given favorable results. The conditions of occurrence on all of them are essentially the same. No foreign wash was observed, and it would seem that the gold has been derived from the rocks in which the creeks have cut their channels.

These rocks are mostly schists, often containing small quartz stringers, and the fact that igneous rocks are associated with them suggests the possible relationship of these to the mineralization.

The pay is generally found at a considerable depth, and, with a few exceptions, in frozen ground. The creeks are small, carrying hardly sufficient water for extensive operations, and their grade is low. Timber for mining purposes has to be freighted generally for several miles from the lower valleys. Trails along the ridges are good, and where they traverse the wooded areas have been well cut out, but the sight of heavy loads hauled by horses on sleds over the swampy ground along the creeks is an eloquent illustration of the need of good roads.

Although no large values have yet been discovered, the gold seems to have a considerable distribution on the creeks where it has been found and is known to occur at some localities in sufficient quantity to pay for working under existing unfavorable conditions. The Fairbanks district deserves consideration, and with better means of communication and supplies at more reasonable prices the development will be greatly hastened.

THE KOTZEBUE PLACER-GOLD FIELD OF SEWARD PENINSULA, ALASKA.[a]

By FRED H. MOFFIT.

GENERAL DESCRIPTION.

The Kotzebue placer-gold field is in that part of the northeastern portion of the Seward Peninsula which lies to the south of the eastern extension of Kotzebue Sound, and is nearly 150 miles northeast of Nome. In a rough way, the more important camps may be included in a rectangular area, about 40 miles from east to west and 20 miles from north to south. Deering and Kiwalik are the chief distributing points for provisions and supplies, but during the past season steamers have landed parts of their cargoes intended for the more western camps at the mouth of Rex Creek, west of Deering. The region offers few attractions to the prospector. Low, tundra-covered hills, natural breeding places for mosquitoes and black flies, surround him on every side. Traveling, difficult on the higher ground, is almost impossible over the lowlands bordering the sound and on most of the streams. The only fuel for cooking or heating is that afforded by the low willows scattered along the bottoms of the valleys.

The coast line forming the northern boundary of the field is but 30 miles south of the Arctic Circle, and in consequence of its position the region is subject in summer to much damp weather and in winter to severe cold, with strong winds, more trying to the traveler than the lower temperatures but quieter atmosphere of the interior. The area containing the gold-producing streams is limited in an east-west direction by the one hundred and sixty-first and one hundred and sixty-third meridians, west longitude, and in a southerly direction all of the camps where gold is mined are within 20 miles of the coast, except those on Bear Creek, which are nearly twice that distance.

This area forms the eastern part of the Fairhaven mining district, including the drainage into Kotzebue Sound, beginning with Good Hope River on the west and ending with Buckland River on the east.

[a] This paper is an abstract of a more complete discussion which is shortly to appear in a paper entitled "A Reconnaissance of the Northeastern Portion of Seward Peninsula, Alaska."

Three principal streams flow through the district—the Inmachuk, Kugruk, and Kiwalik rivers. All these have a general northerly course and drain an area of between 1,500 and 2,000 square miles. Of the three the Kugruk is the largest and economically the least important, since very little gold has been taken from it. Kiwalik River, the second in size, is of special interest because its tributary, Candle Creek, has produced more than three times as much as the combined output of the other creeks. The Inmachuk and two of its tributaries, Old Glory and Hannum creeks, have afforded much the larger part of the remainder. Besides these Bear Creek, which empties into Buckland River, and the Alder Creek beach diggings should be mentioned, as well as Chicago Creek, a tributary of the Kugruk, on which a coal or lignite bed was worked during the past winter.

The topography of the country south of Kotzebue Sound is generally of low relief and monotonous appearance. Here and there, as in the vicinity of the Asses Ears, a prominent elevation south of Good Hope Bay, so named by Kotzebue in 1816 because "its summit is in the form of two asses ears," and on the divide between Kiwalik and Buckland rivers, more elevated masses of limestone or eruptive rocks reach a height of from 1,500 to 2,500 feet above sea level.

The field may be reached from Nome either by overland trail or by boat through Bering Strait and Kotzebue Sound, the distance in the first case being over 150 miles directly across the peninsula, and in the second case about 300 miles. Of the two the water route is now generally preferred, but can be used only for about three months in the year, since navigation is closed by the ice during the remaining nine months.

GEOLOGIC SKETCH.

The rocks of the Kotzebue gold field are almost entirely micaceous and graphitic schists of uncertain age and thickness, interstratified with occasional beds of limestone and overlain by an extensive flow of recent cellular lavas.

The highly metamorphosed rocks must have suffered an immense amount of erosion and were reduced to an almost level plain with here and there low hills of limestone and sometimes of granite rising above it. Over much of this plain was then poured out a thin sheet of lava, which overflowed several thousand square miles of territory, filling up the depressions and surrounding the higher points. On account of the lava and overlying tundra, outcrops of the schist are *not* plentiful and are generally found where the streams have cut their way through the eruptive sheet, forming canyon-like valleys bordered by rims of broken lava blocks.

Both schists and limestones are much folded, showing that they have been subjected to great pressure, and the schists have been further modified by the formation of a complicated series of quartz veins and lenses, fragments of which form a considerable portion of the gravels.

In the southwestern part of the field, in the neighborhood of the Asses Ears, is an elevated area of white crystalline limestone resting on or, as is much more probable, intruded by masses of very coarsely crystalline granites, one of which forms the "Ears." At the eastern border of the field the schists are interrupted by a great mass of eruptives, with a central core of granites and diorites flanked by andesites and lavas. The andesites are more widely developed than the granites and surround them on all sides, so that in approaching the higher elevations of the divide one meets first the cellular lavas, then andesites, and finally the granites, extremely coarse and in places with little or no quartz.

A characteristic feature of these mountains is the terraced appearance which they present when viewed from a distance, produced by the benches of broken blocks of the country rock.

GOLD OCCURRENCES.

For convenience in description the principal streams where gold has been produced may be divided into two main districts—the Inmachuk River drainage area and the Candle Creek area, belonging in the Kiwalik River drainage system. Of these two districts, viewed from the standpoint of production in the past, Candle Creek is by far the more important.

Inmachuk River.—The Inmachuk River is between 25 and 30 miles in length. It rises in the limestone area of the western part of the field, flows toward the northeast to the flats bordering Kotzebue Sound, and then meanders slowly in the same general direction to the sound. At Record City the eastern fork, known as Pinnell River, joins the main stream from the south.

The most productive portion of the Inmachuk begins near the mouth of Pinnell River and extends down the stream for a number of miles. The valley is much broader than those of the tributaries, and in this portion is occupied by a series of broad flats, having in places a width of more than a quarter of a mile.

The gravels occasionally reach a thickness of 6 to 8 feet. They are invariably frozen, except in the channel of the river, and are often covered by an ice bed. The bench and creek claims on the Inmachuk have been more extensively prospected than on the other streams, with the result that in a number of places a well-defined pay streak is known. At two localities lines of holes, extending across the valley, have been thawed down to bed rock, and at a number of places lines of holes have been sunk part way across. This work is carried on with the aid of thawers, the boilers ordinarily furnishing steam to 4-foot points set twice each day. The consumption of fuel in work of this kind is large, and greatly increases the cost of mining.

Hannum Creek, which flows into the Inmachuk above the mouth of the Pinnell, has produced a small amount of gold during the last two years. This stream flows through a narrow canyon-like valley surrounded by a rim of lava and sheeted over with gravels, consisting mainly of schist with smaller amounts of quartz, limestone, and lava, which appear in places as broad tundra-covered flats one-fourth to one-half mile long.

The gold is irregularly distributed along the bed rock of the channel, or "spotted," as the prospectors say; with it is associated some pyrite and a very small amount of galena.

Old Glory, on which the original discovery of gold in this region was made, is a short creek about 6 miles in length, rising in the limestone area north of the Asses Ears and joining Pinnell River 1¼ miles above its junction with the Inmachuk. The valley of Old Glory is cut in a series of schists with occasional interbedded limestones; it is broader than that of Hannum Creek, and is covered with a sheet of wash gravel, largely quartz, which extends well up on the slopes. Near the bottom of the valley the gravels have been much disturbed by the sliding of rock, gravel, and tundra from the sides. These gravels differ further from those above in the much larger amount of schist which they contain and the decrease in rounded quartz pebbles. No pay streak is known, the creek being "spotted," as is Hannum Creek.

Candle Creek.—In the eastern district Candle Creek, which has produced more than three times as much as the combined output of all the other camps, joins Kiwalik River about 9 miles above the town of Kiwalik on the sand spit at the entrance to Spafarief Bay. The creek is nearly 16 miles long. It flows in a northeasterly direction through a broad V-shaped valley with gentle slopes and rounded tundra-covered hills, which are always wet and make difficult traveling for men and horses.

Sixty-six claims, containing 20 acres each, are said to have been staked on the creek, besides a considerable number of bench claims on either side of these. The gravels of Candle Creek are almost entirely schist with a small amount of quartz. On some of the bench claims the gravels have a thickness of 8 feet, exclusive of "slide" and tundra. Near the stream they are generally overlain by a bed of ice. Owing to the low grade of the channel the use of bed-rock drains has not been possible on this creek, and the China pump is universally employed for keeping the pits clear of water. The cost of mining is considerably increased for this reason, since one extra man and sometimes two are required to work the pumps.

During the last two years the channel has been nearly worked out, and attention is now turned toward the bench claims, on which the future of the camp largely depends. These bench claims are known

to carry gold, and in one or two instances have yielded large returns, but the successful treatment of the deposits depends on securing a supply of water of sufficient head and volume to remove the overlying tundra and ice economically and to work the gravels on a considerable scale.

Bear Creek.—Bear Creek, which empties into Buckland River between 40 and 50 miles to the southeast of Candle City, is about 17 miles long, and rises in the eruptive area east of Kiwalik River. During the past season some 40 men have been at work on the creek. The output is derived chiefly from two small tributaries, Sherdon and Cub creeks, and that portion of Bear Creek which lies between them. On account of the difficulty of obtaining supplies, all of which must be brought overland from Candle City, none but the richest of the claims have paid for working under present conditions, and many of the prospectors report that they have not made wages.

Alder Beach.—These diggings are located near the mouth of Alder Creek, which flows into Kotzebue Sound about midway between Kiwalik and Deering. The gold-bearing gravels, being shallow and of no great extent, have furnished work for only a few men. The gold occurs on bed rock; it is fine and little worn, and is clearly derived from the neighboring schist.

The output from Alder Beach diggings for the past two years is reported to be between $12,000 and $14,000.

CHARACTER AND ORIGIN OF THE GOLD.

The gold production of the Kotzebue field from the year of its discovery, 1901, to the present is estimated to be not far from $415,000. Of this amount some $325,000 came from Candle Creek, about $12,000 from the Alder Creek diggings, $10,000 from Bear Creek, and the remainder from Old Glory, Hannum Creek, and Inmachuk River. The production of Hannum is very small.

Gold from the Inmachuk district is dark and heavy, assaying about $18 to the ounce; almost no black sand is present, but considerable gray sand or pyrite is seen in the pan and the boxes always contain a large quantity of rounded hematite pebbles which the miners call "ironstones." The gold frequently contains a little quartz and is sometimes seen in the form of fine veinlets in the ironstones. Small pieces of rutile are occasionally found with the heavy concentrates and have been mistaken for cassiterite. Dr. Cabell Whitehead, of the Alaska Banking and Safe Deposit Company, has informed the writer that about 27 ounces of tin were recovered in cleaning gold brought to Nome from Old Glory Creek, so that the tin ore, cassiterite, must be present on that stream. On the upper part of Hannum Creek, a small quantity of galena is associated with the gold and ironstones. Much of the gold from the Inmachuk and its tributaries is coarse and

rough. Pieces of the value of $2 or $3 are not uncommon, but no large nuggets have been found.

Candle Creek gold resembles very much that from the Inmachuk, but is usually somewhat darker and is said not to assay as well. The minerals associated with the gold are the same as those found on the Inmachuk. Many of the ironstones are nearly always present and a decrease in their amount is regarded by the prospectors as an unfavorable sign. So dark is the gold that it is not an uncommon sight to see a miner, when panning, bite a nugget in order to make sure of its being gold and not one of the ironstones. One nugget worth $62.10 and a second, $36, have been taken from the creek.

Bear Creek gold, assaying over $19, is flattened and much brighter in color than that from any other part of the field. With the gold is found considerable black sand, which is entirely removed by the magnet, and is undoubtedly derived largely from magnetite in the granites and andesites forming the eruptive mass in which the stream rises. The presence of black sand constitutes a second difference between this gold and that from Candle Creek or the Inmachuk district. Gold from Sherdon Creek is much coarser than the fine, flaky gold on Bear and Cub creeks, but the Cub Creek gold occurs throughout the whole thickness of the gravel, differing in this respect from Sherdon and Bear creeks, where it is found on bed rock. Cub Creek gravels also show a large amount of a heavy, red, cherty rock, which sticks in the pan or riffles and causes inconvenience in sluicing.

The gold from the Alder Beach diggings is flaky and bright. It occurs on the shallow bed rock and includes some wire gold, showing that it can have traveled but a very short distance before reaching its present resting place.

There can be little doubt that the gold of the Alder Beach, Candle Creek, and the Inmachuk region has had very much the same history as is ascribed to the other deposits of Seward Peninsula—that is, that the gold is of local origin and is concentrated from an original supply widely disseminated in small quartz veins and stringers and impregnated zones of the bed rock. This is shown both by the character and occurrence of the gold itself.

The valuable gravels are all derived from the weathering of rocks which have been subjected to intense pressure, heat, and other influences of such a nature as to change entirely their original character and fill them with an intricate network of small quartz veins and lenses known in some cases to be gold bearing. The concentration due to the action of running water on the vast amount of material derived from the decompositon of these gold-bearing schists, amounting to a vertical thickness of hundreds and possibly thousands of feet, has without much doubt given rise to the rich gold deposits now found in the gravels. So constant is the association of the gold with the

schists that the prospectors refuse to waste time in the search for gold in a place where the schist is not found.

It is further probable that in nearly every case the gold has traveled but a relatively short distance from its original source; its rough, unworn appearance, the absence of any large amount of fine, bright, flaky gold, the occurrence of wire gold in one instance, and the presence of considerable quartz in the nuggets, all tend to establish this conclusion.

COAL.

The discovery on Chicago Creek of what appears to be a good-sized bed of lignitic coal has been of considerable interest to prospectors in the neighboring country, where small willows constitute the chief supply of fuel. Chicago Creek, which is tributary to Kugruk River, is about 9 miles from the coast and lies between Candle City and the mining camps on Inmachuk River. The coal occurs at a point somewhat more than a mile from the mouth of the creek and was discovered by prospectors who found pieces of float in the stream gravels and traced them to their source, which they located for mining purposes. During the past winter a slope was driven into the coal for a distance of 150 feet or more, and it is said that a crosscut of 60 feet was made without finding the walls, thus seeming to indicate that the deposit lies in a horizontal position and has considerable thickness. The coal is solidly frozen so far as uncovered and contains a large percentage of ice, which causes it to check and crumble on being thawed. It burns quickly with a bright flame, leaving a small quantity of fine, white residue like wood ash. The miners regard two tons of this coal as equivalent in value to about one ton of Wellington coal, which ratio is also expressed by the prices of the two, since Wellington coal sells for about twice as much as the native product. For use in boilers the imported coal is preferred, although costing over $80 per ton at the camps, but for cooking purposes, as well as for heating, the Chicago Creek coal is satisfactory and may perhaps prove to be of some local importance.

STREAM TIN IN ALASKA.

By ALFRED H. BROOKS.

While studying the gold placers at York, on the Seward Peninsula, Alaska, the writer's attention was called to the occurrence of stream tin (cassiterite) in the placers. The stream tin was found at two localities in the region. The first is on Buhner Creek, a westerly tributary of the Anikovik River. The mouth of Buhner Creek is about 3 miles from Bering Sea. The occurrence is best located by stating that it lies about 10 miles east of Cape Prince of Wales, and very near the northwestern extremity of the continent. On Buhner Creek 2 to 3 feet of gravel overlies the bed rock, which consists of arenaceous schists, often graphitic, together with some graphitic slates. The bed rock is much jointed, the schists being broken up into pencil-shaped fragments. They strike nearly at right angles to the course of the stream and offer natural riffles for the concentration of heavier material. A hasty reconnaissance of the drainage basin of this stream, which includes not more than a square mile of area, showed the same series of rocks throughout its extent. At a few localities some deeply weathered, dark-green intrusives were found, probably of a diabasic character. The slates and schists are everywhere penetrated by small veins, consisting usually of quartz with some calcite, and frequently carrying pyrite and sometimes gold. These veins are very irregular, often widening out to form blebs, and again contracting so as not to be easily traceable.

The stream tin is concentrated on the bed rock with other heavy minerals, and was found by the miners in the sluice boxes. A sample of the concentrate in one of the sluice boxes was examined by Mr. Arthur J. Collier, and yielded the following minerals: Cassiterite, magnetite, ilmenite, limonite, pyrite, fluorite, garnets, and gold. The determination of percentage by weight was as follows: 90 per cent tin-stone; 5 per cent magnetite; other minerals, 5 per cent. The cassiterite occurs in grains and pebbles, from those microscopic in size to those half an inch in diameter; they have subrounded and rounded forms. In some cases there is a suggestion of pyramidal and prismatic crystal forms. The cassiterite varies in color from a light brown to a lustrous black.

A second locality of this mineral was found on the Anikovik River about half a mile below the mouth of Buhner Creek. Here the cassiterite was also found with the concentrates from the mining operations. One pebble of stream tin obtained from this locality was about 2 inches in diameter.

It will be necessary to make a more detailed examination of this region to determine where this mineral occurs in the bed rock. The facts obtained by the writer point toward the conclusion that its source was in the quartz and calcite veins in which the gold was found. No cassiterite was, however, found in this vein material.

No evidence was found that this cassiterite is in any way connected with granitic intrusions, which is its usual association in other regions. As far as known there are no intrusives of such rocks within the drainage basins of streams where the tin was found. The nearest known granitic rock is the biotite-granite stock which forms the promontory of Cape Prince of Wales and which is at least 10 miles distant.

This discovery of stream tin has, at present, scientific rather than commercial interest. No developments have been made which would warrant the conclusion that valuable tin deposits exist in the York district. It is worth while, however, for the prospectors who visit this region to familiarize themselves with the physical properties of the mineral, so as to be able to recognize it if found. By this means deposits carrying values may be discovered, and the cassiterite will probably be traced to its source in the bed rock.

TIN DEPOSITS OF THE YORK REGION, ALASKA.[a]

By ARTHUR J. COLLIER.

INTRODUCTION.

The known occurrences of tin in Alaska are in what is called the York region of Seward Peninsula. This region derives its name from Cape York, an ill-defined promontory on Bering Sea about 90 miles northwest of Nome. It extends northwestward from this cape and includes Cape Prince of Wales, the most western point of the continent. The region has the general form of an isosceles triangle, with its apex at Cape Prince of Wales and its two sides formed by the shore lines of the Arctic Ocean and Bering Sea. (See map, fig. 6.)

The southern coast line is, in the main, inhospitable and unbroken by inlets or harbors. Back of narrow beaches the land usually presents to the sea an abrupt escarpment, giving it a forbidding aspect. On the north the land slopes more gently to the Arctic Ocean and the coast is characterized by barrier beaches which cut off broad lagoons from the open sea. Such a one is Lopp Lagoon, a large body of water, but unfortunately too shallow for any but light-draft boats. Port Clarence, 20 miles east of Cape York, is the only harbor worth mentioning in the region.

[a] Abstract of a report in preparation.

The York Mountains, comprising an area of rugged land forms, occupy the southeastern part of the triangle and culminate in Brooks Mountain, 2,900 feet in altitude, the highest point in this part of the peninsula. Northward and westward from this mountain group stretches the so-called York Plateau, a comparatively smooth upland which stands at 200 to 600 feet above sea level and comprises the greater part of the region under discussion. On the south this plateau presents an escarpment to Bering Sea, but on the north it slopes off gently to the coastal plain.

The chief settlement of the region is York, situated at the mouth of Anikovik River, about 12 miles southeast of Cape Prince of Wales and 8 miles northwest of Cape York. This town is on the open coast

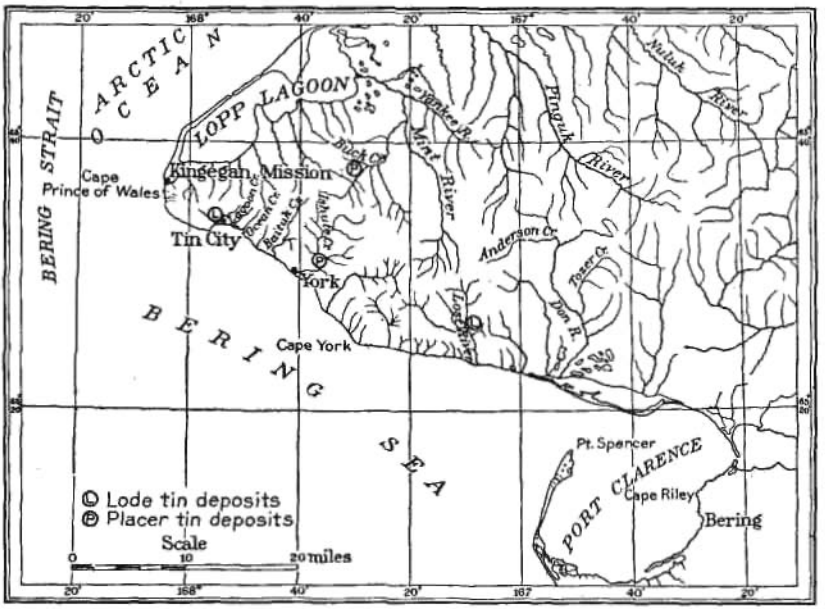

FIG. 6.—Map of the York tin region, Alaska.

of Bering Sea and landings are made through the surf, as at Nome. The nearest harbor for seagoing vessels is Port Clarence, 20 miles eastward.

After the discovery of gold at Nome, in 1898, prospectors rapidly extended their search to all parts of Seward Peninsula, and as early as the fall of 1899 placer gold had been found in Anikovik River. In 1900, Mr. Alfred H. Brooks, of the United States Geological Survey, visited the York region and found in the placers of Anikovik River and Buhner Creek, one of its tributaries, some specimens of stream tin. Early in 1901 an account of these discoveries was published by Mr. Brooks, and the general interest in the tin deposits of the York region dates from that publication. Since that time tin ore

has been found both in lodes and in alluvial deposits at a number of widely separated localities.

In 1903 the writer, assisted by Mr. Frank L. Hess, was detailed to continue the investigation of the mineral resources of Seward Peninsula. In the course of the investigation the York region was again visited, hasty examinations were made of the three localities which give the most promise of the production of tin, and reports were obtained from many other localities which have been prospected to some extent. The three localities visited are known as Lost River, Buck Creek, and Cape Mountain, the two extreme points being 25 miles apart. The examination of the Lost River locality was made by Mr. Hess and the writer, jointly, while Buck Creek was visited by Mr. Hess and Cape Mountain by the writer.

GENERAL GEOLOGY OF THE YORK REGION.

The geology of the York region has been the subject of investigation during the years 1900, 1901, and 1903, but all of this work has been of a reconnaissance character. Four distinct rock types have been recognized in the region. These include slates and limestones, both probably of Paleozoic age, and some granular intrusives, chiefly of acid character. The slates and limestones, broadly speaking, form north-south belts of irregular outline, while the igneous rocks are found in intrusive stocks or dikes, the former outcropping in more or less circular areas. Besides these bed-rock formations, Pleistocene sands and gravels mantle the northern coastal plain, and are also found along the valleys of many of the streams.

The larger part of the area of the York Mountains is occupied by limestone of ash-gray color, which exhibits little evidence of metamorphism. This formation, called the Port Clarence limestone in previous reports, is of upper Silurian age. West of this large limestone area there is a broad belt of slates or phyllites, often so much altered as to be more properly called schists. They are of a graphitic arenaceous and sometimes calcareous character, are of a fine texture, and are much jointed, the lines of cleavage breaking them into rhomboidal blocks and pencil-shaped fragments. The bedding is often obscured and sometimes completely obliterated by the highly developed joint structures.

The age of these slates and their relation to the Port Clarence limestone have not been determined. There is some indication of faulting along the contact.

West of the slate area there is a belt of highly altered limestone more or less interbedded with micaceous schists. This belt, about 4 miles in width, lies between the slates on the east and the large mass of granite which forms the peak known as Cape Mountain on the west. Some obscure fossils collected last season indicate that these

limestones are of either Devonian or Carboniferous age. The stratigraphic relation of this rock to the slates and limestones already described has not been determined.

Two distinct types of igneous rock are represented in the region. The first group comprises basic rocks in the form of dikes and probably sills, more or less altered, and sometimes sheared, which may be grouped together under the name of greenstones. The greenstones and greenstone-schists include a number of intrusive masses and find their greatest development in the slates near the contact with the limestones which form the York Mountains. These rocks are often called granite by the miners, but they can be readily distinguished from true granite by the absence of quartz and the generally greenish color. This distinction is of importance, since, so far as known, no tin deposits have been found in association with the greenstone.

The second group comprises the acid igneous rocks and includes a number of large masses of granite, as well as dikes of fine-grained porphyritic rock containing quartz phenocrysts.

These rocks find their greatest development in Cape Mountain, which is essentially a granite stock intruded in the limestones. The rock, a white, coarsely crystalline, somewhat porphyritic granite, is made up essentially of quartz, microcline, and biotite, but also contains as accessory minerals albite, muscovite, zircon, apatite, tourmaline, pyrite, and fluorite. Granitic rocks also occur in this district at Brooks Mountain and on Lost River, and similar rocks are found at Ears Mountain, Hot Springs, and Asses Ears, northeast of the York region, and in the Diomede Islands, west of Cape Prince of Wales. These granites are generally unaltered by dynamic influences such as would produce gneissoid and schistose phases, but in some places they have been considerably affected by processes which have produced various forms of granite called "greisen." The distribution of the granite is of the greatest economic importance, since it is in granite dikes and near their contacts that the lode tin deposits have most frequently been found. The prospectors of the region have not been backward in taking cognizance of this, and have made careful search for tin along these contacts.

The unconsolidated gravels and silts form a group of younger sediments. This formation covers the broad coastal plain along the Arctic coast and, extending southward in the river valleys, connects with the alluvium of the smaller streams. In the southern part of the York region these surficial deposits are confined to the creek beds and narrow strips along the coast. They are of economic interest because in them is found the stream tin.

ECONOMIC GEOLOGY.

The occurrence of tin-bearing lodes in the bed rock has been verified by the Geological Survey at points known as Lost River and Cape

Mountain. The occurrence of tin in placer deposits has been confirmed on Anikovik River, Buhner Creek, a tributary of the Anikovik, and on Buck Creek, a tributary of Grouse Creek which flows through Mint River into the Lopp Lagoon. Tin ore has also been reported from a great many other localities which have not been thoroughly examined by geologists. The tin deposits, as far as known, do not follow any definite system, and are confined to no particular belt or zone. The ore, either in lodes or in placer deposits, has been found in association with all the sedimentary formations above described. The known occurrences of tin ore will be described under the headings "Lost River," "Cape Mountain," "Buck Creek," "Buhner Creek," and "Anikovik River."

LOST RIVER.

Lode tin deposits have been found 4 or 5 miles from the coast on Lost River, which enters Bering Sea 10 miles west of Port Clarence. Lost River has a length of about 10 miles, and drains the central part of the York Mountains. Its two tributaries, Tin Creek and Cassiterite Creek, enter from the east about 3 miles and 4 miles, respectively, from its mouth, and tin ore has been found on both of these creeks. Cassiterite Creek, which is really the larger fork of Lost River, has a length of about 3 miles. Tin Creek, about 2 miles long, heads within about a mile of Cassiterite Creek, and, flowing parallel with it for about the same distance, turns westward and enters Lost River through a canyon cut in the limestones of the York Mountains. Lost River itself flows in a comparatively broad valley cut in these limestones. The bed of the river is not deeply gravel filled, and the valley floor is practically cut out of the limestones and not to any extent built on them. The mouth of Cassiterite Creek is about 100 feet above the sea. In the latter part of July, 1903, Lost River, just below this place, carried approximately 1,000 miner's inches of water.

The York Mountains, in the vicinity of Lost River, are composed almost wholly of ash-gray Silurian limestones showing little metamorphism and dipping at low angles. From the coast to Tin Creek the limestones generally dip to the north, and unless there be faulting, not detected in the hasty examination that was made, a thickness of over 4,000 feet must be exposed.

Dikes of igneous rocks were found cutting this limestone at several places, and are readily traceable by a growth of moss and other vegetation which forms over them, the limestone itself being utterly devoid of vegetation. Between Tin Creek aad Lost River there is a boss or stock of granite intruded into the limestone, which outcrops in a nearly circular area, probably half a mile in diameter. Around the margins of this area the limestone is considerably altered and contains small dikes of fine-grained pegmatitic rock, presumably offshoots from the granite, cutting the limestone apparently parallel with the contact

of the limestone and granite. Many bowlders and pebbles containing minerals derived from this contact have been found along Tin Creek, which follows the contact for some distance. The more common of these are tourmaline, garnet, epidote, and fluorite. Large bowlders have been found which are wholly composed of minerals of this kind.

A white porphyritic dike cutting the limestone 4 or 5 miles from the coast forms the present focal point of interest to the tin miner. This dike, which is about 100 feet wide, has been traced from Tin Creek on the east to Cassiterite Creek on the west, a distance of about a mile. Tin ore has been found on the croppings of this dike and strewn over the surface along its course, but varies in general appearance and character. Some of the weathered ore from the croppings is highly siliceous and has the appearance of weathered iron-stained vein quartz, with small crystals of black cassiterite distributed through it, while other specimens show clearly their granitic origin, but contain comparatively little quartz. In the ore of the latter type the cassiterite occurs both as disseminated crystals, varying from the size of a pin head to a walnut, and as veinlets and irregular masses. Some of this granitic ore that was prepared and examined microscopically is found to be very much altered from its original character, now consisting essentially of calcite, fluorite, quartz, and large crystals of lithia mica; no feldspars remain, and the quartz is probably secondary. In addition to the cassiterite, tourmaline, pyrite, galena, and garnet occur as accessory minerals. The siliceous ore mentioned above, when examined with the hand lens, occasionally shows spangles of free gold. A small piece, but not a commercial sample, was assayed for gold and silver, and gave 0.36 of an ounce of gold per ton and a trace of silver. Assays reported to the writer show the presence of gold, though in less amounts than the above. The occurrence of so much gold associated with the cassiterite is unusual in tin deposits and merits further investigation. Pannings from the croppings of this ledge have yielded tin ore in angular unworn crystals. One specimen of placer tin of this kind, obtained near the croppings of the large dike described above, consists mainly of cassiterite, but contains also wolframite and garnet.

To summarize briefly the evidence in regard to this deposit, the tin ore is, in part at least, essentially an altered granite-porphyry, or "greisen," having crystals of cassiterite disseminated through it. This greisen forms a dike, which has been followed eastward from Cassiterite Creek to Tin Creek, a distance of about 6,000 feet, and has been examined at its eastern and western ends by United States geologists, who collected specimens of tin ore from it near Cassiterite Creek. At its eastern end, near Tin Creek, no specimens containing cassiterite were collected by members of the Geological Survey, but such specimens have been obtained by others.

When the dike was examined in the latter part of July, 1903, no excavations had been made on it, and it was therefore impossible to measure its exact width at any point, owing to the talus covering it, though considerable breadth was indicated by the fragments on the surface. Since that time crosscut trenches have been made near Cassiterite Creek, which are reported to reveal a width of approximately 100 feet. The excavations have not gone far enough to allow of systematic sampling, and the value of the lode must therefore be left an open question until further developments are made.

Tin ore has also been found in place on Tin Creek, about half a mile south of this main lode, at the northern contact of the large granite area which has been described. Specimens of mineralized granite were obtained that, on examination in the laboratory at Washington, are found to contain stannite, or tin pyrites, together with other metallic sulphides. Mineralized granite of this character apparently covers a considerable area, but the ore is probably of little value except as indicating a wider distribution of tin through the granites.

In 1898 and 1899 some prospecting for gold was done in the vicinity of Lost River, but nothing of importance was found, and the region was abandoned by prospectors for several years. In the winter of 1902 prospectors, searching for tin ore, again turned their attention to this region. Early in the summer of 1903 the interesting minerals above described were discovered in the bowlders in Tin Creek, and a thorough search for tin was made. When the Geological Survey party arrived at Teller, in July, 1903, they were enabled to examine a large collection of minerals from this vicinity. Metallic tin was readily obtained from one small specimen by the aid of a blowpipe, while the larger part of the collection was shown to contain minerals of no value. After examining these minerals, Mr. Hess and the writer proceeded to the Lost River country and made an examination of a part of the region in more detail than had been done in 1901, and were able to trace the tin ore which had been seen at Teller to the granite-porphyry dike above described, on Cassiterite Creek.

CAPE MOUNTAIN.

The Cape Mountain tin deposits occur in a high peak which marks the most western point of America. A settlement called Tin City has grown up within the last year on the southeastern side, while on the northwest side, facing toward Bering Strait, the old Eskimo village of Kingegan is located. East Cape and other points on the Siberian coast, only 60 miles distant, are plainly visible on a clear day from the summit of this mountain. On the west and south sides the mountain slopes down to bluffs which drop almost perpendicularly into the sea. On its southeast side, where Tin City is located, there is a small bight in the coast line that affords some protection from west winds, but for

the prevailing south winds of summer the harbor is practically an open roadstead, and affords little if any better landing facilities than can be found at Nome or York. Tin City is 40 miles distant, and northwest of good anchorage on Port Clarence. East of Cape Mountain, the flat-topped upland called the York Plateau has an elevation of about 300 feet, and is made up of limestones and interbedded slates which have been already described. Cape Mountain itself is composed almost entirely of granite in the form of a boss or stock intruded in the limestone. The contact relations of the granite and limestone have not been studied in detail, but, from data gathered in the reconnaissance, it appears that the granite cuts across the stratification of the limestone.

The writer's visit to this locality was of necessity a very hasty one, and he was embarrassed by exceedingly rainy weather, so that his observations were limited in extent. However, specimens of tin ore were obtained, which undoubtedly came from the granite of the mountain, though the ore was not definitely traced to its position in the bed rock. It is reported that tin ore has been found at three distinct points on this mountain, and that it occurs in somewhat irregular deposits which have an east-west trend. Several tunnels were being driven into the mountain, but it was reported that ore bodies had not been found in any of them.

The ore obtained at Cape Mountain differs in general appearance from that seen on Lost River. Large pieces of nearly pure cassiterite, one of which weighed about 9 pounds, are said to have been found on the surface of the mountain. A specimen obtained by the writer weighs approximately 2 pounds, and is nearly pure cassiterite, showing little, if any, outward signs of crystallization, but has embedded in it and surrounding it much tourmaline in slender needles. While in this vicinity the writer was shown a number of large crystals of cassiterite which were nearly colorless and practically transparent. Much of the supposed tin ore contains a great many dark minerals that have been mistaken for cassiterite, but are simply tourmaline in slender black or brown needles.

Tin ore was discovered on Cape Mountain in July, 1902, and extensive developments were planned for the season of 1903. The plan of this work was as follows: A large dynamo driven by a gasoline engine was to be placed near the beach at the point now known as Tin City, and from this dynamo wires were to be run to several points on the mountain to supply power for electric drills. By the use of these drills it was expected that prospect tunnels could be rapidly extended into the heart of the mountain, in order to crosscut the ledges from which the float ore, above described, had been derived. After spending nearly the whole of the season of 1903 in getting the machinery in place, it was found that the engine for driving the dynamo was defective, and the plan for development work during the winter of

1903–4 was necessarily suspended. At the present writing, so far as is known, no work is in progress on Cape Mountain, and very little advance has been made in real knowledge of the nature of the ore deposits.

BUCK CREEK.[a]

Buck Creek is the scene of the first attempt at tin mining on a practical scale in Alaska, and is the present center of tin placer-mining activities. This settlement is on the Arctic slope of Seward Peninsula, about 20 miles northeast of York and 4 miles from tidewater on Lopp Lagoon, an inlet from the Arctic Ocean. It is reached by a wagon road from York, which follows the bed of Anikovik River for 10 miles, then crosses a low divide to Grouse Creek and follows down the bed of Grouse Creek to its junction with Buck Creek. This road is fairly good except for a mile and a half of deep, soft tundra in the divide between Anikovik River and Grouse Creek, where it is almost impassable for heavy wagons. A good roadbed could probably be easily built here by bringing gravels from Anikovik River. Lopp Lagoon is not navigable for deep sea-going vessels, and it is not probable that it will ever be used as a means of transportation of ore from the Buck Creek diggings.

The so-called York Plateau is well developed from the town of York northward to the Arctic Ocean. This plateau near York has an elevation of about 600 feet, and slopes northward to sea level along the Arctic coast. Buck Creek and other streams in its vicinity flow in comparatively new valleys cut in this plateau. Above the surface of the plateau there are several buttes of monadnack type, of which Cape Mountain and Potato Mountain are the most prominent. Potato Mountain, which is also known as Conical or Cone Hill, has an elevation of 1,370 feet. From its northern side a low range of hills extends northward for 3 or 4 miles toward Lopp Lagoon.

Buck Creek, which is a small stream about 5 miles in length, rises in this range of hills and flows southeastward to its junction with Grouse Creek, which in turn flows northward through Mint River and Lopp Lagoon to the Arctic Ocean. About a mile from its mouth Buck Creek receives a large tributary from the south, called Sutter Creek, and about 4 miles from its mouth it again forks, the two branches being known, respectively, as the Right and Left forks. Several smaller tributaries are received between Sutter Creek and the forks.

The bed rock out of which the York Plateau is cut and in which Buck Creek Valley is incised is a dark, slaty schist. Along Buck Creek this is characteristically jointed, as has been described. The mountains west of Buck Creek, including Potato Mountain, are composed of the same slates or schists. They apparently contain no beds of

[a] This description is based on the field work of Mr. Frank L. Hess.

intrusive igneous rock, either of the greenstone or of the granite type. Some bowlders and pebbles of greenstone occurring in the gravels of Buck Creek near its mouth have not been traced to their source, but probably came from a group of greenstone hills on the south of Grouse Creek.

Small quartz veins were found in a number of places along Buck Creek, cutting both across the bedding of the slates and running parallel with it. Some of these quartz veins are 3 or 4 feet wide, and one or two of them can be traced for a quarter of a mile or farther. Most of the veins are mere stringers 1 or 2 inches thick and only a few feet long. At one place on the upper part of the creek a vein of nearly pure pyrite 6 or 8 feet wide was seen. Pebbles of pyrite 2 or 3 inches in diameter, oxidized on the outside to limonite, are found in the gravels below this vein.

Mr. Edgar Rickard, in the Engineering and Mining Journal for January 3, 1903,[a] reports that the source of the cassiterite can be readily found in the slate of the Potato Mountain range, where it undoubtedly occurs in countless small veins and vugs, sometimes associated with quartz scattered through the mass of slate. The action of the elements has worn away the slates, leaving the cassiterite on the hillsides, and the streams have concentrated it into appreciable deposits.

Though specimens obtained from the gravel justify this conclusion, no veins of this kind were seen by Mr. Hess nor by any of the considerable number of prospectors who were actually engaged in the search for veins containing tin.

The gravel deposits in the bed of Buck Creek are ordinarily from 100 to 150 feet wide, varying greatly in different parts of the creek. Excepting a few greenstone bowlders found below the mouth of Sutter Creek, they consist of slate and quartz, together with other minerals derived from the country rock, such as hematite, limonite, magnetite, ilmenite, pyrite, cassiterite, and a small amount of gold. Cassiterite in the form of stream tin is distributed from the mouth of the creek to within a mile of its head, above which point little more than traces have been found. The ore varies in size from fine sand to pebbles weighing 13 or 14 pounds. Several pieces from 5 to 8 pounds in weight were seen by Mr. Hess, though the average size is much smaller. A few of the pebbles are perfectly rounded, but most of them are subangular. The ore from the workings near the mouth of Buck Creek is generally well rounded, while that from near the head is sharp and angular. In general, the farther up the creek it is obtained the more angular is the ore. In color the ore varies from black to light resin or amber. All that has been seen makes a light-colored resinous powder, by which it is readily distinguished from hematite or other

[a] Rickard, Edgar, Tin deposits of the York region, Alaska: Eng. and Min. Jour., vol. 75, p. 30.

iron minerals that are frequently mistaken for it, since they give a distinct red, black, or brown powder.

A number of specimens were obtained that showed pieces of quartz and slate from the bed rock still attached to them, leaving no doubt as to the origin of the fragments. Some small pieces of cassiterite have been found inclosed between the fragments of slate, showing that they were broken out of small veins in the slate.

Near the head of Buck Creek Mr. Edgar Rickard, in 1902, tested the gravels and found them to contain about 8 pounds of 60 per cent ore to the cubic yard. Mr. Hess saw pannings made at a number of places along Buck Creek, but not enough to thoroughly test the richness of the ground. The best seen came from immediately above the mouth of Sutter Creek, where a drain ditch from 2 to 2½ feet deep was in construction. From these pannings Mr. Hess estimates that the gravels contained approximately 27 pounds of 60 per cent concentrates to the cubic yard of gravel. The gravel deposit here was about 5½ feet thick and approximately 100 feet wide. At this point there seemed to be no difference in the distribution of the tin ore through the gravels from the surface down, and the largest pieces were found on the surface.

From the evidence of prospectors it seems that this uniform distribution through the gravel prevails generally along the creek, though at one place it was found to be richer on the bed rock.

On Grouse Creek below the mouth of Buck the amount of tin ore is reported to be very small, and Mr. Hess found no evidence of prospecting in this section. The gravel deposits of Grouse Creek are more extensive than those on Buck, and seem to be worthy of attention. No large amounts of cassiterite have been reported from either Gold Creek, a tributary of Grouse above Buck, or from Sutter, a large southern tributary of Buck, nor has much gold been found there.

To briefly summarize the evidence regarding the Buck Creek region, tin ore has been found in the gravels of Buck Creek from its mouth to within a mile of its head. The pay streak is confined to the present stream-bed and flood-plain deposits, and probably varies from 10 or 12 feet to 150 feet in width. In the present creek bed the ore is found from the surface down. Outside the creek bed there is a covering of moss and muck above the gravels. No ore is known to have been found on the hillsides surrounding Buck Creek or on the plateau surface in which Buck Creek is incised, though such an occurrence is to be expected. The thickness of tin-bearing gravels varies from a few inches to 4 or 5 feet. Estimates of the amount of tin ore in the gravels vary from 8 to 27 pounds per cubic yard, but probably the former amount is more nearly the average of the creek.

Tin ore was discovered on Buck Creek in the fall of 1901, and some mining for stream tin was attempted in the summer of 1902. As a

result of this work several tons of ore were shipped out to the States. During the summer of 1903 several companies were exploiting claims on the creek. The methods of mining and sluicing stream tin were all modifications of somewhat primitive methods of gold-placer mining. It is reported that considerable ore was obtained and hauled to York for shipment. Should the tin prove to be in sufficient quantity on this creek or in any of the creeks in its vicinity, more economical methods of mining must be adopted. In other parts of Seward Peninsula hydraulic mining has been practiced with marked success in the gold placers, and could probably be adapted to the tin placers as well. Water for this purpose can be obtained from the streams rising in the York Mountains, and can probably be brought in mining ditches to the tin placers of Buck Creek and vicinity, though this will be somewhat expensive.

ANIKOVIK RIVER AND BUHNER CREEK.

The first discoveries of tin ore in the York region were made on Anikovik River and Buhner Creek, a tributary of this river, by Mr. Alfred H. Brooks, by whom they were first described.[a]

Anikovik River enters Bering Sea at the town of York, and has a length of about 15 miles. It flows in a comparatively broad valley cut in the York Plateau. In the lower part of the Anikovik Valley there are rather extensive gravel deposits. The bed rock consists for the most part of slates, which break up into pencil-shaped fragments, as has been described.

Buhner Creek is a small tributary of Anikovik River, from the west, about 3 miles from the coast. This creek has a length of about a mile, and flows in a short V-shaped gulch cut in the slates. On this creek the stream tin was found concentrated on the bed rock with other heavy minerals. A sample of the concentrates from the sluice boxes yielded the following minerals: Cassiterite, magnetite, ilmenite, limonite, pyrite, fluorite, garnet, and gold. The determination by per cent of weight was as follows: 90 per cent of tin stone, 5 per cent magnetite, other minerals 5 per cent.

On Anikovik River, about one-half mile below the mouth of Buhner Creek, at the time of Mr. Brooks's visit to the region, sluicing for gold was in progress and specimens of cassiterite were obtained from the sluice boxes. One pebble of stream tin obtained from this locality was about 2 inches in diameter. Mr. Brooks was of the opinion that the source of the tin stone would be found in the quartz and calcite veins which carried the gold, though no cassiterite was found in any of this vein material.

Since 1901 these workings have been abandoned by miners, neither gold nor cassiterite having been found in paying quantities.

[a] Brooks, Alfred H., A reconnaissance of the Cape Nome and adjacent gold fields of Seward Peninsula, Alaska, in 1900 (a special publication of the U. S. Geol. Survey), 1901, pp. 132-138.

On Anikovik River there are extensive gravel deposits, which it is possible might be made to yield fair returns, either in gold or in tin, if economically worked on an extensive scale by hydraulic methods. Sufficient water for this purpose can probably be obtained either from the head of Anikovik River or from Kanauguk River.

REPORTED OCCURRENCES OF STREAM TIN.

Prospectors who are familiar with the stream tin from Buck Creek report finding small amounts of the ore in a great many streams in the York region; among these are Baituk and Kigezruk creeks, flowing into Bering Sea; Banner Creek, a tributary of Anikovik River; several small creeks flowing into Lopp Lagoon; Clara Creek, a tributary of Mint River; and York Creek, a tributary of Pinguk River.

Stream tin has been reported from all parts of Seward Peninsula where gold mining is in progress, but except in respect to the York region, these reports have generally been found to be without foundation.

REPORTED OCCURRENCES OF LODE ORE.

Discoveries of tin-bearing lodes have been reported by prospectors from many other localities in Seward Peninsula, some of which deserve notice, since geologic conditions are known to be promising. These are the localities in which intrusive stocks of granite occur, but in no case has the presence of tin ore in appreciable amounts been confirmed by the Geological Survey, and they can be passed over with mere mention. These localities are Brooks Mountain, near the head of Lost River, and 4 miles north of the Lost River tin deposits; the hills east of Don River; Ears Mountain, about 50 miles north of Port Clarence; Hot Springs, about 70 miles northeast of Port Clarence; Asses Ears, about 20 miles south of Kotzebue Sound, and the Diomede Islands, in Bering Strait, about 30 miles west of Cape Prince of Wales.[a]

CONCLUSION.

The above facts show cassiterite to be rather irregularly distributed through an area of about 450 square miles, embracing the western end of Seward Peninsula.

At three localities—Anikovik River, Buhner Creek, and Buck Creek—its occurrence in placers has been verified by the Geological Survey, and lode tin has been found by the Survey at Lost River and

[a] Since this was written, four specimens obtained from Ears Mountain have been analyzed by Mr. Eugene C. Sullivan, chemist of the U. S. Geological Survey. In each case traces of tin amounting to a few hundredths of 1 per cent were found. The rocks assayed consist of a granite-porphyry in which the original constituents are largely replaced by calcite, tourmaline, and pyrrhotite. The occurrence of cassiterite in the Asses Ears region has been confirmed by Dr. Cabell Whitehead, of the Alaska Banking and Safe Deposit Company, who found it in fine grains in the placer gold from Old Glory Creek.

at Cape Mountain. There are a number of other places where prospectors report its occurrence in lode or placer form.

The tin ore is almost all cassiterite, though a little stannite has been found at one locality. Its original source is in deposits of at least two essentially different types. In the one it is in quartz veins, which cut phyllites or metamorphic slates; in the other the cassiterite is disseminated through more or less altered granitic rocks. This second type of lode deposit is the one which gives promise of commercial importance.

In estimating the value of tin ores in this northern region several facts should be borne in mind. The region is utterly without timber and is accessible by ocean steamers only from June to the end of October at the longest. Harbor facilities are poor, and all supplies and wages are high. On the other hand, the construction of railroads and wagon roads is not difficult, and will require comparatively small outlay. All of the occurrences described are within a few miles of tidewater. Freight rates to Puget Sound ports should be very low, as the large fleet of ocean steamers which run to Nome returns empty. Last summer upward of 98,000 tons of freight were brought to Alaska by vessels that called at Nome. It is fair to say that these tin deposits are well worth careful and systematic prospecting.

PETROLEUM, NATURAL GAS, AND ASPHALT.

PETROLEUM FIELDS OF ALASKA AND THE BERING[a] RIVER COAL FIELDS.[b]

By G. C. Martin.

INTRODUCTION.

For several years indications of petroleum have been observed at Cape Yaktag,[c] near Controller Bay, on the western shore of Cook Inlet, and at many points on the Alaska Peninsula; and high-grade coal has been known on Bering River. A large amount of capital has been invested in these fields, several wells having been drilled, many coal openings made, and other improvements undertaken and projected. The verbal and newspaper reports from the region have been varied and conflicting, while such statements as have been published by geologists have not been based upon their own observations. Some of the petroleum and coal properties have been carefully examined by geologists or mining engineers in the interests of the owners, but their reports have not been made public.

In response to the general demand for information, a reconnaissance of the petroleum and coal fields in the vicinity of Controller Bay and Bering River and of the petroleum fields on the west shore of Cook Inlet and at Cold Bay was made by the writer during the months of June, July, and August, 1903. The following is a brief statement of the results of the investigation; a more complete discussion, together with maps of the regions, is in preparation and will shortly be published:

These fields, though widely separated, are all on the southern coast of Alaska and, except the Bering River coal field, on tide water. The Controller Bay petroleum fields are near the mouth of Copper River, and the Cape Yaktag fields are 75 miles farther east. The Cook Inlet fields are about 320 miles west of Controller Bay, in the middle part of the western shore of Cook Inlet, and the Cold Bay field is about 160

[a] On some maps called Chilkat River. [b] Abstract of report in preparation.
[c] Commonly spelled Yakatag or Yakataga.

miles to the southwest, on the southern shore of the Alaska Peninsula. The Bering River coal fields are from 20 to 40 miles from the coast, in the valley of Bering River, which flows into Controller Bay.

All these regions may be reached directly from Seattle by steamer, except the Cape Yaktag field, where there is no steamer landing. Controller Bay is from seven to nine days' sail from Seattle; Cook Inlet is about three days farther, while Cold Bay is two days beyond this. In order to reach the Cape Yaktag fields it is necessary to secure a small boat for the trip from Controller Bay.

CONTROLLER BAY PETROLEUM FIELD.

GEOGRAPHY.

Controller Bay is an indentation of the coast about 100 miles west of Mount St. Elias, sheltered on the southeast by Cape Suckling and on the southwest by a group of islands of which the largest is Kayak. The area here to be discussed includes the shores of Controller Bay and the adjacent region, with an irregular group of low peaks having no uniform elevation or trend, which form the foothills of the Chugach Mountains to the north. These foothills are highest near the mountains and fall away irregularly toward the sea, where few points are more than 2,000 feet high. The eastern shore of Controller Bay and of Bering River is low and almost flat.

Bering River, with its tributaries, drains the central part of this region and flows through Bering Lake, which is about 10 miles from the sea. Above the lake it receives as tributaries Canyon Creek and Stillwater Creek, which drains Lake Kushtahkah. Shepherd Creek enters Bering Lake from the north at its northeast corner. Nitchawak River enters Bering River from the east between the lower end of the lake and Controller Bay. Katalla River and a number of small streams drain the peninsula between Bering Lake and Controller Bay. The region northwest of the valley of Katalla River drains into the Copper River delta.

Most of the lowlands about Controller Bay are covered with a dense forest. Spruce, fir, and hemlock predominate among the larger trees and are of good size and fair quality. This heavy growth extends up the hillsides to an elevation of about 1,000 feet, where it gives way to less dense timber of the same species, and grades into a zone in which scrub alders are far in excess of the other trees. In the lower part of the valley of Shepherd Creek and in the valley of Katalla River there are meadows covered with a luxuriant growth of grass.

The various companies interested in the development of this region have built trails from cabin to cabin, and land travel is confined to these. The network of rivers, however, makes it very easy to get about in small boats, so almost all travel is done in this way.

The most important settlements are Kayak, on Little Kayak Island, which is the steamer landing and post-office for the entire region, and the town of Katalla, at the mouth of Katalla River. There are no other settlements, except the camps of the various operating companies and several small Indian villages.

GEOLOGY.

The rocks include a complex semimetamorphosed series, a series of oil-bearing shales, a series of coal measures, and a few igneous rocks.

The semimetamorphosed beds consist of sandstone, limestone, and shales, which are well exposed on the coast west of Katalla. Fox Islands and apparently the extreme southwestern point of Little Kayak Island are also composed of these rocks. They vary in color from dark gray to dull tones of red and green, and frequently have a mottled appearance. They are usually somewhat crumpled, and do not carry any evidence of their age or of their relation to the other rocks of the region.

The oil-bearing shales consist of a series of dark argillaceous and carbonaceous shales, with occasional bands of sandstone, limestone, conglomerate, and glauconitic rock. They occupy the peninsula between Controller Bay and Bering Lake and extend beyond Bering River to the east. No estimate could be made of the thickness of these shales. The few fossils which have been obtained indicate that they are of Tertiary age.

The Coal Measures, which apparently overlie the oil-bearing shales, consist of many hundred and perhaps several thousand feet of sandstone and shale, with many coal seams. The sandstones are usually coarse and are frequently feldspathic. There is no evidence as to the age of the formation, except that the general structure of the region is such as to indicate very strongly that the Coal Measures overlie the oil-bearing sands, which are of an indefinite horizon in the Tertiary.

There are several masses of igneous rock in various parts of this region.

Structure.—The structure is very complex, at least so far as the minor details are concerned. There appears to be a larger folding, modified by a minor folding, that often reveals itself merely as a crumpling in the softer shales, but which is locally so strongly developed as to obscure the major folding. There are thus two sets of structural features, one of which reveals itself in an east-west, the other in a northeast-southwest strike. The first is well shown in the great anticline which is described below as extending along the coast at Cape Yaktag, and again appears in many of the exposures of this region, especially along the coast near Katalla. Of the second series of folds, those extending in a direction from northeast to southwest, one of the most illustrative is the anticline which apparently extends

along the center of the Katalla Valley. This is paralleled by a number of other folds east of it in the peninsula between Bering Lake and Controller Bay, one of the most distinct being the anticline in the little valley nearest Bering River. The central part of the peninsula appears to consist of a succession of folds, several of which are exposed in the valley of Burls Creek.

OCCURRENCE OF PETROLEUM.

Petroleum seepages.—Petroleum seepages are very abundant in the Controller Bay region. Those which are best known are situated about 4 miles east of Katalla. The flow of oil is here very large, and good-sized pools have collected on the surface. Another group of seepages is on the headwaters of Burls Creek, where the petroleum may be seen oozing from the joints and bedding planes of the carbonaceous and glauconitic shales which are exposed in the deep ravines. The quantity of petroleum here exposed is not as large as at the seepages east of Katalla, but is more widespread. The small stream between Burls Creek and Bering River has several seepages along its east bank. Seepages occur, too, in other parts of the peninsula between Bering Lake and Controller Bay and in the region west of Katalla. The so-called Nitchawak region, which is situated on the banks of the various branches of Nitchawak River and in the vicinity of Mount Nitchawak, also presents a number of seepages. Some of these are located on the banks of a small lake, which is reported to be at times covered with petroleum. The small creeks which enter Little Nitchawak River from the north have a number of seepages on their banks, in some of which oil issues directly from the rock, which is here a shale.

A strong flow of gas bubbles to the surface of the water at a number of places along the lower course of Katalla River. In places this flow is so strong that it can be heard for a distance of several hundred feet. The composition of the gas is not known.

Several large sulphur springs issue from the northern bank of Bering River within a mile on either side of the Indian village.

Petroleum wells.—The first well in the Controller Bay region was drilled in the summer of 1901. Work upon it was stopped owing to the loss of tools.

The same company drilled another well in the summer of 1902, which at a depth of about 250 feet yielded petroleum. At a depth of 350 feet the tools appeared to break through into a cavity of the rock and a large flow of oil began, spouting, it is reported, many feet above the top of the derrick. No estimate of the amount of the flow has been made. This well was immediately capped, to be reopened in July, 1903, and drilled deeper. In September of this year the depth attained was between 400 and 500 feet, drilling still continuing.

Encouraged by such success, another company in the spring of 1903 began work on a well about 4,000 feet south of the first one. In July this well was abandoned at a depth of 1,700 feet, that being as far as it was possible to drill with the light rig which was used. No flow of oil was encountered in this well, but a little was brought up in the bailer from time to time.

It should be noted, in comparing the results obtained in these two wells, that the location of the second with reference to the first is in the direction of the dip. The dip is very steep in the interval of 4,000 feet between the wells, and while the exact amount is undetermined, it is surely enough to carry the oil sand which was tapped in the first well to a depth considerably exceeding 3,000 feet at the location of the second.

A third company began drilling in July, 1903, on one of the islands of Bering River, about 7 miles above the mouth. In September they had reached a depth of over 500 feet, with no indication of oil.

Another well, also begun during July, 1903, is on the north bank of Katalla River, about 2 miles above the town of Katalla. No information has since been obtained concerning it. At the time the writer left Alaska, in September, a number of other wells were about to be drilled, but no account of their progress has been received.

Structural relations of the petroleum.—The conditions believed by the majority of observers to be necessary to the occurrence of petroleum in commercial quantities are, first, the presence, originally, of a large amount of organic matter in the sediments from which the oil was derived; second, the existence of a porous rock, in the aggregate very considerable, in which the oil could accumulate; and, third, the protection of this rock in such a manner that the oil can not escape. The condition generally regarded as affording the most efficient protection is the presence of an overlying stratum of fine, compact rock, which the oil can not penetrate, and the flexure of the strata into a gentle anticline, so that escape of the oil is cut off, both in an upward direction and laterally, in the latter case, it may be, by the body of water behind it. Other conditions which govern the accumulation and distribution of oil are changes in the porosity of the containing bed, either from variation in the coarseness of sediment, or from the filling of the interstices with mineral deposits; for example, carbonate of lime. Underground water, also, doubtless plays a part in the accumulation and distribution of oil.

From the size and distribution of the seepages it may be reasonably inferred that a vast amount of organic matter which was subsequently converted into petroleum was incorporated with the sediments now constituting the oil-bearing shales of the Controller Bay region. The appearance of the rocks is evidence that there are numerous horizons in the series sufficiently porous to afford reservoirs for the accumula-

tion of oil, and the successful well shows that the conditions are favorable for at least one productive field. It is, however, frequently very difficult to ascertain conditions below the surface, and the aid ordinarily derived from well records is not yet sufficient in this field to show conclusively the relation in depth between the occurrence of the oil and the structure and stratigraphy of the containing series. The structure of the field is complex, but if drillings are made after a careful consideration of all geologic details, the existence of valuable oil areas may perhaps soon be proved and their definition safely suggested.

Properties of the petroleum.—A sample of the petroleum from the well near Katalla has been tested by Penniman and Browne, of Baltimore, with the following results:

Test of petroleum from Katalla, Alaska.

Specific gravity	39.1° B. (0.828 at 15.5° C.).
Distillation by Engler's method:	
Benzine (80°–150° C.)	21 per cent, 54.9° B. (0.7573)
Burning oil (150°–300° C.)	51 per cent, 40.6° B. (0.8204)
Residuum (paraffin base)	28 per cent, 23.9° B. (0.9096)
Sulphur	Trace.

The burning oil was purified by concentrated sulphuric acid and soda, the volume of acid used up being too small to measure. The purified burning oil was put into a small lamp, where it burned dry without incrusting the wick or corroding the burner, and without any marked diminution of flame. The burning oil compares very favorably in these respects with Pennsylvania oil prepared in the same way.

The results of the tests may be compared with those of other petroleums in the following table:

Tests of petroleum from Alaska and other fields.

	1. Alaska.	2. Pennsylvania.	3. Ohio.	4. Colorado.	5. Mexico.	6. Beaumont.
Benzine (80°–150° C.)	21	16½	10	16	10	2½
Burning oil (150°–300° C.)	51	54	50	40	60	40
Residuum	28	29	40	44	30	57½
Sulphur	Tr.					1.7
Specific gravity	39.1°B.			43°B.		22°B.

1. Penniman and Browne for this report.
2. S. F. Peckham, Report on Petroleum, p. 365.
3. Durand Woodman, Jour. Am. Chem. Soc., vol. 13, p. 168.
4. F. H. Oliphant, Mineral Resources U. S., 1901, Petroleum, p. 560.
5. T. B. Stillman, Engineering Chemistry, p. 364.
6. Hayes and Kennedy, Oil fields of Texas-Louisiana coastal plain: Bull. U. S. Geol. Survey No. 212, pp. 146–151.

The petroleum is clearly a refining oil of the same general nature as the Pennsylvania petroleum. It resembles the latter in having a high

proportion of the more volatile compounds and a paraffin base, and in containing almost no sulphur.

The proportions of the several constituents given in the table above do not necessarily represent the full amounts that could be obtained in practice by different treatment.

CAPE YAKTAG PETROLEUM FIELD.

Cape Yaktag is situated about 75 miles east of Controller Bay. The shore line is here straight and there is no harbor which affords shelter for any kind of boat. A strip of land from 5 to 10 miles in width lies between the coast and Bering Glacier. The ice front is marked by a line of hills which are parallel to the coast and from which a steep slope descends to the sea. This slope is drained by many short parallel streams, some of which head in the ice. The Cape Yaktag oil field extends eastward for about 25 miles from the mouth of Yaktag River, which is the easternmost of the longer streams reaching the ocean near Cape Yaktag.

GEOLOGY.

The writer was not able to visit this region, so that the following observations are based upon the statement of others. The structure, it is said, is anticlinal, with the axis parallel to and very near the shore line. The dip on the southern flank of the fold is very steep, the rocks standing vertically along the beach. The dip on the northern side is much gentler, seldom exceeding 20°. The rocks consist of shales with interbedded sandstone and limestone, the whole resembling very closely in lithologic character the rocks of the Controller Bay oil field. The northward dip continues inland as far as the region has been explored. The structure is very uniform, no marked variations from the strike and dip recorded above having been noticed.

BERING RIVER COAL FIELD.

Bering River coal field is situated from 12 to 25 miles inland from Controller Bay. The coal area, as far as known, is restricted to the region north of Bering Lake and upper Bering River. Its southern boundary appears to coincide approximately with the position of the lake and with Bering River above the lake. The western boundary, although not definitely known, is assumed to lie along a north-south line extending through the north arm of Bering Lake parallel to its western shore. The northern and eastern boundaries are also uncertain, but are probably at a considerable distance beyond the region as now known. The coal area as at present recognized includes about 85 square miles.

The following sections of the coal seams have been measured:

Section in tunnel on east bank of Carbon Creek.

	Ft.	In.
Dark shale	2	0
Coal	20	0
Massive, arkosic, cross-bedded sandstone with many thin carbonaceous streaks	10	0

The strike at this point is N. 65° E. The roof of the seam dips 60° NW., the floor 78° NW.

About 100 yards northwest of this point a seam containing about 3 feet of clean coal has been exposed. One mile northwest, at what is known as Doyle Camp, a coal seam 20½ feet thick is exposed. The strike of the roof is N. 10° E., of the floor N. 30° W.; the dip is from 75° to 85° E. Both roof and floor are very irregular.

Section 1 mile northwest of canoe landing on Shepherd Creek.

	Ft.	In.
Coal	3	0
Shale	0	2
Coal	4	4

The strike at this point is N. 20° E., the dip 65° NW. This opening is on the west side of the valley of Shepherd Creek, at an elevation of about 200 feet above the lake.

Four seams are exposed on the east bank of Canyon Creek. Three miles above the mouth of Canyon Creek the coal has a thickness of 2 feet, 9 inches. It is overlain by sandstone and has a shale floor. The strike is N. 80° E., the dip 35° W. The section was measured at the level of the valley floor. This seam is variable in thickness, pinching out somewhat higher in the bluff.

Four miles above the mouth of Canyon Creek the coal has a thickness of 4 feet, 2 inches; it strikes N. 10° E., and dips 60° W. It has a shale roof and shale floor.

At the south end of Carbon Mountain there is a high bluff where Bering River has been pushed against the end of the mountain by the Bering Glacier. In this bluff the following section was measured:

Section at south end of Carbon Mountain.

	Feet.
Sandstone	30
Coke	1
Sandstone	20
Coke	2
Sandstone	2 to 5
Coke	1 to 5
Sandstone	3
Coke	1
Sandstone	8
Coke	1¾ to 2¼

The strike at this point is N. 80° W., the dip from 20° to 25° N.

The following section is exposed in the west bank of Trout Creek, 2 miles above its juncture with Stillwater Creek, and 6 miles above the mouth of the latter:

Section on Trout Creek.

	Feet.
Shale	4
Coal	6½
Sandstone	5

The strike is N. 40° E., the dip 38° W.

At a point on the north shore of Bering Lake a coal seam has been exposed which has a thickness of about 2 feet. The roof was not seen; the floor is massive sandstone.

The preceding include all the coal sections which were accessible at the time the region was studied; it is reported, however, that there are many other seams, some of them exceeding in thickness any which the writer saw. Two of these, said to be 35 and 40 feet thick, have been opened on the headwaters of Carbon Creek, and it is rumored that a still thicker seam had been discovered in the Stillwater Valley during the latter part of the summer of 1903. Smaller seams have been opened on the shores of Lake Kushakah and on the north shore of Bering Lake.

It is the opinion of the writer that the foregoing sections represent distinct coals, and that furthermore, from the smut observed by him in the development of the country, many additional ones will be discovered which are now concealed beneath the soil and the dense vegetation.

Owing to the general northerly dip throughout the coal field, the northern portion of it, as at present recognized, is underlain by a far greater number of seams than the southern. The northward extent of the field, however, the nature of its structure, and the manner of its termination, remain unknown.

The features to be considered by the mining engineer embrace faults and their attendant problems; steep dips; the physical properties of the coal as affecting its shipment and market value, a tendency to crush being especially noticeable; the proportion of the seams above water level, and their accessibility.

CHARACTER OF THE COAL.

The physical properties of the coal are very much alike in all seams and in all parts of the field seen by the writer. The coal resembles the harder bituminous coals of the East more than it does anthracite. It is doubtful if much of the coal could be sized so as to compete with anthracite coal for domestic use. Under ordinary handling it will probably crush to almost the same extent as the harder grades of semi-bituminous coal. This will not, of course, impair its value as a steam

fuel, but it will necessitate careful handling if the coal is to compete with Pennsylvania or Welsh anthracite as a domestic fuel.

The following table includes all the analyses and calorimetric tests which have been made upon the Bering River coal. The first five samples were collected by the author and represent the composition of the entire seam; that is, coal was cut evenly from the seam from roof to floor.

Analyses and tests of Bering River coals.

Locality.	Thickness of coal.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Color of ash.	Calories.	Recalculated. Fuel elements. Volatile matter.	Recalculated. Fuel elements. Fixed carbon.	Recalculated. Fuel ratio.
	Feet.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*			*Per cent.*	*Per cent.*	
1. Carbon Creek [a]	20	2.41	15.03	79.24	3.32	0.51	Reddish	8,345	15.94	84.06	5.27
2. Shepherd Creek [a]	7½	1.54	14.58	72.99	10.89	.69	Yellow	7,664	16.65	83.35	5.01
3. Trout Creek [a]	6½	2.36	18.12	71.87	7.65	.73	Reddish	7,819	20.14	79.86	3.97
4. Canyon Creek [a]	4⅛	3.24	9.79	62.97	24.00	1.94	Yellow	6,502	13.45	86.55	6.43
5. South end of Carbon Mountain (coke) [a]	5	1.34	6.30	84.57	7.79	.77	Very red	7,776	6.93	93.07	13.43
6. Controller Bay [b]	.....	.75	13.25	82.40	3.60	.69	.....	.....	13.85	86.15	6.22
7. Icy Bay [b]	.....	.78	13.22	80.30	5.70	2.90	.....	.....	14.13	85.86	6.07
8. Bering River [c]	.....	.77	13.79	82.36	3.08	2.68	.....	.....	14.34	85.66	5.97

[a] Sample collected by G. C. Martin. Analysis and calorimeter test by Penniman and Browne.

[b] Analysis furnished by F. H. Shepard. Published by J. E. Spurr: Reconnaissance in Southwest Alaska. Twentieth Annual Rept. U. S. Geol. Survey, pt. 7, p. 263.

[c] Sample collected by W. M. Carless. Analysis by W. F. Hillebrand. Published by Schrader and Spencer. Geology and Mineral Resources of a Portion of the Copper River District, Alaska, p. 91.

These coals vary greatly in composition and in heating power, and it seems likely that in this field, as everywhere, each seam will be found to have a characteristic composition. The source of Nos. 6, 7, and 8 is not known, but possibly Nos. 6 and 8 are from the opening on Carbon Creek, from which No. 1 was obtained. The difference in the amount of moisture in these samples and in those collected by the author is probably due to the fact that the latter were placed in sealed cans as soon as taken and no opportunity was given for the coal to dry out. The very high percentage of sulphur in Nos. 7 and 8 is probably due to their having been taken, not from the entire thickness of the seam, but from pieces of coal which were picked for their hardness and apparent cleanness. The one who took the samples evidently overlooked the fact that their exceptional hardness was not due to the coal being a higher grade of anthracite, but to its containing a large amount of pyrite (sulphide of iron).

The 20-foot seam now exposed in the tunnel on Carbon Creek is the most promising coal seen by the writer. It not only possesses the

greatest thickness and is entirely free from bands of shale and other impurities, but, as the above table shows, it is the purest coal and has the highest heating power. Its composition shows it to be semianthracite of somewhat the same composition as the coal of the Bernice Basin (Loyalsock) in Pennsylvania,[a] although it is purer and has a higher heating power than that coal. It differs from the anthracite of Pennsylvania and Wales in having more volatile matter in proportion to the amount of fixed carbon. In the ratio of fixed carbon to volatile matter it is nearer to the Bernice Basin coal than to any other coal that reaches the general market. In heating power as well as in the low amount of impurities it is almost identical with the Pocahontas steam coal of West Virginia, but excels this coal by having a higher proportion of fixed carbon. There is no other coal with which it is likely to come into general competition with which it is to be compared, for it is far higher in heating power and in purity than any coal that is mined upon the Pacific coast, either in the United States, Canada, or Australia.

The seams opened on Shepherd Creek 1 mile northwest of Canoe Landing, and also near the headwaters of Trout Creek, are probably representative of the thinner seams of this region. These coals differ from the coal of the 20-foot seam in having a less amount of fixed carbon in proportion to the volatile matter and in having a higher percentage of ash and sulphur. The heating power is consequently less. They resemble coals of the semibituminous type that enter the market as high-grade steam coals. They correspond in texture, composition, and heating power to the high-grade Pocahontas (West Virginia) and Georges Creek (Maryland) steam coals, and also to some of the semibituminous coals of Wales.

The coke exposed in the southern end of Carbon Mountain is an interesting deposit, which may prove to be of considerable value. The analysis shows it to be of great purity and high heating power. It will be seen from the section given on page 372 that it is broken up by partings into a number of thin seams which vary considerably in thickness within short distances. It may be that some of these will be found sufficiently thick and persistent to be of economic importance. Part of the coke is dense and hard and shows a well-marked columnar structure. The latter will break into fine fragments on handling, and will thus be at a disadvantage from the market standpoint. The product should be carefully screened, when the lump will make a high grade of domestic fuel.

[a] The following is an average of several analyses of Loyalsock coal:

	Per cent.
Moisture	1.49
Volatile material	11.07
Fixed carbon	78.88
Ash	7.70
Sulphur	.86

COOK INLET PETROLEUM FIELD.

GEOGRAPHY.

The region under discussion occupies the western shore of Cook Inlet from the foreland on the north side of the entrance of Chinitua Bay southwestward for about 40 miles to the mouths of Enochkin[a] and Iliamna bays, and extends inland, with a maximum width of about 10 miles, to the crystalline rocks at the eastern front of the Chigmit Mountains. Its coast includes the deep indentations of Chinitua, Enochkin, and Iliamna bays and the lesser ones of Oil and Dry bays.

The region includes a high mountain range, a range of lower hills, and an intervening valley region. The rugged Chigmit Mountains have an average elevation of about 5,000 feet and are parallel to the general shore of the inlet. The range of lower hills, unnamed, extends from the mouth of Enochkin Bay northeastward to Snug Harbor, paralleling the coast at the distance of a mile. The general height of these hills is about 2,500 feet. A general area of depression occupies the position between these two ranges. This consists of many valleys drained by streams flowing into the bays named above, and of irregular, low, rounded hills. The divides between the drainage systems are low and permit easy portages. The streams are all small, for the most part unnamed, and entirely unnavigable.

The lowlands are covered with dense vegetation and consist of about half meadow and half forest. The meadows are deeply grassed and are dotted with groves of cottonwood and thickets of alder and willow. The forests consist of a fair growth of spruce and hemlock. The tree are not large, but are straight and sound.

A wagon road has been built from the lower landing point of Enochkin Bay to the head of Oil Bay, and there are cleared trails from the head of Oil Bay to Dry Bay, to the head of the eastern arm of Enochkin Bay, and to a point on the shore of Enochkin Bay 2 miles above the lower landing. There are also two trails from Dry Bay to the shores of Chinitua Bay, and a portage trail from the head of Enochkin Bay to the head of Chinitua Bay.

GEOLOGY.

The rocks of this region consist of a zone of a massive crystalline series exposed in the Chigmit Mountains, a sedimentary formation of Jurassic age in a belt east of them, and a series of overlying agglomerates, shales, and bedded volcanic flows, which are exposed in the coastal range of hills. The formations lie in belts parallel to the coast. The relation of the sedimentaries to the crystallines is complex and obscure,

[a] This has been variously spelled as Inerskin, Innerskin, Inischen, and Innisken, but as here given is said to be the correct spelling of the Russian name.

but the remainder of the series is conformable throughout and is gently and simply folded. The general section is as follows:

General section of Chigmit Mountains.

	Feet.
1. Sandstone, shale, and conglomerate with fossil trees	100 ?
2. Volcanic rocks (andesite, etc.) with some interbedded shale	2,000 ?
3. Shale	580
4. Volcanic rocks (andesite or agglomerate)	300
5. Shale	1,650+
6. Coarse crystalline rocks.	

The crystalline rocks of the Chigmit Mountains extend along the entire western shore of Enochkin Bay, and both shores of the northern arm of that bay. There is considerable variety to the series, but granite and rocks similar in texture and general appearance predominate.

Jurassic shales.—The rocks overlying the crystallines consist of a thin conglomerate at the base, followed by more than 1,600 feet of dark sandy shales with occasional bands of sandstone, conglomerate, and limestone and many fossil beds; they are well exposed in the cliffs on the east shore of Enochkin Bay. Rocks of the same lithologic character extend along the strike northeastward from these exposures, passing the heads of Oil and Dry bays to Chinitua Bay. They have not been followed beyond the north shore of Chinitua Bay by the writer, but from the great thickness exposed it is evident that they must extend a considerable distance. Rocks of similar lithologic character have also been reported from the vicinity of Snug Harbor. Fossils are distributed throughout the formation and show the age to be middle Jurassic.

Volcanic flows and agglomerate.—The Jurassic shales are overlain by a series of volcanic flows, probably of andesite, and by coarse agglomerate. There is some interbedded shale. The agglomerate seems to be confined to the shore of Enochkin Bay. These rocks form the high coastal ridge which extends from Enochkin Bay to and beyond Chinitua Bay, their total thickness being probably more than 2,000 feet.

Structure.—The structure of this region consists of a broad, low, somewhat undulated anticline parallel to the shore of Cook Inlet and to the general line of the eastern front of the Chigmit Mountains, followed on the west by a narrow syncline, beyond which is a second, very closely folded and probably faulted anticline. The dip in the broad, easternmost anticline is moderate in amount and very regular, except on the crest of the fold, where it is undulating, but is not in excess of 10°. On the eastern limb the dip varies from 20° to 28°, diminishing as the shore is approached, and on some of the long points and islands becoming almost or quite horizontal. The steepest dip in the southwestern part of the field was observed on the shore of

Enochkin Bay, where the rocks are inclined southeastward at an angle of 28°. The greatest dip at the northern end of the field is between half a mile and a mile southeast of the entrance to Chinitua Bay, where it is from 25° to 45° SE. On the western flanks of this anticline the dip is about 17°.

The nature of the undulations at the crest can be seen in the cliffs on the eastern side of Enochkin Bay.

The syncline which adjoins this anticline on the west is a much narrower and simpler fold. It is characterized by a steeper dip on the western than on the eastern flank. It appears to die out toward the northeast and was not recognized on Chinitua Bay.

West of this syncline is an anticline in which the rocks are badly crumpled and faulted. The crystalline rocks are exposed on its western side and at places within it. The contact of the westernmost outcrops of the shales with the crystalline rocks appears to be along the line of a great fault. The amount of pitch of the axes of these folds is not known.

OCCURRENCE OF PETROLEUM.

Surface indications.—The surface indications of petroleum in this region consist of seepages or oil springs, and the so-called gas springs. In the first, the petroleum may be seen oozing from the cracks in the rock or coming out of the soil. On the east shore of Enochkin Bay a good seepage was seen about 1,000 feet below the lower cabin, although the spring is covered at high tide. The flow is often so strong that the petroleum collects in large blotches on the pool, or even covers its entire surface. At one point it issues from a crevice in the rock, which is Jurassic shale.

In the vicinity of the cabin at Oil Bay are a number of large springs. From the bottom of one the petroleum is almost continually rising, the flow varying, however, from time to time, now almost ceasing, now becoming very strong. It is frequently possible to skim several quarts of petroleum from the surface of the pool.

About 2 miles west of the beach at Dry Bay is a so-called gas spring, gas of unknown composition rising in a continuous stream of bubbles to the surface of the water. From the north shore of Chinitua Bay both oil and gas springs have been reported, but they were not seen by the writer.

The geologic structure of this region has already been outlined. It consists of a long anticline, parallel to the coast, with an axis having a N. 80° E. trend. The dip on each flank is regular and comparatively moderate, seldom exceeding 20°. Although in the axial region of the fold the strata are faintly undulating, the crown of the arch is almost flat. Other things being equal, the fold is such, indeed, as should yield a good flow over a considerable area, granting the existence below

of a porous reservoir capped by impervious beds and filled with oil. A line extending from about a mile above the lower cabin on the shore of Enochkin Bay to a point a half mile northwest of the beach at Oil Bay, thence through a point 2 miles above the beach at Dry Bay to the center of the high cliff on the north shore of Chinitua Bay, would lie at about the center of the zone which at the present seems to be the most promising. The oil sand would probably be found nearer the surface along this line than either to the southeast or northwest.

As in all cases, however, drilling is necessary to obtain a knowledge of the underground conditions, as well as to estimate the economic and commercial value of the field; thus far this has been insufficient. As regards the entire Enochkin Bay region, it is almost certain that the oil will be confined to the easternmost anticline.

Development.—Indications of petroleum were discovered in this region about fifty years ago. The first was taken out in 1882 by a Russian named Paveloff. A Mr. Edelman staked ground in 1892. His location was near the divide at the head of the creeks entering Oil and Dry bays, but the claims were subsequently abandoned. In 1896, Pomeroy and Griffen also staked property at Oil Bay, and during the next year organized the Alaska Petroleum Company. Work was begun in 1898. The Alaska Oil Company was organized in 1901, and in 1902 began drilling at Dry Bay.

The well at Oil Bay is reported to have struck a flow of 50 barrels of petroleum at a depth of about 500 feet. On drilling deeper a strong flow of water was encountered which shut off the flow of oil. The well is now over 1,000 feet in depth and affords a continuous flow of gas, which at times becomes very strong. Attempts have been made to shut off the flow of water and either recover the lost oil or drill deeper. No log could be obtained.

The well at Dry Bay was drilled to a depth of 320 feet, without encountering oil. The tools were then lost and the hole abandoned. In August, 1903, a new well was started in close proximity to the first.

The shipment of petroleum from this field would probably be from Enochkin and Chinitua bays, which are harbors affording safe anchorage to large vessels in all weather, as well as good wharf sites. Ships can, however, anchor in the mouth of Oil Bay and off Dry Bay except during very bad weather. If docks should be built either at Enochkin or Chinitua, it would be necessary to build pipe lines and pumping stations to transfer the product from the field to the shipping point. This would not, however, be a serious matter, as divides are low and construction and operation would be easy.

COLD BAY PETROLEUM FIELD.

GEOGRAPHY.

Cold Bay is situated on the south shore of the Alaska Peninsula at the southwest end of Shelikof Strait and opposite the west end of Kodiak Island. It may be reached by steamer from Seattle either direct or by transfer at Valdes or Kodiak, or from Dutch Harbor. From Seattle the time is about fifteen days; from Valdes, four. It may also be reached from Bristol Bay by a canoe and portage across the peninsula.

The southern shore of the Alaska Peninsula is very sinuous, with deep indentations and long, rugged forelands. Cold Bay is one of the best of the harbors. It is roughly triangular in shape, about 10 miles long by 7 wide at the mouth, and contains a very large area of deep water.

The surrounding country consists of an elevated upland with gently rounded or flat-topped hills rising above it. Its general level is about 750 feet above tide. Most of the higher peaks rise to an elevation of about 1,500 feet, while farther back from the coast, in the central part of the peninsula, are mountains 5,000 feet or more in height.

The streams emptying into Cold Bay and into the other bays in the vicinity are short and swift, but carry a large amount of water. The northern slope of the peninsula, on the other hand, is drained by a comparatively small number of fairly large rivers which empty either into shallow bays or directly into the sea. All of these rivers have lakes either at their headwaters or along their courses. Lake Becharof, the head of which is situated about 15 miles from the landing at Cold Bay, is one of the largest.

Timber is almost entirely lacking in this region, the only trees being a few small cottonwoods, willows, and scrub alders along the banks of the streams. This is characteristic of the greater part of the Alaska Peninsula.

GEOLOGY.

The rocks observed in the vicinity of Cold Bay consist of a few thin limestones and dark shales which break on the weathered surface with a conchoidal fracture. These alternate irregularly. Their age is Mesozoic, corresponding closely to that of the rocks of the Cook Inlet oil fields. They carry Jurassic fossils everywhere except at the promontory on the east side of the bay, where Triassic forms have been reported.

Structure.—The rocks either lie horizontal or with a dip that is very gentle, though somewhat irregular, both in amount and direction. In the forelands the general dip is northwestward. Several miles back this dies out and the rocks lie horizontal or dip slightly toward the

east. Farther inland the northwestward dip is resumed and continues to the limit of the area examined by the writer. According to reports, the dip is reversed again near the center of the peninsula, so that Becharof Lake lies in a syncline, while near its northwestern shore a sharp anticline is said to rise, which brings to the surface not only the entire sedimentary series but also a mass of crystalline rocks that form the core of the peninsula throughout most of its length. It has been stated that there is a great anticline parallel to the southern coast that has its axis near the ends of the forelands. This view is sustained by the fact that on one of these promontories at least rocks older than the Jurassic are exposed, but the writer has not seen any evidence which would show how far seaward this northwestern dip may extend.

INDICATIONS OF PETROLEUM.

Petroleum seepages occur in or near the first zone of horizontal or southeastward dip described above. In this same position two wells were begun in the summer of 1903. They are located about 5 miles from the landing on the west shore of Cold Bay, and at an elevation of about 750 feet above tide. They are distant also about 9 miles in an air line from Becharof Lake.

If petroleum be stored within the series of rocks about Cold Bay, other things being equal, the very gentle folding which the strata have undergone should be favorable to the formation of large pools. The petroleum from this field has a paraffin base and is probably similar to the Controller Bay petroleum.

If petroleum should be discovered in commercial quantities in this region, it can be piped from the wells to Cold Bay by gravity and shipped from thence to San Francisco or to Puget Sound ports.

PETROLEUM RESIDUE.

On some of the hillsides several miles inland from Cold Bay are seepages of petroleum that are in some cases continuous, in others intermittent. The petroleum runs down the hillsides in the watercourses, and, in several instances, collects at the bottom of the hills in peat bogs. Losing enough of its volatile constituents by evaporation to render it immobile, it there remains, impregnating the peat and forming over its surface a thick coating of black paraffin wax.

These deposits have already been of considerable importance in the development of the region, for the peat impregnated with paraffin wax has proved a fuel of greatest value, replacing even coal from the mines of Puget Sound, imported in large amount for use under the boilers in drilling operations. The deposit which has furnished this fuel for the past season has an area of about 1½ acres, the material having been dug to a depth of about 3 feet without in some cases

reaching bottom. This deposit alone contains enough of the residue to supply all local needs for fuel for some time to come. Another deposit has, however, been discovered in the vicinity which has an area of 3 acres and a thickness of at least 10 feet. Many more, also, will doubtless be brought to light.

Chemical and calorimetric tests of the petroleum residue have been made by Penniman & Browne, of Baltimore. The result of their tests follows:

Test of petroleum residue from Cold Bay.

Moisture:	
Volatile matter	85.40
Fixed carbon	7.76
Ash	6.84
Sulphur	0.36
Soluble in gasoline	68.20
Calories	8,193

The table shows a material that compares favorably with most of the coals sold on the Pacific coast. It is, indeed, their superior as regards calorific power, ash, and amount of sulphur. The amount indicated in the table as soluble in gasoline represents the petroleum residue present, the remaining 31.8 per cent consisting of peat and earthy material.