LODE MINING IN SOUTHEASTERN ALASKA.

By CHARLES W. WRIGHT.

INTRODUCTION.

The results of the developments in the lode mines of southeastern Alaska during the year have been encouraging. Many of the prospects have grown into metal producers, and the mines have with but few exceptions increased their output. The Ketchikan district, the most active in these advances, is now an established mining center. In the Juneau district considerable progress has been made, though much looked-for development did not materialize. Mining interest in the Sitka district was renewed by the discoveries and successful explorations near Cape Edward, on Chichagof Island, but no important mine improvements are to be noted in either the Wrangell or Skagway districts.

The investigations of each successive field season bring forth new facts bearing on the geologic as well as the economic conditions in the southeastern portion of Alaska. Although much of the information contained in the present report has already been published,^a it is, nevertheless, advisable to repeat the general facts so as to combine with them the results of the present year. In this manner the important conclusions are presented without delay, and the more detailed discussions of the geology and mines are given in the separate reports^b on each district.

GEOLOGY.

Only those few geologic facts can here be given which are necessary to an intelligent description of the mines and which may also serve in some degree to guide the prospector in his search for new ore bodies.

a Wright, F. E. and C. W., Economic developments in southeastern Alaska: Bull. U. S. Geol. Survey No. 259, 1905, pp. 47-68; Lode mining in southeastern Alaska: Bull. U. S. Geol. Survey No. 284, 1906, pp. 30-54.

^b Spencer, A. C., The Juneau gold belt; Wright, C. W., A reconnaissance of Admiralty Island: Bull. U. S. Geol. Survey No. 287, 1906. Brooks, A. H., Preliminary report on the Ketchikan mining district: Prof. Paper U. S. Geol. Survey No. 1, 1902. Wright, F. E. and C. W., The Ketchikan and Wrangell mining districts (in preparation).

BEDDED ROCKS.

Limestone, slate, sandstone, and conglomerate, with intercalated greenstone and tuff beds, constitute the stratified rocks. In most places these have been profoundly metamorphosed and are represented by the crystalline limestones, mica and chlorite schists, cherts, and graywackes.

By far the greater portion of the rock strata are of Paleozoic age. These consist of the metamorphic limestones, schists, cherts, greenstones, and other rock types, which together form the underlying bedded rocks of the entire area. The Mesozoic and Tertiary formations are represented by the unmetamorphosed conglomerate, sandstone, and shale beds, which in places are coal bearing. They are only local in occurrence and of no great extent, occupying limited areas on Admiralty, Kupreanof, Kuiu, and Prince of Wales islands. Basaltic lava flows of late Tertiary age cover the southern portion of Admiralty Island, the northeast side of Kuiu Island, the south shore of Kupreanof Island, and a small area on the south end of Prince of Wales Island. Overlying these rock strata are beds of clay and gravel and the recent volcanics at Mount Edgecumbe and at points along the mainland.

INTRUSIVE ROCKS.

The intrusive rocks occupy about one-half of the aggregate land area of southeastern Alaska, as is well shown on the accompanying map (Pl. III). Coarse granular rocks, granitic in character, form the great mass of the Coast Range bordering the mainland and occupy wide areas in the central portion of many of the islands. They are in direct relation to the geologic structure, and their longitudinal axes and lines of contact parallel the direction of strike of the bedded rocks. Such intrusives vary in composition from granodiorite to quartz diorite and hornblende diorite. In general they invade the Paleozoic bedded rocks, but do not cut the more recent Mesozoic beds. Other intrusives are those of andesite, diabase, basalt, and melaphyr, usually in the form of dikes cutting both the older and younger sedimentary rocks.

STRUCTURE.

The sedimentary formations distributed along the mainland strip and adjacent islands all strike northwest and dip, as a rule, steeply to the northeast. The structure of the outer islands includes two separate systems of large and small folds. The main system, which is the younger of the two, has a northwesterly axial trend and is most pronounced adjacent to the wide areas of the intrusive rocks namely, along the mainland and on Chichagof and Baranof islands. The minor system, which in most places has been obliterated by the



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MAP OF SOUTHEASTERN ALASKA, SHOWING DISTRIBUTION OF MINERAL DEPOSITS AND AREAS OF INTRUSIVE ROCKS.

later and more intense folding of the beds, has a northeasterly axial trend and is prominent in the less disturbed and less metamorphosed areas. In many places both directions of folding are observed, those having the northeasterly trend being represented by a number of minor folds, which as a whole are combined in much broader anticlines or synclines having a northwesterly trend. Observations of this sort were made along the north shore of Chichagof Island and the west coast of Prince of Wales Island.

MINERALIZATION.

The direct relation of mineralization, or the occurrence of ore, to the rock structure and to the intrusive rocks is very evident. Without exception the ore bodies are found in the vicinity of, or more rarely in, the larger intrusive masses, and only in those places where the rock structure in general has a northwesterly trend. In a broad way the mineralization is confined within contact aureoles of the granitic and metamorphic rocks. Along the main Coast Range granite belt this contact zone is several miles in width, whereas along the outlying granite belts of the islands it is but a few miles wide. The larger areas occupied by this intrusive rock, so far as known, are shown on the sketch map (Pl. III), and the positions of the mines and prospects are indicated by crosses.

The most extensive and productive area is the Juneau gold belt, which has been irregularly traced along the contact of the Coast Range intrusive from Windham Bay to a point 10 miles north of Berners Bay, where it enters Lynn Canal, a total length of 120 miles and a width of less than 10 miles.^{*a*}

The Admiralty Island mineral zone starts at a point just north of Mole Harbor on the west side of Seymour Canal and may be traced northwestward. It includes the Young Bay and Funter Bay deposits, crosses Lynn Canal, and is again exposed in St. James Bay and above the main forks of Endicott River. Mining and prospecting within this zone have been extensive but have met with little success.^b

In the Sitka mining district a mineral zone begins on the southeast shore of Baranof Island and follows in a northwesterly direction along the west flank of a large granitic belt which forms the backbone of Chichagof and Baranof islands. Five miles above Cape Edward this belt enters the Pacific Ocean. Within this mineral zone the important deposits are quartz veins of free-milling gold ore. Several such veins in the Silver Bay region have been mined and have been productive in past years, and at the present time the Cape Edward prospects are making small shipments of gold ore.

^b Wright, C. W., A reconnaissance of Admiralty Island: Bull. U. S. Geol. Survey No. 287, 1906, pp. 138-155.

Bull. 314-07-4

a Spencer, A. C., The Juneau gold belt: Bull. U. S. Geol. Survey No. 287, 1906.

A second, less important zone of mineralization follows the east flank of the granitic belt already mentioned, though in this zone no ore bodies of consequence have been developed. The belt includes several prospects at the head of Hooniah Sound and Idaho Inlet. A northern continuation of this zone appears to traverse the head of the several bays northwest of Cape Spencer as far as Lituya Bay.

On Kupreanof Island are scattered indications of a widespread mineral-bearing zone, which extends from the head of Portage Bay down the east side of Duncan Canal and includes prospects along the west shore of Wrangell Narrows. The ore bodies thus far opened carry small values in both copper and gold. No deposits of ore have yet been discovered on Kuiu Island.

On Prince of Wales Island the regularity of the rock structure is locally interrupted by the broad and irregular intrusive masses, and for this reason the ore bodies are not traceable along definite lines. Where zones of mineralization occur they follow the lines of contact of the intrusive rock masses closely, as is well shown, for example, at Copper Mountain and on Kasaan Peninsula.

ORE BODIES.

Within the zones described above mineralization is widespread, metallic sulphides occur disseminated throughout most of the beds, and quartz veins or veinlets are everywhere present. A sample taken almost anywhere within such areas will usually yield a trace of gold and silver, though concentrations of these metals into workable deposits are much less numerous than one would anticipate with the vast amount of mineralization present.

The ore bodies are of many types. Strong gold-bearing quartz veins of moderate-grade ore, occurring either in the intrusive rocks or adjacent metamorphic rocks, are mined at Berners Bay, Eagle River, and Sheep Creek, in the Juneau district; on the west coast of Chichagof Island, north of Sitka; at Helm Bay and Dolomi near Ketchikan; and at many other localities. Lodes or stringer leads in the slates and schists or following wide dikes of a mineralized basic rock are most strongly developed up Gold Creek in the vicinity of Juneau and at numerous other points along the mainland belt.

Bands of heavily mineralized schist following the trend of the rock structure and cut by rich ore seams are shown at the Nevada Creek mines on Douglas Island, the Gold Stream mine on Gravina Island, and at other localities. The ore bodies of the Treadwell group of mines, as shown by Becker^{*a*} and Spencer,^{*b*} are brecciated masses of intrusive syenite, intersected by a network of quartz and calcite veinlets and impregnated with pyrite, which is found both in the veinlets

a Becker, G. F., Reconnaissance of the gold fields of southern Alaska: Eighteenth Ann. Rept.U. S. Geol. Survey, pt. 3, 1898, pp. 1-86.

^b Spencer, A. C., The Juneau gold belt: Bull. U. S. Geol. Survey No. 287, 1906, pp. 93-115.

and in the rock itself. The ore bodies are several hundred feet in width and several thousand feet in length. No similar deposits have been discovered elsewhere in Alaska.

The copper deposits prominent on Prince of Wales Island can not be classed under the above-mentioned forms of occurrence. They are, with few exceptions, irregular lenses or masses of chalcopyrite ore, many of them rich in magnetite, and occur either as replacement or contact deposits adjacent to a granitic intrusive mass, and more rarely as heavily impregnated portions of schists.

GOLD.

OCCURRENCE.

Although gold is universally distributed along the coastal mountains of southeastern Alaska in lodes, and less commonly in placer deposits, there are relatively few localities which show a sufficient concentration of auriferous minerals to make valuable ore bodies, and in these places the ore is usually low in grade. The possibility of mining such ores, however, is obvious when one considers the available water power and favorable means of transportation the country affords. In the gold-quartz veins or lodes the gold is found both in the native state and also combined with metallic sulphides, which usually penetrate into the inclosing country rock. These quartz-filled fissures were formed subsequent to the general metamorphism of the coastal mountain range and after the granodioritic invasion, and their content is in genetic relation to the intrusive rock.

PRODUCTION.

The subjoined table shows the gold produced in southeastern Alaska in 1905. The placer deposits yield but a very small proportion of the gold production, their total output in 1906 being less than \$20,000. Placer mining was advanced at only two localities, in Silverbow Basin and at Windfall Creek.

Ore mined.	· Gold.		Silver.		Average per ton.			
	Amount.	Value.	Amount.	Value.	Gold.		Silver.	
					Amount.	Value.	Amount.	Value.
<i>Tons.</i> 1,365,316	Ounces. 162,353	\$3,335,466	Ounces. 31,110	\$ 18,789	Ounces. 0. 118	\$2. 44	Ounces. 0. 023	\$0.014

Production of the gold mines in southeastern Alaska, 1905.

To the above figures must be added the gold produced from the copper mines, which amounted to \$71,170 in gold and \$16,021 in silver. It should also be stated that nine-tenths of the total output was from the Treadwell group of mines on Douglas Island.

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The gold production for 1906 will slightly exceed that for 1905.

JUNEAU MINING DISTRICT.a

Those mines which were operated during the year in the Juneau district have, with hardly an exception, given satisfactory returns, though many of the new and extensive developments that were planned failed of accomplishment. Two large stamp mills, at the head of Gold Creek and on Nevada Creek, were built, and the capacity of some of the power plants and mills at present in operation was increased.

MINES OF DOUGLAS ISLAND.

Douglas Island, though small, has become widely known as the locality of the Treadwell group of mines. The geologic features of the Treadwell deposits and the methods of mining employed have been discussed in detail by Spencer^{*b*} and by Kinzie.^{*c*}

At the Alaska-Treadwell mine the shaft has now reached a depth of 1,500 feet, and from it the 1,450-foot level is being opened. Other developments have been confined to the 1,050-foot and 1,250-foot levels. There is apparently little change in the character and value of the ore with increasing depth. On the surface the Glory Hole, or open-pit workings, have reached the 330-foot level below the adit tunnel, and the ore is being mined close up to the walls. The openpit method of mining will not be carried below this level. Most of the ore milled has come from the stopes on the 600-foot, 750-foot, 900foot, and 1,050-foot levels. The annual report for the year ending May 31, 1906, states that a total of 888,411 tons of ore was milled during the year, yielding \$1,902,455, or \$1.07 per ton in bullion and \$1.07 per ton in concentrates. The mining and development expense was \$0.84 per ton, and the cost of milling \$0.15 per ton. For the shipping and treatment of concentrates \$0.12 per ton is to be added, and this with minor expenses makes the total operating cost \$1.19 per ton of ore milled.

On the Seven Hundred Foot fraction operations were renewed this year and considerable ore was mined from the 660-foot level. On the 770- and 880-foot levels developments were advanced and some ore was mined. The lowest, or 990-foot, level was opened and the sample returns were reported to be encouraging.

The Mexican mine is now developing its 880-foot, 990-foot, and 1,100-foot levels. The ore mined has been mainly from the 550-foot

c Kinzie, R. A., The Treadwell group of mines, Alaska: Trans. Am. Inst. Min. Eng., vol. 34, 1904, pp. 334-386.

a As the detailed report by A. C. Spencer on the Juneau gold belt (Bull. U. S. Geol. Survey No. 287) has recently been published, only brief mention will be made of the late improvements on the mines within this area.

b Op. cit.

and 660-foot levels, and to some extent from the 770-foot and 880foot levels. The last annual report gave a total of 233,985 tons ore milled to January 1, 1906, yielding \$703,765, or an average of \$3.01 per ton.

At the Ready Bullion mine the inclined shaft has been sunk to the 1,500-foot level and developments furthered on the 1,350-foot and 1,200-foot levels. The ore mined was principally from the 750-foot and 1,025-foot levels. The yearly report to January 1, 1906, gave a total tonnage of 233,480 tons, yielding \$439,815.

The power plants that operate this group of mines have undergone many interesting changes within the last year. The supply of water power has been increased by the building of a new dam at the headwaters of Fish Creek, thus forming a storage basin which will increase the supply by 200 miner's inches during the two months of low water in the winter. This will increase the amount of all ore milled by water power from 87 per cent to 93 per cent. Another large saving is to be made by the use of oil in place of coal, thus doing away with a large expense in the handling of coal and a reduction in the initial cost. For this purpose large supply tanks are being installed, pipe lines laid, and oil burners introduced in the boilers.

The Nevada Creek mine, belonging to the Alaska Treasure Consolidated Mines Company, on the southeast end of Douglas Island, has been energetically developed this year, both underground and with reference to surface improvements. The mine is located 1 mile from tide water, at an elevation of 825 feet. At this point a tunnel 700 feet in length has been driven in a southwesterly direction, nearly at right angles to the-trend of the rock structure. Drifts 100 to 300 feet in length have been extended to the northwest and southeast from points 450 and 550 feet from the mouth of the tunnel, and from these other exploratory crosscuts have been driven. The country rock is essentially greenstone and greenstone schist, with intercalated bands The ore bodies may be defined as narrow bands of graphitic slate. parallel with the rock structure within which a concentration of metallic minerals has taken place. The ore minerals, essentially auriferous pyrite with sulphides of copper, lead, and zinc, are accompanied by both quartz and calcite veinlets. Intruding these rock beds are narrow dikes of basalt, striking in a northwesterly direction, which appear to have little effect on the ore occurrence. A change in the structural trend or a wrinkling of the schistose beds is indicative of an ore body. At such a place, 450 feet from the mouth of the tunnel, an ore body 10 feet wide and containing a narrow seam of high-grade quartz ore 2 to 12 inches wide is being opened. The values in this body appear to be limited to a distance of 100 feet along its strike, and the rock structure indicates that the deposit is in the form of a shoot pitching at an angle of 40° in a northwesterly direction and parallel

with the axis of minor folding or wrinkling. The present underground developments are confined to the exploration of this ore body.

From tide water to the mine a cable tramway 1 mile in length has been built. Just below the main tunnel a 20-stamp mill has been erected and was to be in operation by the end of 1906. For power purposes a 450-foot flume, with intake at 1,050 feet elevation on Nevada Creek, is connected by a pipe line 925 feet long with the compressor plant and mill at 750 feet elevation.

The operations on the Red Diamond group at the head of Nevada Creek, which were started the year previous, were discontinued early in 1906. On the Mammoth group and other adjacent properties assessment work alone was done.

The properties of the Alaska Atlin Mining Company, the Yakamaw Mining Company, the Alaska Consolidated Mining Company, and others located on the island have been idle for several years, and no improvements of consequence have been made on them.

GOLD CREEK MINES.

The proposed mining improvements on the lode system which is strongly developed within the Gold Creek drainage and extends over the Sheep Creek divide were not accomplished, and progress in actual mining over the preceding year has been slight.

Briefly, the deposits are of low-grade, free-milling ore and occur within an 800-foot belt of black slate which has been intruded by numerous dikes 10 to 50 feet in width of a dark-brown, altered basic rock, probably a gabbro. Numerous quartz gash veins are present within this belt, cutting both bedded and intrusive rocks, but are most plentiful near their contact. The auriferous sulphides, essentially pyrrhotite and pyrite, impregnate both the black slate and dike rocks, but the values are principally in the quartz veins. The average value of the ore mined in a large way is very low, and this has to some extent discouraged the investments of capital necessary for their economic development. It has, however, been demonstrated at both the Ebner and Alaska-Juneau mines that the ore can be profitably This, with the undoubted persistence of mineralization and mined. values in the lode system to a depth below which mining will likely go, should tend to encourage mining operations.

Operations at the Ebner mine were continuous during the year, and results similar to those of former years were attained. In the upper tunnel the drifts were extended 350 feet, and in the lower tunnel 150 feet of drifting was done. During the year the 15-stamp mill on the property was in continuous operation except for a few weeks in the winter. The water power of Gold Creek at this point was sufficient to develop 125 horsepower throughout this period. At the Alaska-Juneau mine operations were renewed in May and continued until November, as in previous years. During this time the 30-stamp mill was in continuous operation, an average of 4,200 tons of rock being milled per month. The ore mined was mainly from the open cuts and raises which were driven to open the back pits at lower levels.

At the Perseverance mine the greater portion of the work done was in the erection of a 100-stamp mill, which is to begin operations early in 1907. In the mine developments have been confined to an ore body 60 to 80 feet wide, consisting of a heavily mineralized black slate, cut by numerous quartz veins carrying pyrrhotite, chalcopyrite, galena, and sphalerite. This lode has a general northwesterly strike and dips 65° NE. At the time of the writer's visit it was exposed by a drift 1,000 feet in length at tunnel level and partially by a raise 920 feet long from the tunnel to the surface. From this raise 100 feet above the tunnel an intermediate drift, 350 feet long, has been driven in both directions along the lode and connected by raises with the tunnel drift. Other levels at intervals of 100 feet will be started from this main raise.

On the Boston group of claims, at the mouth of Gold Creek, a mineralized dike 50 feet wide is exposed similar to those found at the Ebner mine. This dike as a whole forms a very low-grade ore, and as yet no attempt has been made to begin its extraction in large quantities. The annual assessment work has been accomplished from year to year, and the present developments consist of a shaft 118 feet deep, from which 500 feet of drifting and crosscutting have been extended.

No improvements worthy of note were made on any of the other lode mines or prospects within the Gold Creek or Sheep Creek drainage areas last year.

The placer deposits of Silverbow Basin were again leased by the Silver Bow Hydraulic Company, and operations began the latter part of April and closed the latter part of October. During September work was suspended because of low water. The gravels were worked by a hydraulic giant having a 6-inch nozzle, and bowlders were handled by a cable with boat attachment. The gravel bank under attack is 75 feet high and in it the highest values are found where the oxidized sand streaks are present.

At the lower basin, on the property of the Jualpa Mining Company, no attempt was made to mine the gravels.

MINES NORTH OF JUNEAU.

SALMON CREEK.

At the mouth of Salmon Creek, the first stream north of Juneau, is the Wagner group of claims, located on a mineralized basic dike from 8 to 12 feet wide, cut by numerous quartz veinlets. This corresponds in character to the exposures on the Boston group mentioned above and lies in the same line of strike. Three other similar dikes were observed outcropping at different elevations on the mountain slope above. A total of 675 feet of tunneling has been driven 250 feet along the vein and 425 feet crosscutting the country rock. A small 2-stamp mill has been installed for test purposes.

MONTANA CREEK.

On McGinnis Creek, the eastern branch of Montana Creek, are the properties of the Mansfield Gold Mining Company, consisting of both lode and placer claims. These properties are located on the northeastern portion of the wide mineral belt, but all attempts to work either placer or lode deposits have failed, mainly because of their lowness of gold values. During most of the year this property was idle.

There has been no change in the mining conditions or developments on the Montana Basin group of claims at the head of the creek. Small amounts of assessment work were done and some additional surveys made. The inaccessibility and distance from salt water appear to be the chief cause for their nondevelopment.

WINDFALL CREEK.

Just above the divide from Montana Creek, at the head of Windfall Creek, is the Smith & Heid group of claims, located upon low-grade belts of mineralized schist and greenstone, traversed by quartz veinlets in which the gold values are irregularly distributed. There was no renewal of interest in this property during the year.

The first of May the Detroit-Alaska Mining Company began operations on its placer claims on the lower portion of the creek, half a mile above Windfall Lake. Work was continued at intervals until September 15, but owing to lack of water the actual number of days of gravel washing was only 28. A total of 1,000 cubic yards was sluiced. The gravels are of moderate grade and, with a sufficient water supply, should yield profitable returns.

PETERSON CREEK.

On the Peterson group of claims work has been continuous on the gold-quartz veins by the owner and a few helpers. A small testing mill has been erected, and it is reported that from this mill sufficient - gold bullion is recovered to defray mining expenses.

EAGLE RIVER.

At the Eagle River mine there has been a steady output during the year, and the 20-stamp mill has been in operation most of the time. The ore body, which is a wide quartz vein containing shoots of rich ore, is displaced by faulting, which is apparently confined to a depth of a few hundred feet from the surface. These displacements have shattered the country rock across considerable width and have been the cause of much trouble in the exploitation of the vein and in the extraction of the ore from it. Late reports, however, state that developments have extended into the solid formation below the faulted area, and that the vein is apparently in place. The total amount of drifting, crosscutting, and shaft sinking amounts to about 6,000 feet.

YANKEE BASIN.

The principal work done in the Yankee Basin area was the driving of a crosscut tunnel to undercut the Dividend and Cascade lodes. This tunnel begins at a point just above the miner's cabin and was 400 feet in length in October of last year. It was estimated to undercut the Dividend lode at a distance of 530 feet and the Cascade at 1,200 feet from the mouth of the tunnel.

Except the small annual developments necessary no important progress was made on any of the other mines or prospects in this belt, extending as far as Berners Bay.

BERNERS BAY.

The limits of the Berners Bay region include the drainage areas of both Johnson and Sherman creeks. Extensive mineral bodies, consisting of huge stockwork deposits, well-defined fissure veins, and lodes, are exposed up these creeks. From these ore bodies the total gold production has been nearly a million dollars in value, the larger portion of which was obtained from the Sherman Creek mine previous to 1900.

Since 1901 the only producing property has been the Jualin mine, located on Johnson Creek, 4 miles from its mouth and 730 feet above tide water. Three separate ore bodies, inclosed in the diorite country rock and having a general northwesterly trend and a dip of 60° NE., are exposed in the mine workings. Of these the foot-wall vein carries the highest values, and upon it mining and developments have been concentrated this last year. This west vein, as it is called, is a strong quartz-filled fissure, about 400 feet in length and averaging 5 feet in width. Just below the adit level a fault was encountered with steep pitch toward the northwest; the displacement, however, was not great and the vein was readily recovered. This year a 50-foot inclined shaft was sunk from the 170-foot level below the adit tunnel. At this depth, 220 feet below the adit tunnel, drifts were extended to the northwest and southeast along the vein and the ore thus developed was mined.

In 1906 operations were begun the first of May and discontinued in October, and during this period the 10-stamp mill on the property was operated without interruption.

At the other mines within the Berners Bay region no additional developments have been made, principally because of litigation difficulties. The nature of the ore deposits and mine developments at these points was discussed in last year's report.^{*a*}

MINES SOUTH OF JUNEAU.

Mining progress during the last year has been very slight along the mainland belt to the south of Juneau. None of the mines or prospects have been extensively worked, and their production has been nil.

At Taku Harbor and Limestone Inlet gold-bearing veins of exceptional promise are said to have been opened up during the year, but little work was done on them. At Port Snettisham the only work reported was on the Crystal mine. Here the quartz ore was being mined in a small way and milled in the 5-stamp mill on the property, yielding profitable returns. No noteworthy improvements were made on any of the other prospects about this inlet.

To the south the Holkham Bay group of claims, located on the south side of Endicott Arm, is reported to have been sold, and a small crew of men are to be employed during the winter to drive a 400-foot tunnel, which will develop the vein in depth. The ore body is a mineralized quartz lode, in a schist country rock, within 2 miles of the main Coast Range intrusive belt. The ore minerals are galena, arsenical pyrite, pyrite, and small particles of chalcopyrite, all of which occur both in the quartz veinlets and inclosed in fragments of country rock. Sixty per cent of the gold content is said to be free milling, and the concentrates contained in the ore are estimated at 2 per cent. At 1,800 feet elevation a tunnel undercuts the lode 175 feet from its mouth, and from this point nearly 200 feet of drifting has been extended. Other improvements consist mainly of surface cuts exposing the lode at various points along its strike.

At the Sumdum mine, in Holkham Bay, no attempt was made to renew operations, which were discontinued in 1904.

At most of the properties at the head of Windham Bay, which were energetically developed during 1902–3, operations were discontinued soon after that time. The only company which carried on active work in 1906 was the Helvetia Gold Mining Company. Long crosscut tunnels have been driven into the mineralized belts of schist, and

a Wright, F. E. and C. W., Lode mining in southeastern Alaska: Bull. U. S. Geol. Survey No. 284, 1906, pp. 31-34.

quartz stringers were followed by drifts. Tests have been made on the ore obtained in the 10-stamp mill on the Red Wing group, just below this company's property, but apparently the results were not encouraging.

Prospecting on the divide between Windham Bay and Endicott Arm has revealed several quartz veins, carrying moderate values, but their inaccessibility and distance from tide water render them of little economic value at present.

ADMIRALTY ISLAND.

The mining interests on Admiralty Island have changed but little, and on the two properties, the Portage group at Funter Bay and the Mammoth group at Young Bay, there has been a notable lack of development.

The deposit on the Portage group is a mineralized band of chloritemica schist, cut by quartz-calcite veinlets and containing small masses and particles of copper and iron sulphides scattered across a width of about 40 feet. This band has been exposed by an open cut, and the ore is apparently of low grade. Just below the open cut a tunnel was started to undercut the lode, 40 feet in depth. When visited, this tunnel was 30 feet in length and had not reached the ore.

Two miles southeast of the Portage group investigations have been in progress by the Mansfield Gold Mining Company on copper deposits, consisting of several quartz ledges, 3 to 6 feet wide, 100 feet or more apart, and striking northwest, parallel with the trend of the country rock. These deposits carry considerable chalcopyrite and pyrrhotite, also some galena and sphalerite. The main vein outcrops at 1,380 feet elevation on the north slope of Funter Mountain, and at this point has been exposed by a 20-foot tunnel and surface stripping. At 550 feet above tide water a crosscut tunnel has been started to investigate these veins in depth, and work in this tunnel will be furthered during the winter months.

On the Mammoth group, to the southeast of the Portage group and on the same mineral zone, the annual assessment work alone was done.

SITKA MINING DISTRICT.

GEOLOGY.

The geology of the Sitka district, which includes Baranof and Chichagof islands, is comparatively simple. The bedded rocks of the islands are in the main broadly folded Devonian limestone and chert beds with interstratified basaltic flows, and overlying these along the outer coast are slate-greenstone strata, which in turn are overlain by a wide belt made up of pre-Cretaceous graywackes and conglomerates. The most recent rock formations are represented by the lava beds about Mount Edgecumbe. The core of both of the islands is made up of granitic intrusives, forming broad belts that strike across the island in a northwesterly direction and invading all the bedded rocks except the recent lavas. Near the contact of these granite masses are located the mineral deposits.

BARANOF ISLAND.

Many gold- and silver-bearing quartz veins and lodes, usually of low grade, have been discovered in the area adjacent to Silver Bay. Of importance are the Cache, Lucky Chance, Liberty, and Silver Bay prospects, at which much development work was done in former years. For a number of years, however, no attempt has been made to work these properties and only meager developments have been accomplished.

At Rodman Bay, on the north side of the island, mining operations were closed in 1904, and most of the machinery and mine equipment has been sold and removed from the property. A vast amount of capital was invested in these prospects, and not until a railroad and 120-stamp mill had been built did the investors realize the actual value of their mine.

Other prospects were observed in Port Conclusion and Port Lucy, but these, too, have been abandoned.

CHICHAGOF ISLAND.

The only area on Chichagof Island within which auriferous veins of importance have been discovered lies to the east of Cape Edward, an island point projecting into the Pacific Ocean. These deposits were first noted early in 1905 by Indian fishermen, and within the last two years valuable veins have been developed at this locality. The prospects are on the north and south slopes of a mountainous divide between Klag Bay and Hirst Cove. The country rock is made up of an outlying belt of slates, graywackes, and conglomerates constituting the lowlands along the coast and overlying the slate and greenstone tuff beds which compose the flanks of the bordering mountain range. Farther inland and to the east of this series belts of limestone interstratified with metamorphic schists skirt the contact of the granodiorite intrusive which forms the core of the island.

The auriferous veins so far discovered lie near the line of contact between the outlying slate-graywacke beds and the slate-greenstone strata, at a distance of 3 miles from the granodiorite belt to the northeast. These strata strike northwest and dip steeply to the southwest. The veins have a general trend parallel with the rock beds, though some of them crosscut decidedly and in a northerly direction. The occurrence of the ore in shoots is apparent from the localization of very rich ore at certain points and the barrenness of the veins at other points. The gold is present both native and combined with the sulphides, the latter composing but a small percentage of the ore.

The Young group of claims, generally known as the De Groff mine, extends from tide water on the north side of Klag Bay for over half a mile up a gulch. The principal workings are at 220 feet elevation, where a crosscut 30 feet long undercuts the vein 45 feet in depth, and from the end of this crosscut over 100 feet of drifting has been extended. The vein has also been explored by surface trenches and is found to vary from 2 to 7 feet in width. The ore mined has been principally from the surface outcrops and masses of quartz float near the vein. This has been sorted, sacked, and shipped in several-ton lots to the smelter at Tacoma. The ore, however, is a free-milling quartz rock, and it is planned to erect a 5-stamp mill on the property early in the spring of 1907, and thus save the present shipping and smelting expense.

Just above the Young group to the northwest are the Golden Horn and Golden Gate claims, located upon quartz veins similar to the one already described. The ore body on the Golden Horn claim has been prospected by a tunnel about 40 feet in length, and a vein 3 to 6 feet wide is exposed. On the Golden Gate claim the developments consist of surface cuts exposing a strong fissure vein many hundred feet in length. Though the values are found to be low, shoots of rich ore are likely to occur.

Over the divide and down the north slope of the mountain is the Bear group of claims. The workings are in a gulch half a mile from Hirst Cove and at 440 feet elevation. The quartz vein at this point is but a foot in width, though the country rock itself for a few feet on each side of the vein is sufficiently mineralized to make ore. In strike the vein coincides with the structure of the slate-greenstone schist inclosing rock, which trends N. 50° W. A small shipment of the ore was made to the Tacoma smelter and the returns were reported as favorable.

Along this mineral belt, bordering the outer shore of Chichagof Island, prospecting should be encouraged. The inaccessibility of the valleys and the dense undergrowth present a somewhat formidable outlook to the prospector; a careful search, however, within this area is undoubtedly•warranted.

KETCHIKAN MINING DISTRICT.

Gold plays but a very minor rôle in the mining interests of the Ketchikan district, and its production has been largely from the copper ores, which carry from \$0.50 to \$2 in gold per ton of ore. In this section there are apparently no defined lines or zones along which gold has been extensively distributed. It is found scattered here and there at numerous localities, but at only a few of these have developments been extensive.

PRINCE OF WALES ISLAND.

Near Hollis, on the north side of Twelvemile Arm, are the Crackerjack, Puyallup, Flora and Nellie, Dew Drop, and Julia claims. The most work done in this section was on the Julia claim, situated on Harris Creek, 21 miles southwest of Hollis and from 800 to 1,200 feet from tide water. At this point a shaft 100 feet deep has been sunk on an incline of 25°. At the 50-foot level a drift has been run 35 feet long, and another started at the 100-foot level. The ore body is a quartz vein, striking north-northwest and dipping 25° SW., in a black-slate country rock. At the surface it has a width of 1 foot of solid quartz. This, however, becomes a stringer lead, consisting of numerous quartz veinlets across a width of 41 feet, at a depth of 100 The ore contains auriferous pyrite, with some galena and feet. sphalerite. An arrastre was installed and mining on a small scale is to be advanced during the winter.

Investigations at the Crackerjack mine were made by the Brown-Alaska Company early in 1906, but no development work has since been done. The Puyallup mine was leased and prospected by two miners, who discontinued work in February, 1906. The other properties in this section were idle.

At the Treasure group, on Granite Mountain, which promised well to become a producer, only small improvements were made within the year, and on the near-by claims the assessment work alone was done.

At Dolomi a small crew of six men was employed and developments were furthered on the Valparaiso vein. The shaft has been extended to 180 feet in depth, and at the lower level the pay streak is reported to have widened from 16 inches to nearly 30 inches. On the Amazon claim limited explorations were also made underground. On the Paul and Lakeside claims inclined shafts 60 feet deep have been sunk and drifts started on the veins. The properties of the Golden Fleece Mining Company were sold by the action of the court early in the year and no attempt was made to operate them.

The prospects at Dakoo Harbor, on Dall Island, southwest of Prince of Wales Island, have been developed in a small way during the year, though no important improvements in the ore bodies are to be noted. The deposits at this point are quartz veins and lodes of low-grade ore.

GRAVINA ISLAND.

At the Gold Stream mine, on the east side of Gravina Island, operations were renewed July 15 and a dozen or more men were employed until the 1st of October. An exploratory drift was extended in a northwesterly direction from the shaft, and a body of good ore was

LODE MINING IN SOUTHEASTERN ALASKA.

exposed. On the surface considerable investigations and improvements were also made. Two smelter shipments of ore were made during the year, but this ore is by no means a smelting ore. It contains a high percentage of free gold and but a small proportion of concentrates, and with careful amalgamation and separation it may be reduced at small cost.

REVILLAGIGEDO ISLAND.

The Sea Level mine, on Thorne Arm, which was one of the first gold mines of the district and has been idle since 1903, was carefully examined late in 1906, with the view of resuming operations early in 1907. The properties in the near vicinity of Ketchikan have all been closed.

CLEVELAND PENINSULA.

Mining and prospecting on Cleveland Peninsula have been confined to Helm Bay and Smuggler Cove, on the southwest end. Mineralization occurs in a narrow belt of schist and slate, and from this belt seams and pockets of rich free-gold ore have been mined. Though numerous claims are located upon this belt, the only important work done during the year was on the Gold Standard and Old Glory groups. At the former a 2-drill compressor plant was installed, besides exploratory work underground. The 5-stamp mill on the property was reported in October to have been in operation for sixty days, crushing 15 tons of ore per day. The richest ore is sorted out and shipped to the smelter. At the Old Glory group small developments were advanced and the ore obtained was treated in the 2-stamp testing mill on the property.

WRANGELL MINING DISTRICT.

Last year brought little progress in the mining enterprises of the Wrangell district. Late in the summer interest was revived on Woewodski Island by the Olympic Mining Company, and a renewed attempt was to be made to mine and mill the ore from the several quartz lodes and veins on this company's properties.

The mineral deposits are zones of brecciation in the greenstone country rock, from 5 to 15 feet in width, into which quartz has been generously introduced, carrying with it sulphide ores and small amounts of gold. But a small percentage of the ore is free milling, and as a whole the deposits are rather low in grade.

Though there are many other prospects in the district there was no gold production and but little mining was done within the year.

SKAGWAY MINING DISTRICT.

GENERAL STATEMENT.

There are no gold-quartz mines in the Skagway district. The only gold produced has been from the placer mines on Porcupine and Nugget creeks in the Chilkat drainage basin and from the beach diggings at Lituya Bay. These placer mines were mostly idle in 1906, and the production for the year was nil.

At Porcupine Creek nothing has been attempted since the washout in July, 1905. At Nugget Creek small improvements were made on some bench claims just above Salmon River, but no work was done on the deposits of this river.

LITUYA BAY.

Lituya Bay forms a deep indentation in the coast line 50 miles to the northwest of Cross Sound. Although it is an excellent harbor, a bar composed of large bowlders and gravel wash almost locks the entrance, and through the boat channel, which is but a hundred feet in width, the tide rushes at great velocity, so that it is dangerous to enter except at slack water during calm weather.

The lowlands flanking the abrupt mountain slopes at the head of the bay are composed of Pliocene conglomerate and shale beds carrying narrow seams of coal, the latter of no commercial importance. These strata overlie a belt of slates and greenstones, which in turn overlie the metamorphic schists exposed along the precipitous shore at the head of the bay. The mountain range in the background is composed essentially of an intrusive granodiorite. Indications of mineralization were observed in these schists bordering the granite belt, and from them the placer gold occurring in the beach sands along the coast is supposed to have originated.

The auriferous beach sands are distributed along the Pacific shore to the northwest of the bay for a distance of about 10 miles, and similar occurrences are reported at Yakutat. These auriferous deposits consist of black and ruby sands, occurring in layers from a few inches to a few feet thick and extending in places for 100 yards back from tide water. The black or magnetite sands are by far the richest, and a pan test gave numerous fine colors ranging from a fraction of a cent to several cents in value.

At a point 4 miles northwest of Lituya Bay a river which flows nearly parallel with the shore for about 3 miles enters the ocean, and here the fine wash which is derived from the mountain streams and carried in suspension is deposited by the counter action of the surf against the stream current. During periods of high tide and storms these auriferous sands are concentrated by the waves in layers high up on the beach. Since 1890 these deposits have been worked at intervals, and are reported to have produced in $1891 $15,000.^{a}$ In later years even higher returns are said to have been obtained, but no authentic statements could be procured.

In 1901 the Lituya Bay Gold Mining Company built a large warehouse and flumes and installed machinery to conduct large-scale operations, but the limited extent of the pay streaks and lack of near-by waterfor power and hydraulicking purposes prevented it from furthering the work to a successful outcome. Small parties of miners, however, at different periods have worked these deposits with shovel, sluice box, and rockers to good advantage, and report that the auriferous beds yielded from \$5 to \$10 a day per man. The presence of gold in these sands appears to warrant a thorough prospecting of the mineral-bearing schists which traverse the head of Lituya Bay and parallel the coast line.

COPPER.

PRODUCTION.

The remarkable increase in the production of copper from the mines on Prince of Wales Island has brought Alaska well to the front as a copper-producing territory. Practically the first shipments were made in the latter part of 1905, and since that time there has been a steadily increasing production. For the most part the ores of southeastern Alaska carry but a small percentage of copper and less than a dollar in gold, and therefore require exceptional mining and transportation conditions to insure profitable extraction.

The following table shows the amount and value of the copper, gold, and silver produced from copper ores in Alaska in 1905:

<u> </u>	Total.	Copper.		Gold.		Silver.	
		Amount.	Value.	Amount.	Value.	Amount.	Value.
Total	Tons. 52,199	Pounds. 4,805,238.0 92.6	\$748,616.00 14.44	Ounces. 3,441.84 .066	\$71,170.36 1.36	Ounces. 26,500.00 .497	\$16,021.00 .298

Production of copper ore in Alaska, 1905.

The production for the Prince William Sound area, as well as southeastern Alaska, is included in the above table, thus increasing the total by a little less than 3,000,000 pounds of copper. The ores from the Prince William Sound area are of comparatively high grade, and the averages per ton given in the table are higher than the yield from the ores in southeastern Alaska.

For 1906 the production of copper from southeastern Alaska alone is valued at nearly \$1,000,000.

a Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, p. 85.

Bull. 314-07-5.

KETCHIKAN MINING DISTRICT.

All the copper-producing mines of southeastern Alaska are on Prince of Wales Island, in the Ketchikan district. The ore bodies are genetically related to the intrusive rocks and occur either as contact or replacement deposits in the form of lenses or irregular masses. They are found in limestone, quartzite, or a greenstone-schist country rock. The chief copper ore is largely chalcopyrite, accompanied by pyrite, magnetite, and pyrrhotite, besides various gangue minerals. Enrichment zones are lacking, evidently on account of the absence of the zone of weathering which was removed during the glacial epoch; and at only one locality (Copper Mountain) are secondary ores present in quantity. At this place they extend only a few hundred feet below the surface.

KASAAN PENINSULA.

Kasaan Peninsula is a promontory 12 miles long and 3 to 6 miles wide, projecting into Clarence Strait and sheltering Kasaan Bay, a deep embayment. Its high points reach elevations of 500 to 3,000 feet, and the mountain mass is made up principally of eruptive rocks. The sedimentaries exposed are small areas of marbleized limestone and schists varying in composition. These are invaded by wide diorite masses and by dikes of felsite, diabase, andesite, and basalt, in many places forming an intricate complex of intrusives, both previous and subsequent to the deposition of the ore bodies. Faulting was observed locally, but displacements were small and their effect on the ore bodies was slight.

The ore bodies occur as lens-shaped masses within the contact aureole of the invading diorite batholiths. The diorite is not invariably exposed on the surface at the mine, but its presence may be usually found in the near vicinity. The presence of a huge underlying mass of igneous rock is clearly shown by the vast amount of contact metamorphism and contact minerals within the ore bodies. Garnet, epidote, hornblende, calcite masses, and many other secondary minerals are present and form the gangue of the copper deposits. Associated with the chalcopyrite is a large percentage of magnetite, thus making a base ore and necessitating the addition of much siliceous ore on its reduction in the smelter. This latter problem has been a source of difficulty the last few years, but has apparently been overcome by the development of extensive bodies of copper-bearing quartz at Maple Bay, on Portland Canal.

There is every reason to suppose that these copper deposits originated from considerable depth and were laid down from the solutions given off during the solidification of the dioritic batholiths. It seems safe to assume, therefore, that other ore bodies similar to those exposed on the surface may be found within the contact zones in depth. The progress in mining development of the Mamie and Stevenstown mines, on the east side of the peninsula, may be best expressed in the number of tons of ore reduced in the smelter at Hadley, just below the two mines. This smelter, which began operations December 5, 1905, and was in blast at different periods for about two hundred and sixty days during the year 1906, reduced nearly 90,000 tons of ore, most of which was from the two mines mentioned.

At the Mamie mine notable progress was made and its output of ore was increased. Exploratory developments by drifts and diamond drill were also advanced.

The Stevenstown mine has had a successful year, with a large ore production. The ore body is much like that at the Mamie mine, consisting of a flat-lying lens of chalcopyrite-pyrite and some magnetite associated with hornblende and calcite. These lie in a banded garnetepidote country rock and are crosscut by porphyrytic and diabasic dikes striking in various directions, most of which were intruded subsequent to the deposition of the ore. To the northeast a narrow belt of crystalline limestone was observed at one point overlying the ore body and apparently is the remnant of a broad limestone belt that has been removed by erosion. The developments consist of wide surface pits undercut by tunnels from which the ore is delivered to the aerial tram and thence to the smelter 1 mile distant.

An exploratory tunnel 300 feet in length, which undercuts a lowgrade magnetite ore body exposed on the surface, has been driven on the Blue Jay claim, and at other points on the property small cuts and trenches have been made. It is planned to extend the investigation of these deposits by a diamond drill.

On the west slope of Kasaan Peninsula is the Mount Andrew mine, which for several years previous to 1906 was idle. The first of the year operations were renewed and were energetically advanced, so that at the time of the writer's visit, in October, the first ore shipments were being made to the smelter at Crofton, B. C. The underground workings consist of nearly 500 feet of tunnel drifts and crosscuts, and in the main tunnel two workable ore bodies, from 25 to 75 feet in lateral dimensions, have been opened. On the surface a third ore body, similar in size, but of somewhat lower grade, has been partially developed. A cable tram 3,600 feet long has been installed and large ore bins and a wharf have been built at tide water.

From the White Eagle mine a shipment of 350 tons of ore was made in February, but since that time work has been suspended. Prospecting during the summer between the White Eagle and Mount Andrew properties revealed new bodies of copper-bearing ores, which were located and exploitation was begun.

To the northwest, about 3 miles from the village of Kasaan, is the Mammoth group, purchased by the Haida Copper Company in June. Previous developments at this mine consisted of a shaft 35 feet deep on the ore body, with two crosscuts 30 to 40 feet in length, and a 110foot tunnel was started to undercut just below the shaft. Under the new management the tunnel was completed and a surface equipment comprising an aerial tram and wharf was being built preparatory to the shipping of ore early in 1907. The mine is at 480 feet elevation and 1,800 feet from tide water. The mineral deposit is a low-grade magnetite-chalcopyrite body with basic gangue minerals and is less than 100 feet in its greatest dimensions.

Four miles northwest of Kasaan post-office, and half a mile from the beach, locations were made in September upon an ore body of the Kasaan type. Soon after its discovery this property was bonded to a mining company that was planning to carry on its investigation during the winter.

Developments on the ore bodies at the Copper Queen mine, the Poor Man's group, and the Sunny Day group of claims, all situated on the Kasaan Bay side of the peninsula, have been suspended, principally on account of litigation, and the required assessment work alone has been done on them during the year.

The mines at Karta Bay, on the northwest end of the peninsula, have added considerable to the copper production of the island. The ore bodies are large magnetic masses, in which chalcopyrite occurs in concentrated patches and irregularly disseminated throughout the whole. These are included in an altered dioritic rock which intrudes and includes narrow beds of limestone and chlorite schist. The surrounding country is comparatively low in elevation, and shaft mining and exploration is a necessity. These magnetic bodies have been located by magnetic surveys, and the largest bodies of ore are apparently at the points of maximum attraction.

The Rush & Brown property, which is connected by a railroad $3\frac{1}{2}$ miles in length with the wharf at Karta Bay, has been the mining center of the Karta Bay area. A lease of this mine was taken by the Alaska Copper Company, and the ore mined, which has amounted to several thousand tons, is shipped to its smelter at Coppermount. The deposit is a body of magnetite-chalcopyrite ore carrying small gold values and inclosed in a diorite country rock. It is oval in cross section, being 150 feet in length and 50 feet in width, and has been developed 100 feet in depth. A second ore body from 10 to 20 feet in width and of greater longitudinal extent occurs about 150 feet to the northeast, and from it much ore has been mined.

On the Venus group, 2 miles south of the Rush & Brown mine, a large body of pyrrhotite-chalcopyrite ore has been exposed by surface strippings and two short tunnels. The ore is low in grade, and little work was done on the property during the year.

SKOWL ARM.

During 1906 the Kiam mine, on Skowl Arm, and the adjoining Mammoth and Lake View groups to the east were idle. The smelter returns from a large shipment of the ore were not satisfactory, and its high content of sulphur made it an undesirable smelting product. After a careful examination made of these properties this last summer the owners decided to discontinue operations at this point.

The ore bodies which have been developed are heavily mineralized masses of pyrite and pyrrhotite ore containing chalcopyrite and occurring in a schist country rock. These masses coincide in trend and dip with the rock structure. At the Kiam mine the mineralized band is continuous over a length of possibly a thousand feet and has an average width of 20 feet, though in places it is 60 feet wide. In depth, however, the deposit was not undercut by the tunnels crosscutting the ore-bearing zone, and it appears to be limited to some tens of feet from the surface at the point where it has been developed by the Powell tunnel. The tonnage of available ore is therefore relatively small, and though it could be readily mined its value is reported as insufficient for profitable extraction.

The Mammoth and Lake View groups are clearly in the general line of strike with the Kiam ore bodies, and so far as developed the deposits are of the same character. They appear to be merely smaller and weaker examples of the Kiam type.

NORTH ARM.

At the head of North Arm locations were made in 1905 on copperbearing veins about a mile from tide water and less than a hundred feet in elevation. Early in 1906 these were transferred to the Cymru Mining Company, which immediately began operations and the 1st of October began shipments.

The veins, four of which have been exposed, lie in the limestone and greenstone-schist country rock and strike N. 35° W., nearly parallel to its structure, dipping 70° SE. They vary in width from 1 to 5 feet and contain chalcopyrite and pyrite scattered through a quartz gangue. Near the surface the ore is changed to the oxides and carbonates of iron and copper. A shaft 105 feet deep has been sunk on the larger of these veins and at the 100-foot level a drift extended. A large percentage of the ore mined was from a surface trench 500 feet long and 4 to 8 feet wide, following the vein. From these workings a surface tram leads to ore bunkers, from which the product is loaded directly into hulks or barges for shipment.

NIBLACK ANCHORAGE.

The Niblack mine, on the south side of Niblack Anchorage, has been operated steadily throughout the year and has yielded a large production of copper ore.

The ore bodies occur as mineralized portions of schist bands in a complex consisting chiefly of greenstone schists with a few belts of quartz-sericite schist and allied rock types. The formation strikes N. 60° W., with a dip of 60°-70° SW., and is cut by several later diabase dikes. Folding and faulting occur at many places and have an important bearing on the extent and shape of the ore bodies. Detailed work on these structural features in the mine has shown that the irregular outline of many of the ore bodies is the result of intersecting fault planes. The ore is essentially low-grade chalcopyrite, with small values in gold and silver. Pyrite occurs in great abundance and renders the ore suitable only for smelter treatment. Small veinlets of nearly pure chalcopyrite are associated with ferruginous quartz and constitute then the jasper ore of the miners.

The development work for the year was as follows: Drifting and crosscutting, 1,670 feet; shaft sinking, 80 feet; raises and winzes, 425 feet. The inclined shaft is now 225 feet deep and will be extended to a depth of 300 feet. On the 225-foot level a new ore body 90 feet long and 15 feet wide and following a diabase dike has been exposed. It extends to the 150-foot level above, and the ore from it was being mined.

HETTA INLET.

The mines on the west coast of Prince of Wales Island are centered within a small area about Copper Mountain and along the east shore of Hetta Inlet. A geologic sketch map of this area has already been published, with a description of the mines.^{*a*} Briefly, the ore bodies are masses of chalcopyrite or carbonate ores associated with magnetite and pyrrhotite in a gangue of garnet, epidote, and calcite. As a rule these occur along the contact of a granitic stock, intruding beds of limestone and quartzite. The exceptions are the massive sulphide veins occurring in the greenstone schist at the Corbin and Copper City mines.

Investigations on the New York and Indiana claims, the principal holdings of the Alaska Copper Company, have been advanced throughout the year. The developments consist of several exploratory tunnels at different elevations below the surface exposures of the ore bodies, but no noteworthy ore exposures have been made in them.

On the north slope of Copper Mountain are the Jumbo mine workings, belonging to the Alaska Industrial Company, which are also upon contact deposits of chalcopyrite ore. The principal workings are on Jumbo No. 4 claim, where three tunnels crosscut the contact zone and expose ore bodies at 1,650, 1,770, and 1,876 feet above sea level, and are themselves connected by raises. Similar ore masses have been opened by surface cuts at 2,000 feet elevation. From this mine a short aerial and surface tram connects with an aerial tram 8,228 feet long, over which the ore will be transported to 3,000-ton bins built on a wharf at tide water.

Other ore bodies developed in former years by this company are Jumbo Nos. 1 and 2 claims, and on the Green Monster group to the east, but these were neglected last year and mining was confined to the above-described property.

A mile to the north of the Jumbo claims are the Houghton claims, located along the granodiorite contact on similar chalcopyrite-magnetite deposits. These were transferred within the year to the Cuprite Copper Company, which has undertaken large developments.

Early in the year the Corbin property, 3 miles north of Copper Harbor, on the east shore of Hetta Inlet, was transferred to the Alaska Metals Company, which has begun developments, consisting essentially in the erection of buildings, a compressor plant, and wharf. The ore body is a narrow vein of massive sulphide ore, carrying but a slight percentage of copper and small values in gold and silver. It follows the general northwesterly structure of the greenstone-schist country rock. At a point 45 feet from the mouth of the tunnel to the south the vein narrows to a mere seam, and in the shaft, 22 feet below the surface, it was faulted. From all indications the deposit appears to be a small ore shoot, less than a hundred feet long and 3 feet wide, pitching at an angle of about 60° NW.

At the Copper City mine, 8 miles south of Copper Harbor, operations began in May and continued throughout the year. The ore body is a narrow vein of massive sulphide ore, occurring in the slategreenstone schist country rock. The vein parallels the vein structure and varies from 1 foot to 5 feet in width. It is crosscut by dikes of diabase, which apparently are later than the deposition of the ore. Several shipments of the ore were made to the smelter at Tacoma during the year. The principal feature in the mine workings was the development of the vein below the 100-foot level. Along this level the ore body wedged away rather suddenly and was found to be displaced for a short distance toward the foot-wall side. At a point in the drift 60 feet northwest of the shaft a winze was being sunk on the vein to the 200-foot level, and in this a good width of ore was reported.

GRAVINA ISLAND.

Copper-bearing deposits are known to occur on both the south and north ends of Gravina Island. The properties at Seal Bay and on Dall Head were prospected to some extent during the summer, and on the north end of the island west of Vallenar Bay new ore bodies were located. Developments were advanced by the Victor Copper Mining Company on the Bay View and War Eagle claims at Seal Bay. From the former a small smelter shipment was made, the ore being mined from a quartz vein carrying chalcopyrite, exposed along the south shore of the bay.

WRANGELL DISTRICT.

The mineral bodies exposed at the head of Duncan Canal and on Woewodski Island at the entrance both carry small percentages of copper. At the former locality little advance has been made on the groups of claims owned by the Portage Mountain Mining Company. On Woewodski Island the Olympic Mining Company renewed operations late in the summer at the Smith camp, and further investigations will be made on the quartz veins, which were extensively developed in former years.

SILVER, LEAD, AND ZINC.

Deposits of silver, lead, and zinc are not plentiful along the coastal belt, and except small amounts of silver accompanying the gold and copper ores the production has been nil.

The galena veins recently discovered in Cholmondelev Sound, on Prince of Wales Island, however, promise well to become producers in 1907. The Moonshine group of claims, situated at from 2.000 to 2,400 feet elevation on the east slope of Granite Mountain, in Cholmondeley Sound, was located in the spring and soon after was leased to a mining company, which began operations. The ore body, a welldefined vein or mineralized shear zone, obliquely traverses the limestone-schist country rock in a northeasterly direction and occupies a nearly vertical position. It has been exposed at points along the surface over a length of 600 feet and varies from 2 to 4 feet in width. The ore is massive galena associated with pyrite, chalcopyrite, and zinc blende in a gangue of quartz and calcite. Portions of the vein include brecciated masses of country rock, and at these points the distribution of the ore is irregular. The vein was being developed by two tunnels at 2,000 and 2,200 feet elevation and a shaft at 2,400 feet elevation. An aerial tram 5,000 feet long and a wharf must be built before shipments of the ore can be made.

In the Wrangell district explorations on the silver-lead properties located in Glacier and Groundhog basins on the mainland have been meager, and though these properties have been investigated by outside persons no mining company has yet undertaken their development, owing to their distance from tide water.

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NONMETALLIFEROUS MINERAL RESOURCES OF SOUTH-EASTERN ALASKA.

By CHARLES W. WRIGHT.

INTRODUCTION.

The recent developments and increasing production from the gypsum and marble quarries of southeastern Alaska have shown that the nonmetallic deposits are an important resource of this region. Structural minerals, such as marble, granite, gypsum, and cement, are widely distributed along this coast, and, besides these, both mineral and thermal springs have been found and coal seams located, though the latter are of no consequence at present.

Little consideration has been given to the nonmetallic products of this Territory, and the increasing use in the United States for such materials demands a more thorough investigation of these resources. Though distant from the market, many large deposits of structural material are well located for quarrying purposes and transportation by water.

In the following pages a brief description of the known workable deposits is given, together with a short discussion of their distribution and of the characteristics and market value of such nonmetalliferous materials.

ORNAMENTAL AND BUILDING STONES.

GENERAL STATEMENT.

The only stones of value in southeastern Alaska, so far known, are the marbles and granites. The market for these stones is in the cities along the Pacific coast, 600 to 1,000 miles distant. They must, therefore, be of more than ordinary quality to bear the expense of freight, as good stone is found in the vicinity of most large cities, and builders, as a rule, prefer to use a known rock which is near at hand and can be readily obtained.

To place the Alaskan product on the market, it will be necessary to establish supply stations with dressing and cutting plants in the larger seaboard cities, where cheaper and more efficient labor may be obtained than in Alaska. To supply these points, the rough granite

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and marble blocks could be transported in hulks or barges carrying several thousand tons at a low freight rate and the necessity of careful handling during shipment would be avoided.

To determine the structural value of a building stone, microscopical, chemical, and physical tests should be made. This is more necessary for marbles and cement stone than for granite. Most university laboratories are equipped for such tests and will make them at a reasonable cost.

MARBLE.

DISTRIBUTION.

Beds of marble are known to occur at points along the mainland portion of southeastern Alaska, as well as on many of the islands. They are invariably at or near the contact of an intrusive belt of granodiorite, which has been one of the principal factors in metamorphosing the original limestone beds to their present crystalline or marbleized condition. The age of the limestone beds is Paleozoic, and only in a few places could a more definite determination be made. The largest deposit of marble under development is on the northwest end of Prince of Wales Island, near Shakan. This and other deposits are described on pages 75-77.

NECESSARY QUALITIES.

Commercially marble includes all limestone rocks susceptible of receiving a good polish and suitable for ornamental work. It is no simple problem to judge the value of a marble deposit, and this can not be done from mere tests of small samples, which, nevertheless, may often give significant results. Some of the more important factors governing the value of a body of marble are the quality and soundness of the material as a whole, extent of the deposit, absence of fractures or joint planes, color, lack of objectionable impurities—such as silica, pyrite, and bitumen—facility of extraction, and location of the deposit relative to the market and transportation.

COMPETITIVE DISTRICTS.

Most of the marble used in western cities for monumental and interior decorative purposes is furnished by eastern dealers and must be shipped across the continent. This is mainly the product of the Vermont and Tennessee quarries or is imported from Italy. Stevens County is the only producing locality in the State of Washington; there are none in Oregon, and but two of importance, the Inyo and Columbia quarries, in California. The total value of the marble production for 1905 from these localities was less than \$150,000. This product sold in a rough state at \$1 to \$2 per cubic foot, and dressed for ornamental and monumental purposes at \$2 to \$8 per cubic foot. Cut in slabs 1 inch to 2 inches thick and polished on one side the retail price varied from \$0.50 to \$1.50 per square foot. The eastern and foreign marbles sold for higher prices.

DESCRIPTION OF LOCALITIES.

PRINCE OF WALES ISLAND.

Several deposits of marble have been located on Prince of Wales Island, and, as stated above, the largest of these is at Marble Creek, a few miles north of Shakan, on the north side of the island. Other deposits are at El Capitan, also near Shakan; on Marble Island, adjacent to the northwest coast of Prince of Wales Island, and at Baldwin and Dolomi, on the east coast of the island.

At the Marble Creek locality are the properties of the Alaska Marble Company, located upon a belt of Devonian limestone half a mile or more in width flanking the contact of an intrusive granite mass which forms the low mountain ridge to the east and which is evidently the direct cause of its alteration to marble. Small dikes of diabase, much altered and faulted, though rare, were observed intersecting the marble beds, and apparently antedate the metamorphism of the limestone and the intrusion of the granite. They are, however, not sufficiently numerous to affect the value or expense of quarrying the marble, and in the present opening only one dike is exposed.

The extent of the deposit has been investigated by a number of drill holes and surface openings, and it is exposed at points over a length of 2 miles and a width of half a mile. Three varieties—pure white, blue veined with white background, and light blue, much of which has a mottled appearance—are found, the pure white rock being the most valuable. All of the marble is free from silica or flint beds, and though thin seams of pyrite were observed they do not occur in a quantity detrimental to the stone. Analysis of the rock shows 99.2 per cent calcium carbonate and 0.3 per cent magnesia. Though not equal to the best Italian grades, this marble is better than most American marbles and in the market will compete on at least equal terms with the Vermont, Georgia, and Tennessee products.

The principal workings on this deposit are 100 feet above sea level on the south side of Marble Creek and 3,200 feet from deep water. A gravity railroad extends from the quarry to the end of the wharf, where loading facilities have been erected. Quarrying has extended below the more or less jointed surface rock, and solid blocks 6 by 6 by 4 feet are being mined and shipped. With increasing depth

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both soundness and quality of the marble greatly improve, and flawless blocks of large size may be quarried. The dimensions of these blocks, however, are dependent on the handling capacity of the machinery. Small shipments of this product have been made to many of the large cities as far east as Ohio, though the greater portion is sent to Tacoma, where a cutting and polishing plant has been built. Last year the capacity of the mining plant was materially increased with a view to an enlarged production in 1907.

On the opposite side of the low mountain range a similar marble deposit is exposed, and has been partially developed by the El Capitan Marble Company. This property is located on the north side of Klawak Passage, 6 miles from Shakan village. The marble exposed in the quarry close to tide water is comparable with that at Marble Creek above described, except in solidity. Thin fragments of the marble crumble more readily in the hand, and the position of the present workings is less favorable for extensive quarrying. A thousand feet back from tide water surface cuts and strippings have exposed a much firmer and better marble at the foot of a steep bluff. This company began operations in 1904, installed channeling and gadding machines, erected a marble-sawing plant, and made a small shipment. During the last two years no further quarrying has been done and only small developments have been made.

A number of marble claims were located in 1902 about 30 miles to the south of Shakan, on the northwest side of Marble Island, in Davidson Inlet, but practically no work was done on them and they were relocated in 1906. Several varieties of marble of good quality are exposed and the deposits appear worthy of further investigation.

At Baldwin, near the head of North Arm, an inlet on the east side of Prince of Wales Island, beds of marble have been located and developed by the American Coral Company. The deposit at this point consists of marble beds interstratified with chloritic schists striking N. 65° W., with a nearly vertical dip. The marble varies greatly in color and composition, and although some of it is of excellent quality it would probably be difficult to obtain any large quantity of a uniform grade. Most of the product contains a small percentage of silica and some alumina and magnesia. Pyrite in disseminated particles was also observed in some of the marble. The surface exposures were badly fractured in places, but this condition is probably confined to a depth of 10 to 20 feet from the surface. In 1905 a wharf was built, machinery installed, and buildings erected. In 1906, however, practically no work was done.

At the north entrance to Johnson Inlet, about 3 miles east of Dolomi, a second group of claims has been located by this company on a similar marble belt. Work at this point has been meager and but little was accomplished during 1906.

HAM ISLAND.

Two deposits of marble have been developed to some extent on Ham Island, an islet in Blake Channel at the southeast end of Wrangell Island. The Woodbridge-Lowery property lies on the west side and the Miller property on the east side. Exploratory work has been advanced at both localities, large blocks have been quarried, and from them many tombstones have been chiseled and polished for local use.

ADMIRALTY ISLAND.

A number of marble deposits occur on Admiralty Island—at Marble Bluffs on the west shore, at Square Cove, at Hood Bay, and in Chiak Bay. Some of the marble at these points is of excellent quality, but most of it contains silica and pyrite and is of an inferior grade. The deposits at Marble Bluffs are apparently the most extensive and of better grade than the others.

OTHER LOCALITIES.

Belts of marble exposed in cliffs at tide water have been located on the north side of George Inlet, also in Carroll Inlet to the southeast, both located on Revillagigedo Island. The extent and value of these marble beds have not been investigated.

On the mainland to the north, at the head of Limestone Inlet, 30 miles southeast of Juneau, extensive areas of a coarsely crystalline marble are located. The marble is colored and not of the best grade.

GRANITE.

DISTRIBUTION.

The granitic intrusive rocks occupy about one-half of the aggregate land area of southeastern Alaska. (See Pl. III, p. 48.) In composition they vary from granite to granodiorite and to quartz or hornblende diorite. The core of the Coast Range, as well as the central portion of many of the islands, is composed of this intrusive rock. The metamorphism in the granite, its nonuniformity in color, and the presence of joint cracks, so far as observed, make most of the stone undesirable for building purposes. However, granite masses of good quality, uniform in color, and favorably located for purposes of quarrying, were observed along the mainland up Portland Canal, in Behm Canal, at Thomas Bay, and Taku Inlet. On Baranof Island exposures of this rock of similar good quality occur at Gut Bay, on the east side, and at the head of Whale Bay and near Silver Bay, on the west side.

CHARACTERISTICS.

All the granite masses in southeastern Alaska are similar in composition, having plagioclase feldspar as an essential constituent. Hornblende is the usual dark mineral, though biotite mica is present in

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much of the rock and in a few places exceeds in amount the hornblende. Quartz is commonly present, though usually in small amounts. The accessory components are apatite, titanite, and magnetite; secondary minerals, due to general metamorphism, are sericite, epidote, zoisite, chlorite, and calcite. Petrographically much of the rock is related more closely to the diorites than to the granites and is usually referred to as a diorite.

The prevailing color of the granite is a light gray and only in a few places were pink or reddish masses observed. The grains of the component minerals are ordinarily of medium size, not varying greatly in the different localities. Evidence of the durability of the granite is afforded in many places where long exposure to the influence of weathering has caused little or no disintegration of the surface.

MARKET.

No attempt has yet been made to quarry or even investigate the Alaskan granite. There is practically no market in Alaska for the stone, and along the Pacific coast to the south the demand has been supplied by the quarries in the States of Washington, Oregon, and California.

The long haul necessary to the market appears at first unfavorable to granite quarrying along this portion of the northwest coast, but the present freight rate of less than \$2 per ton to Puget Sound is not greater than the cost of the transportation from some of the quarries in California to the larger cities. The cost for quarrying the stone in the State of Washington is estimated at 35 cents per cubic foot, and the proportion of marketable rock obtained from the amount quarried is about 60 per cent.

The value of the production of granite from States along the west coast amounted to nearly a million dollars in 1905. The average selling price per cubic foot for building and monumental purposes at the quarries in these States is given in the following table:

Average selling price per cubic foot of granite at the quarries in Pacific coast States.

	Rough.	Dressed.	For curb- ing.
California	\$1.10	\$5. 20	\$0.78
Washington	.60	2. 20	.90
Oregon	.65	4. 00	1.40

The above prices do not include the cost of transportation, which is from \$0.50 to \$3 per ton from the quarries to the cities. This adds from 5 to 30 cents to the cost per cubic foot.

GYPSUM.

OCCURRENCE.

Within the last two years extensive developments have been made on beds of gypsum at Iyoukeen Cove, on the east side of Chichagof Island, with encouraging results. The extent of this deposit, which occurs in the bottom of a valley, is practically unknown. There are only two exposures of this rock on Gypsum Creek, namely, at the lower and upper mine workings 1 mile from its mouth, and the entire area except a few outcrops of a cherty limestone is deeply buried by a dense undergrowth. The gypsum beds apparently overlie the Carboniferous rocks exposed along the southwestern shore of the cove and forming the southwestern valley divide, though the area of contact was buried under deep gravel deposits along the beach and in the valley. They are temporarily assigned to late Carboniferous or To the north the mountain is made up of a Permian formations. granite mass intruding the older limestone beds.

The geology in the immediate vicinity of the gypsum beds is obscure and neither foot nor hanging wall has been exposed in the mine workings. Bluffs of a cherty limestone striking northwest and dipping to the northeast are exposed near the entrance to the tunnel at the lower workings. The gypsum beds in the tunnel and lower levels have an east-west to N. 70° E. strike, with a northerly dip of 20° to 60°. Channels representing old watercourses and now filled with gravel wash are numerous throughout this deposit. These gravels resemble unconsolidated conglomerate beds and have been mistaken for both hanging and foot wall of the gypsum beds at points in the workings. A careful inspection of the gravels shows that the wash has the same character as that now in the creek bed. Of significance is the presence of granite cobbles corresponding to the intrusive mass at the head of the creek, which invaded the area subsequent to the deposition of the gypsum beds. Dikes of a basaltic rock were present in the beds, and one of these occurring at the south end of a drift on the first level was mistaken for the foot wall of the deposit.

DEVELOPMENTS.

This deposit, the property of the Pacific Coast Gypsum Company, of Tacoma, Wash., was extensively developed during last year. A wharf 2,000 feet in length extending to deep water, with rock bins of 1,000 tons capacity, has been built, and a railroad to the mine workings a mile from the shore completed. Rock bins of 1,500 tons capacity and a shaft house have been erected at the mine. At the lower workings a shaft 190 feet deep has been sunk, and from this two levels consisting of 600 feet of drifting have been extended, exposing

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a deposit 150 by 200 feet in lateral dimensions, though no well-defined limits have yet been reached. At the upper workings, 800 feet to the west, investigations were made in 1905 by a 75-foot shaft and drifts almost entirely in gypsum, but no further work has been done.

Shipments from this mine began in May, and several cargoes of rock have been delivered to the plaster mill at Tacoma, where it is prepared for the market.

MARKET.

Gypsum is in much demand along the Pacific coast as wall plaster, fertilizer, and in the manufacture of cement. The Puget Sound market is supplied in large measure from the deposits in Kansas, Colorado, Wyoming, and Utah. The California market is supplied by local deposits and those in Nevada and Utah. Transportation from these points to the seaboard cities costs from \$4 to \$7 per ton, and the present market prices in these cities of first-grade gypsum products are as follows: Crude, \$5 to \$7 per ton; land plaster, \$6 to \$8 per ton; plaster of Paris, \$8 to \$11 per ton; wall plaster, \$9 to \$12 per ton.^a

CEMENT.

The demand for cement all along the Pacific coast is rapidly increasing, but deposits of raw materials for this industry along the Alaskan coast are of little value. The reason for this, in the first place, is the high cost of the fuel necessary for its manufacture. The difficulty in obtaining efficient and cheap labor, as compared with the Puget Sound area and California, must also be considered, and the long haul necessary to the market is unfavorable to such an industry. To ship the cement rock as mined to a cement factory established somewhere near the point of coal supply and the market would be the most feasible mode of procedure; but to do this would bring little or no profit, as vast areas of cement rock are exposed in the proximity of all the larger cities and can supply the cement plants along the coast for many years to come.^b

COAL.

The most extensive explorations for coal in southeastern Alaska have been at Kootznahoo Inlet and Murder Cove, on Admiralty Island, and at Hamilton Bay, on Kupreanof Island. At these localities the coal-bearing formations are Tertiary in age and made up of

a For descriptions of the gypsum deposits of the United States, introduced by a discussion on the geology, technology, and statistics of gypsum, see Adams, G. I., and others, Gypsum deposits of the United States: Bull. U. S. Geol. Survey No. 223, 1904.

^b For a discussion of the distribution of cement materials and its industry in the United States, see Eckel, E. C., Cement materials and industry of the United States: Bull. U. S. Geol. Survey No. 243, 1905.

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conglomerates, sandstones, and shales. The beds are all more or less faulted and appear to occupy basins formed in the more ancient rock beds. The coal is with few exceptions an impure lignite and occurs in narrow seams of no commercial value.

At Murder Cove explorations were made on a seam 5 feet thick, located 2 miles from deep water. This deposit, which contains the best grade of coal in the region, proved to be of very small extent and not worthy of further development. No developments have been made at any of the above localities and most of the prospects have been abandoned.^{*a*}

^a For a more detailed discussion of the coal deposits on Admiralty Island see Wright, C. W., A reconnaissance of Admiralty Island: Bull. U. S. Geol. Survey No. 287, 1906, pp. 151-154.

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