MINING IN SOUTHEASTERN ALASKA.

By Adolph Knopf.

INTRODUCTION.

Southeastern Alaska has long held the world's record for the production of low-grade gold ore, a position due in the past mainly to the output of the Treadwell group of mines on Douglas Island. These mines are operating on a mineralized dike of albite diorite—a type of ore body of which this is so far the only one exploited in the region. On the mainland there exist behind the town of Juneau enormous bodies of low-grade ore, consisting of slate irregularly cut by auriferous quartz stringers. Mines have been operating on these ore deposits at a profit for a number of years, and the mining and milling costs have even been brought below those existing at Treadwell, but because of the disadvantageous situation of the mines several miles from tidewater the ore bodies have never been exploited on a scale commensurate with their magnitude. Plans have been formulated for their extensive development, but the execution of these large projects has necessarily been slow. Construction, however, was actually started in the later part of 1910, and it now appears that several hundred additional stamps will be dropping in the Juneau region in 1912. It is safe to say that, with this increase of milling capacity and the new developments contemplated or in progress at Douglas Island, Berners Bay, and Chichagof the gold production of southeastern Alaska will at least be doubled within a few years.

In contrast to this marked expansion of the gold-mining industry the copper-mining industry shows a stationary condition, nor with the prevailing low price of the metal is there likely to be any greatly increased output of ore.

Marble continues to attract attention as one of the mineral resources of southeastern Alaska. Prospecting continues and claims are located at widely separated localities, as at Dall Island, on the west coast, and at Limestone Inlet, 25 miles south of Juneau, and the productive quarries are enlarging their capacity.

GOLD MINES AND PROSPECTS.

PRODUCTION.

According to preliminary estimates, the production of gold for 1910 in southeastern Alaska was substantially the same as that for 1909, in round numbers $4,000,000. The following table gives the tonnage and value for a number of preceding years. It shows clearly the preponderant influence of the low-grade ores of the Juneau district on the average value per ton:

Production of gold ore in southeastern Alaska.

Year.	Ore mined.	Gold.		Silver.		Average value per ton.
		Amount.	Value.	Amount.	Value.	
	Tons.	*Ounces.*		*Ounces.*		
1907	1,206,639	132,300	$2,734,885	22,203	$14,653	$2.28
1908	1,475,516	161,975	3,348,312	31,834	16,872	2.28
1909	1,478,429	198,285	4,098,900	27,481	14,290	2.78

JUNEAU AND BERNERS BAY REGIONS.

DOUGLAS ISLAND.

The steadily increasing depth from which ore is extracted at the Treadwell group of mines has made advisable an enlargement of the hoisting capacity. In order to realize the economies of a central hoisting plant, it has been decided to make the shaft of the 700-foot claim the main hoisting shaft of the three mines that are grouped on the same lode—the Alaska-Treadwell, the 700-foot, and the Alaska-Mexican. A contract has been let for a balanced hoist capable of lifting 5,000 tons from a depth of 3,000 feet in 20 hours, the net load being 8 tons. A new gallows frame will be erected and new crushing machinery of heavier capacity installed. It is anticipated that the entire plant will be ready for operation by the fall of 1911.

The hydroelectric plant at the mouth of Sheep Creek, which is capable of generating 2,500 horsepower for about two-thirds of the year, and the transmission line to Treadwell were completed during the year. Work was started on a transmission line from Treadwell to Nugget Creek at Mendenhall Glacier, a distance of 12 miles, where it is proposed to build a dam, probably 125 feet high, which will have a storage capacity equivalent to approximately 5,000 horsepower for 90 days. When this project is completed, it will be possible to run the 300-stamp mill of the Alaska-Treadwell the entire year. At present it is shut down during the winter months on account of lack of water power.

Pelton wheels have been installed at the Ready Bullion and Mexican mills, and the stamps are now operated by water power developed from the Ready Bullion dam.

A thoroughly equipped cyanide plant, capable of handling 100 tons of concentrates a day, has been completed and will render shipment of the sulphurets to the smelter unnecessary in the future.

At the Alaska Treasure mine, on Nevada Creek, 3,100 feet of the projected 3,500-foot double-track tunnel has been completed. A rate of 50 to 76 feet a week is attained and the ore body will doubtless be undercut before this report goes to press. No extensive surface improvements have yet been undertaken, pending underground development of the ore body.

GOLD CREEK MINES.

The mines situated in Silverbow Basin, at the head of Gold Creek, operate at a maximum only six months in the year. As winter approaches, freezing weather sets in, water runs low, and the mills, which are operated by water power, are necessarily shut down. To remedy this it has been proposed to build new mills at tidewater on Gastineau Channel, where they could be operated the year round. Haulage tunnels from 10,000 to 13,000 feet long would be required to bring the ore to the mills, but although these plans have been under consideration for several years, little has been done toward their accomplishment. A partial fulfillment, however, seems likely during 1911.

Mining was resumed at the Perseverance mine on May 25. A force of 110 men were employed and the 100-stamp mill was in operation during the season.

The Alaska-Juneau started up on June 4, employing 30 men. Most of the ore extracted during the year came from the upper pit. It was stated by the managers that a 6,000-foot tunnel would soon be driven from Snowslide Gulch, undercutting the ore at a depth of 600 feet; from the portal of the tunnel the ore would be taken by a surface tram to tidewater below the town of Juneau, where a stamp mill of 23,000 tons capacity per month is to be erected.

On the Ebner property the California & Nevada Copper Co. commenced work on a new 200-stamp mill. Framed timbers, mortars, and other equipment were landed at Juneau, and late in the fall grading was commenced on the mill site near Shady Bend, on the road from Juneau to Silverbow Basin.

OTHER MINES AND PROSPECTS.

The several mines and prospects at Berners Bay lay idle during 1910, but it is confidently expected that they will be opened in 1911 on a scale commensurate with their magnitude and importance.

There was little activity in the region lying between Berners Bay and Eagle River, to the south. At Amalga the Eagle River mine operated 10 stamps intermittently during the year. Exploration work was continued in the endeavor to find the extension of the lode in unbroken and undisturbed ground, and late in the year it was reported that ore had been found in solid bedrock.

At the Mitchell & McPherson prospect, which is situated on the northwest flank of Thane Mountain between Eagle and Herbert glaciers, a new tunnel projected to undercut the ore body 100 feet vertically below the lowest outcrop was commenced at a position secure from the rock slides that endangered the older workings. Thirty-five feet of tunnel was completed.

Considerable development work was done on the Peterson group of claims on Peterson Creek with a view to test the property adequately. A 4-mile planked horse tramway was built from Pearl Harbor to the camp on the Prairie claim, a 500-foot crosscut tunnel was started, and a diamond drill was acquired, with which it was proposed to put down six 500-foot holes to determine the behavior and value of the ore body in depth.

On the Dull & Stephens prospect near Auke Bay a large body of low-grade quartz has been exposed by stripping the overburden of moss, vegetation, and glacial clay and gravel, which was hydraulicked off by booming. Work was in progress during the early part of the year under a bond but was suspended in August.

Extensive croppings of quartz have been uncovered near Treasury Hill, a few miles from Auke Bay, but owing to negotiations concerning the sale of the property no important development work was undertaken during 1910.

There was little activity in the gold belt south of Juneau. At the Crystal mine, at Port Snettisham, operations were suspended in September and the mill was closed. The ore body consisted of a quartz fissure vein averaging 4 feet in thickness, inclosed in a country rock of zoisite amphibolite probably derived from an andesite porphyry and dipping 10° to 40° NE. In recent years the ore has been extracted by tunnels drifted on the vein at successively higher levels.

At Limestone Inlet the main work has been done on a prospect known as the Enterprise, which is situated at an altitude of 1,370 feet. The country rock is a somewhat porphyritic quartz diorite, which is intrusive into a series of old volcanic rocks exposed along the north shore of the inlet. The ore body consists of a sheeted quartz vein striking N. 20° E. and dipping 45° W. The walls are well defined and the vein ranges between 2 and 3 feet in thickness. The quartz carries coarse pyrite and galena and shows free gold, the ore averaging, it is said, $15 a ton for the whole ore body. The prospect has been developed by a drift tunnel 30 feet long and by stripping of the ledge along the outcrop for several hundred feet.

SITKA AND KETCHIKAN MINING DISTRICTS.

The only active gold mines in the Sitka district are the Chichagof (locally known as De Groff) and Golden Gate mines. They are situated at the head of Klag Bay, on the west coast of Chichagof Island, 50 miles north of Sitka. Both mines are operating on what is presumably the same lode and are extracting a comparatively high-grade ore. The De Groff mine and mill are situated near sea level and the Golden Gate mine at 1,000 feet altitude, but the mill has been built at tidewater.

At the De Groff mine the present milling plant, consisting essentially of two batteries of two 850-pound stamps each and an edge-runner mill of the Chili type, proved to be inefficient and subject to vexatious delays, and in consequence it was decided to erect a new 10-stamp mill with heavier stamps and standard equipment. The ore milled during the year came from the rich ore shoot developed by the raise from the adit level to the upper tunnel; this ore was found to have a greater strike length than was indicated by the earlier workings.

On the Golden Gate property the stamp mill and aerial tram were completed and the milling of the ore commenced. The mill has been built for 10 stamps, but only 5 have been installed. The ore milled was mainly that which had accumulated on the dump during the early development of the mine and was rather medium or low grade. Underground development was continued, and an ore shoot comparable in value to those of the De Groff mine was reported to have been encountered late in June.

In the Ketchikan district several hundred feet of tunnel were driven on the proposed 1,600-foot crosscut tunnel at the Lon-de-Van group, which is situated on the north shore of George Inlet. This tunnel, which commences at the beach, is projected to undercut the ore body exposed at 900 feet above sea level.

Development continued on the Julia claim at Hollis until September, when the mine was shut down. Late in the year a small force of men was put to work on the Goldstream property on Gravina Island, 3 miles from Ketchikan, with a view to reopening the property. The main work done consisted of drifting on the 50-foot level. It is proposed to conduct experimental treatment of the ore to find a process that will give an economic extraction of the values, which have hitherto proved not readily amenable to ordinary stamp-milling practice.

COPPER MINES AND PROSPECTS.

GENERAL STATEMENT.

During 1910 copper ore was shipped from four mines, three of which are situated on Kasaan Peninsula and one on Hetta Inlet. They are all on Prince of Wales Island, in the Ketchikan mining district.

The main productive properties, as is well known, are located upon contact-metamorphic ore bodies, which commonly occur at or near the contact of limestone with intrusive masses of dioritic rocks. The ore is confined to the limestone and occurs in deposits of irregular shape and value. Many of the bodies are rich, consisting of masses of nearly solid copper mineral. These are easily exploited and a considerable tonnage of high-grade ore is rapidly extracted. They are then found to be surrounded on all sides by barren gangue material consisting either of magnetite, or crystalline limestone, or masses of lime silicates such as garnet, epidote, and pyroxene. The problem is then to find more ore. Inasmuch as the ore masses are without walls or other features that usually serve as guides in the search for new ore, the problem is difficult and no consistent or systematic method of development work has yet been evolved. At two of the mines diamond drills have now been installed to expedite the exploration for more ore.

A fear seems to exist in the district that ore will not persist in depth. Exploration work has been mainly in the lateral directions at comparatively shallow depths. Deeper development has perhaps been retarded by the apprehension that the ore will not go down. This fear appears to the writer to be groundless. It should be borne in mind, however, that although the ore bodies are likely to persist downward their distribution within the ore-bearing zone will be as irregular and erratic in depth as it is in the upper levels. This is no peculiarity of the Alaskan deposits but is common to all ore bodies of contact-metamorphic origin. Inasmuch as the primary sulphide chalcopyrite—the only cupriferous mineral in the ore—outcrops at the surface and, furthermore, as the origin of the ore bodies is independent of any relation to the existing topography, there is no reason to anticipate that the ores on the average will become richer in depth.

These deductions follow purely from the geologic evidence. The record of actual producing mines affords welcome data as to the possibilities of this type of ore deposit at increasing depth. On Texada Island, British Columbia, ore bodies of contact-metamorphic origin persist to a depth of at least 1,000 feet and the values in copper, gold, and silver hold in the bottom levels. At the Jumbo mine, on Hetta Inlet, in the region under discussion, the vertical range throughout which bodies of ore are known to occur exceeds 700 feet.

On the whole it can be said that the past record of the main producing mines on Prince of Wales Island shows that the masses of ore are encountered within the ore-bearing zone in sufficient number to maintain a profitable production; that this will continue in depth seems probable enough to justify in some mines a more systematic method of development than has yet been attempted. Extremely long adit levels that aim to undercut the ore-bearing zones at depths of more than several hundred feet, however, are inadvisable, on account of the proved capricious character of contact-metamorphic zones.

PRODUCTION.

The production of copper ore in southeastern Alaska during 1910, as shown by a preliminary estimate, is 2,250,000 pounds, which is less than that of 1909. The output for a number of preceding years is shown in the following table:

Production of copper ore in southeastern Alaska.

Years.	Ore mined.	Copper.		Gold.		Silver.		Average value per ton.
		Amount.	Value.	Amount.	Value.	Amount.	Value.	
	Tons.	*Pounds.*		*Ounces.*		*Ounces.*		
1907	79,982	4,758,814	$951,761	3,384	$69,960	44,196	$29,143	$13.14
1908	43,215	3,260,399	430,372	2,213	46,310	24,648	13,063	11.10
1909	28,491	2,705,988	351,778	1,946	40,228	16,679	8,641	14.06

KETCHIKAN MINING DISTRICT.

KASAAN PENINSULA.

The Mount Andrew mine, which is operating on a contact-metamorphic ore consisting essentially of chalcopyrite in a gangue of magnetite, maintained its usual annual production and in addition undertook some important new development work. The main supply of ore was obtained from stopes 2 and 4. Considerable drifting was done on the 50-foot level and good ore was encountered at several places. A raise was put through from this level to ore shoot No. 4, from which a large tonnage of rich ore has been extracted in the past and which is now being stoped downward from the main adit level, tunnel No. 1. A new tunnel, known as No. 2, was started several hundred feet northwest of No. 1, undercutting the outcrops at a depth of 100 feet, and enough ore was encountered to continue prospecting. The most noteworthy development work commenced during the year was that done on the new tunnel, designated No. 3, which, commencing at the old camp, is projected to undercut the ore body 300 feet below the present working level. The length will be 1,600 feet; 100 feet had been driven by the end of September.

At the It mine operations for the year commenced early in April. The main ore bodies lie in an embayment of limestone in an intrusive mass of diorite. The limestone has been coarsely recrystallized and more or less converted into lime-silicate rock. The ore consists of chalcopyrite in a gangue of calcite; the silicates, consisting of garnet, epidote, pyroxene, and others, contain only a small amount of copper mineral irregularly scattered through them. Development is proceeding on three levels below the working tunnel, the lowest being at a depth of 150 feet. From these levels the surrounding territory is being carefully prospected by diamond drilling.

At the Dean, a newly discovered prospect not far from the It mine, a tunnel 100 feet long was driven and a shallow winze was sunk 50 feet in from the portal. The ore is of typical contact-metamorphic type and consists of chalcopyrite in a gangue of coarsely crystalline pinkish calcite, associated with varying amounts of garnet, pyrite, and hematite. Several hundred feet northeast of this tunnel another has been driven approximately 75 feet long in a mass of lime-silicate rock.

Operations were resumed late in March at the Goodro mine after the winter shutdown. The main development undertaken consists of a winze sunk a depth of 100 feet below the tunnel. From the bottom of the winze drifts were driven both east and west and aggregate 150 feet in length. The winze is said to have been sunk in ore for 45 feet—that is, bornite in a heavy gangue composed essentially of pyroxene and biotite, with some feldspar and epidote. In the bottom level, which is 200 feet below the outcrop, some finely disseminated chalcocite and native copper were encountered. A width of 14 feet of this kind of ore is said to have been crosscut. All work was suspended after the middle of September, but it is planned that future exploration shall be done by diamond drilling. The discovery of chalcocite at a depth of 200 feet shows that the process of secondary sulphide enrichment has gone far deeper than would have been considered probable in this highly glaciated region. No such enrichment has affected the contact-metamorphic deposits, and this occurrence is therefore the more surprising.

HETTA INLET.

The only property on Hetta Inlet productive during 1910 was the Jumbo mine of the Alaska Industrial Co. This mine is the largest producer of contact-metamorphic copper ore in Alaska. The ore is mainly derived from the upper levels, in which there still remains a large amount of unexplored territory. In the stope on tunnel No. 4, the working tunnel and deepest level, a vertical diamond-drill hole was put down 130 feet and ore was encountered, proving that at this property the contact-metamorphic ore has a vertical range of at least 700 feet. On the level of tunnel No. 1 the ore-bearing zone is being explored southeastward by diamond drilling. A tunnel, projected to be 5,000 feet long and to undercut the ore bodies at 1,500 feet depth, has been started from tidewater, but work on it is not being pressed.

At the Red Wing mine it was reported that a crew of 12 men were employed in sinking a new shaft, planned to be 500 feet deep. This was the only other mining activity of note on Hetta Inlet during the year.

OTHER LOCALITIES.

At Big Harbor, near Klawak, on the west coast of Prince of Wales Island, the Northland Development Co. is said to be prospecting an ore body 62 feet wide and has driven an aggregate of 400 feet of drifts and tunnels. The ore was reported to consist of chalcopyrite in a lime gangue, but the samples shown to the writer proved to be a highly siliceous sericitic schist carrying disseminated chalcopyrite and pyrite. Some ore rich in black zinc blende was seen that came from the same locality.

At Seal Bay, on Gravina Island, the main crosscut tunnel has now attained a length of 1,700 feet, but driving ahead has been suspended. Eight quartz-chalcopyrite veins are reported to have been crosscut; at present the vein known as No. 3 is being drifted on and shows 5 feet of ore running 2 per cent in copper.

Late in the year a crew of six men was employed at the Rush & Brown mine, which is situated near the head of Karta Bay, on Prince of Wales Island. The mine was unwatered and preparations were made to get out a shipment of ore.

Development work continued at a number of other copper prospects scattered throughout the Ketchikan district, such as the Yellowstone group, on Dall Island; the Veta group, at Mallard Bay, near the south end of Prince of Wales Island, and others; but no operations of any considerable magnitude are to be recorded.

It is reported that work was resumed by a small force of men on the Moonshine vein, on the South Arm of Cholmondeley Sound. The values in this property are silver and lead, and it is one of the few of its class in southeastern Alaska.

THE EAGLE RIVER REGION.

By Adolph Knopf.

INTRODUCTION.

The Eagle River region as defined in this report embraces the portion of the Juneau gold belt extending from Berners Bay on the north to Salmon Creek on the south. A topographic map of this region on the scale of 1 mile to the inch was commenced by J. W. Bagley in 1909 and finished in May, 1910. The accomplishment of this work completed the detailed mapping of the northern portion of the Juneau gold belt, which contains all the important mines and most of the prospects under development. The Juneau and Berners Bay maps have already been issued, and the map of the intervening territory is now in course of preparation.

Detailed geologic examination of the region has succeeded the topographic mapping. Detailed reports are available on the geology and ore deposits of the Juneau and Berners Bay regions.[1] The present report, which is based on work done during parts of the field seasons of 1909 and 1910, aims to give in summary form the essential geologic features of the Eagle River region. A detailed report is now being prepared.

GENERAL GEOGRAPHY.

The gold belt consists of a narrow strip of country lying between the high peaks of the Coast Range and salt water. The general trend is northwest and southeast; the length of the belt as measured from Salmon Creek, which is 3 miles northwest of Juneau, to Berners Bay, on the north, is 32 miles; the width ranges between 4 and 5 miles.

The region is one of abrupt topographic features which increase in ruggedness toward the northeast. Here the numerous glaciers and precipitous relief make the mountains nearly inaccessible. The drainage of the region is mainly longitudinal, but the larger streams, like Eagle and Mendenhall rivers, which are of glacial origin, flow across the general trend of the belt.

[1] Spencer, A. C., The Juneau gold belt, Alaska: Bull. U. S. Geol. Survey No. 287, 1906. Knopf, Adolph Geology of the Berners Bay region, Alaska: Bull. U. S. Geol. Survey No. 446, 1911.

Gastineau Channel and Lynn Canal bound the region on the southwest, so that it is easily accessible by water, but owing to the facts that there are few good harbors and that the mountains rise directly from the coast, ingress to the interior of the belt is practicable at a few points only.

A well-built Government trail traverses the length of the belt and connects Amalga, on the head of Eagle River, with Juneau. This trail renders the extreme inland portion of the gold belt somewhat more accessible than it has been in the past, but for the transportation of heavy freight from Juneau the waterway is far more serviceable. The economical development of any mining property in the belt necessitates the building of a tramway to the nearest harbor, and this is the course that has been adopted at those places where any operations of importance have been undertaken.

GENERAL GEOLOGY.

The rocks of the region are arranged in belts striking parallel to the general trend of the gold belt. The dip is generally steep to the northeast.

Quartz diorite gneiss forms the northeast boundary of the belt. This rock, which in local speech is accurately enough known as granite, consists essentially of plagioclase feldspar (near labradorite), quartz, biotite, and hornblende, all of which are discriminable by the unaided eye. The gneissic structure, which is in part a primary structure but was produced mainly by the crushing of the component minerals of the diorite, toward the northeast grades into the massive granular texture characteristic of normal granitic rocks. Viewed broadly this gneissic belt, which is from 1 to 2 miles or more wide, forms the foliated margin of the quartz diorite core of the Coast Range.

A belt of schists adjoins the gneiss on the southwest. Its width ranges from 2 miles at Mendenhall Glacier to a few hundred feet at Berners Bay. The schists comprise a considerable variety of rocks, mainly of original sedimentary origin, and show a considerable diversity of mineralogic make-up. Biotite, garnet, and amphibole are the most common minerals of metamorphic origin that are easily distinguishable, and of these biotite is by far the most abundant and widespread. Coarsely crystalline white limestones are interstratified with the schists in small amount but are disproportionately conspicuous. Along the southeast side of Herbert Glacier a large volume of augite melaphyres is included in the schist belt. On glaciated surfaces the weather tinting shows that some of these rocks were originally conglomerates or breccias. The shapes of the fragments are well shown, and the fragments differ from one another in that some are more thickly studded with augite phenocrysts than others.

The schists are in many places exceedingly contorted. They are most highly crystalline where they adjoin the diorite gneiss, but toward the southwest they grade imperceptibly into the clay slates and graywackes of the next belt of rocks. In fact the boundary between the schists and the slate-graywacke formation was arbitrarily fixed by determining the first appearance of visible flakes of biotite in the rocks as the diorite gneiss is approached.

At many places along the contact of the schists and gneiss the schists are extensively injected with dioritic dikes. The dikes possess a gneissic structure and lie parallel to the foliation and stratification of the schists; in places this interlayering is so thorough and the alterations induced so profound that it is impossible to tell what is diorite and what is schist.

South of Mendenhall Glacier the schists are intruded by numerous white granitic dikes of both coarse and fine grained varieties. Many of the dikes are contorted with the schists, but others cut across the folds.

The belt of slates and graywackes lying between the schists and the volcanic rocks (greenstones) paralleling the coast comprises the most important rocks in the region. Nearly all the ore deposits are located in it. This formation is typically displayed along the shores of Berners Bay and has been named the Berners formation.[1] Fossil leaves were found at that locality and indicate that the rocks are of Jurassic or Lower Cretaceous age.

The general strike of the rocks is northwest and southeast and the dip is almost invariably northeast, ranging from 20° to vertical. Angles of 40° to 60° are the most common. In places the rocks are acutely folded and the axes of the folds stand vertical, but no evidence of more extensive folding was procured. The cleavage in the rocks is generally parallel to their stratification, but discrepancies occur locally.

At Berners Bay the graywackes are intimately interstratified with the slates. Toward the south they become less abundant and are comparatively scarce south of Eagle River. At Auke Bay the graywackes are practically absent and the rocks consist of fissile black slates. The strata of graywacke, so far as observed, range to a maximum thickness of 80 feet.

The graywackes are gray or greenish-gray rocks of roughly schistose or massive structure. They are composed largely of grains of plagioclase feldspar and quartz, together with fragments of other minerals and rocks, embedded in an argillaceous cement. Except the glassy

[1] Bull. U. S. Geol. Survey No. 446, 1911, p. 17.

grains of quartz and the fragments of black slate, none of these constituents are recognizable by the eye. The fresh rock taken from mine openings is black, owing to the presence of finely disseminated carbonaceous material; that taken from the natural exposures is gray or mottled gray, because bleached by the action of the sunlight. The graywackes are far harder rocks than the soft slates interstratified with them.

With increase of argillaceous material in the graywackes the cleavage approaches in perfection that of the interbedded clay slates. Such rocks might be called graywacke slates. On cross-fractured surfaces some of them show only numerous glistening particles of quartz embedded in an aphanitic matrix.

Masses of volcanic rock form scattered areas throughout the belt of graywackes and slates. The most persistent development, however, is in the long belt fringing the coast from Point Bridget to Auke Bay. The volcanic rocks include lavas, flow breccias, tuffs and coarse breccias, and conglomerates. Clay slates are intercalated with them at some places, and it is a general rule that beds of fragmental igneous rocks alternate with normal sedimentary rocks near the margins of areas of dominantly volcanic rocks.

The characteristic feature of these rocks is the widespread prevalence in them of numerous well-formed and well-preserved augite phenocrysts set in a dark blue-green matrix of aphanitic texture. Feldspars are notably absent. Pending more complete petrographic investigation these rocks will be designated augite melaphyres, according to the descriptive field classification of Pirsson. In places they are extremely amygdaloidal; between Yankee Cove and Bridget Cove they display a striking ellipsoidal structure. The conglomerates consist essentially of volcanic material; the pebbles range from well rounded to angular; the matrix is tuffaceous or of volcanic origin, so that it is in many places impossible to discriminate conglomerates from breccias.

The bulk of the rocks show no schistose structure. The strike is northwest and southeast; the dip ranges from 20° N. at Auke Bay to vertical at Bridget Cove.

A considerable number and variety of dikes, mainly greenstones according to local usage of the term, are intrusive into the slates and graywackes, but with few exceptions all of them lie parallel to the stratification of the inclosing rocks. Dikelike masses of augite melaphyre, identical with the rock of the volcanic areas, are common, but whether they represent interbedded lava flows or intruded sills is determinable in few places. It is probable that both forms are present, but the distinction does not appear to be of practical importance. These sheets range from a few feet to 300 feet in thickness. They are hard massive rocks, but the contacts are, as a rule, thoroughly schistose.

Dikes of augite lamprophyre have a widespread distribution throughout the region, being found from Berners Bay on the north to Douglas Island on the south. They resemble the augite melaphyres in some respects but consist essentially of large augite phenocrysts embedded in a finely granular gray-greenish matrix. In some of these dikes augite crystals form the bulk of the rock; in the better-preserved specimens the augites are of fresh green vitreous appearance. Dikes up to 100 feet thick were noted.

Diorite porphyry dikes are found in the region south of Eagle River. Some of them, on account of their resistance to erosion, are unusually well exposed and form the beds of streams for several miles. These dikes are light-gray rocks consisting of white feldspar phenocrysts and scattered hornblende prisms set in a finely granular or dense groundmass. Some dikes of quartz diorite porphyry are found on the peninsula on the east side of Auke Bay.

A narrow belt of diorite 5 miles long extends south from Eagle River. This rock is of medium to fine grained granular texture and is composed of plagioclase feldspar, augite, and biotite. The feldspar is somewhat epidotized, and the rock tends to assume a green hue. This diorite differs considerably in appearance from the quartz diorite that occurs along the northeast margin of the gold belt, nor does it possess a gneissic structure. It probably represents a separate intrusion like the Jualin diorite at Berners Bay. A porphyritic diorite dike several hundred feet thick was traced for a distance of 7 miles southeastward from Eagle River along the hills flanking the east side of Peterson Creek. The rock carries numerous large tabular feldspars, which impart to it an individuality that distinguishes it from other dikes in the region.

ECONOMIC GEOLOGY.

The ore bodies are exclusively gold deposits. The great majority are stringer lodes; a few are fissure veins, and a number of mineralized dikes have been discovered.

Nearly all the ore bodies occur within the belt of slates and graywackes; a few are found in the quartz diorite gneiss; none of economic importance are known to occur in the belt of schists. The marginal portion of the slate-graywacke belt that adjoins the schists appears from present developments to be the longest zone of continuous mineralization in the district.

The ore bodies designated stringer lodes are belts of slaty or schistose rock cut by irregular quartz stringers. As a rule the ore bodies tend to follow the structure of the inclosing rocks, both in strike and in dip, but individual stringers commonly cut across the cleavage irregularly. Solid bodies of quartz are occasionally found and may apparently show the normal attributes of ordinary fissure veins, but such masses of quartz are invariably found to fray out into stringer lodes along both strike and dip.

Many of these ore bodies can hardly be said to possess definite walls. At some places, however, the better ore is found to occur in slate that rests upon a footwall of graywacke; at other places mineralization has taken place in slate lying along a footwall of augite melaphyre. In general terms, an intercalated sheet of harder and more massive rock is likely to serve as footwall. Where this is so the melaphyre, which is usually referred to as greenstone, is more likely to form a continuous wall than the graywacke, for the graywacke beds are inclined to have a short lenticular structure and to be discontinuous along strike and dip.

Except for sporadic shoots of rich ore, the stringer lodes are of low grade. They range in width from a few feet to 100 feet and apparently at a few prospects to 300 or 400 feet. The greatest depth attained anywhere in the district does not reach 200 feet. The average value of a stringer lode is dependent upon the number and richness of the individual quartz stringers contained in the whole mass of slate. As a rule the quartz veinlets are leanly mineralized with sulphides, and these have a tendency to be massed in and around fragments of slate inclosed in the vein stuff. Arsenopyrite is the commonest sulphide, and pyrite, galena, pyrrhotite, and sphalerite are found in the order named, but as a rule all do not occur together in the same deposit. Free gold is rarely seen. Auriferous arsenopyrite running several dollars to the pound is found near Echo Cove, and the association of arsenopyrite and galena is everywhere accompanied by high values in gold.

The fissure veins differ from the stringer lodes in consisting essentially of narrow tabular masses of quartz. Only a few representatives of this class are known—not more than five—and all of them have this feature in common, that they cut across the stratification and cleavage of the inclosing rocks. One or both walls are generally marked by fault planes.

The mineralized dikes are few in number and from present development appear to be of little economic interest, but in the writer's opinion they are entitled to a somewhat more careful examination by the prospector than has been accorded to them. They were noted on the northwest side of Mendenhall Glacier and between Lemon and Salmon creeks, where they are about 30 feet thick. The dikes are dioritic in composition and dark colored but where mineralized have been changed to a white rock, which is cut by numerous veinlets consisting of quartz, albite, and dolomite. The principal sulphide is pyrite; galena and arsenopyrite are present in minor amounts. Rutile occurs in sporadic large crystals of adamantine luster but more commonly forms acicular aggregates in which the individual needles lie at angles of 60° to one another. The smaller veinlets through the rock consist largely of albite, and where the structure is drusy this mineral is crystallized in typical feldspar forms. This highly interesting kind of mineralization is essentially similar to that which has affected the Treadwell dikes, a few miles to the south; unfortunately this mineralization was not everywhere accompanied by auriferous deposition of commercial value.

DEVELOPMENT.

The earliest operations in the region were those of placer miners on the heads of Montana and Windfall creeks in 1882. Old wing dams, ditches, and bowlder piles show where the pioneers labored, but because their efforts yielded a bare wage only, attempts at placer mining were soon abandoned. The first lode locations were made also in 1882 at Montana Basin and near Auke Lake. Prospecting has continued intermittently ever since. New discoveries are made from time to time and as late as 1908 extensive quartz croppings were uncovered near the point where the old trail crosses the summit between Auke Bay and Montana Creek. To those familiar with the region such discoveries occasion no surprise. Outcrops throughout the inland portion of the gold belt below timber line are effectually buried under several feet of glacial drift and this overburden is itself covered by a heavy growth of moss and vegetation. These features, together with the wet climate, render prospecting a difficult and onerous employment. It is therefore to be expected that occasional discoveries will continue to be made, aided as they have been in the past by the overturning and uprooting of trees and by the formation of landslides which from time to time bring to light new exposures of bedrock.

The state of development of the region in 1903 was described by Spencer [1] and in 1905 by Wright.[2] The development since that time has been far less rapid than was anticipated, and in view of the fact that a detailed report is in course of preparation, descriptions of individual properties are omitted in this preliminary account. Many causes have combined to retard the progress of the mining industry—litigation in some cases, inflated valuation in others—but principally the essentially low grade character of the ores. A large capital expenditure is necessary to open the properties, and such investments usually demand a more adequate development of the ore bodies than has so far been made in most places. Even at Juneau, where the ore bodies have had the advantage of being near a center of population, the formulation and adoption of plans for the working of the low-grade gold deposits on a scale proportionate

[1] Bull. U. S. Geol. Survey No. 287, 1906, pp. 117-134.
[2] Bull. U. S. Geol. Survey No. 284, 1906, pp. 34-37.

to their magnitude has required many years' time, and it is only recently that these plans have been nearing achievement.

The production of the region, with the exception of a few thousand dollars, has been the output of a single mine at Eagle River, which has been in operation since 1903.

PRACTICAL CONCLUSIONS.

The foregoing sketch of the geology presents only those features having a bearing upon the occurrence of the ores in this region. Some inferences of a practical character have already been pointed out. The most striking fact in the geology of the region is the almost complete restriction of the ore bodies to the belt of slates and graywackes. Although the ore bodies have been found distributed throughout the length and breadth of the area underlain by those rocks, they are nevertheless most numerous in the zone lying along the belt of schists. Moreover, the highest-grade ore yet found in the region and the only productive mine are in that zone. The conclusion is therefore obvious that those portions of the belt adjoining the schists that have not been adequately prospected are the most favorable fields for further investigation, notably the stretch between Windfall Basin and Eagle River, and possibly that between Mendenhall Glacier and Montana Basin.

In other parts of the slate-graywacke area the contacts with the intercalated masses of augite melaphyre, breccias, and conglomerates (rocks that are collectively known in the region as greenstone) appear to form favorable localities for mineralization. The masses of harder rock are apt to betray their presence, at least in parts of the region, by forming the bedrock of knobs or other topographic prominences.

A few small fissure veins have been found that break across the structure of the quartz diorite gneiss. The entire length of some of these veins is absolutely exposed on the bare glaciated surfaces and does not reach 200 feet; the width is a few inches. Although some of these veins contain considerable free gold, they nevertheless show a surprising lack of alteration of their wall rocks such as generally accompanies productive ore deposits. In view of this unfavorable feature and the short, narrow character of the veins, extensive sinking of shafts on them is a waste of time and energy. Where larger and longer ore bodies are indicated and the diorite is intensely altered by the action of vein-forming solutions, as on the flank of Mount Thane, further prospecting is to be encouraged.

The future of the district will, however, depend largely on the exploitation of the low-grade stringer lodes. The history of the mineral development of Silverbow Basin, at Juneau, will repeat itself here. In early days attempts were made to mine some of the stronger veins found in the stringered zones of slate in Silverbow Basin, but owing to the nonpersistent character of these veins such attempts assured a precarious existence to the mines founded on them. By a natural evolution that is still going on methods have gradually been developed to mine and mill the whole mass of rock of the ore-bearing zone, and the practice has now settled down to exploiting ores ranging from $1.25 to $3 a ton in value. This is likely to be the course of development in the northern extension of the Juneau gold belt.