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SOME MINERAL DEPOSITS OF GLACIER BAY AND VICINITY, ALASKA.[1]

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CONTENTS.

ABSTRACT.

Prospecting in the Glacier Bay National Monument has been confined so far to granitic rocks near contacts with Paleozoic sediments, which they intrude.

Near Reid Glacier thin veins, a few of which are traceable for about 300 feet both horizontally and vertically, trend northerly and carry sphalerite, galena, and pyrite. Gold was panned from some of the better looking material.

Near Sandy Cove, 30 miles away, more irregular, but locally

[1] Published by permission of the Director, U. S. Geological Survey. Presented before the Society of Economic Geologists, New York Meeting, February, 1937.

thicker, veins appear to carry only pyrite. Here pyrite also occurs along the contact between the granitic rocks and the intruded limestone.

Sparse ore minerals have been seen at other places in and near the monument. As yet, no large mineral deposits have been found there, but many miles of igneous contacts have not been prospected. In southeastern Alaska, as elsewhere, such contacts are considered favorable places in which to search for mineral deposits.

INTRODUCTION.

GLACIER BAY is in the northwest part of southeastern Alaska (Fig. 1).

The entrance to Glacier Bay is about 60 miles west of Juneau from which place it is reached by plane or boat.

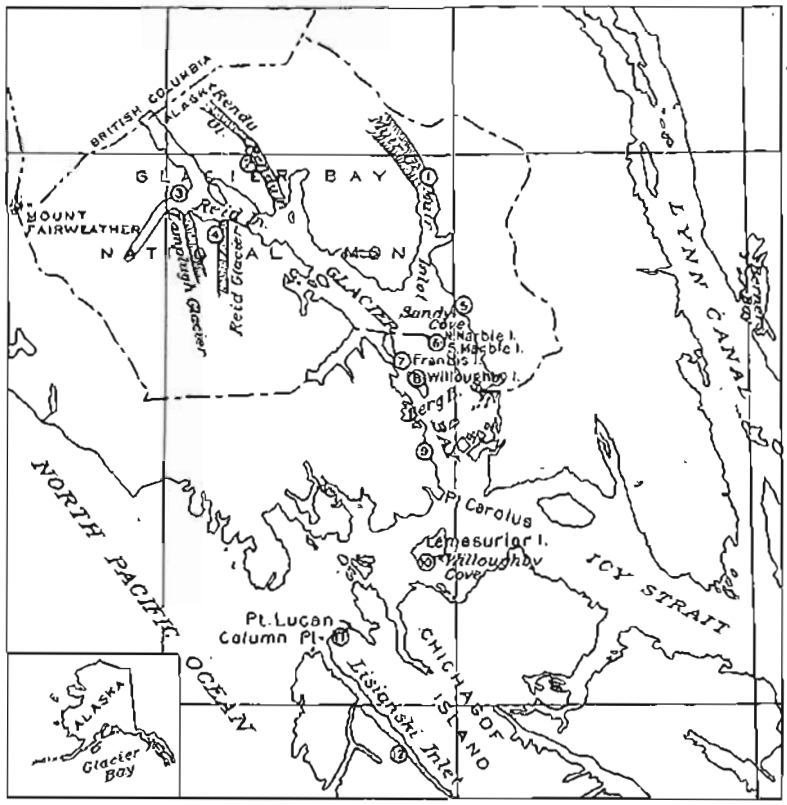

FIG. 1. Outline map of Glacier Bay and vicinity, Alaska, showing locations of some mineral deposits.

Glacier Bay has been visited by several geological expeditions but most of these were principally concerned with the study of glacial phenomena that are well displayed there. Greatly increased interest, because of the recent opening of the Glacier Bay National Monument to prospecting and mining, in the economic possibilities of the mineral deposits of Glacier Bay resulted in their investigation by the United States Geological Survey during a 4-week period in August, 1936.

The investigation included the examination of most of the known deposits of metallic minerals in the Glacier Bay district as well as brief visits to a few deposits south of there on Lemesurier Island in Icy Strait, and on Chichagof Island.

Most of the deposits examined do not appear to be of very great commercial importance. A few may have some commercial possibilities but have not yet been prospected sufficiently to permit safe appraisal. Two formerly productive mines were visited, the Apex and the El Nido on Chichagof Island. The deposits at these mines are more developed than those seen at any of the other places.

Most of the deposits visited appear to be genetically related to bodies of granitic rock. Because many of these granitic masses, and particularly their contacts against older rocks have not been explored geologically, even in a reconnaissance way, a general statement that the area either is or is not one in which commercial ore bodies are likely to occur is probably not yet warranted.

In this paper a short outline of the general geology of the area is followed by descriptions of the deposits examined, and by a summary of some of their outstanding geological features.

GEOLOGIC SETTING.

The area in which the deposits visited lie is one of limestone and marble, probably of Upper Silurian age, and other sediments including argillite, slate, quartzite, and hornfels, that also are probably Silurian or older. The sediments were intruded probably in Upper Jurassic or Lower Cretaceous time by many dif-

ferent-sized, irregularly shaped masses of granitic rocks, principally diorite.

Along Lynn Canal is exposed a group of sedimentary rocks younger than those around Glacier Bay. Most of the rocks of the group are probably Jurassic or Cretaceous but some of them may be Triassic and others Paleozoic. The principal types represented are slate and graywacke with some greenstone.

The principal bed rocks of Glacier Bay and vicinity are cut at many places by a variety of dike rocks including pegmatites, aplites, and lamprophyres; the last are the most abundant. The pegmatites and aplites are regarded as being genetically related to the diorite intrusions but the lamprophyres are probably much younger.

Large areas of the bed rocks are concealed beneath unconsolidated Quaternary fluviatile and glacial deposits and still larger areas are covered by snow and ice fields and by active glaciers.

The general structural trend in the northern part of southeastern Alaska is northwest. At most places the dip is steep. Apparently the magmas, which upon crystallization formed the granitic bodies, were more readily intruded along the pre-existing structural trend than across it and many of the bodies, particularly the larger ones, are elongated in that direction.

According to Buddington and Chapin [2] the belt of rocks east of the Glacier Bay district along Lynn Canal is part of the Juneau synclinorium whereas the rocks of the north end of Chichagof Island and Glacier Bay comprise part of the Chichagof-Glacier Bay anticlinorium.

F. E. and C. W. Wright [3] believe that Lynn Canal and Chatham Strait have been eroded along a major fault plane that trends slightly west of north.

DESCRIPTIONS OF DEPOSITS AND LOCALITIES.

The numbers in parentheses after the following paragraph headings correspond to the locality numbers on Fig. 1.

[2] Buddington, A. F., and Chapin, Theodore: Geology and mineral deposits of southeastern Alaska. U. S. Geol. Surv. Bull. 800, pp. 298 and 315, 1929.

[3] Wright, F. E. and C. W.: The Glacier Bay National Monument in southeastern Alaska, its glaciers and geology. U. S. Geol. Surv. unpublished manuscript.

Head of Muir Inlet (1).

A small mountain, 1,150 feet high by aneroid barometer, rises near the head of Muir Inlet on the east side of the main Muir Glacier and between it and a large area of stagnant ice farther east. The country rock is principally hornfels; its general strike is N. 40° E. and its dip about 50° N.W. Two varieties of hornfels are distinguished by color differences, one is composed of bands, many less than an inch thick, of nearly white and light gray or buff rock; the other is much darker and may be either dark green or gray.

The light colored hornfels is made up principally of crushed quartz grains and variable amounts of zoisite. Some rounded and strained quartz nuclei are present in the ground mass of more finely crushed material. Some of the bands carry needles of pale green amphibole. Pyrrhotite, pyrite, and possibly chalcopyrite are accessory minerals. The rock is cut by tiny seams of coarser-grained quartz and zoisite.

The darker hornfels is so fine grained that the principal mineral constituents are determined with difficulty even with the microscope. Apparently quartz is the most abundant mineral. In other respects the rock is similar to the lighter variety except that green amphibole is more abundant and zoisite less abundant. The amphibole is probably responsible for the darker color of this variety of the hornfels.

Granitic dikes up to more than 100 feet thick are common in the hornfels and are particularly abundant near the top of the mountain. The rock of the dikes is porphyritic quartz diorite. The plagioclase phenocrysts appear to range from oligoclase to andesine whereas the ground-mass feldspars are albite or oligoclase. The dark minerals have been altered to serpentine but the shapes of the serpentine masses indicate that the principal original dark mineral probably was hornblende. Pyrite, apatite, and birefringent garnet are accessories.

Small mineralized quartz veins are, like the quartz diorite dikes, more abundant near the top of the mountain. The veins are apparently confined to the hornfels and were not seen in the

dikes. None of the veins observed is more than 6 inches thick. Many of them strike N. 70° W. and are vertical. Some trend in other directions.

The mineralogy of the quartz veins has not yet been studied in detail. The principal metallic minerals appear to be magnetite and chalcopyrite in an intimate mixture. Pyrite is not abundant. Some other minerals are known to be present, among them one that appears creamy-white when polished, isotropic, soft, and shows reddish internal reflections around its borders. Possibly it is ruby silver.

Although the mountain appeared as a nunatak through the ice of Muir Glacier less than 50 years ago, the sulphides are partly oxidized where the veins outcrop. Hydrated oxides of iron, chrysocolla, malachite, and possibly cuprite are common.

West Side of Rendu Inlet (2).

According to Buddington's unpublished notes,[4] 2 claims [5] on the west side of Rendu Inlet were patented about 1892. Tetrahedrite is reported to have been found on them. An attempt to identify the claims with certainty proved unsuccessful. A rock monument found along the shore about three miles down the inlet from Rendu Glacier may represent the location of the claims.

The country rock in the general vicinity is quartz diorite, which appears very similar to the granite near Reid Glacier (4). It is composed principally of quartz, oligoclase-andesine, and pale green amphibole. It contains some orthoclase and biotite and carries accessory calcite, sericite, chlorite, epidote, zoisite, apatite, and magnetite.

At most places seen the quartz diorite contains many different-sized lenticular inclusions of a finer grained, darker colored, porphyritic rock. Mineralogically and texturally the inclusions resemble lamprophyre. The most abundant mineral is oligoclase. Many of the oligoclase crystals are lath-shaped and untwinned. Blunt laths of light green amphibole are abundant. A little

[4] Buddington, A. F.: U. S. Geol. Surv. unpublished notes, 1924.

[5] Reported to belong to the Presbyterian Home for Elders in Seattle.

chlorite, apparently at least in part after biotite, magnetite, apatite, calcite, and epidote were also recognized.

The country rock is cut at a few places by light colored dikes. Several altered zones, which contain tiny mineralized quartz veinlets, were observed. These appear similar to the altered zones with quartz veins near Reid Glacier (4) but are not as wide, as continuous, or as numerous.

North Shore of Reid Inlet (3).

In a contact zone along the north shore of Reid Inlet, from a point across the inlet from Lamplugh Glacier, for several miles westward to about the sharp bend whence the inlet trends southwestward, a large granitic mass on the east gives way to a thick sequence of limestone and slate that appears to occupy a considerable area to the west. An abundant rock of this zone is dark gray, blocky slate that is composed largely of quartz and feldspar grains that form a fine-grained ground mass in which are numerous large, broken grains of the same minerals. Carbonaceous material is common and pyrite and zoisite are present. The rock is traversed by a few thin calcite seams. Another common rock is calcareous green slate. Some bands are made up of quartz in broken grains and calcite. Other bands are shaly. Zoisite is common.

Throughout this zone, different-sized masses of the sediments lie out in the granitic rock. The strike at most places in the zone is between N. 40° W. and N. 55° W. and the dip between 60° and 75° S.W.

Locally the sediments of the engulfed masses of the contact zone are replaced by bodies of massive pyrite. The largest such deposit seen is about 10 feet thick at the water line but thins to about a foot about 50 feet above the water. This deposit can be traced by eye, because of the conspicuous staining by hydrated oxides of iron, for a long distance up the fiord wall.

Some quartz and a very little chalcopyrite are present in the massive pyrite. An estimate of the percentages of pyrite, quartz, and chalcopyrite in the most completely replaced material in 95, 5,

and less that 1, in the order given. The precious metal content of this material, if any, is not known.

Reid Glacier (4).

J. P. Ibach staked for himself and associates 2 claims in 1924 and many more in the summer of 1936 in the vicinity of Reid Glacier. One group of claims lies west of the glacier and near the ice front. Another group is on the east side of the glacier, and a third is almost on the divide between Reid and Lamplugh Glaciers. These claims have been prospected very slightly and have had no production.

Claims West of Reid Glacier near the Ice Front.

The claims west of Reid Glacier include the Galena and other groups. Fig. 2 is a map of some of the geographic and geologic features of the vicinity.

Rocks.—The principal country rock of the area mapped appears to be granite. The granite contains different-sized masses of engulfed older sediments which are siliceous and possibly originally were sandstones. Marble and slate crop out along the east side of Reid Glacier and on the divide between Reid and Lamplugh Glaciers about a mile south of the mapped area. The granite and older rocks are cut by dark colored dikes including many of lamprophyre and perhaps some of other rocks.

The designation of the intrusive rock as granite is based on the study of one thin section only, but the rock from which the section was cut appears to be typical. The section is made up principally of orthoclase and albite-oligoclase. Quartz is present in considerable quantity. The original dark minerals have been converted to chlorite and other alteration products. The shapes of the chlorite masses in the hand specimen indicate the former presence of hornblende and possibly of some biotite. Accessory minerals include epidote, titanite, and apatite.

The different-sized masses of light colored, cherty-appearing rock that is thought to have been sandstone is made up of a mosaic of angular quartz grains. The grains are crushed around their

edges and most of them are cracked and strained. The grains are partly altered to sericite which has developed in the quartz according to an unusual reticulate pattern. The quartz mosaic is

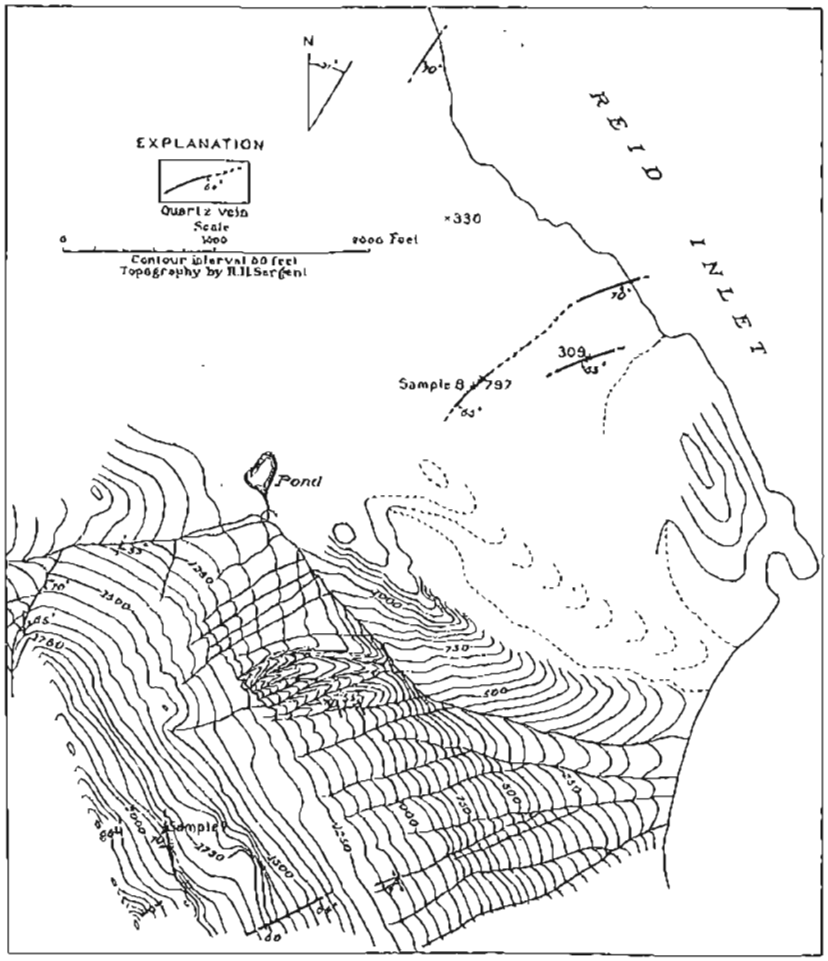

FIG. 2. Map, showing quartz veins, of an area west of Read Glacier near the ice front.

cut by numerous intersecting quartz veinlets that are free of sericite. Calcite is sparingly present in the veinlets. Pyrite is a common accessory of both the veinlets and the main mass of the rock.

The most abundant mineral of the lamprophyre dikes is plagioclase, which is either calcic albite or sodic oligoclase. The dark mineral is pale green hornblende which in many places is partly altered to chlorite and other products. Accessories include calcite, epidote, magnetite, pyrite, and sericite.

The sedimentary rocks east of Reid Glacier and those south of the small mapped area trend in general northwest but locally the strikes diverge from that direction. There appears to be no consistency of dip. No directional features reflecting the general structural trend of the older rocks were observed in the granite. The engulfed quartzite masses are too irregular and poorly exposed to indicate the structure by their shapes and attitudes, and the rock is metamorphosed to such a degree that bedding has been obliterated.

Most of the lamprophyre dikes in the granite trend about E. and dip steeply, ordinarily more than 70 degrees, either N. or S. The dikes of this group are larger, more abundant, and older than lithologically similar dikes that strike in general about N. 15° E. and dip between 65° W. and vertical. The range of strikes of 6 dikes of the latter group is from N. 5° W. to N. 35° E. (Fig. 3).

Veins.—The bed rocks of the mapped area and vicinity are cut by quartz veins that range in thickness from a small fraction of an inch to as much as 18 inches. Several of the veins were traced horizontally for about 400 feet and for about the same distance vertically. One, with some interpolation, is mapped for a horizontal distance of about 1600 feet and over a vertical range of more than 800 feet (Fig. 2).

Most of the veins range in strike from N. 25° W. to N. 57° E. and have steep dips (Fig. 3). The veins appear to fill fractures of the same group as those occupied by the later lamprophyre dikes.

The granite of the country rock is commonly intensely altered for several feet on each side of a vein. In several places fractures were observed along which alteration has taken place but which contained no vein. Locally several thin veinlets occupy

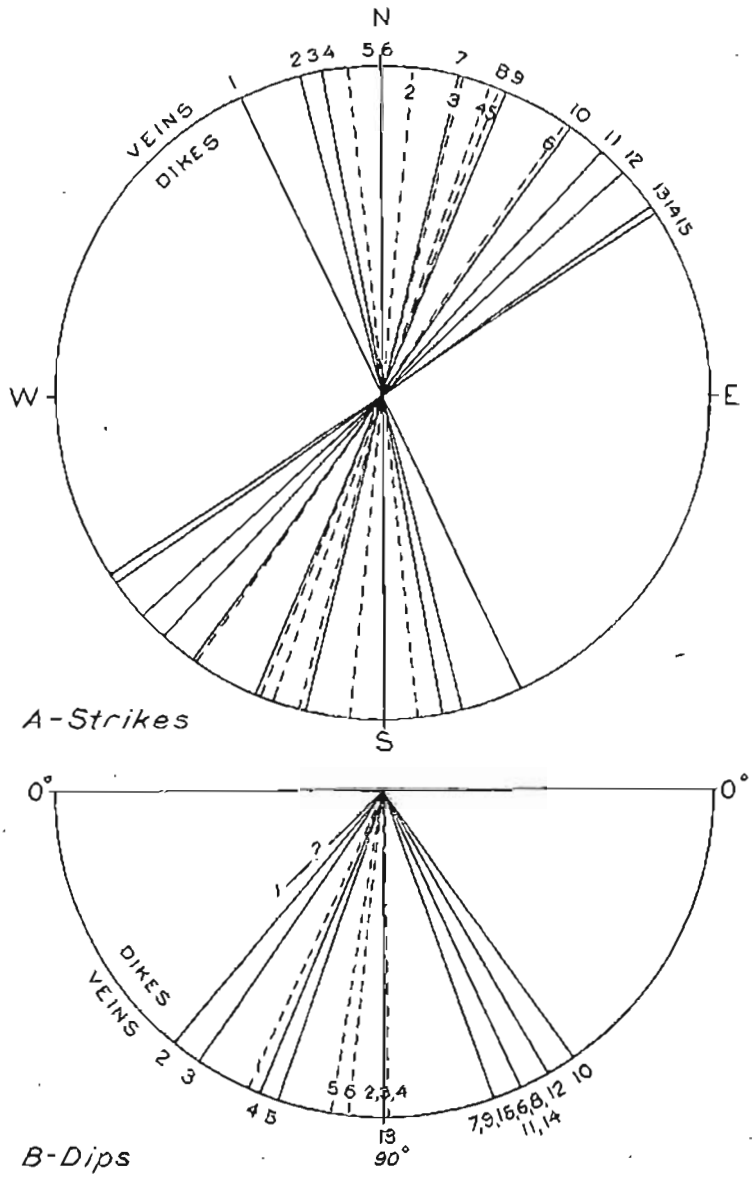

FIG. 3. Diagram showing attitudes of veins and of younger lamprophyre dikes near Reid Glacier.

single fracture zones. The altered zones are apparent in the field because of their conspicuous bright color due to hydrated oxides of iron. The principal changes in the rock by the alteration are the addition of a great deal of quartz, the destruction of all of the hornblende, most of the orthoclase, and part of the plagioclase, and the formation of considerable calcite, sericite, and pyrite. Many of the altered zones are 20 feet thick and few are less than 10 feet.

The quartz of the veins is commonly banded, with comb quartz and vugs near the centers. The walls are free and are locally marked by a little gouge. Ore minerals observed include pyrite, marcasite, sphalerite, galena, and chalcopyrite. Of these, pyrite and sphalerite are the most abundant. The deposition of the ore minerals appears to have been partly controlled by the banding of the vein, for the metallic minerals are largely confined to thin zones between bands. The sphalerite and galena are more abundant in the comb quartz of the interiors of the veins whereas the pyrite appears to be distributed through all the quartz.

Not much is known about the precious metal content of the veins as they have never been adequately sampled. Free gold, some of it coarse, was panned from some of the richer looking vein material. A sample cut from a vein 12 inches wide that outcrops a short distance south of the mapped area at an altitude of about 340 feet yielded[6] 0.16 oz. gold, 0.30 oz. silver and 0.79% zinc per ton. Two other samples (No. 7, 18 inches wide and No. 8, 6 inches wide) cut from veins within the mapped area (Fig. 2) yielded the following results:

No.	Gold, oz.	Silver, oz.	Zinc, per cent.
7	0.97	0.50	1.08
8	0.84	0.10	1.02

[6] All assays, unless otherwise noted, by W. T. Burns, U. S. Geological Survey, Fairbanks, Alaska.

Claims East of Reid Glacier.

The Sunrise group of 10 claims lies along the east side of Reid Glacier and extends north of the ice front for several thousand feet.

Here white marble, bluish marble, and dark green, blocky slate are cut by numerous lamprophyre dikes similar to those described from the west side of Reid Glacier. The metamorphic rocks strike from about N. 20° W. to N. 15° E. The general dip along the glacier and the inlet in front of it is about 55° E. but a short distance to the east the beds dip west.

The lamprophyre dikes and a few small quartz veins are about parallel to the beds. The dikes range up to 30 feet thick, and in places are bordered by a silicious contact rock. A thin section of this is composed largely of quartz grains. About 20 per cent of the section is pinkish-brown mica, and it contains considerable plagioclase (mostly untwinned), which ranges from albite to sodic andesine. Apatite is a common accessory as is zoisite, which is present in veinlets cutting the other minerals. A polished section of the same rock reveals about 15 percent sulphides among which pyrrhotite, pyrite, and arsenopyrite were recognized. Of these the first is the most abundant. At other places along dike contacts are small irregular patches and kidneys of sulphides in calcite, none of which are more than a few inches in diameter; they contain chalcopyrite and pyrrhotite.

The quartz veins of this vicinity are small and discontinuous. None was traced definitely for more than a few tens of feet. One vein that, where observed, ranges in thickness from 2 inches to 18 inches was sampled where it is 10 inches thick, and yielded 0.08 oz. in gold and 0.20 oz. in silver per ton. Some of the sedimentary material under the vein that was sampled carries sulphides, possibly pyrrhotite, and was reported to contain considerable gold. An assay of this material from about 6 feet under the vein showed a trace of both gold and silver.

Claims Near the Divide between Reid and Lamplugh Glaciers.

The Rambler Group of 6 claims lies about 2 miles southwest of the front of Reid Glacier near the divide between Reid and Lamplugh Glaciers at an altitude of about 2,850 feet.

The mineral showing here is in the same granitic body as those farther north in the vicinity of the front of the glacier. Marble and other rocks crop out a few hundred feet west of the prospect and on the divide north of the prospect. The marble strikes about N. 50° W. and dips about 50° S.W. The typical marble is interbanded dark, impure layers and white, coarsely crystalline layers, which range from about 0.01 to 0.5 inch in thickness. The rock is principally composed of large calcite crystals in a mosaic of finer calcite grains. Small quantities of muscovite, colorless pyroxene, colorless amphibole, quartz, feldspar, and a sulphide, apparently pyrrhotite, are present.

At the discovery, the granitic rock is cut by a zone of intensely altered rock about 20 feet thick, which consists mostly of quartz and calcite. The quartz is greatly strained and locally crushed. Only a little plagioclase is left; it appears to be oligoclase but is so sericitized that its determination was difficult. The rock contains considerable pyrite. The altered zone strikes about N. 10° E. and dips 70° W. To the south, the zone passes under a small glacier and was not found beyond. On the north it appears to split into a large number of smaller zones that are shortly lost in the country rock. In the zone are 4 or 5 parallel quartz veinlets. The largest seen is locally about 2 feet thick. The quartz is vuggy and the vein carries pyrite, sphalerite, and galena.

A sample of typical vein material yielded 0.26 oz. gold and 0.10 oz. silver per ton, and the rock of the altered zone yielded a trace of gold and 0.20 oz. of silver to the ton.

Sandy Cove (5)

Three claims near Sandy Cove on the east side of Glacier Bay are held by the Glacier Bay Mining Co. of Frank St. Clair, Edward Metjay, James Austin, and Wm. L. Paul. The principal development consists of a tunnel which was about 30 feet long

when the property was visited but which was reported in March 1937, to be a little more than 100 feet long. A small compressor, and some other mining equipment are on the property.

Here, a small body of granitic rock intrudes thick-bedded limestone now largely crystallized to marble (Fig. 4). A thin section

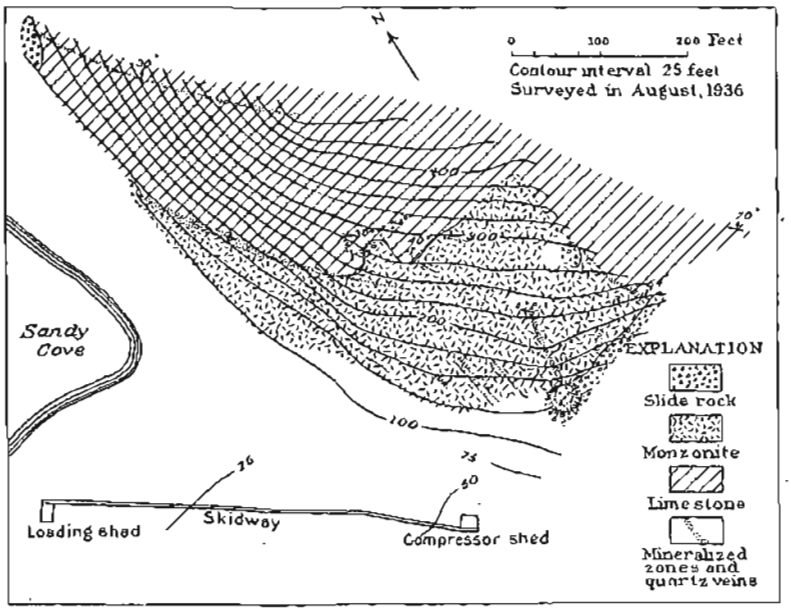

FIG. 4. Topographic and geologic map of vicinity of prospect of the Glacier Bay Mining Co.

of typical granitic rock shows it to be monzonite. It is composed principally of oligoclase, orthoclase, and pale green amphibole. A little quartz is present as well as small quantities of epidote, zoisite, calcite, sericite, and garnet. Pyrite and titanite are common.

At most places the thick-bedded limestone is bluish gray, locally it is coarsely crystalline white marble, and at a few places the rock is stained brown or red by hydrated oxides of iron. At many places along and near the contact between the monzonite and the limestone and in some zones within the limestone, possibly along

certain beds, the limestone has been changed by contact metamorphism into complex rocks largely composed of metamorphic silicates. One type of contact rock consists principally of epidote, zoisite, calcite, and garnet, with a little feldspar. Another type contains calcite and zoisite in some bands and actinolite, zoisite, calcite, an undetermined isotropic mineral, and orthoclase in other bands. Pyrite is common throughout the rock.

The strikes of the limestone and of the contact are in general northwest and both dip northeast. The intrusive body is not entirely concordant however, and some limestone beds are cut out (Fig. 4).

Pyrite deposits in the vicinity are of 2 types: those in quartz veins and those in contact-metamorphosed limestone. Most of the quartz veins are in the monzonite but a few lie in limestone near the contact. One vein runs along the contact about 130 feet east of the prospect tunnel. The veins range from a small fraction of an inch up to 11 feet wide and two were traced horizontally for about 100 feet. Many of the veins strike about N. 10° west and all those observed dip east at angles ranging from 22° to 71°. The vein walls typically grade into altered and sulphide-impregnated monzonite. The vein matter is principally quartz, calcite is locally abundant, and pyrite, abundant in places, is the only sulphide recognized.

The precious metal content of most of the veins is not satisfactorily known. A sample cut across the vein that follows the limestone contact about 130 feet east of the tunnel, at a place where it is 2½ feet wide, yielded a trace of both gold and silver. The values in the vein on which the tunnel is driven are better known but even these are unsatisfactory because the samples are reported to have been cut all the way across the tunnel without separating vein matter from altered wall rock. A sample cut during this survey across a width of 6½ feet at a place about 15 feet in from the tunnel portal contained traces of gold and silver. The following table of assay results is compiled from information furnished by Wm. L. Paul, one of the owners.

TABLE SHOWING GOLD AND SILVER CONTENT OF SAMPLES CUT IN TUNNEL OF GLACIER BAY MINING COMPANY

Feet, from portal.	Back sample.		Face sample.		Floor sample		Assayer
	Au.	Ag.	Au.	Ag.	Au.	Ag.	
38	.02	—	.01	—	.02	—	Alaska Juneau Gold Min. Co.
44	.01	—	.01	—	tr.	—	" " " " "
54	.01	—	.02	—	.02	—	" " " " "
58	tr.	—	tr.	—	.05	—	" " " " "
62	.03	—	.06	—	.09	—	" " " " "
70	.01	—	tr.	—	.02	—	" " " " "
75					.05	.60	Wm. T. Burns, U. S. Geol. Survey
80	.10	.70	.03	tr.	.02	tr.	" " " " " " "
85	.10	.40	.03	.10	.25	.30	" " " " " " "
90	.14	.20	.05	.10	.10	.10	" " " " " " "
93	.04	.30	.12	.10	.08	.30	" " " " " " "
98	.51	2.4	.28	1.0	.38	.40	" " " " " " "
103	.48	1.6	.66	2.4	.32	.40	" " " " " " "

A copy of a Tacoma Smelter return on about 4 tons of selected ore reported to have come from near the portal of the tunnel shows .37 ozs. gold and .15 ozs. silver per ton.

The large ore-bearing zone along the contact northwest of the tunnel is exposed for about 250 feet. To the east it passes into a quartz vein in monzonite; on the west it is covered by talus near sea level. The zone is mineralized across a thickness of at least 10 feet and it stands nearly vertical. Mineralization consists of pyrite distributed through the contact rock and of occasional kidneys, from several inches to several feet long, of pyrite and quartz. A sample of richly pyritiferous material yielded only traces of gold and silver. The pyrite carries a small amount of chalcopyrite in tiny rounded blebs.

A similar zone crops out about 130 feet northeast of the one just described. The strikes of the two zones are about parallel but the northern one, instead of being nearly vertical, dips northeast at about 30 degrees. The rock of this zone, which here appears to be developed along a certain bed, is almost identical with the metamorphic rock along the contact and the sulphide bodies in it are also similar.

North Marble and South Marble Islands (6).

North Marble and South Marble Islands lie in Glacier Bay about half way between Sandy Cove (5) and Willoughby Island (8). According to Buddington [7] a nickel claim was staked on North Marble Island by S. H. Vevelstad.

Both Islands are constituted principally of coarsely crystalline white and blue-gray marble. The marble is cut in several directions by dark colored, fine grained, porphyritic dikes. The largest dike seen is on South Marble Island. It is about 30 feet thick.

On North Marble Island were found bodies of sulphides up to 1½ feet thick and 15 feet long. These are distributed in the marble in the vicinity of the dikes. Deposits along contacts between dikes and marble are common, and many joints in the dikes contain sulphides. The sulphides that were recognized include pyrite, pyrrhotite, chalcopyrite and covellite. Others may be present. Calcite is a common constituent of many of the deposits. Any nickel present is probably in pentlandite but that mineral was not recognized although its presence is suspected.

The sulphide mineralization on South Marble Island is similar to that on North Marble Island but does not appear to be as intense.

Francis Island (7).

An attempt to find a reported ore deposit on Francis Island was unsuccessful as the place where the deposit is reported to lie is covered with a recent landslide. The following is quoted from Buddington's notes [8]:

> Two claims (Dixon No. 1 and 2) have been staked on Francis Island, in Glacier Bay, by M. V. Manville and T. P. Smith. These claims lie along a dike of diorite which cuts across the island from the southwest to the north end. The island is composed of marble. At the southwest end the dike is about 50 yards wide and is bordered by 5 feet or so of green contact garnet rock. A few lenses of serpentine and veins of tremolite occur in the adjacent marble. Near the southwest end of the dike, on the west side, at the top of a cliff, a small pocket of bornite yielding gold and silver assays was found in the contact garnet rock. The dike at the north end is impregnated with pyrite and pyrrhotite.

[7] Buddington, A. F.: *Op. cit.*

[8] Buddington, A. F.: *Op. cit.*

Willoughby Island (8).

Two mineral deposits were seen on Willoughby Island, one in the northeast part of the island and the other about 2 miles S. of the northwest point of the island close to the southwest shore.

The first deposit is at an altitude of about 750 feet. The country rock is limestone and the ore deposit is apparently a replacement body in the limestone (Fig. 5). No intrusive rock was

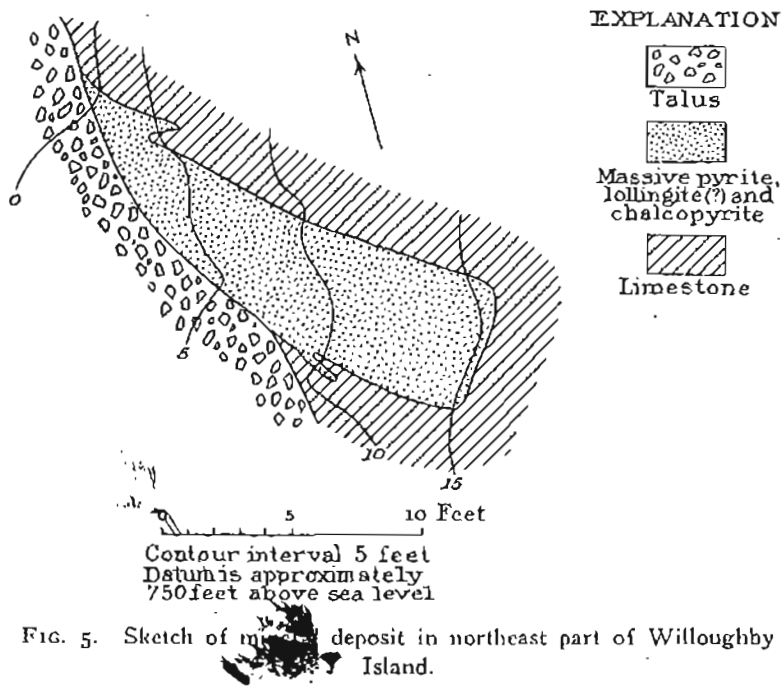

FIG. 5. Sketch of mineral deposit in northeast part of Willoughby Island.

seen in this part of the island but the place is covered with dense vegetation growing on deep forest litter and only a little rock was seen.

The deposit is exposed over an area about 15 feet long and 5 feet wide and for a height of about 15 feet (Fig. 5). One end terminates abruptly against limestone but the other end is covered with talus. The deposit is composed almost entirely of massive metallic minerals among which were recognized pyrite, an arsenic-

bearing mineral that may be lollingite, and subordinate chalcopyrite. The gold and silver content of the deposit is not known.

According to John Johnson, a fox rancher on Willoughby Island, at least 3 other similar deposits are known on the island. Johnson describes an open cut which must be near the deposit found but a search for it was unsuccessful. The cut is said to be in massive sulphides and to be about 30 feet long and 5 feet wide. In a small valley in the same vicinity Lester Rink is said to have prospected a 3-foot zone of massive sulphides.

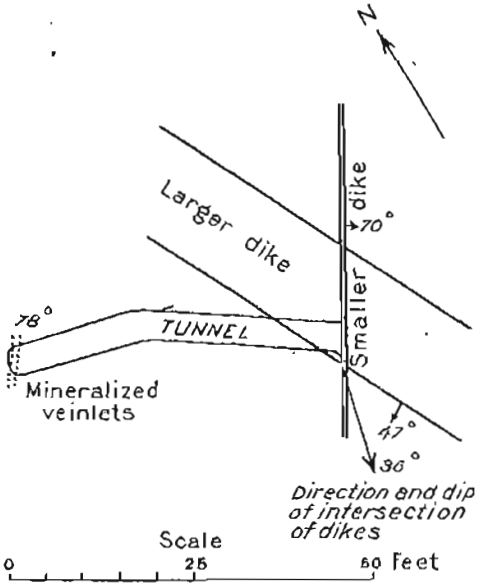

FIG. 6. Geologic sketch of prospect on Willoughby Island.

On the southwest side of Willoughby Island a little prospecting has been carried on. The prospect lies about 1¼ miles south of the northwest point of the island and about 450 feet above the beach. When visited in 1936 the prospect was not being worked and ladders and cables used to reach it were in disrepair.

The country rock is marble. The marble in the vicinity is cut by lamprophyre dikes, two of which intersect at the prospect (Fig. 6).

A thin section of one of the dikes is made up principally of lath-shaped crystals of andesine with considerable chlorite, quartz, pyroxene, and magnetite, and with a little calcite. The larger dike is 9 feet thick and trends N. 25° W. It dips 48° S.W. The smaller is 1 foot thick, strikes N. 31° E., and dips 70° S.E.

A kidney of rich ore is said to have been mined from the intersection of the two dikes at the surface. A tunnel about 50 feet long has been driven westward from that place but it apparently encountered little ore. Sulphides were observed in joints in the marble and along both contacts of both dikes, for a considerable distance away from the intersection. Clearly the mineralization is related to the dikes. Prospecting toward the S.W. and downward along the intersection of the 2 dikes might be justified.

Chalcopyrite, pyrite, and tetrahedrite are readily recognizable in the sulphide kidneys along the dikes. Another metallic mineral has not yet been identified. Buddington [9] records 25% lead, 25% antimony, 1.74 ozs. gold, and 42 ozs. silver per ton, in ore from this place. It is not clear whether this was reported to Buddington or was the metal content of samples actually collected by him. He also reports jamesonite from the northwest side of Willoughby Island, probably from the same place.

West Side of Glacier Bay South of Berg Bay (9).

Several claims were staked many years ago at an altitude of about 1,200 feet on a mountain, locally called Observation Mountain, on the west side of Glacier Bay south of Berg Bay and about half way between Berg Bay and Pt. Carolus. This place is about 1 mile from the shore but about 2 miles by an old, overgrown trail. The claims, which are reported to be now abandoned, constitute the Alaska Chief property.

The principal country rocks are marble and a contact rock consisting mostly of zoisite and epidote, with some chlorite and calcite, and a few thin veinlets of quartz and calcite. The marble contains considerable quantities of chlorite, orthoclase, and quartz. A little quartz monzonite was seen and the presence of a large body of intrusive rock in the vicinity is pointed out by the

[9] Buddington, A. F.: *Op. cit.*

Wrights[10] who visited the claims in 1906 and who say "The workings are . . . at the contact of a large diorite mass intrusive into calcareous argillites and cherts." The marble and contact rocks are locally thin bedded. The general strike is about N. 75° W. and the dip is 30° S.

Mineralization consists of replacement of marble and contact rock by sulphides. The calcareous beds appear to be more completely replaced than the epidote-zoisite rock. Replacement is widespread, intense, and locally nearly complete over a stripped area about 200 feet by 75 feet (Fig. 7). Less intense replacement by sulphides appears to extend over a much wider area.

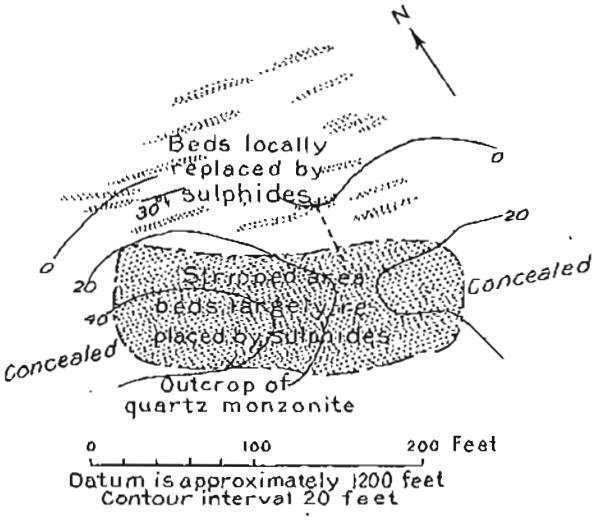

FIG. 7. Sketch of Alaska Chief prospect.

In the stripped area the sulphides are partly oxidized to limonite and copper carbonates are common. A tunnel, 40 feet long, below the stripped area encounters unoxidized sulphides. A tunnel 130 feet long mentioned by the Wrights was not found in 1936. Sulphides that were recognized include pyrite, chalcopyrite, and pyrrhotite.

[10] Wright, F. E., and C. W.: *Op. cit.*, p. 221.

Lemesurier Island (10).

Two claims have been patented by G. H. Whitney on the southern tip of Lemesurier Island about 1 mile S.W. of J. P. Ibach's house on the shore of Willoughby Cove. The claims have been long abandoned. Old development consists of a short tunnel reported to have been driven about 1916.

The prospect is at the contact of a body of quartz diorite on the west and marble on the east. The quartz diorite is made up principally of oligoclase, quartz, and hornblende. A little orthoclase is present. Epidote and chlorite are common, and apatite and titanite are present as accessories.

The contact between the intrusive rock and the marble is exposed for a few hundred feet horizontally and about 150 feet vertically. It trends about N. 10° E. The marble appears to strike about parallel to the contact and to dip toward the east.

Between the quartz diorite and the marble is a contact zone that, where observed, ranges between 20 feet and 50 feet thick. The contact rock is hornfels that is made up of pyroxene, garnet, and quartz. Some calcite is present and locally large, well-shaped apatite crystals with pleochroic cores. Opaque minerals recognized in the hornfels are molybdenite, chalcopyrite, and graphite.

The molybdenite is commonly associated with the quartz and is found disseminated through the hornfels and locally concentrated in streaks.

Buddington [11] who examined the tunnel at the prospect says, "The tunnel starts at a point on the contact between the limestone and the garnet rock. The last 25 feet of the tunnel is in banded hornstone and quartzitic beds. At the breast of the crosscut diorite is exposed. Several pockets of garnet rock are exposed along the walls of the tunnel, but the best exposures are at the surface. Molybdenite occurs as facings along small gash fractures in the contact rock and to a lesser extent in disseminated form. In most of the rock the molybdenite is sparse but small pockets are found in which molybdenite forms several percent of the rock."

[11] Buddington, A. F.: *Op. cit.*, 1924.

Chichagof Island, between Pt. Lucan and Column Pt. (11).

Five claims, comprising the Lincoln group, have been staked on the northwestward-facing mountain slope between Pt. Lucan and Column Pt. Two of the claims are owned by M. J. Marvitz, 2 by Gardner Sullivan, and 1 by J. P. Ibach. The claims are reported to have been staked first in 1926 by Marvitz. They were abandoned in 1928 and restaked in 1932.

Development consists of 3 small tunnels, the lowest and shortest one at an altitude of 850 feet, the intermediate one, which is about 50 feet long at 980 feet, and the upper tunnel, about 210 feet long, at 1,080 feet.

The country rock from the coast to the claims and apparently beyond them higher on the mountain is schist and slate. A typical specimen is quartz-sericite schist which is largely quartz and sericite but which contains also a little biotite and plagioclase.

The rocks strike between N. 25° W. and N. 35° W. and dip from 55° to 70° N.E. In addition to their planar foliation the rocks display a distinct linear foliation, or stretching, that lies in the planar foliation and dips from 0° to 15° S.E. The rocks are cut every few feet by persistent cross joints that strike between N. 47° E. and N. 50° E. and dip between 73° and 80° N.W. The cross joints therefore bear an approximately right-angle relaship to the stretching.

Quartz veins and dikes of quartz andesite on the Lincoln group of claims occupy cross joints. Several dikes up to about 4 feet thick were observed. They were fine grained, greenish-gray, unfoliated, and porphyritic. They are largely composed of sodic andesine, chlorite, and quartz. An undetermined rock that may be part of a dike crops out at an altitude of about 1,500 feet. The rock is impregnated with pyrite and a mineral resembling arsenopyrite and is reported to carry good values. This kind of rock appears to comprise a band about 20 feet thick that dips steeply and strikes about E.

The tunnels and prospect pits expose several veins, of which the widest is about 5 feet. The veins appear to be lenticular but none are exposed for a long enough distance to furnish reliable

data for generalization. Two types of quartz are recognized by Marvitz: An early barren white quartz and a late, mineralized, glassy quartz. Free gold, pyrite, and galena were observed in some of the more heavily mineralized vein quartz.

A sample cut across a vein 2 feet thick above the upper tunnel yielded a trace of both gold and silver. Another sample from a vein 3 feet thick which outcrops at an altitude of about 850 feet indicated a gold content of 0.10 ounces per ton and a trace of silver. Marvitz reports the recovery of about ½ ounce of gold from 1 wheelbarrow full of picked ore from the intermediate tunnel. A polished section of ore from a vein on one of the claims of the Lincoln group contains grains of free gold, arsenopyrite, and pyrite. These minerals are all largely confined to dark glassy quartz in the predominant white quartz.

Chichagof Island, South Side of Lisianski Inlet (12)

The property of the Apex-El Nido Mining Co., is on the south side of Lisianski Inlet and includes about 26 unpatented claims.

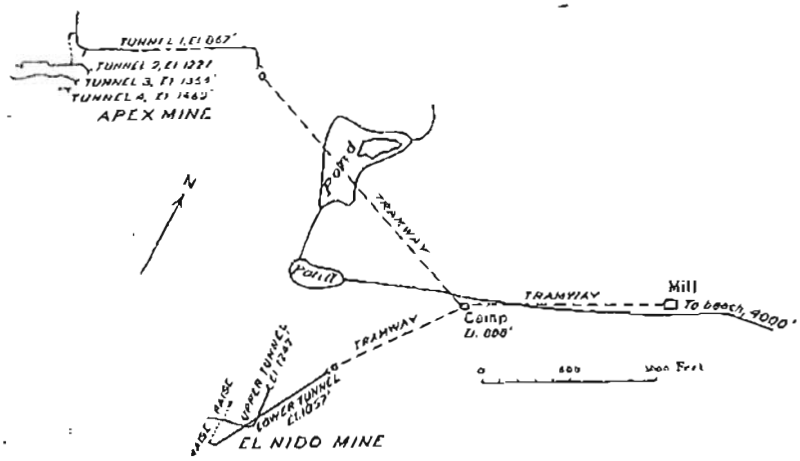

FIG. 8. Sketch of Apex and El Nido mines.

The company is controlled by Jenny R. Cann of Seattle. The principal underground development has been in two mines, the Apex and the El Nido (Fig. 8). The former is developed on 4

levels and consists of about 2,400 feet of tunnels and 1,200 feet of raises. The latter is opened on 2 levels and aggregates about 1,500 feet of tunnels and 300 feet of raises. A considerable amount of stoping has been done in the Apex mine and the ore removed is reported to have yielded about $230,000. Three small stopes in the El Nido mine are said to have produced about $10,000. Surface equipment consists of a water power plant, crusher, stamps, amalgamators, and concentrating tables, pipe lines, aerial tramways, camp buildings, and a road to the beach.

According to local reports the Apex vein was discovered in 1919 and the El Nido vein in 1920 by Jack Cann and associates. From 1920 to 1928 the property was worked by the Chichagof Mining Co. From July 1928 to 1931 the mines were not worked. In 1931 the property was optioned and some work was done by the Condor Mining Company. This company gave up its option in the fall of 1931. In 1934 and 1935 the mines were worked by a few men. Since August, 1935, the property has been shut down.

GEOLOGY.

The principal country rock in the vicinity of the Apex and El Nido mines is hornblende diorite. A thin section of one specimen is composed largely of hornblende and labradorite-bytownite. Zoisite, chlorite, pyrite or pyrrhotite, and sericite were noted also. Another section is similar except that the feldspar is andesine and a little calcite is present. Altered parts of the diorite are in places made up largely of calcite and chlorite, with remnants of plagioclase and with some leucoxene and pyrrhotite. A specimen of rock from the El Nido mine, that was thought to be part of a dike in the field, is principally crushed quartz with calcite, sericite, and pyrite. The rock is cut by many small quartz veinlets. This rock may be silicified diorite.

The Apex vein strikes about N. 60° E., and dips about 45° N.W. The vein ranges from about 5 inches to about 48 inches thick. In places the vein splits into a stockwork of branching veinlets that run in all directions. In addition to the main vein

are some small veinlets, a few inches thick, that strike about parallel to the Apex vein and which are vertical.

The El Nido vein strikes between N. 60° E., and N. 85° E., and its general dip is about 60° S.E. Its thickness ranges from about 4 inches to about 60 inches and may average about 10 inches. The vein is banded and appears more regular and more continuous than the Apex although at most places it is not as thick.

Native gold, pyrite, arsenopyrite, and scheelite were noted, in addition to quartz in vein material from the Apex and the El Nido veins. One specimen of picked ore from the Apex mine shows numerous small grains of gold in cracks in large crystals of pyrite. Another contains abundant arsenopyrite in veinlets that traverse the quartz vein parallel to its walls. A polished section of ore from the El Nido vein contains a grain of free gold and a large amount of arsenopyrite in cracks in the quartz. Assay maps of both veins indicate that the values are widely different at different places but may average about an ounce of gold to the ton.

Buddington and Chapin[12] have noted the scheelite at the El Nido mine as follows: "At the Apex-El Nido property the scheelite occurs in disseminated form in high-grade gold quartz veins associated with arsenopyrite and also in a shoot of solid scheelite 5 inches wide in a quartz stringer."

SUMMARY AND CONCLUSIONS.

It has already been pointed out that most of the deposits examined appear to be genetically related to bodies of granitic rock that were intruded probably in Upper Jurassic or Lower Cretaceous time. Exceptional deposits appear to be directly related to lamprophyre dikes which are younger than the granitic rocks. These exceptional deposits include the following: The small kidneys of chalcopyrite and pyrrhotite in calcite, and the silicious contact rocks that contain pyrrhotite, pyrite, and arsenopyrite

[12] Buddington, A. F., and Chapin, Theodore: Geology and mineral deposits of southeastern Alaska. U. S. Geol. Survey. Bull. 800, p. 330, 1929.

along dikes east of Reid Glacier (4); the bodies of mixed pyrite, pyrrhotite, chalcopyrite, and covellite on the Marble Islands (6); possibly the pyrite-lollingite (?)-chalcopyrite masses in the northern part of Willoughby Island (8) although no lamprophyre dike was found there; and the chalcopyrite-pyrite-tetrahedrite-jamesonite (?) deposit on the southwest side of Willoughby Island (8).

The relationship between the granitic rocks and the ore deposits in southeastern Alaska has long been recognized. Buddington and Chapin [13] go further to say: "Accepting this generalization concerning origin as valid, we face the question whether a particular type of mineralization is prevalently associated with a particular type of mode of occurrence of igneous rock; or with a particular type or stage of differentiation of the magma; or with a particular type of country rock that has certain specific characters, chemical or physical, or both; or with a particular environment of temperature and pressure; or whether it is dependent upon two or more of these factors to varying degrees."

The degrees to which these factors were important in the formation of the mineral deposits of Glacier Bay and vicinity are not yet known and will not be known until much more detailed geological work is done.

Most of the deposits examined appear to belong to types formed at intermediate temperatures at considerable depths below the earth's surface. Some, for example, the contact molybdenum deposit on Lemesurier Island (10), were probably formed at high temperatures.

The deposits examined include both fissure veins and deposits formed by replacement at or near contacts of granitic masses. Some fissure veins are in the granitic rock as at Reid Glacier (4), others are in older sediments as on Chichagof Island between Pt. Lucan and Column Pt. (11).

One of the most outstanding features of the deposits is the unusual diversity of metals present in different deposits that are

[13] Buddington, A. F., and Chapin, Theodore: Geology and mineral deposits of southeastern Alaska. U. S. Geol. Surv. Bull. 800, p. 374, 1929.

not widely separated. The metals represented include iron, copper, nickel, gold, silver, lead, zinc, tungsten, and molybdenum. Why similar intrusive rocks should develop such diverse types as pyritic contact deposits with a little chalcopyrite at some places, such as Sandy Cove (5) and along the north shore of Reid Inlet (3) and contact deposits characterized by pyroxene, garnet, and molybdenite at other places such as on Lemesurier Island (10) is not known.

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