LODE MINING IN SOUTHEASTERN ALASKA, 1907.

By CHARLES W. WRIGHT.

INTRODUCTION.

The mining industry in southeastern Alaska has not advanced materially during the last year, and the total metal production was not as great as that for 1906. This slight decrease is attributed to unfavorable conditions of labor and transportation and the fall in the market value of copper. These adverse factors have affected the mining interests not only of southeastern Alaska, but likewise of many of the Western States.

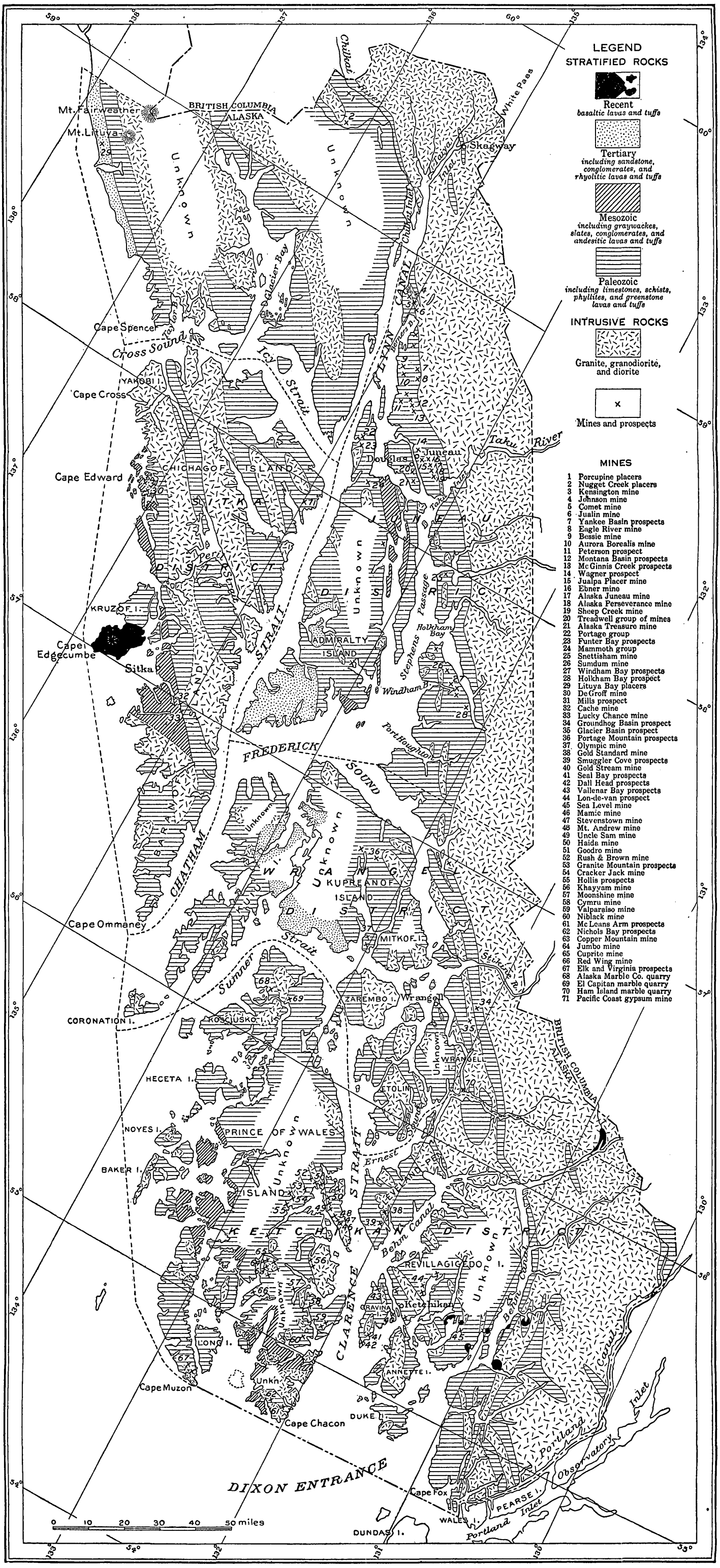
Before considering the ore bodies and mines under development in detail, a brief discussion is given of the general geology of southeastern Alaska and the distribution of the ore deposits within this area. To present the matter more clearly a map (Pl. II) has been compiled showing the general distribution of the rock formations and more particularly the larger areas of intrusive rocks. The scale of this map is about 30 miles to the inch and on it the positions of the mines and prospects are indicated. As the mapping was confined largely to the vicinity of salt water, the geology of many of the inland areas has been inferred and does not represent actual observation.

A striking feature shown on the map is the proximity of the ore bodies to the intrusive areas, thus suggesting a genetic relationship of the mineral deposits of the igneous rocks. The greater occurrence of gold in the northern districts and of copper to the south in the Ketchikan district is also noteworthy.

Detailed statements of the known geologic facts and the character of the ore deposits of the principal mining districts in southeastern Alaska are set forth in the reports on the Juneau gold belt [a] and on the Ketchikan and Wrangell mining districts.[b]

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

[b] Brooks, A. H., The Ketchikan mining district: Prof. Paper U. S. Geol. Survey No. 1, 1902. Wright, F. E. and C. W., The Ketchikan and Wrangell districts: Bull. U. S. Geol. Survey No. 347, 1908.



GEOLOGIC RECONNAISSANCE MAP OF SOUTHEASTERN ALASKA.

The investigations of the United States Geological Survey in southeastern Alaska during 1907 were confined to a study of the copper deposits on Kasaan Peninsula, and the preliminary results of this work are set forth in a separate paper in this bulletin. At the close of these investigations the writer visited the principal mines in the Ketchikan and Juneau districts, and notes on their progress during the last year are contained in this report.

An outline of the general geology of southeastern Alaska, with a geologic map, has been presented each year in the Progress Report,[a] but as each successive year reveals new facts it seems advisable to republish in the present report a brief sketch of the general geology of the region, and to add the more complete accompanying map, representing the distribution of the rock formations so far as known.

Inasmuch as a large portion of the territory still remains unexplored, and as most of the geologic investigations have been of a reconnaissance nature, some of the statements and conclusions in this, as in former reports, may be modified by more detailed studies.

GEOLOGIC SKETCH OF SOUTHEASTERN ALASKA.

The geologic distribution of the rocks along the southeastern coast of Alaska is on a broad scale, and in their strike they follow the general northwest trend of the mountain ranges. The rocks may be divided into two main groups—(1) stratified rocks and (2) intrusive rocks, both having about the same areal extent.

The stratified rocks include those of sedimentary and volcanic origin, which, except the more recently formed rocks, are in general intricately folded and usually show a high degree of metamorphism. As indicated on the map, these rocks are subdivided according to their age: The Paleozoic, including crystalline limestones, quartzites, schists, phyllites, and greenstone lavas and tuffs; the Mesozoic, including slates, graywackes, conglomerates, some limestones, and andesitic lavas and tuffs; the Tertiary, including sandstones, shales, conglomerates, and rhyolitic lavas and tuffs. The stratigraphic succession of these rock strata is complex, and nearly all the geologic periods, from early Paleozoic to the present, are represented.

The intrusive rocks are made up of a complex of coarse granular rocks, mostly granitic in character. They form the great mass of the Coast Range bordering the mainland and occupy wide areas in the central portions of many of the islands. Their mode of occurrence is at many places directly related to the geologic structures, and the

[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. No. 284, 1906, pp. 30–53. Wright, C. W., Lode mining in southeastern Alaska; Bull. No. 314, 1907, pp. 47–72.

longitudinal axes and lines of contact of these intrusive masses are usually parallel with the strike of the bedded rocks. These intrusive rocks, the most dominant geologic feature of the mainland, have been discussed by Brooks [a] in the report on the Ketchikan district, and by Spencer [a] in the report on the Juneau gold belt; their occurrence in British Columbia, where conditions similar to those along the mainland of Alaska prevail, has been carefully considered by Dawson.[b]

The Coast Range massif consists of many separate interlocking batholiths intruded at successive epochs but during the same general period of invasion. At the close of this period pegmatite, aplite, and granite porphyry dikes were intruded into the outer portions of the granitic masses and adjacent schists, and contemporaneous with or just subsequent to the intrusion of these dikes the mineral-bearing solutions were introduced. Both dikes and mineral deposits were probably derived from the same igneous magmas, which were the source of the granitic intrusives near which the dikes occur. This general invasion is believed to have occurred during early Mesozoic times.

The later intrusive rocks consist of felsite, diabase, and basalt in the form of dikes cutting both the older and younger stratified rocks and the Coast Range intrusives. These apparently have no direct bearing on the ore deposits.

That the different masses of intrusive rocks are not surrounded by similar metamorphic phenomena and that the apparent metamorphism caused by the mainland intrusive belt is quite different from that effected by the smaller intrusive masses on the islands are facts that have been frequently noted. The stratified rocks flanking the Coast Range along the mainland are intensely folded and metamorphosed and were without doubt deeply buried at the time of the granitic invasion. Deep-seated metamorphic processes were already active and had probably altered these rocks to such an extent that the igneous intrusion did not disturb their equilibrium greatly, its chief effect being to accentuate the processes of crystallization already in force rather than to replace them by others.

The occurrence of innumerable pegmatite dikes along the margins of the Coast Range batholiths is a significant indication of the immense quantities of pneumatolytic solutions given off by the invading crystallizing magmas. These magmatic solutions, containing dissolved metallic sulphides as well as silicates and other minerals, penetrated the adjacent schists, where the temperature permitted the deposition of minerals composing the pegmatite dikes, but was evidently too intense for the precipitation of the metal-bearing min-

[a] Op. cit.

[b] Dawson, G. M., Report on an exploration in the Yukon district and adjacent portions of British Columbia: Geol. Nat. Hist. Survey Canada, vol. 3, pt. 1, 1887–88, pp. 1–277 B.

erals. Farther away from the granitic intrusion magmatic solutions given off by these igneous masses encountered conditions more favorable to the precipitation of the metallic sulphides, and as a result the principal ore bodies along the mainland are found in the slate and greenstone strata 3 to 10 miles from the contact of the Coast Range intrusive mass.

On the islands the stratified rocks, though much altered, do not show the intense metamorphic character expressed in those of the mainland, and the contact-metamorphic influence of the intrusive masses is therefore in greater evidence. The contact metamorphism is confined in great part to areas within a few thousand feet from the intrusives, the amount of alteration being largely dependent on the distance from the igneous mass and the character of the intruded rock strata. The alteration of slates and quartzites to hornfels, the recrystallization of limestone to marble, and the development of garnet, epidote, wollastonite, scapolite, and other minerals in the rock strata are direct evidences of such metamorphic action.

ORE DEPOSITS.

GENERAL STATEMENT.

The distribution of metallic mineralization in southeastern Alaska is confined to certain rock formations, and in these the mineral deposits occur to some extent along certain zones which have been more or less satisfactorily determined. Because of the rough topography and the dense growth of forest and underbrush, investigations of such belts have necessarily been limited to the vicinity of salt water, where the rock formations and mineral belts are clearly exposed.

Some of the facts that have been set forth in previous reports are the following: (1) The metallic minerals usually occur in the proximity of granitic intrusives; (2) for the most part, the ore bodies were deposited subsequent to the granitic invasion; (3) the rocks of post-Paleozoic age are practically barren of valuable mineral deposits; and (4) the ore deposits are genetically related to the granitic intrusives. From these facts it is evident that the areas occupied by Paleozoic rocks and in proximity to the granitic intrusive masses are the most favorable for the occurrence of ore deposits.

PRINCIPAL CHARACTERISTICS OF ORE DEPOSITS.

Three general types of ore deposits are prominent in southeastern Alaska—vein deposits, lode deposits, and contact-metamorphic deposits. Deposits at variance with these types are the breccia veins in limestone, at Dolomi, and the mineralized diorite at the Treadwell mine, which have been discussed in previous reports.

The vein deposits include any mineral mass or aggregate occupying a fissure or fracture in the rocks. In this region they are usually made up of auriferous quartz and calcite, with a small percentage of metallic sulphides, though veins of nearly massive sulphide ore, rich in copper and in some places carrying lead and zinc, are also present. They range from 1 to 10 feet in width and usually crosscut the inclosing rock. Such deposits occur in practically all the older rocks of the district, including the intrusives, but are rarely found in the Mesozoic rocks and have not been observed in the Tertiary sedimentaries or eruptives. These facts and a lack of evidence suggesting mineral deposition previous to the invasion of the intrusive masses indicate the intrusive rocks as the probable source of the mineral solutions from which these veins were deposited.

The lode deposits consist of bands of schistose rock, in places including dike rocks, which are intersected by veinlets of quartz and calcite and impregnated with metallic sulphides. These lodes range from 5 to 50 feet in width and are usually of great persistence both in length and depth. Gold is the principal metal in them and is confined largely to the quartz and calcite veinlets. The lateral limits of the lode deposits are in few places sharply marked, and in the inclosing country rock the mineralized portion gradually changes to the unmineralized rock. Such deposits are prominent in the Juneau district, where they occur in the slates and greenstones, and they are also present on Gravina Island in the Ketchikan district.

The term contact-metamorphic deposits is here restricted to those mineral bodies which have been formed by contact-metamorphic agencies and which carry the minerals characteristic of such action. Such deposits occur mostly in limestone or calcareous rocks, usually within 1,000 feet of the intrusive bodies. The mineral solutions given off from the igneous masses previous to their entire solidification penetrated the adjacent limestone and quartzite beds and ascended along the intrusive contacts, dissolving channels, though in many places taking advantage of preexisting fissures in both the intrusive and intruded rocks. During their ascent the thermic and other conditions of the aqueous solutions changed and their mineral contents were precipitated, gradually filling the channels and fissures. As carbonate of lime is a ready precipitant of these mineral solutions, the largest ore masses were usually formed at points where limestone is the intruded rock. The contact-metamorphic deposits are composed of a massive garnet and epidote gangue in which chalcopyrite, pyrite, pyrrhotite, and magnetite occur in disseminated grains and masses. Such deposits are largely developed at several localities on Prince of Wales Island. They range from 25 to 200 feet in lateral dimensions and are confined to the contact aureoles of the larger intrusive masses.

DISTRIBUTION OF MINERAL DEPOSITS ALONG THE MAINLAND BELT.

Within the mainland belt, which includes the adjacent islands, mineralization is scattered both in the granitic intrusives and in the adjacent stratified rocks. Along certain lines or zones and in certain rock formations this mineralization is greater than at other points, and such zones are termed "mineral zones." As noted above, the highly metamorphosed schists adjacent to the Coast Range intrusive belt are less favorable for the occurrence of valuable ore deposits than the slates and greenstones which border the coastwise channels.

The most extensive and productive zone is the Juneau gold belt, which has been irregularly traced along the mainland from Windham Bay to a point 10 miles north of Berners Bay, where it enters Lynn Canal. It has a total length of 120 miles and a width of less than 10 miles. In this zone gold is the dominant metal present and occurs in varying amounts disseminated with sulphide minerals in bands of schistose rock 10 to 60 feet wide; in altered diorite dikes, where it is associated with stringers of quartz; and in quartz veins, 1 to 10 feet wide, cutting either the intrusive or schistose country rock. These ore bodies within this zone are discussed at length by A. C. Spencer in his report on the Juneau gold belt.[a]

In the Wrangell district the concentration of metallic minerals along definite zones has apparently not taken place, though a number of mineral prospects have been found, namely, in Thomas and Le Conte bays, along Bradfield Canal, and in Groundhog and Glacier basins. At the last two localities silver and lead ores, occurring in quartz veins inclosed in the crystalline schists, are prominent; at the others gold is the dominant metal.

Within the mainland belt of the Ketchikan district, which includes Revillagigedo Island, quartz veins and mineralized schist bands are found locally, but they are too widely separated to permit the definition of a mineral zone like that in the Juneau district. The slates and greenstones contain the largest percentage of metallic minerals, and in them deposits have been developed on Gravina Island, along the west shore of Revillagigedo Island, and on Cleveland Peninsula. In the slates and schist nearer the Coast Range intrusives vein deposits have been found at the head of Thorne Arm and in George Inlet. For the most part the deposits in the mainland portion of the Ketchikan district consist of simple veins in fissures and lode deposits of complex composition, containing only moderate values in gold.

[a] Op. cit.

DISTRIBUTION OF MINERAL DEPOSITS ON THE LARGER ISLANDS.

On the larger islands of southeastern Alaska the regularity of the rock structure and the continuity of the formations is locally interrupted by intrusive areas of granitic rocks and wide channels separating the islands. For this reason it is not possible to trace for any great distance mineral zones comparable with those along the mainland. The occurrence of the deposits on each island differs somewhat, and the islands are described separately in this paper. In general, the ore bodies appear to be closely connected with the intrusive rock masses, many of them lying at or near the contacts of the intrusives.

On Admiralty Island valuable mineral deposits have been found at two localities. The central and southern portions of the island are occupied by Tertiary rocks comprising sandstones, conglomerates, lavas, and tuffs, in which no mineralization of importance occurs. The northern portion of the island is made up of Paleozoic beds which are metamorphosed and locally intruded by granitic masses. The areas of intrusive rocks, so far as known, are small, and the occurrence of valuable mineral deposits is relatively rare. A poorly defined mineral zone starts at a point just north of Windfall Harbor, on the west side of Seymour Canal, and is traceable northwestward to Funter Bay. It is about 30 miles long and 2 miles wide and includes several prospects but no producing mines. Other prospects are located on the west coast of the island a few miles north of Kootznahoo Inlet.

The two seaward islands, Baranof and Chichagof, which constitute the Sitka mining district, are made up of a central core of intrusive rock. These intrusives invade Paleozoic limestones, quartzites, and schists, which are overlain by greenstones and graywackes of late Paleozoic or early Mesozoic age. A poorly defined mineral zone occurs in the metamorphic schists flanking the west side of the intrusive belt, starting at Red Bluff Bay, on the east side of Baranof Island, and extending northwestward, including the prospects at the head of Silver Bay and in the vicinity of Cape Edward, north of which it enters the ocean. Auriferous vein deposits are the principal type of ore body in this mineral zone. Another zone of mineral-bearing schists was noted along the east side of this intrusive belt, extending from Hooniah Sound to Lisianski Strait and northwestward on the mainland from Cape Spencer to Lituya Bay, where it flanks the St. Elias Range. Only a few prospects in the vicinity of Rodman Bay and at the head of Hooniah Sound have thus far been located in this mineral zone.

Kupreanof and Kuiu islands may be described together. They differ from the other islands in their lack of intrusive areas and in

having relatively low topographic relief. Their central and southern portions are covered by basaltic lavas and tuffs overlying the Tertiary coal-bearing formations exposed in Hamilton Bay, all of which are barren of minerals. Triassic beds appear in Hamilton Bay and overlie Carboniferous limestones. A succession of slates and greenstones, probably of Carboniferous age, occupies the eastern portion of Kupreanof Island, and in these rocks mineral deposits carrying both gold and copper ores occur and have been developed at several points along Duncan Canal and Wrangell Narrows. Along the western and southern shores of Kuiu Island is a great thickness of quartzites and graywackes, which underlie beds of Silurian limestone exposed at Meade Point on the north end of the island. In these rocks no important mineral deposits have been found.

The distribution of mineralization on Prince of Wales Island, like that on the other islands, is dependent on the intrusive areas. Here the direct relations of the ore bodies to the intrusive rocks are more evident because the ores occur in many places along the contacts of the intrusive and intruded rocks. The intrusive areas are irregular masses and are most prominent along the eastern and southern portions of the island. Limestones, greenstones, and phyllites are the principal stratified rocks. Copper is the dominant metal in many of the deposits. It is present within the contact aureoles of the intrusive masses, as on Kasaan Peninsula and in the vicinity of Hetta Inlet, and occurs as lenticular masses or veins along shear zones in a greenstone schist country rock, as at Niblack and Copper City. Gold accompanies the copper deposits as an accessory constituent and is found in vein deposits inclosed in limestones at Dolomi and in black slates or phyllites in the vicinity of Hollis.

GOLD MINES AND PROSPECTS.

GENERAL STATEMENT.

The gold mines of southeastern Alaska are few and scattered and only a small number of the many gold prospects have been developed to the producing stage. Although this metal is widely distributed in all the older rock formations in the form of both veins and lodes, it is rarely found in deposits sufficient in size and grade to constitute valuable ore bodies, and those localities where the ore bodies are being mined are necessarily situated but a short distance from tidewater, where transportation facilities and water power are available. The ore produced from these mines is for the most part free milling—that is, an ore from which the greater percentage of the gold content can be extracted by amalgamation. It is therefore most advantageously treated in a stamp mill by amalgamation and concentration, and the concentrates alone should be shipped to the

smelter for treatment. However, in certain instances, where a siliceous ore is in demand, the gold ore has been sold direct to the smelter. In general the vein deposits contain the largest values per ton, but the lode ores, though lower in grade, are present in greater quantity. Deposits of both types are being mined with profit.

GOLD PRODUCTION.

The 1906 production from the gold mines in southeastern Alaska is given in the following table:

Production of the gold mines in southeastern Alaska, 1906.

Ore mined.	Gold.		Silver.		Average per ton.			
					Gold.		Silver.	
	Amount.	Value.	Amount.	Value.	Amount.	Value.	Amount.	Value.
Tons.	*Ounces.*		*Ounces.*		*Ounces.*		*Ounces.*	
1,399,456	159,634.68	$3,298,943	23,532	$15,772	0.115	$2.38	0.017	$0.011

The production for 1907 has not been as large as that for 1906, though the decrease is slight. The exact figures can not now be given, as the statistics are not complete. To obtain the total gold production of southeastern Alaska, that from the copper mines, which amounted to $62,831 in 1906, should be added to the above figures. It is to be noted that nine-tenths of the gold output was from the Treadwell group of mines on Douglas Island.

JUNEAU MINING DISTRICT.

Operations have been in progress at most of the mines within the Juneau district, though there are few mining developments to be noted. Prospecting has advanced along the gold belt to the north of Eagle River, and at the head of Gold Creek, where auriferous quartz veins are being explored. On Douglas Island and to the south of Juneau no new finds are reported. The production for 1907 from these mines was somewhat less than it was for 1906.

MINES ON DOUGLAS ISLAND.

The Treadwell group of mines on Douglas Island, which is the principal gold producer in southeastern Alaska, has been fully discussed by Spencer[a] and Kinzie,[b] and only a brief statement of the recent developments will be made here. An interesting improvement at this group of mines is the introduction of the use of oil in place of coal for steam-producing purposes. This economizes both in labor

[a] Op. cit.

[b] Kinzie, R. A., The Treadwell group of mines, Alaska: Trans. Am. Inst. Min. Eng., vol. 34, 1904, pp. 334–386.

and the initial cost of fuel, and has greatly reduced the costs for power. The available water power has also been increased by enlarging the dam at the head of Fish Creek and building a small dam on Bullion Creek.

At the Alaska Treadwell mine the principal developments were advanced on the 1,450-foot, 1,250-foot, and 1,050-foot levels, and on these the ore body has been opened for a width of 450 feet. The shaft has been extended to the 1,650-foot level. The ore extracted was derived principally from the 750-foot and 900-foot levels. On the adjoining property, the Seven Hundred Foot claim, the 990-foot level was extended to connect with the 1,050-foot level of the Treadwell mine, and developments were advanced on the 880-foot and 990-foot levels. The ore mined is sent to the mill at the Mexican mine for treatment, though the old 100-stamp mill on the Seven Hundred Foot claim is being remodeled and will be used to treat the ore from this claim in the near future.

At the Mexican mine development work has consisted essentially in the opening up of stopes from the 550-foot and 770-foot levels on the hanging-wall ore body. On the 880-foot and 990-foot levels stopes have been extended into the main ore body. The 1,100-foot level is being extended to the east and west and will undercut the workings on the Seven Hundred Foot claim.

The Ready Bullion mine workings, which extend well out under Gastineau Channel, have attained a depth of 1,650 feet, the principal developments having been extended on the 1,500-foot level. The character of the ore body was not found to change materially at this depth. Most of the ore mined was derived from the 1,300-foot, 1,200-foot, and 1,000-foot levels.

The other properties on Douglas Island have been idle during the year.

GOLD CREEK MINES.

The development of the mines along Gold Creek did not advance to the extent anticipated in 1907, and has been hindered considerably by litigation difficulties. Plans have been made for large improvements during 1908.

The mines, the Ebner, the Alaska Juneau, and the Perseverance, are developing low-grade lode deposits within a mineral belt 800 feet wide, extending from the west side of Gold Creek southeastward over the divide to Sheep Creek, a distance of 6 miles. The lodes, usually from 10 to 50 feet wide, are the richer portions of this mineral belt, within which the black slates and dike rocks are intersected by numerous quartz stringers and the rock itself is impregnated with sulphide minerals.

The Ebner mine was in continuous operation the first half of the year, and during this period the 15-stamp mill was running most of the time. In the second half of the year work was suspended.

Operations at the Alaska Juneau mine were renewed the first week in June and continued till the first of November. The weather conditions during the winter months are unfavorable to the open-pit method of mining employed at this property. The 30-stamp mill was in continuous operation during this period. A tunnel and raise was extended to undercut the west end of the upper pit, and a hoist and tramway were installed at lower pit No. 2, from which one-half of the ore milled was derived.

At the Perseverance mine underground developments were in progress throughout the year. The ore was stoped largely from the main raise extending from the adit tunnel to the surface, a distance of 920 feet. The ore body, which at this point is from 60 to 80 feet in width, has been developed by a drift 1,100 feet in length, and from this drift at intervals of 20 feet chutes are being extended to an intermediate drift 25 feet above. From this intermediate level stoping of the ore has begun over a length of 150 feet to each side of the raise. A stamp mill below the mine began operations with 30 stamps on June 1 and two months later 50 stamps were put into use. In November 100 stamps were ready for use, but the weather necessitated the discontinuance of milling operations for the year. With the completion of the proposed improvements for water-supply and power purposes, it will be possible to operate the 100-stamp mill during the greater portion of the year. Small developments were made by the Alaska Perseverance Mining Company at the adjoining Sheep Creek mine.

Placer mining in Silverbow Basin was advanced by the Silver Bow Hydraulic Company from May 25 to July 15. A hydraulic elevator was then installed, and was operated until August 7, when increased rainfall caused a flooding of Icy Gulch and Gold Creek, which filled the placer excavations and caused a suspension of operations. No further work was done at this locality.

MINES NORTH OF JUNEAU.

At only a few of the mines and prospects north of Juneau have developments been in progress throughout the year. The Salmon Creek, McGinnis Creek, and Montana Basin prospects have been idle, except for the completion of assessment work. At Windfall Creek no attempt was made to operate the placer deposits, and only a small amount of prospecting was done on the quartz veins at the head of the creek. The Peterson Creek prospects were developed in a small way throughout the year by the owner, and the ore mined was treated in a 2-stamp mill on the property.

At the Eagle River mine developments were vigorously advanced during the year in search of the main vein, which is displaced by a fault. The workings now show both the character and the extent of this comparatively wide zone of faulting, and extensive developments are being advanced on this vein deposit at points farther into the mountain beyond the folded zone. The displacement caused by this fault amounts to a lateral throw of 400 feet and a downward movement of 200 feet. The fault plane has a general northeasterly strike and a dip of 30° SE. The strike of the ore body is to the northwest and the dip to the northeast. The vein ranges from 1 to 15 feet in width. Developments are also being advanced on the hanging-wall vein 150 feet northwest of the main vein and parallel to it. This vein ranges from a few inches to 8 feet in width. Similar parallel veins have been prospected by short tunnels at other points on the property. A total of 12,000 feet of drifts, crosscuts, and raises has been opened at the Eagle River mine. The 20-stamp mill on the property has been in continuous operation throughout the year.

Considerable interest has been shown in the prospects to the north of the Eagle River mine, at Yankee Basin, and at the head of Cowee Creek, where auriferous quartz veins are being explored. The Dividend lode was undercut at a depth of 350 feet by a 900-foot tunnel, which is being extended to a length of 1,700 feet, at which distance it is estimated that it will undercut the Cascade vein. The Dividend lode, which is being explored at the tunnel level, is said to have a width of more than 60 feet and to contain gold values. The Cascade is a 6-foot quartz vein developed on the surface by two prospect shafts and open cuts. The Julia, Puzzler, Noonday, and other claims adjoin the above-named prospects and include some promising vein deposits. About 1½ miles northwest of Yankee Basin is the Cottrell-Spalding group of claims, on which a vein is reported to be exposed over a length of 1,500 feet, averaging 2½ feet in width and carrying gold values. A crosscut tunnel 160 feet long undercuts the vein 100 feet in depth. On the Black Chief claim, to the northeast, vein deposits parallel to the Cottrell vein are being explored. Other prospects which have been developed during the year are the Maud S. group, on which an 80-foot tunnel crosscuts a 4½-foot vein 50 feet in depth; the Joyce-Jensen-Johnson group, which is supposed to include the northwestern continuation of the Cottrell vein; the Blue Jay claim, on which a vein deposit is opened by a 25-foot drift tunnel; and the Yankee Boy and Yankee Girl claims, which may be an extension of the Blue Jay vein. On the Gold Standard group, adjacent to Echo Inlet, considerable work was done during the latter part of the year, and favorable results are reported.

In the Berners Bay region the Jualin was the only mine where developments were in progress. This property was operated under a lease, work having begun the first of June and continued until October. During this period the 10-stamp mill was in operation for fifteen weeks. Developments were carried on principally on the 220-foot level, a crosscut being extended for 280 feet from the shaft to undercut the north vein, which at this level was found to be 6 feet wide, and along it 80 feet of drifting was done. The ore mined was taken from the west vein, along which the drift has been carried for 350 feet. Above the 220-foot level most of the ore has been stoped out. Only a few men will be employed during the winter to continue the developments.

The other mines in the Berners Bay region have been idle because of litigation difficulties which still remain unsettled.

MINES SOUTH OF JUNEAU.

Mining progress at the mines and prospects south of Juneau has not been extensive, and at only one locality has there been any gold production. Small developments have taken place during the year on the Bach group of claims at Limestone Inlet, where a quartz vein averaging 2½ feet wide and inclosed in granitic country rock has been exposed over a length of 500 feet.

At Snettisham work was advanced in the Crystal mine from early spring until late in the fall, and a considerable tonnage of ore was treated in the 5-stamp mill on the property. The upper tunnel was connected with the second level by a raise and from the second level a shaft has been started.

At the Holkham Bay group of claims, located on the south side of Endicott Arm, small developments were made during the summer and a right of way for an aerial tramway was cleared from the beach to a point at an elevation of 1,500 feet and 4,500 feet from tidewater. From this point a crosscut tunnel has been started to undercut the vein deposit 400 feet in depth at a distance of 420 feet from its mouth.

No attempt was made to renew operations at the Sumdum mine. Except a small amount of assessment and prospect work, there was no mining activity in the vicinity of Windham Bay.

ADMIRALTY ISLAND.

There has been no noteworthy mining progress at the prospect on Admiralty Island. Small improvements have been made on the properties adjacent to Funter Bay, and assessment work is reported to have been done at the Mammoth group of claims near Young Bay.

SITKA MINING DISTRICT.

The only active mining operations during the year within the Sitka mining district have been at the DeGroff mine, owned by the Chichagof Gold Mining Company. At this mine a 2-stamp mill with a Wilfley concentrator was erected and a steam plant and a 2-drill air compressor installed. The drift along the vein at the upper tunnel level was extended for 260 feet, and at a point 156 feet lower, on a level with the ore bin in the mill, a second tunnel has been started to develop the vein at this depth. The mill began operations the first of September and was run to its full capacity the rest of the year. On the Mills prospects, just above the DeGroff mine, a 300-foot drift tunnel was extended along the vein, and below this a 70-foot drift tunnel, and encouraging results are reported.

The vein and lode deposits adjacent to Silver Bay, on Baranof Island, some of which were extensively developed in former years, have received little attention this year, no work, except assessment work on some of the properties, having been in progress.

WRANGELL MINING DISTRICT.

There has been little progress within the Wrangell district during the last year and no new discoveries are reported. The Olympic Mining Company renewed operations with a small crew of men in May and continued until August, work being done on the Helen S. group of claims. No important developments were accomplished on the gold-copper prospects at the head of Duncan Canal.

KETCHIKAN MINING DISTRICT.

Gold plays but a minor rôle in the mining interests of the Ketchikan district, and its production has been largely from the copper ores, which carry from 50 cents to $2 in gold per ton of ore. In this district gold deposits occur locally, but are too widely separated to permit the definition of a mineral zone. The most general distribution of this metal is in the slates and greenstones bordering Tongass Narrows and extending northward on Cleveland Peninsula, where the gold occurs in lode deposits. On Prince of Wales Island it is found in vein deposits inclosed in limestones, as at Dolomi, and in black slates or phyllites in the vicinity of Hollis.

PRINCE OF WALES ISLAND.

Mining progress near Dolomi has been confined principally to the Valparaiso and Paul claims. On the former there are two shafts 150 and 225 feet deep, and from the deeper one three levels at depths of 90, 150, and 200 feet have been extended along the vein for 175,

350, and 250 feet, respectively. The Valparaiso vein ranges from 4 to 10 feet in width, trends N. 55° W., and dips 30° to 50° NE. On the Paul claim, along the north shore of Paul Lake, several shafts have been sunk from 10 to 80 feet on the vein, and from the bottom of these shafts drifts are being extended. A tramway from these properties to the beach was also completed during the year. No work was accomplished at the Golden Fleece property, just north of Dolomi.

The developments near Hollis were principally on the Julia claim, which was sold early in the year. An inclined shaft 220 feet deep was sunk on the vein deposit, and from this shaft drifts were extended. At the Crackerjack mine operations were in progress from March until June. The other prospects near Hollis were idle during the year.

Gold deposits are being prospected at other localities on Prince of Wales Island and on Dall Island, but as yet they have not become producers.

GRAVINA ISLAND.

Developments at the Gold Stream mine, owned by the Irving Consolidated Mining Company, were in progress during the summer months, but they were not extensive and the 5-stamp mill on the property was idle. The deposit consists of a lode 4 to 8 feet wide inclosed in greenstone schist, and within the lode the principal values are confined to an ore shoot 50 feet in length pitching at an angle of 60° SE. It is developed by a 115-foot shaft and about 600 feet of drifting. A second and wider lode deposit, 100 feet southwest of the first and parallel to it, has been prospected by a shaft and surface trenches, though the ore values in it are lower than those in the smaller deposit. The other prospects on the island were developed to but a slight extent.

CLEVELAND PENINSULA.

Mine developments on Cleveland Peninsula during 1907 were confined to the Gold Standard group of claims at Helm Bay. The deposit at this locality consists of quartz veins in a narrow belt of greenstone schist carrying seams and pockets of rich free-gold ore. The mine is developed by a shaft 115 feet deep and by 700 feet of drifts and tunnels. The surface equipment consists of a compressor plant and a 5-stamp mill. At the other prospects on Cleveland Peninsula assessment work alone was done.

REVILLAGIGEDO ISLAND.

On Revillagigedo Island prospecting has been advanced in a small way at the gold deposits along the shores of Tongass Narrows, George Inlet, and Thorne Arm, though no important developments are noted.

The Sea Level mine, at the head of Thorne Arm, remained idle, though small investigations were in progress on some of the adjoining prospects.

COPPER MINES AND PROSPECTS.

GENERAL STATEMENT.

The occurrence of copper in southeastern Alaska is confined principally to Prince of Wales Island, where it is found in the form of contact-metamorphic deposits adjacent to the granitic intrusives, as at Copper Mountain and on Kasaan Peninsula, and as irregular lenses and masses along the shearing zones in the greenstone schists, as at Niblack. The bulk of the copper ore is chalcopyrite, accompanied by pyrite, magnetite, pyrrhotite, and other sulphide minerals. With one exception, namely, on Copper Mountain, carbonate and oxide ores are practically absent, and the zone of secondary concentration or secondary enrichment is wanting or is too small in extent to be important. In general, it may be stated that where copper ores are being mined in southeastern Alaska the values in the ore will not decrease with increasing depth, though, because of the irregularity of the ore bodies, the rule to observe in exploitation is to follow the ore and not to drive long crosscut tunnels with the expectation of undercutting the deposit in depth. For the most part, the copper ores carry but a small percentage of copper and less than a dollar per ton in gold and require exceptional mining and transportation conditions to insure profitable extraction.

PRODUCTION.

The following table shows the amount and value of the copper, gold, and silver produced from the copper ores in southeastern Alaska during 1906 and the average contents per ton of ore mined:

Production of copper ore in southeastern Alaska, 1906.[a]

	Ore mined.	Copper.		Gold.		Silver.	
		Amount.	Value.	Amount.	Value.	Amount.	Value.
	Tons.	*Pounds.*		*Ounces.*		*Ounces.*	
Total	85,160	4,350,571.00	$839,560.00	3,030.970	$62,651.00	27,152.000	$18,102.00
Average per ton		51.09	9.86	.035	.713	.318	.213

[a] Computations based on average price of copper ($0.193) and silver ($0.67) for 1906.

For 1907 the copper production from southeastern Alaska is estimated approximately at 4,750,000 pounds, valued at $950,000.

KETCHIKAN MINING DISTRICT.

HETTA INLET.

On the west coast of Prince of Wales Island all the important mines and prospects are contiguous to Hetta Inlet, a deep embayment which is connected with the Pacific Ocean through Cordova Bay. The principal mines are centered around Copper Mountain within an area about 8 miles in diameter. An intrusive mass of granodiorite occupies the central portion of this area, and surrounding it are the intruded sedimentary rocks, consisting of limestone and quartzite. At the contacts these sediments are highly altered, and at many localities they have been replaced by ore-bearing minerals, such as garnet and epidote, in which the ore occurs in irregular masses. Overlying the limestone and quartzite and forming the shore outcrops along the east shore of Hetta Inlet are slates and greenstones in which copper deposits occur in the form of veins occupying shear zones parallel to the trend of the inclosing rock. Subsequent to the deposition of the ore there were intrusions of numerous diabase dikes which crosscut the ore bodies and apparently have no genetic bearing on the ore deposits.

The mines and ore bodies have been described in previous reports, and it remains only to discuss the latest developments. At the New York and Indiana mines, on the south slope of Copper Mountain, work was suspended in the fall of 1906, and the properties were idle during 1907. The Jumbo mine, on the north side of the mountain, has been actively developed throughout the year. The aerial tramway from the mine to the wharf was completed early in the year, and ore shipments were begun to the Tyee smelter in British Columbia. The copper deposits under development consist of an irregular body of chalcopyrite ore, 30 to 40 feet wide, 120 feet long, and about 140 feet in depth, occupying a nearly vertical position. The contact zone in which this ore body occurs is 200 feet in length at this point, granite forming the foot wall and limestone the hanging wall. The mine workings consist of four tunnels between 1,500 and 2,000 feet in elevation, the main tunnel being at 1,700 feet elevation and 280 feet long. At a point 180 feet from its mouth a 130-foot vertical raise connects the level with the stopes in the ore body. A lower tunnel has been started at a point 1,570 feet in elevation, on a level with the ore bins at the upper terminal of the aerial tramway, and is to be extended to undercut the present mine workings. To the northeast of the mine, on Jumbo claims Nos. 1, 1A, and 2, a large deposit of magnetite ore carrying copper has been developed, though as yet transportation facilities have not been extended to this locality.

At the Houghton group of claims, owned by the Cuprite Copper Company, which adjoin the Jumbo claims on the east, explorations

were in progress during the greater part of the year. The mine workings are at an elevation of 1,600 feet, and an ore body included in the contact zone between the granite and limestone is being developed.

The Corbin mine, owned by the Alaska Metals Company, was operated during the first few months of the year, after which work was suspended and the mine has since been idle. The ore body is a vein deposit, 1 to 3 feet wide, of nearly massive sulphide ore, inclosed in a greenstone schist country rock. It has been developed by a drift tunnel 210 feet in length and a shaft 100 feet deep. From the bottom of the shaft crosscuts were driven to investigate deposits at this depth, but the results are reported not to have been favorable.

The Copper City mine, also known as the Red Wing group, has been developed throughout the year. The ore body is similar to that of the Corbin mine, though the ore contains a higher percentage of copper. The mine is developed by an inclined shaft 120 feet deep, from which two levels at 50 and 100 feet in depth have been extended. From the 100-foot level a winze has been sunk for 60 feet, and from this a third level is being started. Most of the ore above the 100-foot level has been mined.

At the other prospects near Hetta Inlet, namely, the Green Monster group, Hetta Mountain prospects, Gould Island prospects, and Sultana group, little or no development work was accomplished during the year.

KASAAN PENINSULA.

On Kasaan Peninsula are located the principal mines on the east side of Prince of Wales Island, and because of their importance a detailed topographic and geologic survey was made of this area during the last summer. A statement of the results of this work and a description of the mines is contained in a separate paper in this report. (See pp. 98–115.)

NIBLACK ANCHORAGE.

The Niblack mine, on the south side of Niblack Anchorage, has been operated steadily throughout the year. The shaft has been extended to a depth of 320 feet, and from this the 300-foot level is being opened and investigations are being advanced on the 225-foot level. The total underground workings at the close of 1907 were estimated at 5,500 feet. Three large ore bodies have been opened in this mine, besides smaller veins and masses. The north or foot-wall vein is 200 feet in length, averages 20 feet in width and about 100 feet in depth, and has been developed on the 50-foot and 100-foot levels. The south vein, exposed on the 150-foot level, is similar in character, but not so large. The third important ore body has been developed on

the 225-foot level and is exposed for 90 feet in length and 15 feet in width. Recent discoveries of new ore bodies containing higher values in copper are reported from the 300-foot level and are being developed. The other properties in Niblack Anchorage were idle except for the assessment work accomplished.

NORTH ARM.

The Cymru mine is located on Mineral Creek, three-fourths of a mile from the head of North Arm. Developments at this mine were in progress the first half of the year, but were then discontinued. The property is developed by a 100-foot shaft from which two levels, at 50 and 100 feet, have been extended. From the mine a tramway 4,200 feet long has been built to the beach, where ore bunkers and a wharf have been erected. The ore bodies are vein deposits from 1 to 10 feet in width, inclosed in a limestone country rock which is interstratified with beds of quartzite and greenstone schist. The ore consists of pyrite and chalcopyrite in a quartz-calcite gangue.

SKOWL ARM.

At the head of McKinzie Inlet, a south branch of Skowl Arm, is the Khayyam mine, owned by the Omar Mining Company. The mine is located 3 miles from tidewater, at an elevation of 2,600 feet. In July, 1907, operations were renewed and were in progress until October, and ore shipments were made to the Tyee smelter in British Columbia. The ore bodies are elongated lenses of sulphide ore coinciding in strike and dip with the schistosity of the inclosing gneissoid diorite country rock. They have been exposed on the surface by open pits and trenches and are crosscut in depth by the Powell tunnel, 220 feet in length. Four ore bodies are exposed in this tunnel, from 6 to 20 feet in width, and have been developed by 350 feet of drifting. The ore is composed principally of pyrite, with a small percentage of chalcopyrite and accompanied by pyrrhotite, sphalerite, and some magnetite.

SILVER, LEAD, AND ZINC PROSPECTS.

Deposits of silver, lead, and zinc ores are not plentiful in southeastern Alaska. They are being developed at only three localities, and from these the metal production has been slight. Silver is present in amounts ranging from one-fifth of an ounce to 3 ounces per ton in the copper ores,[a] and in the gold ores[b] its content is dependent on the amount of gold present, the ratio being approximately 2 ounces of silver to 1 ounce of gold. Lead occurring in the form of galena is

[a] See table for copper production, p. 93.
[b] See table for gold production, p. 86.

being mined in small quantities from the prospects on Coronation Island and the Moonshine prospect in Cholmondeley Sound. Zinc is not known to occur in commercially valuable amounts, though in its sulphide form it accompanies both the copper and gold ores.

The Moonshine prospect is located on the west side of the south arm of Cholmondeley Sound, at an elevation of 2,400 feet. Developments were energetically prosecuted on this property during the year from May until November, though the results attained were not so favorable as was expected. The ore body is a vein deposit occupying a fissure cutting obliquely across limestones and schist country rock and traversing the top of the mountain ridge. Where it crosscuts the limestone it is apparently a replacement deposit, ranging from a few inches to several feet in width; but in the inclosing schists the vein is smaller and is in many places represented by a narrow gouge seam. Throughout the vein the ore occurrence is irregular, the ore being found in scattered masses. It has been developed by a shaft 100 feet deep and at a point 550 feet farther west by a drift tunnel 200 feet in length which is being driven to connect with the shaft at a depth of 225 feet.

Narrow, irregular vein deposits of galena ore have been developed at Egg Harbor, on the north end of Coronation Island. These deposits occur in a limestone country rock, forming small masses along slipping planes, and have been developed by short tunnels at points between 700 and 1,000 feet in elevation.

The silver-lead prospects in Glacier Basin, on the mainland east of Wrangell, are located 7 miles from tide water, at an elevation of 2,200 feet. The ore deposit consists of well-defined quartz veins traceable for long distances along the surface and ranging from 4 to 20 feet in width. The veins are heavily mineralized with galena, zinc blende, pyrite, and chalcopyrite, the principal values being in silver and lead. The properties at this locality were bonded early in the spring and investigation was carried on during July and August, after which period work was suspended.

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COPPER DEPOSITS ON KASAAN PENINSULA, PRINCE OF WALES ISLAND.

By Charles W. Wright and Sidney Paige.

INTRODUCTION.

The geologic studies of Kasaan Peninsula carried on during the summer of 1907 by the writers and the topographic map of this area made by D. H. Witherspoon and J. W. Bagley represent the first detailed investigations by the United States Geological Survey in the Ketchikan mining district. The area embraces about 65 square miles between latitude 55° 25′ and 55° 40′ and longitude 132° 5′ and 132° 35′. During the geologic investigations special attention was given to the occurrence of the copper ores and their relation to the different rock formations, and it is expected that the knowledge gained by these studies will indicate where practical exploration may be most advantageously extended in the search for new ore bodies. In this preliminary report only an outline of the geologic facts, tentative conclusions regarding the ore deposits, and brief descriptions of the mines and prospects are presented. The final conclusions may be at variance in certain particulars with those here set forth, inasmuch as the areal mapping was not completed and the notes and collections have not been studied in detail.

GENERAL DESCRIPTION.

Kasaan Peninsula is a promontory on the east side of Prince of Wales Island, 18 miles in length and from 3 to 6 miles wide, projecting into Clarence Strait and sheltering Kasaan Bay. (See fig. 1.) It is a steep, heavily timbered mountain ridge with summits reaching altitudes of 1,000 to 3,000 feet. Near the center of the peninsula a valley nearly separates the mountain range and extends from the "Hole in the Wall" to a point 3 miles southeast of Kasaan. At the northeast end of the peninsula there is also a broad, low, marshy valley 4 miles in length, extending from the head of Tolstoi Bay to a point 3 miles northwest of Kasaan, and another valley 3 miles in length extending from the head of Thorne Bay to the east side of

Karta Bay. The upper limit of timber on the peninsula is from 1,500 to 1,800 feet above sea level; the valleys and gulches contain a dense growth of shrubbery, which renders prospecting difficult. The summits of the ridges are open, except for small clusters of scrub pine.

The relief of the peninsula is typical of the more mature topography of the islands as compared with the rugged, more abrupt topography of the mainland. The mountain summits are dome-shaped and on them lie large erratic bowlders, an evidence of glaciation.

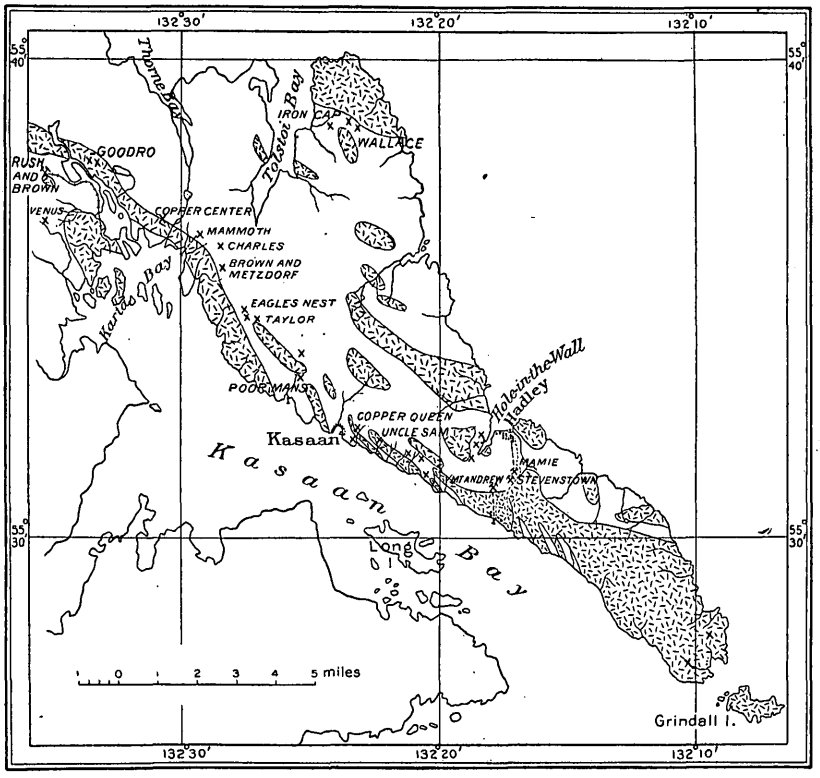

FIG. 1.—Map of Kasaan Peninsula, Prince of Wales Island, showing distribution of intrusive rocks, mines, and prospects.

The valleys, which extend northward from points near the head of Kasaan Bay, are broad and contain many lakes; they are occupied by deep deposits composed of large and small bowlders embedded in glacial clay. The islands and shoals at the entrance to Karta Bay are made up largely of these glacial deposits and represent the terminal moraines left by former ice fields.

The occurrence of copper on Kasaan Peninsula was known to the Russians as early as 1865, but not until 1900 did active mine developments begin. It is now the principal copper-producing area in southeastern Alaska.

PRODUCTION.

The first production of copper from Kasaan Peninsula was made in 1905, the year in which the smelting plant at Hadley was completed. This production continued, gradually increasing in amount, until the autumn of 1907, when all the mines ceased operations. The following tables show the total metal production of the ores derived from the copper mines on Kasaan Peninsula, and the average content per ton of ore.

Production from copper mines on Kasaan Peninsula, 1905 to 1907.[a]

Year.	Ore mined.	Copper.		Gold.		Silver.		Total value.
		Amount.	Value.	Amount.	Value.	Amount.	Value.	
	Short tons.	*Pounds.*		*Ounces.*		*Ounces.*		
1905	20,659	1,194,917	$186,407	932.1	$19,266	5,946	$3,502	$209,175
1906	68,399	3,318,633	640,496	2,413.5	50,078	17,244	11,554	702,128
1907	52,177	2,307,578	461,516	1,282.1	26,500	14,055	9,276	497,292

[a] Average price of metals: 1905, copper, $0.156 per pound; silver, $0.604 per ounce; 1906, copper, $0.193 per pound; silver, $0.67 per ounce; 1907, copper, $0.20 per pound; silver, $0.66 per ounce.

Average content per ton of ore from copper mines on Kasaan Peninsula, 1905 to 1907.

Year.	Ore mined.	Copper per ton.		Gold per ton.		Silver per ton.		Total value per ton.
		Amount.	Value.	Amount.	Value.	Amount.	Value.	
	Short tons.	*Pounds.*		*Ounce.*		*Ounce.*		
1905	20,659	57.8	$9.02	0.045	$0.90	0.29	$0.18	$10.10
1906	68,399	48.7	9.40	.035	.70	.25	.17	10.27
1907	52,177	44.2	8.84	.025	.50	.26	.17	9.51

GEOLOGY.

The rocks which compose Kasaan Peninsula are of intrusive, extrusive, and sedimentary origin. The intrusives include granodiorite, syenite, hornblende diorite, and, more rarely, granite. These rocks invade limestone beds and strata of highly altered sedimentary and pyroclastic rocks ranging from greenstone tuffs to sandstones and conglomerates composed largely of igneous material.

STRATIFIED ROCKS.

The stratified rocks include those of sedimentary and volcanic origin. They occur principally on the northern portion of the peninsula and adjacent to Tolstoi and Thorne bays, and are made up of metamorphosed bedded rocks, usually epidotized and containing amphibole and pyroxene crystals and in places altered to hornfels, quartzite, and mica schists. These range in texture from fine-grained tuffs, slates, and sandstones to conglomerates containing pebbles 2 inches in diameter. The conglomerates are made up of

fragments of igneous rocks, as well as of limestone and quartzite. The sandstones and greenstone tuffs are composed largely of volcanic material, and because of their induration they closely resemble massive igneous rocks, though in most places their fragmentary character can be recognized. The limestone beds exposed on the peninsula are entirely recrystallized and both evidence of structure and organic remains are lacking. They are of importance because of their association with and relation to the ore deposits. On Long Island, which occupies the central portion of Kasaan Bay and lies 1 mile southwest of Kasaan Peninsula, occur limestone beds conformably underlain by feldspathic sandstones. Interstratified in these limestone beds near their contact with the underlying rocks are thin beds of sandstone and conglomerate, most of the pebbles in the latter being of porphyry. In the limestone beds themselves Devonian fossils are abundant, and collections at this locality were first made in 1901 by A. H. Brooks, and in 1905 a more complete collection was made by E. M. Kindle. Because of the analogy of these rocks to those on Kasaan Peninsula the latter are provisionally considered to be Devonian.

The structure of the sedimentaries exposed on Long Island is of interest because of the two systems of folding represented—an older system of small folds with a northeasterly strike, and a later system of broader folds which trend to the northwest and belong to the main system of the Coast Range. On Kasaan Peninsula the structure of the bedded rocks has been so greatly interrupted by the intrusive masses that no persistent lines of strike and dip could be followed, though the most prominent direction of the bedding planes was from northwest to west, with a steep dip to the southwest. Two prominent jointing systems are also present on the peninsula—one striking N. 15° to 25° E. with a dip of 60° to 80° SW., and the other striking N. 50° to 70° W. with a steep dip to the northwest.

INTRUSIVE ROCKS.

The intrusive rocks occurring on Kasaan Peninsula all invade the sedimentary strata and are, therefore, of more recent age. (See fig. 1.) The principal intrusive is the granodiorite which forms the entire southern portion of the peninsula and occupies wide areas in the central and northwestern portions. But little is known of the rocks that were intruded into this area previous to the granodiorite, this being the oldest intrusive rock recognized. The granodiorite intrusives, however, vary considerably in composition and probably represent several periods of igneous invasion during one general epoch, though in some of them this difference can undoubtedly be attributed to segregations within the igneous magma during solidification.

After the granodiorite invasion granite and syenite dikes, some of them many hundred feet in width, were intruded, besides numerous dikes of pegmatite and aplite. Somewhat later, or possibly during the same period, rocks more basic in composition intruded the area, also in the form of dikes. These were followed by felsitic dikes from 1 to 100 feet in width. Still more recent are the diabase and basaltic dikes, both of which are later than the ore bodies.

ORE DEPOSITS.

The occurrence of ore on Kasaan Peninsula is similar to that in the vicinity of Hetta Inlet. The ore bodies are contact-metamorphic deposits, occurring usually at the contact of an intrusive syenite mass with limestone or, in some places, with greenstone tuff or conglomerate. They are included in a garnet-epidote gangue and are generally associated with magnetite, this mineral forming in many places half of the gangue. The principal mineral zone defined on this peninsula follows the contact of a syenite intrusive mass with a narrow belt of limestone, and is traceable from the east side of Mamie Creek for 2 miles in a westerly direction. This zone ranges from 100 to 300 feet in width, though, because of its flat dip and its conformity with the contour of the mountain slope, it appears locally to be much wider. The Mamie, Stevenstown, and Mount Andrew mines are included within it. Another smaller zone, with a diorite intrusive on the southwest side and both limestone and greenstone tuff to the northeast, extends along the western side of the peninsula about 1 mile inland, beginning 3 miles northwest of Kasaan and continuing northwestward to Karta Bay. The Sea Island, Haida, and Copper Center prospects are included in this belt. Besides the contact-metamorphic deposits, copper ores associated with quartz occupy shear zones in the greenstone tuff and conglomerates at the head of Karta Bay, being found in the Rush & Brown mine at the Venus prospect. On the east side of Karta Bay bornite and chalcopyrite occur in small masses and disseminated throughout a basic diorite intrusive belt on the Goodro and Stevens prospects.

The extent of these various ore bodies depends largely on the type. The contact-metamorphic deposits are generally irregular masses of small extent, as a rule no more persistent in depth than they are laterally; but where the contact zone is more extensive, investigations within it will probably reveal similar ore masses both laterally and in depth. The copper-iron-sulphide deposits occupying shear zones in the stratified rocks are more persistent than the contact ore bodies and will probably extend to a considerable depth.

The principal copper mines in the region are developing deposits of a low-grade copper-iron-sulphide ore which can be profitably

exploited only by extreme economy in extraction. At certain mines the accessory gold content of $1 to $2 per ton is depended on to raise the total value of the ore above the commercial limit. The copper ores generally contain high percentages of iron and lime and are classed as "base ores." To accomplish their reduction, therefore, it is necessary to mix them with siliceous or quartz ores. The lack of available siliceous ore has been a serious handicap to the smelters of the district. Increasing the value of the copper ores by concentration alone would as a rule be of little advantage, both because of the high percentage of iron minerals and because only the lighter siliceous minerals, which are necessary as a flux, would be separated. Some of the ores, however, might with advantage be ground and treated in a magnetic separator.

These facts are clearly brought out in the following table, which shows the composition of the gangue content of the ores from the principal mines as determined by smelter assays.

Smelter assays of ores from copper mines in the Kasaan Peninsula.

Name of mine.	Silica (SiO_2).	Iron (Fe).	Lime (CaO).	Sulphur (S).	Alumina (Al_2O_3).
Mamie:					
Siliceous ore	30.6	17.5	10.4	5.9	17.2
Base ore	10.6	47.8	2.7	6.3	7.7
Stevenstown	16.4	34.1	7.6	6.9	11.7
Mount Andrew	15.2	42.8	.4	4.3	----------
Karta Bay	16.5	35.6	6.8	6.2	----------
	19.6	28.3	7.0	8.0	----------

The preceding analyses, though incomplete, show the relative basic and siliceous content of the ores. The portion of the analyses not given represents the moisture (H_2O), the carbon dioxide (CO_2), the undetermined elements, including the alkalies contained in the ores, and also their content of precious metals.

MINES AND PROSPECTS.

MAMIE MINE.

Situation and development.—The Mamie mine, owned by the Brown Alaska Company, is situated 1¼ miles south of Hadley, in the central portion of Kasaan Peninsula, at an elevation of 700 feet. (See fig. 1.) The mine workings are connected with the smelter at Hadley both by an aerial tram 5,500 feet in length and by a horse tram 7,700 feet in length. The horse tram is used for the transportation of supplies. Mine developments in a large way were not begun until 1904. During that year the ore bodies were explored by numerous open cuts, tunnels, and diamond-drill holes. In the following year mining of the ore was begun from the open pits and new ore bodies were developed by tunnels and shafts. At the close of 1905

considerable ore was delivered to the smelter and throughout 1906 the production was large. In 1907 diamond-drill investigations were advanced, new ore bodies were located at greater depth, and the ore production continued with little interruption until late in September. In October all operations were suspended. The total developments consist of 5,000 feet of tunneling, drifting, and crosscutting and about the same amount of diamond-drill prospecting.

The smelter or reduction plant at Hadley, belonging to the Alaska Smelting and Refining Company, is controlled largely by the owners of the Mamie mine. It consists of a blast furnace of 350 tons daily capacity, a sampling mill, coal and coke bins, ore bunkers of 10,000 tons capacity, boiler house, engine house, electric-light plant, and other conveniences. The ores from the Mamie and Stevenstown mines first go through the samplers, next to the ore bunkers by gravity, and thence by gravity to the furnace. The slag from the furnace is granulated and carried by water to the beach. A cable tramway extends from the wharf to bins above the sampling mill, which have been built to receive custom ore. The plant is so arranged that its daily capacity may be doubled if necessary. Smelting operations began December 5, 1905, and in 1906 the furnace was in blast about twenty days each month. In September, 1907, this plant was closed.

Ore bodies.—The ore bodies at the Mamie mine are contact-metamorphic deposits included in a zone 400 feet wide lying between a syenitic intrusive and limestone. Within this zone the masses of valuable copper ore are defined either by such a decrease in the copper content of the inclosing rock as to prohibit profitable extraction or by fault planes. Garnet, epidote, and magnetite compose the contact rock, throughout which chalcopyrite is present in small quantities. The ore bodies, or portions of the contact rock where the concentration of the copper values is sufficient to make ore, are irregular masses ranging from 50 to 100 feet in length and thickness and from 10 to 40 feet in width, the major axis striking northward. Nine such ore masses are exposed in the mine workings. Some of them are included entirely in magnetite masses, forming basic ore; others occur in the garnet-epidote gangue, making a siliceous ore. Small veinlets of calcite, and rarely quartz, intersect the ore masses, thus indicating a later period of mineralization, though the main ore bodies are believed to have been deposited contemporaneously with the inclosing contact rock.

STEVENSTOWN MINE.

Situation and development.—The Stevenstown mine, owned by the Hadley Consolidated Copper Company, is situated just above and southwest of the Mamie mine, at an elevation of 1,000 feet. (See fig. 1.) From the mine a surface tram 700 feet long connects with the

aerial tram at the Mamie mine, over which the ore is transported to the smelter at Hadley. A trail also leads from the mine down the south side of the peninsula to Boggs Landing, on Kasaan Bay, a distance of 1 mile. The mine has been developed by three "glory holes" or open pits connected by raises with a 550-foot tunnel penetrating the crest of the mountain. Actual mining developments were begun in June, 1905, previous to which prospecting alone had been carried on; and in September of that year ore shipments to the Hadley smelter began. A large amount of ore was produced during 1906 and until July 1, 1907, when mining operations were suspended.

Ore bodies.—The ore bodies on the Stevenstown property correspond both mineralogically and genetically with those at the Mamie mine. They occupy a relatively flat position on the crest of the mountain ridge and are apparently underlain by the syenite intrusive which forms the foot wall of the mineral belt and which is exposed throughout the tunnel that penetrates the mountain top. The hanging wall, as well as a large portion of the ore bodies on this property, has been removed by erosion and the contact zone is only from 20 to 40 feet in width, instead of 200 to 400 feet, the width on the Mamie property just below. To the northeast of the ore bodies strata of limestone and greenstone tuff occur and continue westward toward the Mount Andrew mine, forming the hanging wall of the mineral zone.

The mine workings are all surface pits connected by raises with the main tunnel, and in these several relatively flat-lying ore masses have been developed. These masses are included within an area 350 by 200 feet, the pit being from 20 to 40 feet deep. The central portion of this area is traversed in a southerly direction by a 40-foot felsite dike, which is of later intrusion than the syenite and crosscuts the ore body. Smaller dikes of diabase and basalt 1 foot to 5 feet in width were observed crosscutting the ore bodies and country rock at several points in the mine workings.

The ore is composed largely of magnetite, chalcopyrite, and pyrite associated with hornblende and calcite, all of which are included in a more or less banded garnet-epidote gangue.

Surface oxidation has produced considerable limonite and some malachite and azurite; small particles of native copper also occur along slipping planes. These secondary minerals are relatively unimportant.

MOUNT ANDREW MINE.

Situation and development.—The Mount Andrew mine workings are situated three-fourths of a mile from Mount Andrew Landing, on the southwest side of Kasaan Peninsula, and one-half mile west of the Stevenstown mine, at an elevation of 1,400 feet. A cable tram-

way 3,600 feet long leads from the mine over a 1,440-foot knoll just south of the workings to the ore bunkers and a wharf at Mount Andrew Landing. (See fig. 1.)

This mine is developed principally by a tunnel 620 feet long, undercutting the ore bodies from 60 to 100 feet or more in depth. From this tunnel several hundred feet of drifts and crosscuts have been driven, and upraises have been extended through the ore bodies to the surface. The ore is mined out of large underground stopes and from surface pits or "glory holes," and is delivered through chutes at the tunnel level to the ore bunkers at the head of the aerial tram and thence carried to the wharf, where it is loaded for shipment. Developments in a large way were not begun until late in 1905, and during 1906 the aerial tram was erected, the wharf built, the compressor plant installed, and considerable ore developed. The first ore shipments were made in October, 1906, and production continued until October, 1907, when operations were suspended.

Ore bodies.—The ore deposits on this property are included in the same mineral belt as those at the adjacent Mamie and Stevenstown mines, with which they are in every way comparable. Six ore bodies consisting of irregular magnetite-chalcopyrite masses associated with the garnet-epidote contact rock have been developed and mined to a considerable extent. These bodies of ore are 10 to 50 feet wide, 40 to 80 feet long, and 100 feet or more in depth, and have a general northerly strike and pitch. They are separated by barren areas of contact rock cut by dikes 20 to 60 feet wide of altered syenite porphyry. The mine workings consist essentially of surface pits which are undercut by a crosscut tunnel running east and west. This tunnel with connecting drifts and raises includes 2,200 feet of underground developments. Numerous gouge seams and slickensides indicating faulting were observed in the mine workings, and lateral displacements of the ore bodies for 1 to 6 feet were also noted. Dikes of diabase and felsite 2 to 12 feet wide crosscut the ore bodies and country rock in various directions and were evidently intruded later than the formation of the ore deposits.

At other points on Mount Andrew large masses of magnetite carrying but a small percentage of copper, insufficient in amount to make a copper ore, have been developed. These deposits, though not valuable for copper alone, may at some future time be of importance as a source of iron ore.

RUSH & BROWN MINE.

Situation and development.—The Rush & Brown property includes eight claims extending northwestward from the "Salt Chuck," the principal mine workings being located on the Iron Cliff claim, about 2 miles from the wharf at the head of the bay, at an

elevation of 300 feet. (See fig. 1.) In 1904 this property was prospected by long trenches and open cuts, and a shaft 25 feet deep was sunk on the ore body. In 1905 it was leased by the Alaska Copper Company, and a new shaft was started 120 feet south of the old shaft and sunk to a depth of 100 feet. From the bottom of this shaft the principal ore body, the magnetite deposit, was developed by drifts and crosscuts and a drift was extended to a second ore body, the sulphide deposit, 160 feet farther northeast. At the close of 1907 the greater portion of these ore bodies had been stoped out and the shaft sunk for an additional 100 feet, to a point from which a 200-foot level was started. The ore from the mines is transported by a gravity tram to ore bunkers one-fourth mile below the mine, and thence by a railroad $2\frac{3}{4}$ miles long to the wharf at the head of the bay, where ore bunkers of 2,000 tons capacity have been built. During 1906 ore was shipped to the smelter at Coppermount, and in 1907 shipments were made to the Tyee smelter at Ladysmith, B. C.

Ore bodies.—Two ore bodies have been developed at the Rush & Brown mine. One is a contact-metamorphic deposit consisting of a copper-bearing magnetite body 100 feet long by 30 feet wide in a garnet-epidote-calcite gangue lying between granodiorite and an indurated greenstone tuff, the line of contact striking nearly east and west. The other deposit, 160 feet to the north, occupies a shear zone in the greenstone tuff and conglomerate beds and is a sulphide body composed of pyrite and chalcopyrite in a quartz-calcite gangue. It is from 4 to 8 feet in width and has been developed over a length of 85 feet. The strike of this sulphide deposit is northeastward and its dip 60° SE., toward the larger deposit.

UNCLE SAM MINE.

Situation and development.—The Uncle Sam mine, originally called the White Eagle group, lies 3 miles northwest of Mount Andrew Landing and half a mile from Kasaan, on the south slope of Kasaan Peninsula. (See fig. 1.) The mine workings are 430 to 550 feet in elevation and less than half a mile from the beach. Mining operations have been conducted on this property at various intervals since its discovery in 1899, and in 1901 an aerial tram, ore bunkers, and a wharf were built. Early in 1906 a shipment of ore was made, but no further work was done until March, 1907. At that time operations were renewed, continuing until July, when another ore shipment was made. The mine is developed by a tunnel and drifts amounting to about 800 feet in length, and by open pits exposing the ore body on the surface above the tunnel. From this working tunnel a surface tram, 1,150 feet long, conveys the ore to the wharf.

Ore body.—The ore body exposed in the tunnel consists of an irregular lens of chalcopyrite-pyrite ore 6 to 8 feet in width, striking

north and south and pitching about 45° N. It is cut off to the north by an east-west fault dipping 80° N., which shows but a small amount of gouge. At the open cut above the tunnel similar masses of ore are exposed, but no large ore bodies have been defined. Garnet, epidote, magnetite, and calcite occur as gangue minerals and in many places form small geodes. The chalcopyrite ore contained in this gangue is irregularly distributed in small masses and not along definite lines. The country rock is made up of strata of chloritized and epidotized greenstone tuff, which is underlain by the intrusive syenite and crosscut by small dikes of diabase, of later origin than the ore bodies.

COPPER QUEEN GROUP.

The Copper Queen group of claims, which represents the first copper locations on Prince of Wales Island, lies about half a mile southeast of Kasaan. In 1898 these claims were sold to the Kasaan Bay Mining Company, which made additional locations. Small operations were in progress from 1899 until 1902, and 500 feet of tunneling was done besides surface excavations. Since 1902 the property has been idle.

The principal ore deposit is exposed along the side of a gulch at a point 300 feet in elevation. It consists of an irregular mass of chalcopyrite ore accompanied by pyrite and magnetite in a garnet-epidote gangue at the contact of an altered intrusive syenite with the greenstone tuff. Below these exposures a crosscut tunnel 400 feet in length has been driven in the altered syenite, but has failed to reveal any ore.

Other mineral exposures occur on these claims at points close to tide water and have been prospected by shafts and open cuts, but so far no important deposits have been discovered.

POOR MAN'S GROUP.

The Poor Man's group of two claims is located 2 miles northwest of Kasaan (see fig. 1), and the mine workings are connected with deep water by a surface tramway and wharf, having a total length of about 2,000 feet. The principal developments are at the head of the tramway and consist of a tunnel driven 90 feet in a southwesterly direction which crosscuts a 60-foot body of massive magnetite and 10 feet of garnet-epidote contact rock and at its face enters a dike of red felsite 20 feet wide. At a point 20 feet from the mouth of the tunnel is a vertical shaft extending 30 feet to the surface and 60 feet in depth. This body of magnetite is exposed on the surface above the tunnel and similar masses have been prospected by short tunnels and cuts and shafts at points along the tramway and on adjoining properties. Associated with the magnetite are large

amounts of calcite and hornblende, some pyrite and chalcopyrite, and garnet and epidote. Although the magnetite deposit itself is extensive the chalcopyrite ore occurs only in isolated pockets or narrow veinlets and is not disseminated throughout the magnetite in sufficient amounts to make a copper ore of the entire body. It is noteworthy, however, that these ore bodies may be of value for their iron content. Minor displacements, due to faulting or slipping planes, and dikes of diabase and felsite crosscutting the deposits were noted.

EAGLE'S NEST GROUP.

The Eagle's Nest group of claims, situated 4 miles northwest of Kasaan, was first located in 1906 and in the same year was bonded to the Sea Island Copper Mining Company. Operations by this company were begun in October, 1906, and continued in a small way until September, 1907, when the property reverted to the owners.

The developments have been confined to the mineral exposures on the Alarm claim at an elevation of 400 to 500 feet. On the southeast end of this claim is a 70-foot tunnel essentially in a garnet-epidote rock in which a small amount of ore occurs near the face. Just above the tunnel a body of magnetite-chalcopyrite ore 8 feet wide and 20 feet long is exposed in an open cut, beneath which are beds of limestone. Above this, near the summit of the ridge, is an open cut and a shaft 12 feet deep exposing small amounts of ore associated with garnet in limestone. On the northwest end of this claim an open cut and a shaft 35 feet deep exposes masses of chalcopyrite associated with various contact minerals in a coarsely crystalline limestone. Below these workings diorite is exposed and forms the lower portion of the ridge. No large copper deposits have been developed on these claims, though further investigation may reveal important ore bodies.

TAYLOR PROSPECT.

The Taylor prospect, located early in 1907 as the It claim, adjoins the Eagle's Nest group on the east. On this prospect, at a point 600 feet in elevation, a body of chalcopyrite ore in a gangue of garnet and epidote has been exposed by surface cuts over an area of 20 to 40 feet. The ridge to the southwest, on the foot-wall side, is composed of diorite, and below the prospect to the northeast limestone beds are exposed.

MAMMOTH GROUP.

Situation and development.—The Mammoth group lies on the east side of Karta Bay, about 6 miles from Kasaan and one-third of a mile from tide water, on the top of a low hill 500 feet in elevation. This property was largely developed in 1904–5 by the original owners,

and in June, 1906, was sold to the Haida Copper Company, which began active developments and made plans for the erection of a gravity tram 2,000 feet in length to the beach, and for a wharf and ore bunkers. In April, 1907, these improvements were completed, and the company made shipments of ore to the Hadley smelter. Early in the summer, however, operations were suspended, and the mine has since been idle. The mine is developed by a tunnel 120 feet in length connecting with a shaft 35 feet deep, which in turn connects with a surface pit on the ore body. Exploratory drifts have been extended from the tunnel, and prospect pits and short tunnels have been driven at other points on the property.

Ore body.—The ore body is an irregular magnetite mass carrying chalcopyrite in a gangue of garnet and epidote. The country rock in the immediate vicinity is altered greenstone, tuff, and conglomerate, though just below the workings a belt of intrusive diorite is exposed which forms the western half of the ridge and probably underlies the ore body. The deposit is developed by an open pit over an area about 50 feet in diameter. This is undercut by a tunnel at a depth of 30 feet, and, though the magnetite is exposed at this depth, chalcopyrite is not so abundant. To the northeast the ore body is limited by a fault plane striking nearly east and west and dipping 75° S. Other slipping planes striking at different angles were noted in the ore body and inclosing rock.

GOODRO CLAIMS.

The Goodro claims, also known as the Joker group, are located one-half mile from the head of the "Salt Chuck" entering Karta Bay. (See fig. 1.) The surrounding area is relatively low, the claims being located on a knoll about 400 feet in elevation. The copper deposit at this locality is of special interest because bornite is the dominant ore, and it is the only locality in southeastern Alaska where bornite has been found in quantity. This ore occurs in small masses and disseminated particles associated with epidote, feldspar, and biotite, and is inclosed in a basic diorite which is largely replaced by these minerals. Native gold and considerable chalcopyrite also occur with the ore, and near the surface small amounts of chalcocite and native copper were noted. The diorite forms an extensive belt half a mile wide striking in a northwesterly direction. Laterally this mineralization is exposed across a width of 60 feet and for about 100 feet in length. It has been developed by a surface pit 12 feet deep, by a cut 70 feet long, and by a tunnel 125 feet long which crosscuts the ore-bearing mass 90 feet below the surface and 90 feet from its mouth. Slipping planes were observed at several points, but do not appear to have caused any noteworthy displacements. In an open cut a dia-

base dike is exposed which is evidently younger than the ore deposit. Early in 1907 an ore shipment was made to the Hadley smelter and is reported to have yielded good values in both copper and gold.

TOLSTOI BAY PROSPECTS.

General description.—On the north end of Kasaan Peninsula adjacent to Tolstoi Bay, which forms a good anchorage to the west, considerable prospecting has been done and numerous locations have been made, but none of the properties have been developed beyond the prospecting stage. The small promontory here is composed largely of the granodiorite intrusive masses, which are exposed at Tolstoi Point and along the eastern slope of Tolstoi Mountain. On the western slope and along the east shore of Tolstoi Bay greenstone tuff, sandstone, and conglomerate and a few strata of limestone form the rock exposures. Both the bedded and the intrusive rock masses are crosscut by dikes of porphyry and diabase. The ore bodies are contact-metamorphic deposits similar in character to those at the mines on the southern part of the peninsula. They are lenticular masses of magnetite carrying chalcopyrite and associated with garnet, epidote, calcite, and quartz, inclosed in the bedded rocks near the intrusive granodiorite contact.

Iron Cap group.—The Iron Cap property, also known as the Mahoney group, consists of two claims located on the northwest slope of Tolstoi Mountain at an altitude of 1,000 feet, and is reached by a trail 1½ miles long starting from a cove 2 miles southwest of Tolstoi Point. In 1901 the property was prospected to a considerable extent by open cuts along a gulch and by several hundred feet of diamond-drill holes, but since that time it has been idle. The country rock consists principally of greenstone tuff and a fine conglomerate intruded by syenitic dikes of considerable width, which are apparently related to the ore deposits. Three ore bodies have thus far been located, the largest being 20 feet in width and traceable for 50 feet in length, the major axis striking N. 45° W. A second ore body, separated from the first by a 30-foot dike of altered syenite, is 12 feet in width and is limited on the foot-wall side (to the southwest) by a fault plane showing a considerable gouge seam; toward the hanging wall it grades into a garnet-epidote contact rock. The third ore body, which lies just above the other two at an elevation of 1,080 feet, appears to be a flat-lying magnetite deposit only a few feet in thickness.

Wallace group.—The Wallace group includes four claims situated on the southeast slope of Tolstoi Mountain between 800 and 1,600 feet in elevation. At several points on this property small scattered masses of copper ore are exposed, but at no place have investigations

been sufficient to determine the extent of these deposits. The uppermost ore exposures have been opened by a short tunnel in which a vein of garnet-epidote rock is shown containing chalcopyrite and striking N. 15° W. and dipping 20° SW. At the lower openings a magnetite-chalcopyrite ore is exposed, but the bodies do not appear to be extensive.

Tolstoi group.—The Tolstoi group of claims is located south of the Wallace group, just below the summit of Tolstoi Mountain. The ore bodies are low-grade magnetite-chalcopyrite masses similar to those on the Iron Cap group, but they have not been so extensively prospected. No developments more than the required annual assessment work have been accomplished on this property.

Big Five claim.—The Big Five claim lies half a mile east of Tolstoi Bay, on the trail to the Iron Cap group, at an elevation of 370 feet. A tunnel 50 feet in length and a shaft expose scattered masses of chalcopyrite, pyrrhotite, and pyrite in a gangue of garnet, epidote, and calcite, the deposit being 10 feet wide. This deposit is a replacement in limestone beds and many slipping planes defined by gouge seams traverse both ore body and country rock. Assessment work only is done on this claim each year.

OTHER PROSPECTS.

Venus prospect.—The Venus group of claims is located on Crow Creek 1¼ miles from the head of Karta Bay and about 1 mile southwest of the Rush & Brown mine. (See fig. 1.) This property was located in 1904 by a magnetic survey by U. S. Rush, and at the point of maximum attraction a pit was sunk and a trench 50 feet in length exposing the magnetic deposit was made through the overlying débris. Below these surface excavations, which are at an elevation of 250 feet, a tunnel 75 feet in length has been driven which crosscuts 50 feet of débris and 25 feet of country rock, and at its face exposes ore. The country rock is an indurated greenstone tuff with interstratified quartzite beds, the ore occupying a shear zone. Associated with the ore is considerable sphalerite and pyrrhotite, with quartz and calcite as gangue minerals.

Copper Center prospect.—The Copper Center prospect lies 1 mile north of the Mammoth group, at an elevation of 400 feet. It was located in April, 1907, and in July was bonded to mining men who undertook its development. Several shafts from 10 to 30 feet deep were sunk within an area 300 by 120 feet. In all these shafts and surface cuts a magnetite and chalcopyrite ore associated with a garnet, epidote, and hornblende gangue is exposed. The deposit is apparently flat lying, though the amount of work done is hardly sufficient to prove that it does not continue in depth. It is also probable that further investigations at a greater depth will reveal deposits

at other points on the property. The country rock is largely conglomerate and greenstone tuff, which are underlain by granodiorite, exposed down the hillside to the southwest. The area is densely covered by undergrowth, which renders prospecting difficult. The dip needle has been successfully used within this area and the deposit just described was located by it.

Charles prospect.—The Charles property lies about 1 mile southeast of the Mammoth group and 5,000 feet from tide water, at an elevation of 380 feet. It was located in May, 1907, and only a small amount of work has been done on it. The mineral body exposed in a cut 20 feet long and 10 feet deep consists of chalcopyrite masses associated with some magnetite in a garnet gangue which replaces the greenstone tuff country rock. Granodiorite occupies the hill just west of this prospect, but was not exposed near the mineral body. Dikes of diabase crosscut the ore body and are evidently of later origin. Besides the copper, the ore is said to carry high values in both gold and silver.

Brown & Metzdorf prospect.—The Brown & Metzdorf prospect is located three-fourths of a mile south of the Charles prospect and one-half mile from Kasaan Bay, at an elevation of 310 feet. The ore body is a mineralized mass of garnet rock carrying chalcopyrite and pyrite exposed for a width of 10 feet, showing a banded structure and evidently replacing the bedded quartzite and greenstone tuff country rock. A wide belt of limestone is exposed in bluffs along the trail just below this prospect.

Peacock and Tacoma claims.—The Peacock and Tacoma claims, about 3 miles southeast of Kasaan post-office (see fig. 1), are the property of the Grindall Mining and Smelting Company. The Tacoma claim is located along the beach, where open cuts have been made on ore exposures that are covered at high tide. The ore is confined to a garnet-epidote rock and occurs in irregular patches or finely disseminated particles. In the beach cuts a small amount of ore is exposed, and above it, at an elevation of 50 feet, is a tunnel 60 feet in length entering the hill in a northeasterly direction. This tunnel crosscuts a wide belt of garnet-epidote rock containing some chalcopyrite. Other open cuts expose small amounts of ore at several places, but no large ore masses have been developed.

The Peacock claims adjoin the Tacoma claim on the north and extend to the center of the peninsula. At 600 feet from the beach and 120 feet above tide a tunnel 45 feet long exposes a belt of garnet-epidote contact rock containing magnetite and a small amount of chalcopyrite. Still higher, at 325 feet, a second tunnel 30 feet long, following the contact of a diabase dike, exposes a similar mineral-bearing rock. Here also dikes of felsite and basalt occur, and slipping planes were observed faulting the mineral body in various

directions. The amount of development on these properties has not been sufficient to disclose ore bodies large enough to justify mining, but systematic prospecting may open up deposits of value.

"*Hole in the Wall*" *prospects.*—The small cove known as "Hole in the Wall" lies on the north side of the harbor at Hadley, and along its shores and west of it a number of claims have been located, among which are the Plumley group and the Eureka, Sunrise, Pennsylvania, Venus, and Pelaska claims. (See fig. 1.) On the Hilma claim of the Plumley group, at a point one-half mile northwest of the head of the cove and 310 feet in elevation, a tunnel 25 feet in length has been driven along the contact of an altered limestone belt with a dioritic batholith, in which small masses of chalcopyrite are exposed in a garnet-epidote-calcite contact rock. On the Eureka claim, at tide water, similar contact deposits are being developed and are reported to be of considerable extent. The Sunrise claims, three in all, are located west of the "Hole in the Wall," and on these claims at points along a gulch small ore masses occur replacing limestone beds at or near their contact with granodiorite. At 1,050 feet elevation this contact aureole is 25 feet in width and contains considerable magnetite and chalcopyrite ore which shows much surface alteration. On the south slope of the hill at 950 feet elevation is an open cut exposing a highly crystalline marble, slightly banded, striking N. 65° E. and dipping 60° NW. This marble overlies the contact rock, which carries small amounts of the copper ore. On the Pennsylvania claims, southeast of the Sunrise claims, an open cut following a felsite dike at 850 feet elevation exposes a small vein 2 to 3 feet wide consisting of pyrite with small amounts of chalcopyrite. The prospects on the Venus claims show contact deposits similar to those exposed on the Sunrise claims to the north and are apparently along the same intrusive contact. The Pelaska claim, extending from the head of the cove westward, has been developed by a tunnel over 100 feet in length following a belt of altered limestone intruded by a diabase dike, along which occurs the garnet-epidote contact rock carrying some chalcopyrite. This deposit is interesting geologically, but the amount of ore exposed is small.

PRACTICAL DEDUCTIONS.

From the foregoing considerations it is evident (1) that the ore bodies should be sought along or near the contacts of the intrusive diorite and syenite masses; (2) that the contacts of large intrusive masses are more favorable for ore deposits than those of small masses; (3) that the limestone beds are more likely to be replaced by the ore-bearing minerals than the other intruded rocks, because of their solubility; (4) that the largest deposits are found at the contacts of limestone with the intrusives, as the lime carbonate acts as a pre-

cipitant to the ore minerals; (5) that the felsite, diabase, and basalt dikes are later than the ore bodies and have no genetic relation to them; and (6) that ore bodies may be found at considerable depths within the contact zones as well as near the surface.

Though large areas on Kasaan Peninsula still remain unprospected, there is little to indicate that deposits of much higher grade or of greater extent than those that are being mined at present will be found.

The question as to the extent of the copper-bearing masses is possibly the most vital one. That outcrops may fail altogether to indicate the value of the ground underneath has been shown at several localities, and that the ore may occur in masses of moderate size, which can be mined out in a short time, is shown at several mines, though at these localities further investigation has usually revealed new ore bodies. Under exploitation on the scale which prevails in this district the problem of new ore reserves must inevitably come to the front, and the search for new ore bodies should be vigorously continued by both prospector and mine operator. Such investigations have been satisfactorily prosecuted in the ore-bearing rocks by the use of diamond drills, which are especially adapted to the search for scattered ore masses.

Under existing conditions, with the price of copper at 15 cents a pound, it is not possible to mine profitably ore containing less than 60 pounds of copper and the usual gold content of 75 cents to $1.25 per ton. However, ore containing as low as 40 pounds of copper per ton was mined and shipped at a profit early in 1907, when the market value of copper was 25 cents a pound. The present mining costs average from $1.50 to $2 per ton, including haulage to the wharf; transportation to the smelter at Tacoma or in British Columbia costs from $1.50 to $2 per ton, depending on the tonnage shipped; smelting charges are from $3 to $5 per ton, including the losses in treatment. When the ore is smelted in Alaska, the cost of transportation is somewhat reduced, though the smelting charges are necessarily increased, as the coke required must be shipped to Alaska and the copper matte or smelter product shipped to Puget Sound.

Large bodies of magnetite containing from 0.5 to 1.5 per cent of copper have been developed in the mines and on several prospects. Such deposits can not be mined as copper ore with profit. It may be possible, however, by a method of concentration, by fine grinding and magnetic separation, to produce a marketable product from this low-grade material. The value of these magnetite deposits as iron ore should also be considered. Analyses show that the magnetite is practically free from phosphorus and contains very little sulphur or other impurities. It might therefore be placed on the market as a Bessemer ore.

THE BUILDING STONES AND MATERIALS OF SOUTHEASTERN ALASKA.[a]

By CHARLES W. WRIGHT.

GENERAL STATEMENT.

The only stones of value in southeastern Alaska, so far as known, are the marbles and granites. The market for these stones is in the cities along the Pacific coast of the United States, 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 and marble could be transported in hulks or barges carrying several thousand tons at a low freight rate, and the necessity of careful handling during the 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 marble and cement stone than for granite. Most university laboratories are equipped for such tests and will make them at a reasonable cost.

Deposits of building materials, such as cement, gypsum, and clay beds, are not plentiful in southeastern Alaska, and gypsum alone is being mined at a profit. Both cement and clay deposits have been located, but no attempt has been made to place the material on the market.

[a] The substance of this paper was published in last year's Progress Report (Bull. U. S. Geol. Survey No. 314, pp. 73–81), but as the edition of that bulletin is almost exhausted it seems advisable to reprint here these statements, which are supplemented by descriptions of the progress at the mines and quarries in 1907.

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 deposits of marble under development are at the northwest end of Prince of Wales Island near Shakan and on Ham Island south of Wrangell.

NECESSARY QUALITIES.

Commercially, marble includes all limestone rocks susceptible of receiving a good polish and suitable for ornamental work. It is not a simple matter 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 stone 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.

ALASKA MARBLE COMPANY.

SITUATION AND DEVELOPMENT.

The properties of the Alaska Marble Company are situated on Marble Creek a few miles north of Shakan, Prince of Wales Island, bordering the coast for 2 miles and being over half a mile in width. They are located upon a belt of Devonian limestone about 3,000 feet in width flanking the west side of an intrusive granite mass which forms the low mountain ridge to the east and which is evidently the direct cause of the alteration of the limestone to marble. This deposit was first discovered in 1896 and finally located in 1905, the first work being done along the exposures in the creek bed half a mile from the shore. From 1900 to 1904 prospecting was extended up the hillsides and drill holes were sunk to ascertain the quality of the product in depth. Early in 1904 the Alaska Marble Company was incorporated, and developments on a large scale were immediately begun. At present the plant consists of a wharf equipped with derricks, a gravity railroad to the quarry, 3,200 feet in length, necessary channeling and gadding machines, and various buildings. At the quarry, located on the south side of Marble Creek at an elevation of 100 feet, an area 100 by 200 feet has been stripped and quarried to an average depth of 60 feet, measured on the mountain side.

A test shipment of 100 tons was made in 1902, but actual production did not begin until 1906. The marble is now being placed on the market in the cities along the Pacific coast. The manufacturing plant of the company is located at Tacoma, Wash.

THE MARBLE DEPOSIT.

The extent of the marble deposit at this locality has been investigated at a number of points on the surface by open cuts and trenches and in depth by 18 drill holes, and at all these places marble usually of good quality is exposed. As above noted, the marble belt is approximately 3,000 feet in width, striking in a northwesterly direction and dipping to the southwest. It is limited on the northeast side by an intrusive granite mass and on the southwest by the shore line. To the south it crosses the entrance to Dry Pass, but just back of Shakan it is cut off by a granite mass. To the northwest it extends into the channel and reappears at the entrance to Calder Bay, extending northward and overlying beds of conglomerate. Along the shore exposures and at the quarry small dikes of diabase, striking northeastward and much altered and faulted, were observed intersecting the marble beds. Apparently these dikes antedate the metamorphism of the limestone and therefore the intrusion of the granite. They are, however, but a foot or two in width and not sufficiently numerous to affect the value or expense of quarrying the marble. In the present opening at the quarry only one dike is exposed. Both surface cracks and slipping planes are present in the surface exposures of the marble, but in depth these are less numerous and will not materially interfere with quarrying.

Three distinct varieties of marble are found—pure white, blue veined with white background, and light blue much of which has a mottled appearance. The pure white, which has a finely crystalline texture, is the most valuable. All of the marble is free from the silica and flint beds common in most quarries, and though thin seams of pyrite were observed, they do not occur in a quantity detrimental to the stone. The following is a chemical analysis of the white marble made by E. F. Ladd for the Alaska Marble Company:

Chemical analysis of white marble from Marble Creek, Prince of Wales Island, Alaska.

Insoluble matter	None.
Oxide of iron (Fe_2O_3)	Slight trace.
Sulphuric anhydride (SO_3)	Trace.
Lime (CaO)	55.59
Magnesia (MgO)	.30
Carbon dioxide (CO_2)	43.67
Undetermined	.44
	100.00
Calcium carbonate ($CaCO_3$)	99.26

A qualitative test for magnesia in a sample collected by the writer was made by George Steiger, of the United States Geological Survey, who reports a content of less than 1 per cent.

To determine the crushing strength of the stone the Alaska Marble Company submitted samples to N. H. Winchell, State geologist of Minnesota, who reports an average strength of 10,521 pounds per square inch—a strength ample for all building purposes. 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 product of Vermont, Georgia, and Tennessee.

METHOD OF QUARRYING.

At the quarry it was first necessary to remove the uppermost layers of the more or less fractured marble. This was done by channeling machines, a method which is preferable to blasting, as it does not injure the massive rock in depth. The machine used is mounted with a donkey engine on a truck and cuts a channel 2 inches in width at a rate of 7 to 8 square feet per hour. These channels are extended to a depth of 4 feet and are made at intervals of 4 or 6 feet in one direction and at intervals of 6 feet at right angles, so as to form blocks 4 to 6 feet by 6 feet in surface area and 4 feet in depth. These blocks are undercut by gadding machines, in which a drill is set so as to drill a series of holes under the block, and in these holes wedges are driven and the block is freed from its base. It is then lifted by a derrick to the car on which it is carried to the wharf. The blocks contain from 96 to 144 cubic feet of marble and weigh from 7½ to 11 tons each, the dimensions depending on the handling capacity of the machinery. The larger portion of the marble product is shipped in the rough state to a sawing and polishing plant at Tacoma, where it is prepared for the market. Small shipments have also been made to Chicago, Milwaukee, St. Louis, Cincinnati, and other points for trial tests.

EL CAPITAN MARBLE COMPANY.

The property of the El Capitan Marble Company is situated on the eastern side of a low mountain range 5 miles due east of the Alaska Marble Company's quarry and on the north side of Dry Pass. These locations, including 10 claims, were first made in 1901 and were sold to the El Capitan Marble Company in 1903. Except for a small amount of assessment work, operations were not begun until April, 1904. During that year a quarry consisting of a pit 12 feet deep was opened on a marble deposit close to tide water, a channeling and gadding machine was installed, and a cutting plant operated by steam power was erected. Some marble was quarried and shipped

to Seattle at the close of the year, but since that time operations have been suspended.

The marble deposit flanks the eastern side of the granite mass represented on the geologic map (Pl. II) and from its relative position and general character is similar to the Marble Creek deposit farther west. The marble belt is exposed at tide water and forms high bluffs at 200 to 400 feet elevation one-fourth of a mile back from the shore. In these bluffs it has been prospected by trenches and open cuts. A number of diabase dikes crosscut the marble beds. The dikes are faulted and show in many places several feet of displacement, though this faulting, as well as the intrusion of the dikes, probably occurred previous to the metamorphism of the original limestone beds, as no trace of the fault planes could be seen, and the dikes themselves were much altered and sheared. The marble as exposed in the quarry is not of so good quality as that from the Marble Creek property, being less firm and more coarsely crystalline. Surface cracks and fracture planes are present in the surface exposures, but in the bottom of the pit these features are less pronounced.

AMERICAN CORAL MARBLE COMPANY.

The properties of the American Coral Marble Company are at two localities—(1) at the head of North Arm, where 12 claims have been located along the north shore of the inlet, and (2) at the north entrance to Johnson Inlet, where the company has several claims extending from Dolomi eastward to Clarence Strait. The principal developments have been made at the North Arm property, and at this point a post-office named Baldwin has been established. Active work at this locality began in 1904, and the marble deposits were prospected during that year. In 1905 a wharf was built, machinery was installed, and buildings were erected preparatory to quarrying the marble. During 1906, however, practically no work was done, and all the machinery was removed in 1907. At the Dolomi property a small quarry was started on the hillside, at a point a quarter of a mile northeast of Dolomi post-office and a few hundred feet from tide water on the Clarence Strait side, where buildings were erected. No operations were in progress at these localities during 1907.

The deposits at North Arm and Dolomi consist of marble beds interstratified with chloritic and calcareous schists, striking northwest with steep dips, usually to the southwest. The surrounding area is mantled by a dense growth of vegetation, and the limits of the deposits have not been definitely determined, though where the marble is exposed it is much fractured, variable in color and composition, and intersected by a few narrow dikes of diabase. The fracture planes were probably formed principally during the period of tilting

and folding of the beds and existed before erosion exposed the present surface outcrops. Since that time weathering has accentuated and to some extent increased the number of fracture planes. It seems probable, however, that in depth these planes, although potentially present as lines of weakness, will become less numerous and will not interfere greatly in quarrying.

Although some parts of the deposits consist of pure-white, fine-grained marble of excellent quality, other parts are poorly colored, coarse grained, and of little commercial value, and it will probably be difficult to obtain large quantities of uniform grade. The better grade is reported to give the following analysis: Calcium carbonate, 94 per cent; alumina, 3.9 per cent; silica, 1.4 per cent; magnesia, 0.7 per cent. Pyrite is also present in small amounts, occurring in thin seams and finely disseminated in some of the marble.

MARBLE ISLAND.

Marble Island, a low wooded area of 9 square miles, is one of the larger islands in Davidson Inlet and lies 10 miles due south of Shakan, though by water it is nearly 30 miles distant. On the northwest side of this island marble was first discovered in 1899, and in 1903 a number of claims were located over this portion of the island and a small amount of stripping was done. Samples of this marble were quarried for test purposes and several varieties of good quality obtained. The total developments have not exceeded the assessment requirements.

The marble deposit is exposed in a cove on the northwest side of the island, and half a mile from the shore, at an elevation of 100 feet, it has been worked by an open cut. A considerable area is underlain by marble, though little is known of its extent or value. Along the eastern shore of the island an area of granitic intrusive rock was noted.

REVILLAGIGEDO ISLAND.

A well-defined limestone belt traverses the eastern portion of Revillagigedo Island in a northwesterly direction and is exposed in Thorne Arm, Carroll Inlet, and George Inlet. Its widest development is on the north side of George Inlet near the head, where marble claims known as the Bawden group were located in 1904. The deposit is included in the crystalline schist near the contact with the less altered slates to the southwest. The marble beds range from 10 to 20 feet in width and are separated by strata of calcareous schist. Their strike is northwest, with northeasterly dip. The marble is exposed in cliffs near tidewater and is of good quality, being relatively free from fracture and joint cracks, finely crystalline, and from white to

gray in color. No large developments have been started on this property.

In Carroll Inlet to the southeast claims have also been located on the same belt, but at this locality the deposit is not so extensive as in George Inlet.

HAM ISLAND.

Ham Island lies at the junction of Blake Channel and Bradfield Canal, 25 miles southeast of Wrangell. It is about a mile and a half wide and consists largely of crystalline limestones with interstratified beds of calcareous schist striking N. 35° W. and dipping 75° NE. Intrusive dikes of basalt are common, and across the narrow channel on the mainland and on Wrangell Island wide belts of granite intrude these limestone and schist beds and have probably induced the present crystalline texture in the limestone and thus formed the marble.

Two distinct varieties of marble are found—one fine grained and pure white, the other very coarse grained and pale blue. Several systems of jointing planes traverse the deposits, but the joints are widely separated and will not interfere greatly in quarrying. Checks or surface cracks are practically absent and wide areas of massive marble have been found directly underneath the soil. Much of the marble appears to be free from impurities.

Two groups of claims have been located on this island, the Woodbridge-Lowery group on the west side and the Miller group on the east side. On the former the marble quarried is principally of a white, finely crystalline variety, but at the Miller property the deposit, exposed in a bluff 40 feet high and 100 feet long, is of a coarsely crystalline texture and a bluish color. On both of these properties considerable exploratory work has been done, and large blocks of the marble have been quarried, from which tombstones and small blocks have been chiseled and polished for local use. The properties are favorably located both for quarrying and transportation.

ADMIRALTY ISLAND.

Marble is known to occur at several localities on Admiralty Island, namely, at Marble Bluffs, on the west coast; at Square Cove, just north of Marble Bluffs; and in Hood and Chiak bays, south of Killisnoo. At these points some of the marble is of good quality, but most of the deposits contain silica and pyrite and the rock is not of much value. The deposits at Marble Bluffs are apparently more extensive and of better grade than those at the other localities.

GRANITE.

DISTRIBUTION.

The granitic intrusive rocks occupy about one-half of the aggregate land area of southeastern Alaska. In composition they range from granite to granodiorite or 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, in Taku Inlet, and at the head of Lynn Canal. On the islands numerous granite stocks occur, portions of which are of massive and uniform texture, though these stocks contain numerous segregations of the femic minerals, and pyrite is present in many places, rendering the rock less desirable for building purposes. Rock of good quality was observed at Gut Bay and Whale Bay, on the coast of Baranof Island.

All the granite masses in this region are similar in composition, having plagioclase feldspar as an essential constituent. Hornblende is the usual dark mineral, though biotite mica is present in 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 is light gray and in only 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 to 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 reach the market appears at first unfavorable to granite quarrying along this portion of the northwest coast, but the present freight rate of less than $3 per ton to Puget Sound is not greater than the cost of transportation from some of the quarries in California to the larger cities. The cost of quarrying the stone in the Western States 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 average selling price per cubic foot for building purposes at the quarries in the coast States in 1906 was as follows: Rough, $0.85; dressed, $2.35; for curbing, $1. For monumental purposes the stone sold for $1 to $2 per cubic foot rough and for $3 to $6 dressed. These prices do not include the cost of transportation from the quarries to the cities, which is from 50 cents to $3 per ton. This adds from 5 to 30 cents to the cost of the stone per cubic foot.

GYPSUM.

THE GYPSUM DEPOSIT.

The only extensive deposit of gypsum known in southeastern Alaska is situated on Gypsum Creek a mile from its mouth, at Iyoukeen Cove, on the east side of Chichagof Island. The gypsum beds apparently overlie the Carboniferous rocks exposed along the southwestern shore of Iyoukeen Cove and forming the ridge southwest of Gypsum Creek, though the area of contact is buried under deep gravel deposits along the beach and in the valley. The mountain ridge to the northeast is made up of a granitic mass intruding the older limestone and quartzite. Structurally the gypsum beds are folded and steeply tilted and were probably laid down previous to the granitic invasion. They are at present regarded as of Permian or Triassic age.

The geology in the immediate vicinity of the gypsum beds is obscure and neither foot wall nor hanging wall of the deposit is exposed. Bluffs of a cherty limestone striking northwest and dipping to the northeast are exposed near the entrance to the tunnel at the lower mine workings on Gypsum Creek. 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 walls 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 cobbles of granite corresponding to the intrusive mass at the head of the creek, which invaded the area subsequent to the deposition of the gypsum beds.

MINE DEVELOPMENTS.

This gypsum deposit, the property of the Pacific Coast Gypsum Company, has been extensively developed during the last few years and large shipments of the rock are being made to the plaster mill at Tacoma, Wash., where it is prepared for the market. The developments consist of a wharf 2,000 feet in length extending to deep water, where rock bins of 1,000 tons capacity have been built, and of a railroad about a mile in length to the mine workings. At the mine rock bins of 1,500 tons capacity have been erected, thus affording sufficient storage capacity during intervals of transportation of the gypsum to the plaster mill. A vertical shaft has been sunk for 190 feet and from it two levels have been extended at points 90 and 160 feet in depth, both of which are almost entirely in gypsum. The main developments are on the 160-foot level and include 1,200 feet of workings, exposing the gypsum bed over an area 450 by 225 feet. Both the thickness and the lateral extent of the bed are still undetermined. At a point 800 feet west of the shaft investigations were made in former years of a gypsum exposure on the creek bank, where a short tunnel was driven and a 75-foot shaft sunk almost entirely in gypsum, but work at this point was discontinued.

MARKET.

Gypsum is in much demand along the Pacific coast as wall plaster and 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 from 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 of first-grade gypsum products in these cities 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.

CEMENT.

There are several kinds of cement, the principal kinds being Portland cement and natural cement. Portland cement is produced by burning a finely ground artificial mixture containing essentially lime, silica, and alumina in certain definite proportions. Usually this combination is made by mixing limestone or marl with clay or shale; such a mixture should contain about three parts of the carbonate to one part of clayey material. Natural cement is the product of an impure limestone containing from 15 to 40 per cent of silica, alumina, and iron oxide. Calcareous and argillaceous rocks suitable for cement making are relatively scarce in the Ketchikan and

Wrangell districts. They are metamorphosed, usually containing mica and some pyrite, and are not sufficiently fine grained to be of value. At only one locality—Long Island in Kasaan Bay—have rocks of this sort been located for the manufacture of cement. Here beds of limestone and siliceous shale are exposed around the shores of the island and are apparently of a quality suitable to make cement. The disposition of this product will, however, be confined to the local market, as it can not now be profitably shipped to compete with the cement manufactured along the Pacific coast. 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 labor of the Puget Sound area and California, must also be considered, and the long haul necessary to reach 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 near the market would be the most feasible plan; but this would bring little or no profit, as vast areas of cement rock are exposed near all the larger cities and can supply the cement plants along the coast for many years to come.

CLAY.

Large deposits of clay are known to occur at the head of Vallenar Bay and along the banks and deltas of many of the glacial streams. These clays are fine grained to gritty, bluish in color, and semiplastic, and are usually termed "glacial mud." They are especially suitable for the manufacture of brick. For cement making the clay would require the addition of limestone and fine grinding, as coarse particles are scattered through it. The clay deposits are of only local value, and the material has little or no commercial importance.