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DEPARTMENT OF THE INTERIOR

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CHARLES D. WALCOTT, DIRECTOR

THE

JUNEAU GOLD BELT, ALASKA

BY

ARTHUR C. SPENCER

AND

A RECONNAISSANCE OF ADMIRALTY ISLAND, ALASKA

BY

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THE JUNEAU GOLD BELT, ALASKA.

By Arthur C. Spencer.

INTRODUCTION.

FOREWORD.

Systematic investigation of the mineral resources of Alaska by the United States Geological Survey began in 1898. Much of the region being practically unknown, explorations and general reconnaissances had first to be made, and it was not until 1902 that the demand for general information concerning different portions of the Territory was sufficiently satisfied to permit making plans for detailed investigations similar to those in progress in the States. In the summer of 1902 Mr. W. J. Peters was detailed to make a topographic map of the vicinity of Juneau, and in 1903 Mr. Arthur C. Spencer, assisted by Mr. Charles W. Wright, took up the study of the geologic formations and the ore deposits of the region. In addition to the investigation of the area covered by the detailed map, a geologic reconnaissance was made of the accessible portions of the mainland from Port Houghton northward to the head of Chilkat River, and all the important mining camps of the belt were visited. Unpublished topographic maps prepared by the Canadian Boundary Commission were available and facilitated the plotting of the general distribution of the rocks throughout the belt traversed. The present report upon the work of this field season is accompanied by topographic and geologic maps of the vicinity of Juneau, and of a mainland strip extending approximately 200 miles along the coast. A topographic map of Admiralty Island has been compiled by Mr. Wright, and studies pursued by him during the summer of 1904 form the basis of the geologic map of this large island.

A description of the Porcupine placer district by Mr. Wright has been issued by the Survey [a], and preliminary papers upon the general region and upon the Treadwell mines have been published by the writer.

Acknowledgment is due the mining fraternity of the region for many courtesies, and the writer is especially indebted to the management of the Treadwell mines for facilities extended during the examination of these properties, and to Mr. William Ebner, of Juneau, for cooperation and historical data.

LITERATURE.

A general résumé of the scientific writings which touch more or less specifically upon the geology of southeastern Alaska will be found in the report upon the Ketchikan mining district by Mr. Alfred H. Brooks. Among these the following have been consulted in preparing this report:

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.

Dawson, G. M. Geological record of the Rocky Mountain region in Canada. Bull. Geol. Soc. Am., vol. 12, 1901, pp. 57-92.

[a] Wright, C. W., The Porcupine placer district, Alaska: Bull. U. S. Geol. Survey No. 236, 1904.

BECKER, G. F. Gold fields of southern Alaska. Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 1-86.

BROOKS, A. H. The Ketchikan mining district, Alaska. Prof. Paper U. S. Geol. Survey No. 1, 1902.

GARSIDE, G. W. Trans. Am. Inst. Min. Eng., vol. 20, 1893.

GILBERT, G. K. Glaciers of Alaska. Harriman Alaska Expedition, vol. 3, 1904.

EMERSON, B. K. Notes on the stratigraphy and igneous rocks. Harriman Alaska Expedition, vol. 4, 1904, pp. 11-66.

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SPENCER, A. C. The Juneau gold belt, Alaska. Bull. U. S. Geol. Survey No. 225, 1903, pp. 28-42.

SPENCER, A. C. The Treadwell ore deposits. Trans. Am. Inst. Min. Eng., October, 1904, p. 32; Bull. U. S. Geol. Survey No. 259, pp. 69-87.

SPENCER, A. C. Pacific mountain system in British Columbia and Alaska. Bull. Geol. Soc. Am., vol. 14, pp. 117-132.

WRIGHT, C. W. The Porcupine placer district, Alaska. Bull. U. S. Geol. Survey No. 236, 1904.

HISTORICAL SKETCH.[a]

Prior to the possession of Alaska by the United States in 1867 there had been no gold mining in the Territory. Some old Russian records show that small amounts of the metal had been observed in various localities, though it was not believed to be of commercial importance. In these early years the greater part of the abrupt mountainous belt of southeastern Alaska was known only to the native Indians and a few fur traders.

The auriferous gravels at the head of Stikine River were probably the first gold discoveries in this general region. They were found in the early part of the sixties. During that decade many miners went to the newly discovered Cassiar gold district, on the Canadian side of the international boundary. In 1869 Mix Sylva and other disappointed Cassiar miners traveled northward from Fort Wrangell and made placer discoveries at Windham Bay and on Powers Creek at Sumdum Bay[b]. It is reported that $40,000 was extracted from these placers in 1870-71. This represents the first gold production from Alaska.

At Sitka, the capital of the Territory of Alaska, situated on the west coast of Baranof Island, mining activity began in 1877, when the Lucky Chance and Stewart properties were located. On the latter property a 10-stamp mill was built in 1879, but this was long since abandoned.

In the spring of 1880 N. A. Fuller, of Sitka, on the strength of a favorable report by John Muir,[c] relating to the mainland of southeastern Alaska, sent Joe Juneau and Richard Harris to investigate the coastal belt between Windham Bay and Sullivan Island. These two prospectors, with three Indians as guides and packers, arrived at Windham in May. Though they located and recorded several quartz veins, they were not encouraged by their discoveries here and continued prospecting along the coast to Gold Creek, where they arrived the middle of August. Here they found not only rich gravels, but near the mouth of the creek, specimens of quartz float containing free gold. Following up the stream and crossing the ridge at the head of Snowslide Gulch to Silver Bow basin, they discovered auriferous quartz in place. From these ledges, at present the property of the Alaska-Juneau Company, they carried away nearly 1,000 pounds of ore and, after staking both placer and quartz claims, returned with it to Sitka early in November. This strike caused great excitement, and November 26 a party of thirty started for Gold Creek, where they arrived December 6. Numerous locations were made that winter and, though the hills were deeply covered with snow, the small colony continued to grow and founded the present town of Juneau.

The spring and summer months of 1881 showed much activity in this new gold field and the entire region was prospected. Among the numerous locations made were the Treadwell group of claims and most of the Gold Creek mines now under development. In the autumn of 1881 the population of the village numbered over 100. It was first called Rockwell and later Harrisburg, but at a miner's meeting held December 14, 1881, it was voted to rename the town in honor of the elder of the two discoverers of the district. The record of this meet-

[a] By C. W. Wright. For notes on the early history of mining in the Juneau district, see Rept. Director of the Mint, on Production of Precious Metals for calendar year 1882, Washington, 1883; also Population and resources of Alaska, Eleventh Census, 1890, pp. 47-49, 230-235.

[b] Statement of Eugene Owens, mine owner and operator at Sumdum, Alaska.

[c] San Francisco Evening Bulletin, January 10, 1880.

ing shows that 72 men were present. Later the "Harris mining district," was so named after Juneau's partner, Richard Harris, at that time recorder of the district. The foregoing data were secured in part from Mr. Harris and in part from the early records in the recorder's office at Juneau.

The first work, both on the present Treadwell and Ready Bullion properties and on the mainland near Juneau, was that of placer mining. Evidence of the old placer workings may be seen in most of the gulches and on many of the hillsides in the Gold Creek drainage. At that time it was only natural for the prospectors to seek the quickest returns with the least initial expense and labor. Many of these miners made several dollars a day with shovel and sluice box, working on the gravel deposits in Gold Creek and tributary streams.

Juneau was in 1883 the mining center of Alaska. On Douglas Island the Treadwell claim, owned by San Francisco capitalists, was the only one thoroughly developed. Four tunnels had been run into the ledge and a large body of low-grade ore exposed. A 5-stamp mill, erected in 1882, was in operation, and several bullion shipments were made during the year. This was the first quartz mining undertaken in the district, except some small developments on the ledges of Quartz Creek in the Silver Bow district.

In regard to the discovery and original ownership of the Paris lode, or the property of the Treadwell Mining Company, several different stories are current. The only early official record[a] which we have found concerning the property is the following: "September 13, 1881. Transfer of Paris lode from Pierre Joseph Erussard (or 'French Pete'), original locator, to John Treadwell, in consideration of the sum of five dollars ($5.00)." No other conditions were stipulated. The development of hard-rock mining on the Treadwell property was greatly hindered by placer miners, who claimed the surface rights and by forcible means not only held the ground, but washed gold from the decomposed outcrops to the value of several thousand dollars.

During the succeeding years, until 1885, most of the properties now regarded as of value were located, and from 1885 to 1895 the greater part of the ground was patented and various mining companies formed. As the ore from most of the quartz mines was low in value, it required careful and economic treatment not only to win the free gold, but to save the sulphides or concentrates. Among the first mills constructed for this purpose were two on Douglas Island, the Nowell mill of 80 stamps and that of the Bear's Nest Company of 80 stamps, neither of which was ever operated.

On the Treadwell and adjacent properties, after sufficient ore had been developed to warrant the expenditure, large stamp mills were constructed. The first of these, erected in 1887 at the Treadwell mine, contained 120 stamps, and the following year 120 more stamps were added. Between 1893 and 1896 three mills—at the Mexican, Seven Hundred Foot, and Ready Bullion mines—and the new 300-stamp mill at the Treadwell mine, were built. At present 780 stamps are in operation, the Seven Hundred Foot mill, of 100 stamps, having been closed for several years.

On the mainland there are several mills of from 10 to 30 stamps on Gold and Sheep creeks. At the various mining camps from Windham to Berners Bay are mills of from 10 to 30 stamps, which will be described under the general descriptions of the mining localities (pp. 38 et seq.).

The extensive low-grade gravel deposits of Silver Bow basin were opened in 1891 by the Silver Bow Basin Mining Company. The same year this property was transferred to the Nowell Gold Mining Company, and from 1891 to the end of 1902 it was worked continually during the placer-mining season. The production of this placer alone was estimated at $416,000, and adding to this the output of smaller placers on Gold Creek would give as a total yield over $500,000.

In 1903 there were seven productive mines in the Juneau district, besides the placers of Porcupine and neighboring creeks situated farther to the northwest along the same general zone.

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[a] Book of deeds in office of district recorder.

PRODUCTION.

The mines in the Juneau belt which produced bullion during 1903 were the Alaska-Treadwell, Alaska-Mexican, and Ready Bullion on Douglas Island; the Sumdum Chief, on Endicott Arm, now worked out and abandoned; the Ebner and Alaska-Juneau mines, in Gold Creek; and the Silver Queen, in Sheep Creek. The product of these mines for the year is estimated at $2,400,000.

The total production of the Juneau belt up to January 1, 1904, is estimated at about $28,350,000, derived as follows:

Production of mines in Juneau gold belt to January 1, 1904.

Mines north of Juneau	$1,100,000
Gold Creek	2,250,000
Mines south of Juneau	1,000,000
	4,350,000
Treadwell group (in round numbers)	24,000,000
	28,350,000

GEOGRAPHY.

GENERAL DESCRIPTION.

Southeastern Alaska, or the panhandle of the Territory, extending from Portland Canal northwestward to Mount St. Elias, separates northern British Columbia from the Pacific Ocean. To the northwest this region covers part of the great mountain mass which trends parallel with the coast and culminates in Mounts Fairweather and St. Elias, while south of Icy Strait it comprises a coastal strip about 30 miles in width, together with the many islands forming the Alexander Archipelago, which is from 80 to 120 miles in width.

Both the mainland and the islands are mountainous, the general elevations back from the shore being from 5,000 to 7,000 feet, with occasional summits somewhat higher, while the usual island heights are not in excess of 4,000 feet. The Coast Range, which extends from near the northern boundary of Washington to the head of Lynn Canal, there falls behind the southward continuation of the St. Elias Range and loses its prominence as a distinct range. Throughout its length it forms a continental rim 100 miles in width in the lower latitudes, but somewhat less along its northern half. The range has no distinct crest line, but is an aggregate of mountain masses separated irregularly by deep valleys, the general summit level representing more or less closely the surface of an elevated plateau out of which the present topographic features have been carved by erosion.[a]

The islands of the Alexander Archipelago are separated from the mainland and from each other by usually narrow and often deep channels, while steep-walled fiords penetrate the mountains both of the mainland and the islands. Two large rivers, the Stikine and Taku, cross the portion of the Coast Range north of Portland Canal, and several other waterways penetrate beyond the center of the mountainous belt. These, with their tributaries and the shorter secondary streams flowing directly into the inland passages, together with the numerous narrow fiords, dissect the uplifted region in a very intricate manner, producing a rough topography and an extremely irregular coast line.

The region here designated the "Juneau gold belt" includes a section of the mainland strip of southeastern Alaska lying between Port Houghton and the head of Lynn Canal and extending diagonally to the headwaters of Chilkat River. It lies between 57° and 60° north latitude and extends diagonally from longitude 131° to beyond 136° west.

Admiralty Island, lying opposite the Juneau belt, is one of the larger islands of the Alexander Archipelago. It is a mountainous mass of very irregular outline separated from the mainland by Stephens Passage and from Baranof and Chichagof islands by the channel known as Chatham Strait.

[a]For a general discussion of the physiographic features of the region the reader is referred to a paper entitled "The Pacific Mountain System in Alaska," by Arthur C. Spencer, in Bull. Geol. Soc. Am., vol. 14, 1903, pp. 117-132.

TOPOGRAPHY OF THE JUNEAU BELT.

TOPOGRAPHIC MAP.

The accompanying map (Pl. XXXVI, in pocket) of the mainland from Port Houghton to the international boundary at the head of Chilkat River includes also the peninsula between Lynn Canal and Glacier Bay. With a few minor corrections, it is taken from the lithographed sheets made under the direction of the Canadian boundary commission of 1902.

The maps as originally printed are on the scale of 1 : 160,000 or about 2.8 miles to the inch, but for the present purpose they have been reduced to the scale of 1: 250,000, or about 4 miles to the inch. Upon this scale they give a good representation of the topography and afford an adequate base for showing the distribution of the geological formations. The contour interval is 250 feet, each 1,000-foot line being printed heavier than those intervening. Summit elevations are marked in figures. The delineation of glaciers and ice fields has been found as correct as is warranted by the scale of the map. The accuracy of the work, which may be judged by a comparison of the detailed map of the vicinity of Juneau, is a credit to the topographers who executed it and speaks well for the photographic method of survey which they employed.

MOUNTAINS.

The Juneau belt has the mountainous character which marks the whole of the coastal region throughout British Columbia and Alaska. The higher mountain summits reach an elevation of 5,000 to 7,000 feet, while occasional mountains rise 1,000 feet or more above the general level. Viewed from any high point the general effect of an elevated plateau is given by the common height of neighboring ridges and summits and the absence of dominating peaks. Almost invariably the mountains rise abruptly from the water's edge and heights of from 2,500 to 3,500 feet are common within a mile or so of the coastwise passages (Pl. I). Next to the long fiords which penetrate the range the declivities are even sharper and elevations above 5,000 feet are common in the promontories between neighboring inlets. For instance, in an area measuring 12 by 20 miles in the peninsula between Endicott Arm and Port Houghton the general summit level on the south and east is above 4,700 feet, and two mountains rise above 5,000 feet. On the inland side of Endicott Arm the elevation of the mountain tops is generally above 6,000 feet, rising somewhat as distance is gained from salt water. An exceptional height is seen in Mount Sumdum, which, though bathed on three sides by tidal channels, rises to 6,690 feet.

The region between Tracy Arm and Taku Inlet is intricately dissected by ramifying but close-spaced valleys, yet beginning about 6 miles from Stephens Passage the average elevation of the summits is more than 4,500 feet, and within 20 miles it exceeds 5,000 feet. This latter altitude is often attained within 2 miles of valleys which are cut practically to sea level.

Beyond Taku Inlet as far as Berners Bay elevations near the shore vary in general from 2,500 to 3,500 feet. The latter figure is approached on Douglas Island and somewhat exceeded within a mile of Gastineau Channel, near Juneau. In this district the majority of summits rise above 5,000 feet within 10 miles of the coastwise channels, and where farthest removed from tide water often exceed 7,000 feet.

Opposite Lynn Canal the mountains rising from the shore attain heights above and just below 6,000 feet, and with occasional higher peaks the general elevations of the range rise in the direction of Taiya Inlet, so that east of Skagway many summits are above 6,600 feet. Somewhat greater heights are attained about the headwaters of the rivers radiating from the head of Lynn Canal, but the general surface falls toward Icy Strait, until between Glacier Bay and Lynn Canal many summits lie near 5,000 feet.

INSIDE PASSAGES AND FIORDS.

From Puget Sound, Wash., to Skagway, Alaska, the coast is fringed by islands, back of which a continuous series of navigable channels affords a steamer route protected from the open ocean. This inside passage, though subject to dangers of its own incident upon narrow channels and tidal currents, greatly increases the safety of coastwise travel. The track commonly followed lies close to the mainland and from it all parts of the islands are easily accessible by way of the deep intervening channels; on the land side a multitude of navigable fiords variously known as canals, arms, inlets, bays, or ports afford waterways to points far within the coast range. These deep and narrow fiords penetrate the mainland for from 10 to 30, and in a few instances over 100 miles. Portland Canal, 100 miles in length, is followed by the international boundary and, though diagonal to the trend of the mountains, practically crosses the Coast Range.

Within the Juneau belt thirteen indentations, including the branches but not the main channel of Lynn Canal, afford waterways of an aggregate length of about 150 miles, in addition to the 160-mile stretch of Lynn Canal, Stephens Passage, and Frederick Sound. The largest two of these northern fiords are Lynn Canal and Taku Inlet. The former has a length of 90 miles, giving a short approach to the Yukon basin by way of White Pass; the latter extends 25 miles inland from Stephens Passage to the mouth of Taku River.

Besides furnishing transportation to otherwise inaccessible localities and thus facilitating the development of mineral deposits, several of these inlets afford salmon fisheries, and canneries are located on Taku and Chilkoot inlets.

DRAINAGE.

Within the Juneau belt the Coast Range water parting lies from 15 to 50 miles back of Stephens Passage and Lynn Canal, but the various inlets mentioned above reach into the heart of the range, so that its distance from tide water is seldom 20 miles and is usually much less. These arms of the sea are often longer than the streams which drain into them.

The map shows more than 150 streams 2 miles or more in length emptying directly into tide water. Of these fully 80 per cent are less than 10 miles long from mouth to head, and out of 27 of the longer streams only 13 reach a length of 18 miles or more, though these large streams drain about two-thirds of the total area.

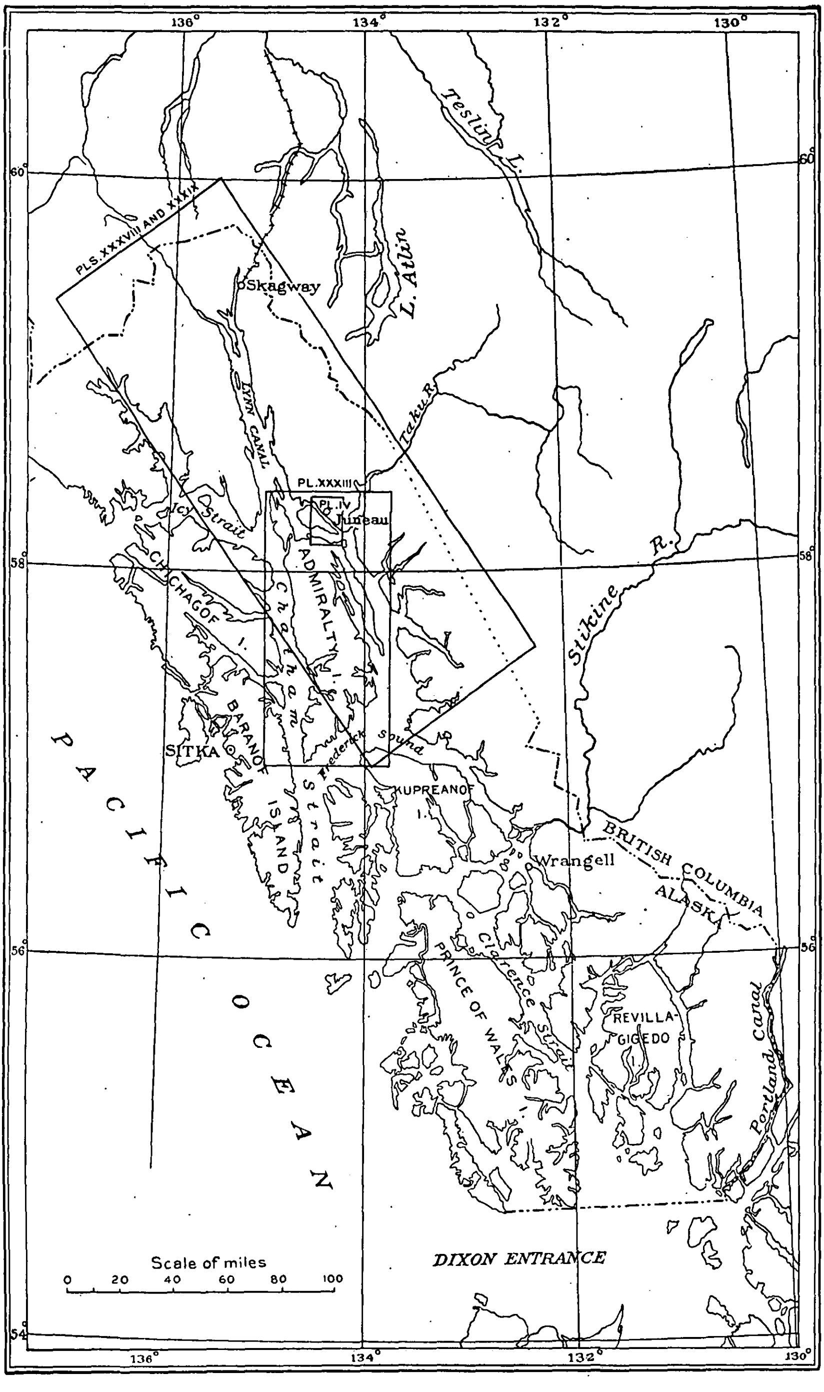
GLACIERS.

All of southeastern Alaska shows evidence of former general glaciation, and there still remain many isolated glaciers and several good-sized snow fields. In the Juneau belt the most extensive collecting grounds are those lying back of Endicott Arm and north of the Taku between that river and Lynn Canal. From these there are many valley and hanging glaciers, but the only ice streams which reach tide water are Dawes Glacier, at the head of Endicott Arm; two glaciers at the head of Tracy Arm; and Taku Glacier, near the upper end of Taku Inlet. However, as shown by the map, there are several others with fronts reaching nearly to salt water.

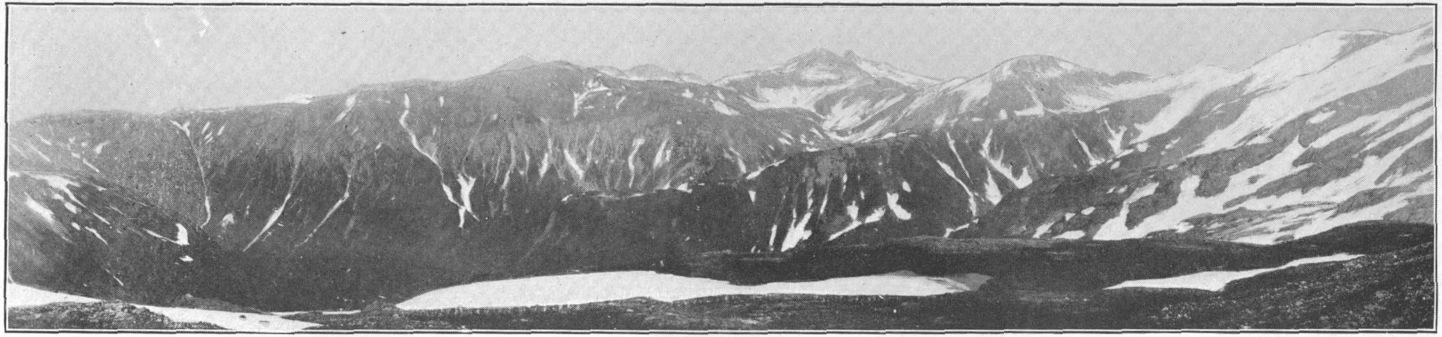
During each winter masses of ice and snow accumulate in the heads of gulches throughout this region, and in the summer months their melting assures a more abundant and continuous supply of water in all the smaller streams, than would be maintained through precipitation alone. Without this regulation of stream volumes the water powers of the Juneau belt would have been much more limited than under existing conditions, since all the streams now utilized have very small catchment basins.

Taku River and the large streams tributary to the head of Lynn Canal have always been native routes of travel to the interior. The former has been occasionally traversed by white men, and since the Klondike excitement in 1898 the White Pass route via Skagway has been one of the main portals to the great Yukon country, its commanding position being assured by the completion of the Yukon and White Pass Railway in 1901. Chilkat River, the natural route to the Porcupine fields, is followed by the Dalton trail, which was at one time used in reaching the Yukon country.

GASTINEAU CHANNEL AND CITY OF JUNEAU.

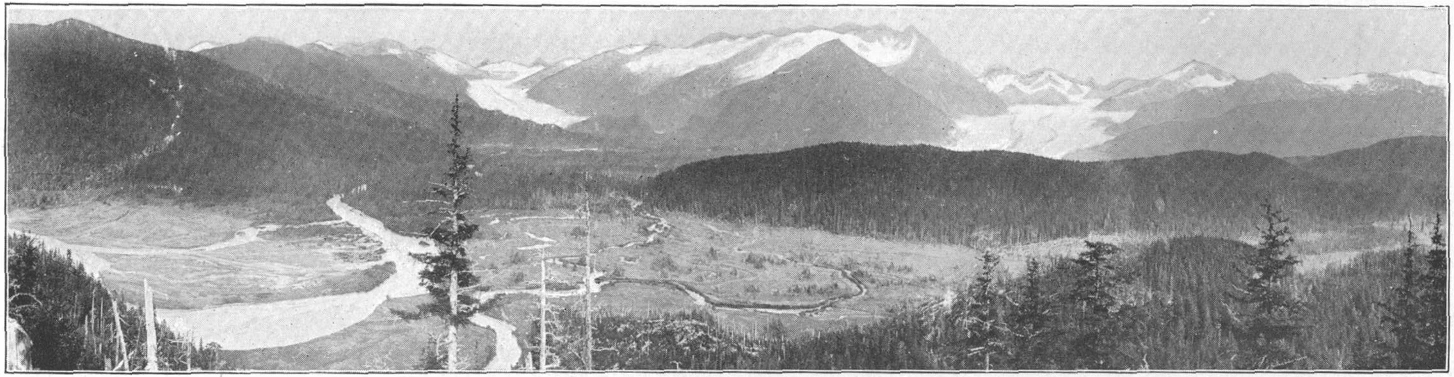


KEY MAP, SHOWING AREAS INCLUDED BY TOPOGRAPHIC AND GEOLOGIC MAPS.



A. COAST RANGE MOUNTAINS NEAR JUNEAU.

Looking north from the divide between Gold and Sheep creeks.



B. VALLEY OF EAGLE RIVER.

Looking northeast from rock ridge next to Favorite Channel. Eagle Glacier on the left and Herbert Glacier on the right.

JUNEAU MAP.

The map of the vicinity of Juneau (Pl. IV), by W. J. Peters, gives the detailed topography of Sheep, Gold, and Salmon creeks, and of the landward side and lower end of Douglas Island. The adjacent drainage of the mainland has been filled in from the map of the Canadian Boundary Commission, already described. The scale is 1:62,500, or about 1 mile to the inch. In the area mapped in detail the contour interval is 100 feet, while elsewhere 500-foot intervals are shown. The adjacent shore of Admiralty Island appears in outline.

The area covered by this topographic sheet lies approximately between longitude 134° 13′ and 134° 33′ W., and between latitude 58° 9′ and 58° 23′ N., measuring therefore about 20 minutes east and west and 14 minutes north and south.

CLIMATE OF SOUTHEASTERN ALASKA.

The following data upon the climate of the region have been compiled from the report upon the Ketchikan mining district by Alfred H. Brooks.[a]

Southeastern Alaska is characterized by mild winters, cool summers, and abundant precipitation, the maximum and minimum temperatures being 80° and—3° at Sitka and 88° and—4° at Juneau. These extremes are, however, exceptional and according to Dall the mean at Juneau is 40° and at Sitka 43.3°. The same authority gives the mean precipitation at Juneau as 67.82 inches and at Sitka as 81.69 inches.

In the Juneau district, up to an elevation of 500 feet, the greater amount of precipitation, even in the winter, is in the form of rain, so that near the shore the snow never attains any great depth. The mountains, however, are snow covered for from six to eight months, and the gulches are filled to a depth of many feet each winter.

In spite of cloudy and rainy weather, the climate is rather pleasant than otherwise. In winter a disagreeable feature, which often interferes with steamer traffic, is the occurrence of fierce land winds blowing down the fiords. These winds are known in Alaska as "woolies," which is possibly a corruption of the term williwaw, the name used for similar winds in Patagonia. When the Taku "woolie" is at its height the passage of coastwise vessels is sometimes prevented for a week or more, and though its effect is mainly concentrated opposite the inlet, its influence occasionally extends to Juneau.

The following tables, taken from the report already referred to, afford a comparison of the average temperature and precipitation for points in southeastern alaska and other regions in high latitudes:

Average temperatures in southeastern Alaska and other regions.

[In degrees Fahrenheit.]

Locality.	January.	February.	March.	April.	May.	June.	July.	August.
Wrangell	26.2	30.8	31.6	42.7	49.3	55.3	58.2	57.5
Sitka	32.9	33.6	37.1	42.1	47.6	51.9	55.1	56.4
Juneau	27.5	24.7	33.5	40.1	47.6	53.6	56.6	55.0
Killisnoo	27.7	26.8	33.1	36.9	45.6	51.6	55.2	54.4
Port Angeles, Wash	34.7	36.7	41.7	45.6	50.6	54.0	56.6	56.8
Trondhjem, Norway	27.4	26.8	28.6	37.9	45.8	53.6	57.2	56.3
Bergen, Norway	34.1	32.2	35.4	43.7	48.9	55.0	57.9	57.5
Christiania, Norway	24.1	23.9	29.5	39.9	50.9	59.9	62.6	60.6
Helsingfors, Finland	20.9	18.8	26.2	34.8	44.1	56.9	61.9	58.3
Stockholm, Sweden	33.5	29.5	33.8	39.5	52.5	57.0	59.1	59.3
Scotland	37.1	38.4	39.4	44.1	49.0	54.8	57.1	56.6
Orkney Islands	38.5	38.2	40.3	43.3	47.8	52.8	55.1	55.0

[a] Prof. Paper U. S. Geol. Survey No. 1, 1902.

Average temperatures in southeastern Alaska and other regions—Continued.

Locality.	September.	October.	November.	December.	Average.	Total temperature, May 1 to Sept. 30.	Sum of effective temperatures, May 1 to Sept. 30.
Wrangell	52.3	45.9	33.5	32.9	43.0	8,343.0	1,764.0
Sitka	52.3	46.2	38.9	35.8	44.2	8,058.1	1,479.1
Juneau	49.9	41.9	31.2	29.3	40.9	8,040.2	1,461.2
Killisnoo	47.8	41.1	33.4	30.1	40.3	7,793.2	1,214.2
Port Angeles, Wash	52.7	47.7	42.4	38.2	46.1	8,285.0	1,671.0
Trondhjem, Norway	50.0	41.1	32.7	27.5	40.6	8,046.3	1,465.3
Bergen, Norway	52.7	45.1	38.5	34.7	44.6	8,324.3	1,745.3
Christiania, Norway	52.7	41.9	32.1	25.6	41.9	8,775.1	2,196.1
Helsingfors, Finland	50.5	43.9	33.7	21.7	39.2	8,315.3	1,736.3
Stockholm, Sweden	53.6	40.6	35.6	27.3	43.4	8,615.9	2,074.9
Scotland	52.8	46.4	40.6	37.8	46.1	8,271.7	1,692.7
Orkney Islands	52.5	47.5	42.6	40.9	46.2	8,053.9	1,474.9

Average precipitation in southeastern Alaska and other regions.

Locality.	January.	February.	March.	April.	May.	June.	July.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Wrangell	3.43	5.70	2.58	3.87	3.06	3.56	3.98
Sitka	7.95	8.02	7.78	5.03	3.89	3.87	4.14
Juneau	10.59	4.80	6.49	5.25	7.36	4.99	5.25
Killisnoo	5.26	5.03	4.39	2.56	2.80	2.00	3.53
Port Angeles, Wash	4.90	3.33	2.53	1.90	1.05	1.50	.27
Trondhjem, Norway	3.36	2.28	2.52	2.20	2.32	2.48	2.56
Bergen, Norway	6.93	5.55	4.33	3.78	4.09	4.37	6.06
Christiania, Norway	1.22	.94	1.06	1.10	1.77	2.04	3.34
Helsingfors, Finland	1.47	1.20	1.16	1.39	1.67	1.72	2.09
Stockholm, Sweden	.88	.44	1.34	2.85	3.12	1.58	2.62
Scotland	3.95	3.00	2.78	2.15	2.29	2.50	3.11
Orkney Islands	4.29	3.11	2.71	1.86	1.55	2.17	2.62

Locality.	August.	September.	October.	November.	December.	Total.	Total precipitation, May 1 to Sept.30.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Wrangell	2.62	9.58	8.16	11.03	9.44	67.01	22.80
Sitka	6.67	10.94	12.96	10.77	8.52	90.54	29.51
Juneau	7.35	10.04	8.49	8.78	7.38	86.77	34.99
Killisnoo	4.80	6.39	6.92	6.43	5.84	55.92	19.52
Port Angeles, Wash	.85	2.10	2.91	3.52	5.35	29.35	5.77
Trondhjem, Norway	2.59	3.27	4.29	3.50	4.25	35.60	13.22
Bergen, Norway	6.85	8.26	8.78	6.73	7.44	69.13	29.63
Christiania, Norway	2.87	2.99	2.56	1.89	1.26	22.56	12.92
Helsingfors, Finland	2.71	2.20	2.57	2.42	1.61	22.25	10.39
Stockholm, Sweden	4.57	1.27	3.28	2.65	.69	25.22	13.16
Scotland	3.55	3.67	4.05	3.82	3.97	38.83	15.12
Orkney Islands	2.84	2.72	4.85	3.89	4.33	36.95	11.94

TIMBER AND VEGETATION.

Plant life in southeastern Alaska exhibits the luxuriance which, though commonly ascribed to the Tropics, is always attendant upon moist and not too cold climates. Growth is here especially stimulated by the long summer days of these high latitudes. The mountain slopes are commonly wooded up to 3,000 feet, and on the islands, where the summits are narrow and therefore unfavorable for the accumulation of snow, even higher areas are forest covered.

The timber trees of the region comprise yellow cedar, the Sitka spruce, white pine, hemlock, and the less valuable balsam fir, scrub pine, cottonwood, and aspens. The last two are mostly confined to the river bars. The timber laws of the Territory provide for lumbering so long as the material is consumed at home, export even to the States being forbidden. In this way this important resource is being conserved to aid in the permanent development of the region.

Shrubby undergrowth, ferns, and tall grasses grow profusely in every favorable location. The former grow everywhere beneath the forest trees, along the streams, and in areas which are snow-covered until late summer, and the latter are found wherever clearings have been made, among the alder thickets, and on muddy flats along the lower courses of certain rivers. Common shrubs are the black and white alder, the latter of which sometimes reaches a height of 30 feet or more, various willows, the thorny devil's club, elderberry, viburnum, or high-bush cranberry, service berry, and the salmon berry, the fruit of which resembles the red raspberry of the States. Mountain ash, yellow birch, vine maple, and crab apple also occur, though none of these are really common in the Juneau belt.

Above 2,000 feet and below the line of permanent snow short grasses cover all unforested slopes where soil exists, and here dwarf alpine willows and several species of heather are found. Purple lupine and many other flowering plants are also common at high elevations.

While the climate of the region offers no particular inducement to agriculture, the possibilities in this direction are nevertheless considerable. At Juneau there are several successful truck gardens, and chickens are said to do well in spite of the prevailing rainy weather. Near the mouth of Mendenhall River a dairy ranch has yielded a good living to its owner during several years, and since the homestead laws have been extended to Alaska several tracts for ranching purposes have been taken up in favorable locations along the shore between Juneau and Berners Bay.

GENERAL GEOLOGY.

GEOLOGIC FEATURES OF SOUTHEASTERN ALASKA.

GENERAL STATEMENT.

The rocks of southeastern Alaska are of many kinds, comprising sediments of various sorts, formed by marine deposition, and igneous types of both volcanic and deep-seated intrusive origin. All of the bedded rocks except those more recently formed are highly tilted or intricately folded, and they usually show a degree of metamorphism which amounts to complete recrystallization. Throughout the region the main structural lines, including axes of folding and of cleavage or schistosity, show a general parallelism, so that the older sedimentary rocks and most of the younger intrusives are disposed in bands which follow the general northwestward trend of the mainland coast and the longer dimensions of the islands which dot the Alexander Archipelago.

BEDDED ROCKS.

Outside of the intrusive core of the Coast Range the mainland of the Alaska panhandle is made up mainly of crystalline schists, slates or phyllites, and greenstones, the last-named of which have been derived from ancient volcanic flows or tuff beds. These rocks correspond in a general way with the Ketchikan series defined by Brooks in the Ketchikan district.[a] The schists lie well back from the coastwise channels; but the greenstones and phyllites, which

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[a] Prof. Paper U. S. Geol. Survey No. 1, 1902, p. 42.

occur in alternating beds of varying thickness, are readily accessible and may be found prominently developed on the Haines Peninsula, at Juneau, and on Douglas Island, on Glass Peninsula of Admiralty Island, in the Wrangell Narrows, on Etolin Island, and in the vicinity of Ketchikan.

These rocks have been regarded as mainly of Paleozoic age, with a probability that they also include Triassic strata.[a] In the Ketchikan district no fossils were found by Brooks, but Mr. C. W. Wright collected forms from limestone strata at Taku Harbor in 1903 and 1904 which show that part of the rocks in this wide zone are of Carboniferous age.[b]

While specific correlation is not yet possible, this determination strongly suggests the correspondence of the slate-greenstone band of the Juneau belt with the formations of broadly similar make-up occurring in Tagish Lake across the Coast Range from Skagway, where Carboniferous fossils are reported by Dawson.[c]

West of the slate-greenstone band a narrow belt of conglomerates, graywackes, and slates is known, from a series of outcrops, to extend from Yankee Cove, 30 miles northwest of Juneau, through Seymour Canal to the lower end of Admiralty Island. Fossils collected from these rocks show them to correspond in age with the Mesozoic Mariposa beds of California. The same formation is probably represented by the Gravina series near Ketchikan.[d] These rocks are generally, though not uniformly, metamorphosed, but, as a whole. the alteration which they have suffered is notably less than that of the Paleozoic beds.

A zone of greatly altered upper Paleozoic rocks lies outside the Mesozoic beds mentioned above. These rocks comprise marble, schist, and phyllite, intruded by various igneous masses and locally overlain with evident unconformity by moderately metamorphosed representatives of the Mesozoic strata and also by slightly disturbed Tertiary strata carrying seams of coal. Fossils found on Long Island in Kasaan Bay (east side of Prince of Wales Island), on Kuiu Island, and the west side of Admiralty Island, on the east side of Chichagof Island, and in the vicinity of Glacier Bay are now regarded by Mr. Schuchert as undoubtedly of Lower Carboniferous age, though some of the collections were originally assigned to the Devonian.[e] Dr. G. H. Girty has determined the forms collected by Mr. Wright in the Porcupine district, at the head of Chilkat River, to belong to the Upper Carboniferous,[f] and fossils of this age have been found at Pybus Bay, on Admiralty Island. (See p. 143.)

Massive beds of marble and associated phyllites, both regarded as Silurian, occupy the central portion of Prince of Wales Island, and beds lithologically similar occurring on Baranof and Chichagof islands carry Silurian fossils in certain localities.[g] Fossils of the same age are also reported from Glacier Bay, so that, although the outer portion of the archipelago is relatively unknown to geologists, there is doubtless an outer band of Silurian rocks quite as extensive and continuous as the several zones which have been mentioned above.

Beyond the western Silurian strip on the outer side of Baranof Island occur slates and graywackes, which are less metamorphosed than the formations of known Paleozoic age, but to a degree comparable with the alteration of the Mesozoic strata on Admiralty Island. The rocks in the vicinity of Sitka greatly resemble the latter, and are provisionally correlated with them by Mr. F. E. Wright, who examined the geology of the Sitka district in the summer of 1904.

Taken together, the metamorphosed bedded rocks mentioned in the foregoing paragraph correspond, from the standpoint of historical geology, with the system of highly folded and altered rocks which has been called the "Bed-rock series" by the geologists who have studied and mapped the Mother Lode district in California. In several localities these

[a] Dawson. G. M., Geol. Nat. Hist. Survey Canada, new series, vol. 3, pt. 1, 1887-88, pp. 32-33. Brooks, A. H., Prof. Paper U. S. Geol. Survey No. 1, 1902, p. 22.
[b] This locality was also visited in 1905 by Messrs. C. W. Wright and E. M. Kindle.
[c] Geol. Nat. Hist. Survey Canada, new series, vol. 3, pt. 1, 1887-88, pp. 32-33.
[d] Brooks, op. cit., p. 45.
[e] Brooks, op. cit., pp. 20-23.
[f] Bull. U. S. Geol. Survey No. 236, 1904, p. 16.
[g] P. 143.

metamorphosed formations are overlain by gently folded and entirely unmetamorphosed strata of lower Tertiary age, consisting of sandstone and shale with accompanying seams of coal. These, with certain recent lava flows which covered them locally, as on the lower end of Admiralty Island, correspond with the "Superjacent series" of the Sierra Nevada. These terms, however, are not employed in the following pages.

STRUCTURE.

The structure of southeastern Alaska is very similar to that of western British Columbia and of the Sierra Nevada in California. The strike of the rock bands and the slaty or schistose structure is generally from northwest to southeast, parallel with the trend of the Coast Range. Along the mainland and in general within 10 or 15 miles of the main intrusive belt of the coastal mountains the prominent structures, including bedding, cleavage, and intrusive contacts, dip toward the northeast, but outside of this zone the dips change constantly, revealing the presence of alternating anticlines and synclines. However, the axial trend of the folds, even in this outer region of the archipelago, corresponds with the general northwest direction of the topographic features and of the wide rock bands which have been noted.

INTRUSIVE ROCKS.

The principal intrusive rocks of southeastern Alaska are diorites, which invaded the field after the Lower Cretaceous rocks were deposited and folded. Many masses of this rock were intruded in different parts of the region, and it occupies extensive areas on most of the islands of the Alexander Archipelago. Its greatest development, however, is in the Coast Range, where it occupies a zone 50 to 80 miles in width, which is continuous from lower British Columbia at least to the head of Lynn Canal and probably well into the drainage of Alsek River beyond.

Other intrusives of frequent occurrence, but of less areal importance, are gabbro, diabase, andesite, etc., the relations of which are almost unknown outside of a few limited areas.

GEOLOGY OF THE JUNEAU BELT.

GENERAL STATEMENT.

In the Juneau belt as defined in this report only the highly disturbed and metamorphosed sedimentary rocks of the general region are found, though large areas are occupied by intrusive diorites, and there are minor occurrences of other invading igneous rocks. The distribution of the various rocks in nearly straight parallel bands, following the general northwest trend of the coast, and the persistence of dips toward the continent are the most prominent structural features of the belt.

Two geologic maps accompany this report, Pls. IV and XXXVII, in pocket. One shows in considerable detail the areal distribution of rock types near Juneau; the other indicates the more general areal relations of the rocks throughout the Juneau belt.

Geologic studies in southeastern Alaska have not progressed to a point where any final classification of the sedimentary rocks into formations is possible. The maps here presented are, therefore, not formation maps strictly comparable with those which have been made in better-known regions, but are lithologic or rock maps showing the distribution of different rock types or groups of types which can not be conveniently separated upon the cartographic scale adopted.

MAP OF THE JUNEAU GOLD BELT.

On the general geologic map, scale about 4 miles to the inch, the distribution of four rock bands has been represented (Pl. XXXVII). The first of these bands, on the northeast, is the Coast Range intrusive complex, which forms the great central mass of the mountains extending into British Columbia. The same sort of rock also occurs in a few outlying masses.

The second band is composed of highly metamorphic crystalline schist, which contains some intrusions of diorite and of gabbro. This schist has been traced from the head of

Endicott Arm, where it occupies a zone 8 miles wide, to a point 30 miles above Juneau, where it is cut out by the slightly diagonal boundary of the main diorite. Opposite Juneau the band is about 2 miles in width, and this is about its average measure.

The third division is a band of slate, or phyllite, lying outside of the schist. It has an average width of about 1 mile and extends parallel with the general coast line from the southern edge of the area mapped to a point 3 or 4 miles south of the northern termination of the schist, where it is likewise cut out by the diorite. As in the case of the schist, this rock also probably includes many dikes of altered gabbro, as is shown in the more detailed map.

The fourth band is composed of altered slate and greenstone, which form the outer mountains of the mainland and extend also to the neighboring islands, including Glass Peninsula, on the west side of Stephens Passage. The mainland portion of this division is nowhere more than 8 miles in width, but the whole width of the band is nearly double this figure.

The third or black-slate band is associated with the slate-greenstone series from which other bands of slate could be separated by more detailed work; but the representation of this zone is of importance, because its outcrop is followed by the main system of quartz veins of the district. The slate-greenstone division has been traced as far north as Haines Peninsula, and probably continues along the northeast side of Chilkat River for some distance, until it is cut off by the edging over of the main diorite contact.

The rocks of Admiralty Island are described in Mr. Wright's report (see p. 139), and the formations which occupy the region between Muir Glacier and Lynn Canal are supposed to correspond to part of these, especially since the rocks occurring along the same trend in the Porcupine district, at the head of Chilkat River, correspond with some of those which have been found on this island.

MAP OF THE VICINITY OF JUNEAU.

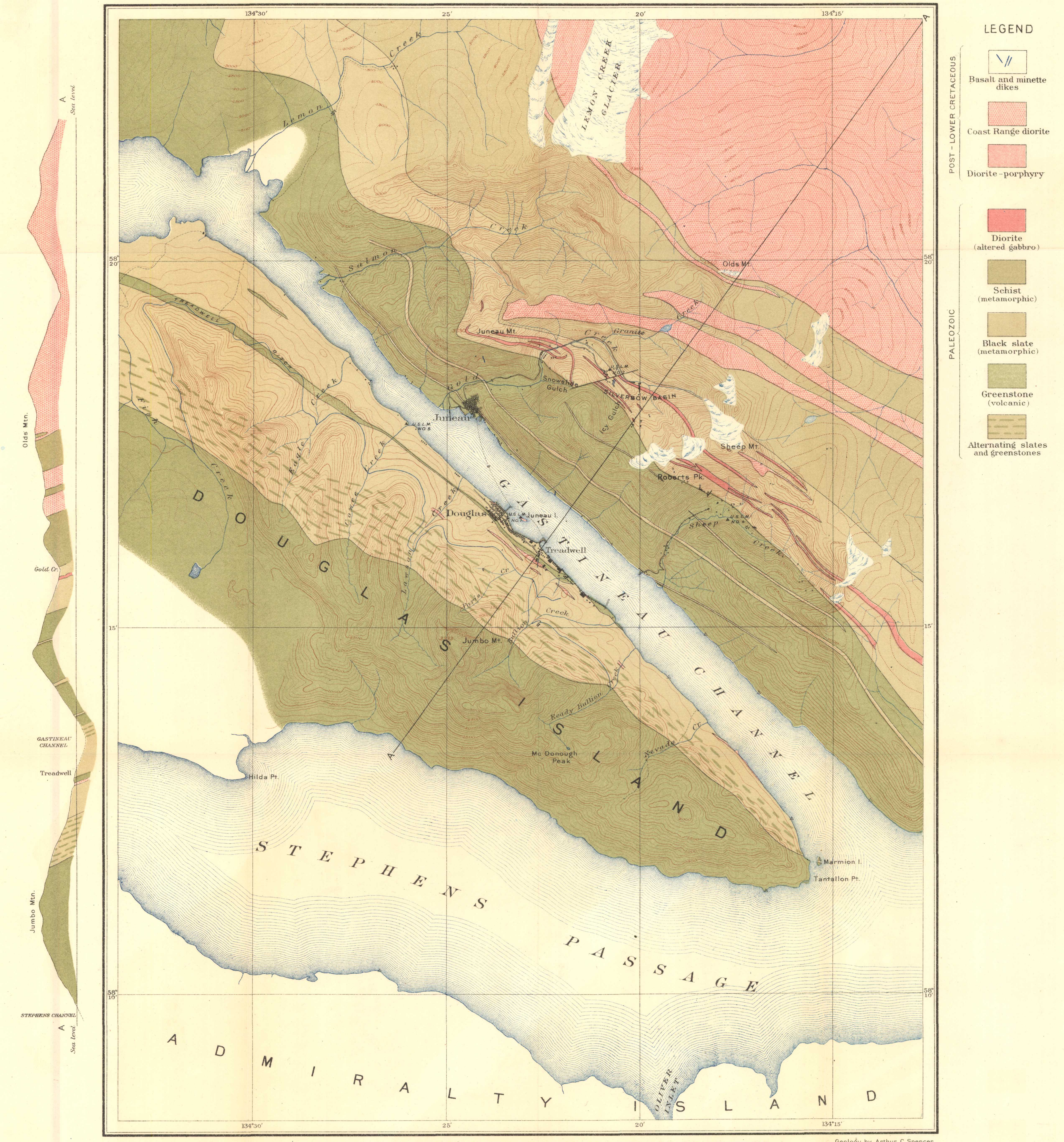
The base of this sheet is the detailed topographic map drawn on the scale of about 1 mile to the inch. The distribution of five types of rock which have been recognized is indicated by distinct colors or patterns, the meaning of which is shown in the key which accompanies the map (Pl. IV).

Beginning on the northeast there is an area covered by the seaward edge of the Coast Range intrusives. This is followed by a 2-mile band of metamorphoric schist, beyond which there comes a band from one-half to 1 mile in width composed of carbonaceous slate. These metamorphic rocks are penetrated by many parallel dikes of green rock which, though now having the mineralogical composition of diorite, is really metamorphosed gabbro. Dikes of this sort have been mapped only in the southeastern part of the black-slate strip, though they are also known to be present in the valleys of Salmon and Lemon creeks. This band of black slates and diorite dikes carries a complex of gold- and silver-bearing quartz veins which in the present report is described as the main lode system.

Between the black slates and Gastineau Channel the principal rock is bedded greenstone and greenstone schist, but with this volcanic rock there are intercalated strata of slate, the distribution of which is shown so far as determined.

The northeast or mainland side of Douglas Island is mainly underlain by black slates occurring in a zone about 2 miles in maximum width. These beds, however, include some intercalated bands of greenstone, and near the Treadwell mines they are intruded by a series of irregular dikes of dioritic rock related to the intrusives of the Coast Range. A dike of diorite-porphyry also occurs along the shore near the lower end of the island.

The middle slopes of the mountains are formed by alternating black slate and greenstone schist constituting a band nearly 1 mile wide, while within the area represented by the map the mountain summits and the slopes to Stephens Passage are formed by massive bedded greenstones.



R. U. Goode, Geographer in charge
Triangulation by U.S. Coast and Geodetic Survey
Topography by W. J. Peters
Surveyed in 1902

GEOLOGIC MAP OF THE VICINITY OF JUNEAU, WITH CROSS SECTION

Geology by Arthur C. Spencer
and C. W. Wright
Surveyed in 1903

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 miles

1 ½ 0 1 2 3 4 5 kilometers

Contour interval 100 feet

Datum is mean sea level

1905

JULIUS BIEN & CO. LITH. N.Y.

GEOLOGIC STRUCTURE.

The occurrence of the different rocks of the Juneau belt in bands which strike from southeast to northwest parallel with the general trend of the navigable coastwise passages is well exhibited on the geologic maps. This distribution expresses a broad simplicity of structure which seems to extend throughout southeastern Alaska and is like that of the Sierra Nevada in California as the structure of the latter region is described and illustrated in the geologic folios of the Geological Survey.[a]

In the Juneau belt original bedding as a rule, slaty cleavage without exception, and the majority of intrusive contacts all follow this southeast-northwest strike of the country, and structure surfaces, wherever they are clearly discernible, dip toward the northeast. The effect is as if the rocks had received a monoclinal tilt toward the northeast, though this interpretation can not be accepted without reservation, in view of the lack of any general knowledge of the sort of folding which exists in southeastern Alaska. (See cross section, Pl. IV.)

Within the Juneau belt there seems to be on the whole very little plication of the rocks, the only cases of such structure noted being in the band of black slates which traverses Gold and Sheep creeks. It is possible, however, that crumpling such as is observed in many regions of intense metamorphism exists to a greater extent than has been recognized, and will eventually be found to explain the great apparent thickness of the bedded rocks in the Juneau belt. If we accept the structure as that of a simple monocline, the bedded rocks between the diorite boundary back of Juneau and the outer side of Douglas Island would have an aggregate thickness of over 7 miles, which is an improbable figure.

The inclination of the structure varies from place to place along the belt. In the southern portion the dips are from 30° to 40°; north of Taku River they pass beyond the vertical, and are slightly overturned for a stretch of several miles, returning to about 60° in the vicinity of the Sheep Creek mines and in Gold Creek. From Juneau Mountain to Mendenhall River the attitude of the beds is flatter, beyond which point as far as Lynn Canal they are inclined from 40° to 60°.

THE ROCKS AND THEIR OCCURRENCE.

COAST RANGE INTRUSIVES.

DESCRIPTION.

The diorites of the Juneau belt have not been studied in detail under the microscope, with the exception of those from the immediate vicinity of Juneau. Here several distinct but related types are found, in all of which plagioclase of a variety near oligoclase is an essential constituent. Hornblende is the most usual dark mineral, though its place may be entirely taken by biotite; frequently, however, both of these minerals occur together. Quartz is commonly present in small amounts and in rare instances exceeds the feldspar. Common accessory minerals are apatite, titanite, and magnetite, while rutile is sometimes observed in the form of needles inclosed in the biotite. Secondary minerals due to general metamorphism or to weathering are sericite, epidote, zoisite, bastite, chlorite, calcite, and possibly magnetite. In the Treadwell dikes where vein waters have affected the rock pyrite and pyrrhotite are the principal metallic sulphides; the secondary nonmetallic minerals, occurring either in veinlets or replacing the diorite, are albite, quartz, and calcite, with some mica, hornblende, and epidote, and often rutile.

Specimens of diorite from other parts of the field show variations in the proportion of the minerals, certain facies being composed mainly of hornblende, but the constituents are apparently everywhere the same as in the neighborhood of Juneau. The rocks are, therefore, diorites, quartz-diorites, or quartz-mica-diorites. They are similar to some of the rocks occurring in the Sierra Nevada, though they do not fall under the definition of granodiorite, as used by Lindgren and Turner, because they are deficient in the potash feldspar orthoclase. This classification of the rocks leads to the use of the name diorite in speaking of the intru-

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[a] Mother Lode district, California: Geologic Atlas U. S., folio 63, U. S. Geol. Survey, 1900.

sives of the Juneau belt, but it is recognized that the rocks are geologically equivalent to those which have hitherto been called granite in descriptions of the geology of British Columbia and southeastern Alaska.

OCCURRENCE.

The Coast Range intrusives form the principal rock of the mountainous belt, from 50 to 80 miles wide, which separates the plateau region of British Columbia from the Pacific Ocean. Related rocks occur also outside of the main area and are important features in the bed rock of many of the islands in the Alexander Archipelago. Conforming with the general structure of the bedded rocks the main boundary of the Coast Range diorite runs northwest and southeast and the outlying masses are nearly always elongated in the same direction.

Throughout the Juneau belt the surfaces of contact between the sedimentary and intrusive rocks dip in the same direction as the stratification, that is, toward the northeast. This conformity with the structure of the inclosing rocks is, however, only approximate, as may be seen from the gradual crosscutting of the main contact and in the case of the wide dike of diorite which terminates on the ridge back of Mount Juneau. Near its end this dike lies very near the inland boundary of the black slates, but within a distance of 3 miles southward it crosscuts so that it lies more than a mile away from this boundary.

The general transgression of the main diorite contact toward the west is also well shown by the wedging out of the schist and slate bands south of Berners Bay, as represented on the geologic map. Still farther to the northwest the whole of the slate-greenstone series is cut out, and in the Porcupine district the rocks which lie next to the main intrusive mass of the Coast Range correspond with those which occupy the central portion of Admiralty Island.

Narrow bands of the sedimentary rocks are known to occur in several places well back in the diorite area. A few of these have been represented on the general map, but their actual extent has not been determined. Black slates are reported to occur in the basin of Katzehin River, on the east side of Lynn Canal, and these may continue northward to connect with certain outcrops observable from the deck of a passing steamer on the east side of Taiya Inlet, about 8 miles below Skagway.

In the great central mass of the mountains the rock is by no means uniform, either in composition or texture, but consists of several varieties of diorite, some of which are granular, but a large part of which are distinctly banded or gneissoid. Further studies within the diorite mountians may show the occurrence of true granite, as this rock has been noted in the vicinity of Skagway, near Wrangell, and on the Portland Canal.[a]

In the vicinity of Juneau the three outlying arms represented upon the map differ from each other in composition and texture. The outermost is gneissoid quartz-mica-diorite, in which the banding follows the strike and dip of the dike. Under the microscope the relations of the component minerals show that the gneissoid structure has been produced secondarily by granulation and recrystallization due to pressure. The second dike has a texture which is essentially granular, with little or no tendency to parallel arrangement of the minerals. It contains very little mica, but a large amount of hornblende and much more quartz than the dike just mentioned. The third dike, which lies near the main contact, is also a hornblende rock and locally this mineral becomes so abundant as to almost exclude the feldspar which accompanies it in the normal rock. Quartz is present in relatively small amounts.

The differences in mineral composition observed in these three dikes lead to the suggestion that though they were probably derived from the same general source—that is, from the same parent magma—they were probably intruded independently. Similarly the core of the Coast Range, instead of being a simple intrusive mass or batholith, may be composed of many separate bodies intruded at various times. Bearing out this idea, as one looks across the diorite mountains anywhere in the Juneau belt, the presence of a well-marked tabular structure, striking parallel with the country trend and dipping toward the northeast, is readily discerned.

[a] By Messrs. L. M. Prindle and F. E. Wright, of the U. S. Geological Survey.

In the region south of Taku Inlet bodies of diorite other than those represented on the map may exist, since no close examination of the schist area was attempted at a distance from the shore.

EFFECT OF THE DIORITES ON THE INCLOSING ROCKS.

The intrusion of the diorite masses has in general produced only a small amount of metamorphism along the contacts with the older rocks. In many cases the immediate walls of the diorite bodies are in no respect different from the rocks at a distance from the contact. This absence of alteration attributable to the igneous rock is notable in the vicinity of Juneau, where certain beds of impure limestone in the schists which are cut by diorite contain none of the ordinary metamorphic minerals, such as tremolite or garnet, the only effect of the igneous rocks having been to produce a rather coarse crystallization.

In the Ketchikan district Brooks has described the development of mica and garnet in zones of limited width near intrusive rocks which correspond to the diorites here described. Also during the summer of 1904 Messrs. F. E. and C. W. Wright noted local metamorphism in several instances next to the diorite masses, so that the relations observed in the vicinity of Juneau do not hold without local exceptions in the region at large.

APLITES ASSOCIATED WITH THE DIORITES.

In the neighborhood of many large masses of diorite the inclosing rocks contain a number of small dikes of fine-grained rock composed of feldspar and quartz. These dikes are evidently connected in origin with the diorites, because they occur only along the contacts of these intrusions, but they are of somewhat later date and, from their small size and lack of continuity, it seems that instead of being true igneous intrusions they may have more the nature of veins deposited by hot waters escaping from the diorite during its consolidation. In favor of this view is the fact that some of the small aplite dikes grade locally into quartz veinlets, though this transition is by no means a common one.

In a few places the aplites contain metallic sulphides, but such occurrences are always of secondary origin, and there is no indication that the aplites ever contain any original metallic minerals.

MINERAL DEPOSITS IN THE DIORITES.

Secondarily fractured and mineralized diorite dikes constitute the ore bodies in the Treadwell group of mines on Douglas Island, and diorite forms the country rock of the many auriferous quartz veins which have been discovered in the Berners Bay district. Elsewhere than in these two places diorites have not been found to be particularly favorable for the occurrence of important metalliferous deposits.

AGE AND CORRELATION.

The Coast Range intrusions have been held by Dawson to be of Mesozoic age because they are found cutting the Vancouver series of rocks, which he defined as including both Carboniferous and Triassic strata. It is now possible to fix the age of these intrusions as middle Cretaceous. This important determination is due to the studies of Mr. C. W. Wright during the summer of 1904.[a] On Admiralty Island conglomerates carrying lower Cretaceous fossils are enfolded with the slate-greenstone series of the present report and with other old slates in such a manner that there can be no doubt that the main structural features throughout the region originated after the Mesozoic rocks were laid down.

The diorites have not been observed cutting these lower Cretaceous rocks, but the period of invasion is regarded as later than the general folding, because the structure of the sedimentary rocks has so completely determined the boundaries of the intrusive masses of diorite.

The coal-bearing rocks which occur on the west side and near the lower end of Admiralty Island have not taken part in the general folding mentioned above, and they are known to have been deposited after the diorite intrusions. These strata contain plants of Eocene age,

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[a] See p. 146.

and similar beds on Kuiu Island furnish upper Cretaceous forms. The observations of Mr. Wright are sufficient to show that middle Cretaceous time is represented by a great unconformity, and it is evident that during this period these dioritic rocks invaded the field.

This determination serves to correlate the diorite invasion of southeastern Alaska with the intrusion of the granodiorites of the Sierra Nevada in California.

SCHIST BAND.

DESCRIPTION.

The rocks here grouped as schists are sediments which have been almost completely changed from their original condition by metamorphism. Beds of quartz sand now indurated to quartzite and strata of limestone now partly changed to marble occur at different horizons, but the great mass of the series is garnet, mica, and hornblende-schist, presumably derived for the most part from the crystallization of calcareous and argillaceous sandstones and shales. It has been proved that certain layers of hornblende-schist are derived from gabbro rocks, such as are locally found in a relatively unaltered state. The schistose or platy structure of the series lies parallel with the stratification as determined by the presence of limestone, quartzite, and other well-defined beds evidently of sedimentary nature, and in general by the surfaces of separation between layers of different composition.

OCCURRENCE.

The schists form a continuous band, lying next to the diorite of the Coast Range, from Port Houghton to the vicinity of Eagle River. Irregularities in the intrusive contact and possibly also folding, which has not been detected, cause a variation in the width of this band of from 6 down to about 2 miles. About 30 miles northwest of Juneau it is cut out entirely by the edging over of the intrusive rocks, and does not appear in the region beyond, so far as it has been examined. Between the schists and the black slates which form the next band to the southwest the boundary is well defined and very regular.

MINERALIZATION IN THE SCHISTS.

In the vicinity of Juneau the schists have not been found to contain any important mineral deposits, but along the shores of Endicott Arm a considerable amount of prospecting on extensive belts of mineralization may eventually reveal workable ores

SLATE-GREENSTONE BAND.

DESCRIPTION.

The rocks here grouped together are in part sedimentary and in part igneous. Carbonaceous shaly rocks with occasional thin beds of dark-colored limestone constitute the sedimentary strata, while the igneous rocks interbedded with these are basalts or andesites, evidently erupted at intervals during the long period in which the water-laid formations were accumulating. The igneous rocks vary considerably in appearance, both because of original differences in composition or texture and because they have been unequally affected by metamorphism. They are all green in color, and the noncommittal name "greenstone" is here used in their description.

Throughout the region in which the slates and greenstones are associated the two sorts of rock vary in relative bulk. In the band as a whole the aggregate thickness of the greenstones exceeds that of the slates, as may be seen from inspection of the detailed map of Juneau and vicinity. In the mainland portion of the belt, however, the slates preponderate over the igneous rocks in the greater number of localities. Such differences as exist in the thickness of individual beds of greenstone are doubtless due to original inequalities in the lava flows.

The greenstones and slates have been intruded by a considerable number of diorite masses in which the rock is evidently the same as in the Coast Range, and besides these there are still older intrusions of gabbro and younger dikes of basalt and related rocks. Locally green rocks which are not distinguishable from the material of the lava flows show intrusive relations, and these are regarded as possibly the feeders of the extrusive masses.

On Douglas Island there are a few dikes of diorite-porphyry different from any rocks found elsewhere in the district.

OCCURRENCE.

The slate-greenstone band lies outside of the schist band already described and runs parallel with it, extending from the sharply defined boundary with the latter to the shore of the mainland and also lapping on to the landward sides of the adjacent islands. The band reaches its maximum width of about 17 miles, including the portion beneath Stephens Passage, opposite the lower end of Glass Peninsula on Admiralty Island. In a section across the lower end of Douglas Island it is not over 11 miles wide, and still farther north it narrows greatly because of the crosscutting course of the Coast Range intrusive. The band is not present in the Porcupine placer district.

This complex group of rocks is represented upon the general map by two colors. A band of black slates from one-half mile to 3 miles in width, lying next to the schists, is distinguished from the remainder of the group because it carries the principal lode system of the Juneau belt. This slate is free from greenstone; its outer limit, as mapped, represents the position of the first beds of the volcanic rock, which in the remainder of the section alternate with the black slates (Pl. XXXVII). On the Juneau map the relations of slates and greenstones are shown in greater detail.

BLACK SLATES.

The sedimentary portion of the slate-greenstone band is almost entirely black slate, produced by the metamorphism of fine-grained carbonaceous shales. Carbonaceous matter, which was present in the original shales, has been converted into graphite, which is now found disseminated throughout the slates in considerable amounts. In some of the mines there is so much graphite that the men appear like coal miners, and in some cases the mineral interferes seriously with ore dressing, because it tends to produce large amounts of slime. The slates are as a whole rather calcareous, and they occasionally contain thin beds of black limestone. The latter are, however, not very persistent. Usually these limestones are graphitic as well as the slates, but at Taku Harbor there are limestone beds so little changed by metamorphism that the fossils which they contain are fairly well preserved. These organic remains are sufficient to show that the slate-greenstone series is of Carboniferous age, and they are therefore to be correlated in a broad way with the very similar rocks occurring throughout the Sierra Nevada of California and in various parts of British Columbia.

MINERALIZATION IN THE BLACK SLATES.

The larger number of mines and prospects in the Juneau belt are located on the band of black slate which lies between the schists on the northeast and the first greenstones on the southwest. Beginning on the south, the mineral claims near the head of Port Houghton, the placers and partially developed lode mines at Windham Bay, and the mines at Sumdum and prospects on Fox Island all occur along or near this black slate. From Holkham Bay to Taku Inlet the slate band is heavily forested and such prospecting as has been done has not shown sufficient indication of valuable deposits to warrant any extensive developments, but from Taku Inlet northward to Eagle River and Kowee Creek veining, though more prominent along certain stretches than along others, is practically uninterrupted. In subsequent pages the complex of veins which follows this black slate is described as the main lode system of the Juneau belt.

GREENSTONES.

The greenstone beds which alternate with the black slates of the Juneau belt have several characteristics which indicate that they were formed as volcanic lava flows. In many places they have been greatly changed by metamorphism, but elsewhere their minerals and crystalline texture mark them as igneous rocks.

In the mountains of Douglas Island they show a rough-bedded arrangement conforming with the general structure of the neighboring formations. A close study reveals layers varying in composition and coarseness of crystallization, and occasionally amygdaloidal structure is found, showing the original vesicular nature of the rock. Angular breccias also occur in which the fragments of andesitic material are contained in a matrix apparently consolidated from a molten condition. All these features are such as would occur in a succession of volcanic flows, and the igneous origin of these rocks is well established.

The greenstones which form the backbone of Douglas Island are in general somewhat less altered than those of the adjacent mainland. Pyroxene is one of their most abundant constituents, occurring in well-formed crystals which give the rock a porphyritic appearance. Olivine is also sometimes present. The groundmass is always decomposed, so that its original nature can not be definitely determined, but it is fairly certain that considerable amounts of feldspar were present and the lavas are regarded as having been originally andesites.

GREENSTONE SCHISTS.

In their most altered form the greenstones are fine-grained schists, composed largely of chlorite and calcite. When less metamorphosed they often contain fibrous hornblende, and feldspar is sometimes observed. Chlorite is always present and makes up the larger part of the groundmass, even when the original pyroxene remains unaltered.

In certain localities where the greenstones have been permeated by mineral-bearing waters they contain considerable amounts of pyrite, and in some places they have been bleached to a light-yellow color, as may be seen in several places on Douglas Island.

GABBROS.

Intrusive dikes of dark-colored rock rich in hornblende are a prominent feature in the neighborhood of Juneau, where they are inclosed in the greenstones, schists, and slates which lie between Gastineau Channel and the diorite mass of the Coast Range. The presence of these rocks has been noted from Kowee Creek southward to Taku Inlet, but they were not found north of Berners Bay nor in the southern part of the Juneau belt. None of them were found on Douglas Island.

These rocks have the composition of diorite or amphibolite. They are dark green or nearly black in color and, therefore, quite different in appearance from the Coast Range diorite; they are, also, as a rule, readily distinguishable by reason of their texture from the greenstones which have been described. They commonly possess a more or less schistose structure and specimens were obtained which give evidence under the microscope that the hornblende is of secondary origin and probably derived from pyroxene. In places where the original texture of the rock has not been destroyed it is distinctly granular and moderately coarse-grained. It is therefore well established that these rocks were originally gabbros. For convenience, however, they may be called diorites in conformity with the established local usage, which is allowable from their present mineralogy.

The dikes of diorite or altered gabbro occur from the vicinity of Gastineau Channel back to the intrusive contact, but they have been represented upon the detailed map only in the black-slate area, which carries the lode system of Sheep and Gold creeks. Along this belt their intrusive nature is exhibited by local crosscutting and on the divide between Gold and Sheep creeks by branching of the dikes. In Gold Creek certain of the diorite bodies are mineralized and have furnished a considerable amount of low-grade ore. In cases where the dikes are charged with sulphides the rock has undergone a second alteration in which the hornblende has been changed to mica and large amounts of calcite have been introduced. This feature is described on page 62.

BASIC DIKES.

Several small dikes of dark-colored rock crosscutting the various formations have been noted in the vicinity of Juneau. In the workings of the Alaska-Juneau mine in Gold Creek three parallel dikes of diabase averaging about 6 feet in width were noted. The rock has a fine-grained diabasic texture and consists of greatly decomposed feldspar, probably labradorite, together with basaltic hornblende partly altered to uralite. Magnetite occurs in disseminated grains.

On the inland shore of Gastineau Channel, about 2 miles southeast of Juneau, is a small dike of dark-brown minette. This rock has a granular texture and is composed mainly of biotite and basaltic hornblende, with some feldspar and a small amount of augite. Accessory minerals are titanite and magnetite.

Basalt occurs in the Treadwell mines in small dikes transverse to the bedding of the slates and the trend of the ore bodies. The rock is greatly decomposed, but its original minerals seem to have been hornblende and feldspar, with a small amount of olivine.

The dikes which have been mentioned have been intruded since the formation of the quartz veins. They are tentatively correlated with basic dikes which cut the Eocene formations on Admiralty Island.

GEOLOGIC HISTORY.

The sedimentary strata which form the main country rock in the Juneau district were laid down in Paleozoic time, and they were afterwards covered by a great thickness of bedded rocks, probably comprising representatives of the different geologic periods up to and including the lower Cretaceous. The greenstones now exposed to view are in part lavas, and in so far they are contemporaneous with the strata with which they occur, but some of them are intrusive and may possibly have been introduced after the close of Paleozoic and Mesozoic sedimentation. Following early Cretaceous sedimentation came a period of disturbance and metamorphism; the bedded formations were subjected to enormous earth stresses which produced internal motion and recrystallization, resulting in the complete conversion of the sedimentary rocks into schists and slates, and in the alteration of the volcanic rocks into chloritic greenstone. The upturning of the strata to their present inclined position may have been contemporaneous with the metamorphism or may have followed it. Decisive data upon this point have not been secured.

After the metamorphism and the extensive disturbance of the previously flat-lying formations, dikes of dark-colored basic rocks were intruded, mainly along the cleavage of the slates and schists. Apparently these were originally gabbros, but they are always metamorphosed and now have the mineralogical composition of diorite. None of the gabbro dikes occur with the Treadwell deposits, but they are characteristic in the Gold and Sheep creek mines.

Subsequent to the intrusion of the more basic rocks came a period of dioritic invasions. The axial mass of the Coast Range is composed of many distinct bodies of granular rock more or less closely related to normal diorite. The composite nature of this core and the structural relations of its different members show that it is not a simple batholith. On the contrary, they lead to the belief that the mineralogically variable and recognizably separate dioritic bodies represent a series of intrusions derived by successive differentiations from a magma of average composition. The position occupied by this hypothetical parent magma must have been far below the portion of the earth shell now open to examination. Its separation and the migration of the resulting generations into the superjacent crust doubtless covered a long period. This explanation for the varying composition of the related granular rocks of the main diorite belt and the conception of many intrusions not strictly contemporaneous are regarded as applicable also to the outlying dioritic masses which occur in all parts of southeastern Alaska. The present knowledge of Alaskan geology shows that this rock invaded the field after the metamorphism which followed Cretaceous deposition and before the upper Cretaceous and Eocene strata were laid down.

The next events plainly recorded in the rocks themselves were the formation of fractures and the deposition of the veins. There is, however, abundant evidence in the physiographic history of the region that many important occurrences came between the diorite intrusions and the mineralization. It is known, for instance, that uplifts have occurred and that erosion has been going on over a large part of the Pacific coast province, with comparatively few and relatively unimportant interruptions, since the late Mesozoic. In southeastern Alaska and at least the adjacent portion of British Columbia one uplift has succeeded another, each favoring renewed activity of erosion, until rocks once deep within the outer earth shell now appear at the surface, because the former covering has been gradually eroded away. For a long time after the diorite intrusions the rocks now exposed, which hold the gold quartz veins in sharply marked fractures, were probably not in a condition to yield to deforming stresses, except in some manner approaching or akin to plastic flow. It may be conceived that they became rigid enough to receive well-defined breaks and to hold the same, without immediate natural welding, only after they had been relieved, by long-continued erosion, of very considerable masses of the originally overweighing rock. As the rocks gradually emerged from the zone of flowage, the same forces which were active in producing continental uplift—namely, forces radically applied—would have been sufficient to cause the fracturing observed. The connection of minor localized adjustments along fissures and joints with known crustal deformation on an extended scale seems more reasonable and satisfactory in the present case than an appeal to tangential forces, because independent evidences of general horizontal compression of correspondingly recent date have not been recognized.

A strong reason for believing in a long interval between the diorite invasion and the formation of the veins and impregnations now observed is seen in the probable origin of the fissures, as briefly outlined above, but there are also other facts pointing to an interval between the two manifestations. In many regions aplitic dikes are found associated with granitic or dioritic intrusions in such relations that it is now generally recognized that these acidic rocks are usually, if not always, among the final products of differentiation in all such magmas. Along the borders of the main diorite core in the Juneau region dioritic aplites occur cutting the large granular intrusions and also inclosed in the adjacent schists. In some case outlying masses of diorite are also accompanied by the later dikes, but they are rarely observed at any great distance from the large intrusive bodies. They are, therefore, regarded as late separations from the dioritic magma. However, a few quartz veins had been formed previous to some of the aplite dikes, for there are cases where they are cut by the aplites. On the other hand, there are later quartz veins which cut the aplites, so that the formation of quartz veins and aplite dikes seems to have been going on during the same general period. It appears probable that the deposition of the quartz veins was mainly after the last of the aplites were formed, for contemporaneous sulphide minerals are found in most of the quartz veins, and, so far as observed, when sulphides occur in the aplites, they always accompany quartz secondarily introduced into the broken or crushed dikes.

The formation of fissures, zones of sheeting, and brecciation furnished channels of free circulation for waters either in part derived from the still deeply buried portions of intrusive masses or at least heated by coming into proximity with them. The waters are thus regarded as ascending solutions carrying various mineral materials from which quartz, calcite, metallic sulphides, and gold were deposited to form the existing veins and impregnations. The presence of gases as accessory mineralizers is evidenced by the occasional occurrence of tourmaline in the quartz veins of the Juneau district. This mineral is characteristically formed by pneumatolitic or gaseous emanations from igneous rocks, and in the region here considered its presence is favorable to a genetic connection between the general mineralization and the latest previous intrusions—that is, with the diorites. Rutile, which occurs in some of the veins and very commonly in the Treadwell ores, is likewise probably an indication of magmatic emanations.

After the ores had been deposited, still further fissuring seems to have been produced, and a few small basalt dikes were intruded, but there is no evidence of important redistribution of the metallic contents in any of the ore deposits which have been examined. Subsequent events seem to have been principally those of continued erosion, which has cut away many veins and brought others to light, and in some cases has concentrated the gold from their superficial portions into workable placers, all of which seem to have originated since the Glacial period.

ECONOMIC GEOLOGY.

DISTRIBUTION OF METALLIC MINERALIZATION IN SOUTHEASTERN ALASKA.

INTRODUCTION.

Southeastern Alaska is a mountainous, densely wooded region threaded by navigable waterways, which separate the numerous islands of the Alexander Archipelago and in many places penetrate the rugged mountains which border the mainland. These channels afford ready access to the different districts where mining operations have been carried on, and the profitable exploitation of mineral deposits depends very largely upon the transportation facilities which they offer. For this reason and because of the physical difficulties presented by the rough topography and the dense growth of forestry and underbrush, prospecting has been mainly confined to the vicinity of salt water. Although no extensive development has been attempted in many localities where the existence of promising veins has been recognized, the whole region has been examined at least cursorily, and the general distribution of mineralization is fairly well known. The data available are very incomplete, but the relations of occurrence are sufficiently well established to show the existence of several bands of zones in which mineral deposits are more numerous than elsewhere.

ZONES OF MINERALIZATION.

Throughout the whole of southeastern Alaska and across the Coast Range in the contiguous portion of British Columbia, almost all the mines and prospects, both lode and placer, are distributed in zones which follow the outcrop of certain bands of rocks more favorable than others for mineralization. Several of these zones may be more or less satisfactorily established, but none of them are sharply limited and mineralization is by no means confined to them.

One of the metalliferous zones lies on the inland side of the Coast Range belt of intrusives and may be traced by prospects located in the region at the head of Portland Canal and on Unuk and Stikine rivers. The country rock in this belt is reported to consist largely of black slate and limestone, although diabase and diabase tuffs which probably correspond to the rocks called greenstones in this report, are also present. So far as known, this easternmost belt is essentially gold bearing. Its extension toward the northwest takes in the valuable placers of the Atlin district, and along the same strike near Lake Bennett sufficient mineralization exists in the rocks to have warranted a considerable amount of prospecting in the past. The rocks in this last-named district are mainly black slates and greenstones, with intercalated bands of bituminous limestone, and all these bedded rocks are intruded by masses of diorite and granite similar to but separated from the intrusive complex of the Coast Range.

Another zone of mineralization lies far to the westward on the outer edge of the Alexander Archipelago. It is marked particularly by a number of gold prospects in the vicinity of Sitka on Baranof Island and farther north by the presence of considerable mineralization in various parts of the peninsula between Glacier Bay and the open ocean, where both copper and gold are known to occur.

Immediately west of the intrusive belt of the Coast Range, and therefore lying between the two belts which have been mentioned, there is a broad zone marked by copper and gold deposits in the Ketchikan district, gold in the vicinity of Wrangell, gold also in the northern part of southeastern Alaska in the region of which the Juneau belt forms a part, and again in the Porcupine placer district in the drainage of Chilkat River to the northwest.

Metalliferous quartz veins and rock impregnations are widely distributed in this zone, which may be defined in an approximate way as limited on the southwest by the massive limestones of probable Silurian age which course from Glacier Bay through the archipelago to the Ketchikan district, and on the northeast by the boundary between the bedded rock of the mainland and the diorites forming the core of the Coast Range.

In the Ketchikan district copper deposits occur in association with dioritic and andesitic rocks, often along intrusive contacts with the sediments, but similar types are not known to exist in the northern part of this general zone.

North of Frederick Sound in the region here under discussion, the zone may be conveniently divided into two parts by a line drawn through Seymour Canal, the upper end of Stephens Passage, and the lower end of Lynn Canal to the head of Chilkat Inlet. Northeast of this line lies the Juneau belt, as the term is here employed, and on the southwest what may be called the Admiralty belt.

The persistent northeast-southwest trend of the geologic formations of southeastern Alaska at large is strongly in favor of the belief that the Admiralty rocks extend northeastward through the mountainous country lying between Glacier Bay and Lynn Canal, connecting with rocks of similar age (Carboniferous) in the Porcupine placer district. Some prospecting has been done adjacent to the shore of Lynn Canal and along Endicott River, and the fact that mineralization is here present in notable amounts, together with the occurrence of gold in the placers of the upper Chilkat drainage, leads to the inference that the rocks along this general strip are very commonly mineralized. It is proposed, therefore, to include in the Admiralty belt all of this band from Frederick Sound northwestward to the international boundary.

The Admiralty and Juneau belts have been separated for purposes of description, but they are essentially parts of one zone in which the nature of the mineralization is the same throughout. On Admiralty Island there has been less prospecting than in the adjacent portions of the Juneau belt, but the explorations of prospectors and the attempts which have been made to develop mines tend to show that, on the whole, conditions are here less favorable than they are along the mainland. The geology and economic resources of Admiralty Island form the subject of a report by Mr. C. W. Wright, printed in the present volume, and the same geologist has previously published an account of the Porcupine district.[a]

ORE DEPOSITS OF JUNEAU GOLD BELT.

INTRODUCTION.

GENERAL STATEMENT.

As the designation is here employed, the Juneau gold belt comprises the mainland strip of southeastern Alaska from Windham Bay northward to the head of Lynn Canal, together with Douglas Island. Besides the band of the slates and greenstones so prominent throughout this region, it is thus made to include both the band of crystalline schists and part of the Coast Range diorites. Its mineral production has been entirely in gold and silver, and except in the case of a single group of mines, the main output has been gold, though this is always accompanied by varying amounts of the less valuable metal.

CLASSIFICATION OF DEPOSITS.

The gold occurs in various forms of lode deposits and in placers which have been formed by the breaking down of the lodes during general erosion of the rocks and the concentration of their contents through the sorting action of streams.

The placer deposits are reserved for description in a later portion of the report. The lode deposits may be divided into three classes: (1) Veins; (2) impregnated masses of rock; (3) mixed deposits, consisting of veins and impregnations together.

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[a]Bull. U. S. Geol. Survey No. 236, 1904.

VEINS.

The word "vein" is here applied to mineral aggregates of whatever form or extent, deposited from water solutions in fractures in the rocks.

In the Juneau belt the vein stuff is ordinarily quartz or calcite, one or both, with variable proportions of other minerals, particularly sulphides of the metals which are commonly accompanied by gold and silver. In their mineralogy the veins show only minor variations from place to place, the most noteworthy differences being seen in the amounts of metallic sulphides present. As a rule these vary from little or none up to 3 or 4 per cent, or in ore shoots of limited extent up to a much higher proportion.

In their form and occurrence the veins exhibit great irregularity. In general, in regions where individual veins are strongly developed, it is sometimes possible to trace them for a distance of several miles. More commonly, however, it is found that uninterrupted vein fillings do not extend for more than a few hundred feet in a horizontal direction. This is notably the case in southeastern Alaska, where the veins are characteristically discontinuous. They are, however, very numerous, and in many instances they are aggregated along certain lines determined by the structural features of the inclosing rocks, so that the combination of many veins, each one unimportant by itself, constitutes a system, and such composite systems are often traceable with considerable distinctness for long distances. The descriptive term "stringer lead" has been applied to complex veining of this sort, and in the present report this designation will be used for aggregates of veinlets which are confined to a comparatively narrow zone. More extensive complexes, such as the one upon which many of the mines in the Juneau belt are situated, will be referred to as "lode systems," which may include many stringer leads and isolated veins.

Throughout the district probably the greatest number of veins, and in general the larger ones, occur in fissure openings which follow the structure of the inclosing rocks. Practically all of the veining has been formed since the schistose and slaty structures were developed, and cleavage, heterogeneity in the bedded rocks, and the presence of intrusive dikes have been determining features in controlling the direction of many of the fractures which were produced by later movements in the lithosphere.[a] Throughout the region stratification, cleavage, and intrusive contacts are commonly parallel with each other, and of the veins which follow these features those which occur between two sorts of rock possessing different rigidity (as between soft slate and greenstone or diorite) are apt to be the strongest and most continuous. In most cases, however, instead of solid veins lying between two different beds, one finds typical stringer leads composed of numerous nearly parallel veinlets occupying irregular openings in the slates adjacent to the contact. Stringer leads are characteristic of the slaty rocks, and they occur in many places irrespective of the proximity of massive strata. These stringer leads are commonly composed of series of parallel overlapping veinlets, occupying openings along the slaty cleavage or in some places cutting across the structure. Though in many cases there is no visible connection between adjacent stringers, the rock is often cut in all directions by reticulating veinlets. In another form of stringer leads gash-like fractures have been opened in some rigid rock, and commonly these are confined to the vicinity of contacts with the inclosing slates. In some instances the veinlets extend across the contact into the more flexible rock, but as a rule the vein stuff stops where the change in rigidity takes place. Vein aggregates of this sort are sometimes traceable for several hundred feet, as may be observed in Gold Creek and in the Windham Bay and Sumdum districts.

Instances of strong crosscutting veins are comparatively rare, though they have been noted. The best veins of this sort which were observed are in the portion of the belt north of Juneau. In the vicinity of Yankee Cove several transverse veins have been prospected, and here they are confined to a certain band of massive greenstone across which they extend

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[a] This term is used in place of the phrase "stony crust of the earth" to avoid any implication of theories concerning either the state of the earth's interior or the relations existing between its outer and its deep-seated layers, such as are naturally connected with the word crust.

from one boundary to the other, a distance of over 2,500 feet. In the Berners Bay district there are also a large number of veins transverse to the general country structure. All of these, so far as developed, occur in an outlying body of diorite, which, like the greenstones mentioned, is a very massive rock. The veins occupy fissures with sharp walls, but while some of them are traceable for upward of 2,000 feet, as a rule their fissures close completely at either end of a more or less lenticular mass of vein stuff varying in horizontal length from 50 to less than 1,000 feet. So far as developments have shown, veins of this sort seem to have a greater continuity in depth than in horizontal outcrop.

IMPREGNATED ROCK MASSES.

In this form of mineralization the metallic minerals are disseminated more or less irregularly through masses of country rock. As in the case of veins, impregnations have been formed through the action of circulating water, but where the mineral is distributed throughout the rock it is evident that no definite channels existed to which the metalliferous solutions were confined and in which deposition could take place. Instead the mineral-bearing waters permeated the mass of rock, attacking it chemically, dissolving out certain substances and depositing others in their place, producing in this way what is known as metasomatic alteration. In many instances one of the products of this replacement is iron pyrites, and other sulphide minerals also occur.

Impregnation deposits have been observed in all parts of the field, and they occur in several sorts of rock. The greenstones seem to have been particularly liable to this sort of mineralization. In most cases where rock masses containing disseminated sulphides have been prospected it has been found that the gold present is not sufficient to constitute an ore. For this reason but little attention was paid to these deposits during the present investigation. There are, however, some deposits which seem to be worthy of further exploration. The largest amounts of disseminated sulphides were observed on Douglas Island, where in two areas, one on Nevada Creek and the other at the base of the mountains back of the Treadwell mines, very extensive alteration of the rocks is to be observed. This alteration is accompanied by a very large amount of introduced sulphides.

MIXED DEPOSITS.

Veining and impregnation are combined in the ore bodies of the Treadwell mines on Douglas Island, and these form the most noteworthy examples of mixed deposits. Others have been noted, however, and will be mentioned in the detailed descriptions which follow.

In the Treadwell deposits the masses of igneous rock which have been transformed into ore have the form of dikes lying parallel with slates and an interbedded stratum of greenstone, between which they have been intruded. These dikes were fractured, and in their broken condition became channels for the circulation of mineral-bearing waters which deposited vein stuff in the open spaces, and soaking into the fragments of the broken rock attacked them as they were able, destroying to a degree certain of the minerals present, and depositing new minerals in their stead. Among these introduced minerals are various sulphides, of which the principal one is pyrite, which is accompanied by a small amount of gold. Pyrite and gold occur also in the veinlets, and the whole recemented mass constitutes the ore of the mines which comprise the famous Treadwell group. Through the activities at these mines the mixed deposits have become the most important of the three classes here recognized.

RELATION OF VEINS TO GEOLOGIC STRUCTURE.

GENERAL STATEMENT.

Throughout the Juneau belt there is a close relation between the distribution of the veins and the geologic structure—a parallelism of vein systems and ore deposits with the outcrops of bed-rock formations, which is one of the most noteworthy characteristics of the district, and therefore worthy of special description.

RÉSUMÉ OF STRUCTURE.

The Juneau gold belt, as already defined, comprises the mainland strip of southeastern Alaska from Berners Bay on the northwest to Windham Bay on the southeast, together with Douglas Island. Three easily distinguishable bands or groups of rocks may be traced throughout the length of this belt—the great dioritic mass of the Coast Range, a band of crystalline schists outside it, and a band composed mainly of alternating slates and greenstones lying between the schists and the coastwise salt-water channels. Rocks of this last group appear also on the inland edge of Admiralty Island, and though the mainland part of the band is never wider than 8 miles, its total width is at least 16 miles.

The persistence and continuity of the formations named above is a reflection of the general parallelism of the structural features throughout southeastern Alaska as a whole, and, so far as observations have extended, the original stratification and secondary schistose or slaty structures strike from northwest to southeast, following the average trend of the geologic formations and the main features of topography. The tilting of the rocks and the formation of secondary structures is known to have taken place prior to the great dioritic invasion in the Coast Range, and the stratification and cleavage together have almost entirely controlled the direction of the main diorite contact and the course of the outlying dikes, both large and small, so that intrusive contacts, wherever observed, are nearly always parallel with the strike of the inclosing rocks.

DISTRIBUTION OF MINERALIZATION.

Of the three bands or groups of rocks mentioned above, the slate-greenstone band is preeminent in the number of quartz veins and in the amount of metallic mineralization which it contains. Both the schists and the main diorite locally inclose veins or metallic impregnations, but while all occurrences must stand on their individual merits, and no hard and fast rule can be established, up to the present such prospecting as has been carried on in the areas covered by these rocks seems to indicate the comparative rarity of valuable mineralization in them.

All the developed lode mines and known valuable placers and nearly all of the promising prospects of the belt occur in the area occupied by the slates and greenstones, though in some cases, as in the Berners Bay district and at the Treadwell mines, the actual wall rocks are intrusive masses in these old bedded formations. Veins and impregnations are found throughout the whole exposed width of the band, between its inner boundary next to the crystalline schists and the shores of Stephens Passage and Lynn Canal; but, especially from Juneau southward, there is a marked grouping of prospects and developed properties along the inland side of the band on or near the black slate strip which adjoins the schist band lying to the northeast. This strip has been represented on the geologic map of the Juneau belt, and the mineral lodes which it carries have been grouped together and called the main lode system, which is more fully described below.

Northward from Douglas Island and Juneau veins and impregnations in the outer part of the slate-greenstone band become more pronounced than farther south, and the main lode system is not so readily distinguished from the rest of the mineralized belt.

On Douglas Island the ore bodies of the Treadwell group are situated 2 miles from the main lode system of Gold Creek, and the undeveloped deposits on Nevada Creek lie 4 miles from the edge of the black-slate strip in Sheep Creek. Farther north, along the mainland from Mendenhall River to Berners Bay, prospecting has revealed promising veins at many horizons in the series of alternating slates and greenstones, between the black slate and Favorite Channel; and beyond Berners Bay, where the bedded rocks are intruded by masses of diorite, veins are very widely distributed.

Prospecting has been done still farther north, well back in the diorite complex on Katzehin River, where it is reported that there are several areas or strips of slate included in the diorite though with what results is not known. In the vicinity of Skagway also there has been a good deal of exploration work, though so far as learned such mineralization as has been discovered gives little encouragement for further development.

MAIN LODE SYSTEM.

One of the most noteworthy features of the Juneau belt is a lode system or complex of veins, which, with certain variations in its development, is traceable throughout the greater part of the belt.

The linear distribution of the mines of this part of southeastern Alaska has been recognized for many years by those interested in the development of the region, and it has been commonly held that a more or less well-defined band exists in which a greater number of auriferous veins are present than in the rocks on either side. The basis of this view is imme-

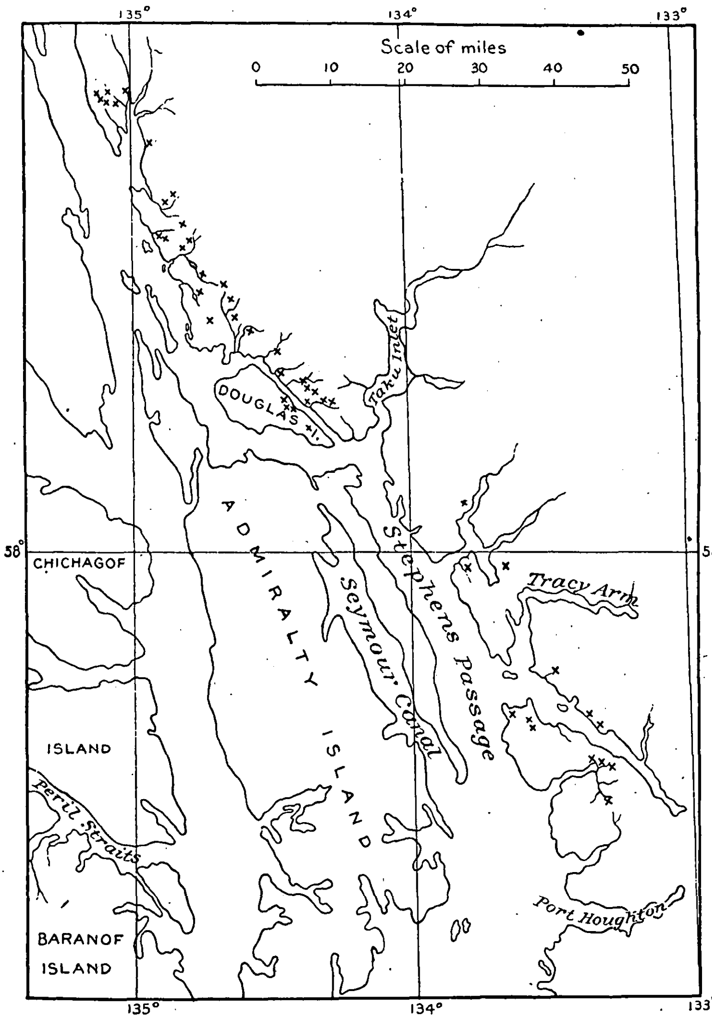

FIG. 1.—Sketch map showing distribution of mines and best developed prospects in the Juneau gold belt.

diately apparent when the positions of the best developed mines of the mainland area are platted on the map, and they are found to lie almost in a straight line running parallel with the general northwest-southeast course of the adjacent coastwise channels [a] (fig. 1).

[a] So far as known to the writer the zonal distribution of the mines in the Juneau belt was first recorded in print by G. W. Garside, who has given a very clear description of the important geographic relations of what he calls the mainland system of lodes, together with valuable notes upon the occurrence and development of the gold ores of the district. See The mineral resources of southeastern Alaska: Trans. Am. Inst. Min. Eng., vol. 21, pp. 815-823.

As already stated, the main structural features of the country have the same trend as these waterways, and with the mapping of some of the more readily distinguishable divisions of the slate-greenstone band, it has been found that the principal lodes on the mainland occur in a sharply defined band of black slates lying between crystalline schists on the inland side and a thick succession of bedded greenstones on the coastward side. These black slates, constituting the uppermost member of the slate-greenstone series, have a width of from one-half mile to 3 miles, and they may be followed northwestward from Port Houghton and Windham Bay to Juneau, and thence nearly to Berners Bay. Farther south their outcrop has not been traced, but there is every reason to believe that they extend for a long distance parallel with the general course of Frederick Sound.

On or near this band of slates are located many of the prospects at Windham Bay, mines at Sumdum and at Snettisham, and those in Sheep and Gold creeks near Juneau, while to the northwest the same rocks, with their contained veins, may be followed continuously across Montana basin, Windfall Creek, and Eagle River nearly to Berners Bay. Here in the drainage of Kowee Creek they are cut out by the main contact between the sedimentary rocks and the Coast Range diorite, which in this vicinity gradually crosscuts the bedding toward the west.

FRACTURES.[a]

GENERAL STATEMENT.

The word "fracture" as here used refers to openings in the rocks which have been filled with vein stuff deposited by aqueous agencies. It is employed more or less interchangeably with "fissure," though the latter is given a less general meaning.

In many cases the fractures are continuous for considerable distances, in some instances for several thousand feet, but as a rule their length, as determined from the veins which they contain, is measured by a few hundreds or a few tens of feet. Many short gash-like fractures also exist, and locally large veins occurring near each other are connected by networks of veinlets which occupy minor cross fractures.

Throughout the Juneau belt all sorts of rocks carry fractures, which vary greatly in their form, both with the character of the rock across which they break and with the relations of the different rock masses. They strike in many directions and dip at different angles, but by far the greater number which are marked by prominent veins have the same strike as the wall rocks and are in fact openings along bedding or cleavage surfaces.

Transverse fractures are commonly short ones, and this is particularly true in flexible beds of slate or greenstone schist, which naturally yield by bending rather than by breaking. In rigid rocks, however, cross veins may extend for long distances, as illustrated by certain veins in the vicinity of Yankee Cove and in the Berners Bay district. In the former locality strong veins in well defined fissures strike directly across the general structure, but are confined to massive beds of greenstone which they traverse from side to side. At Berners Bay they occur in massive diorite. In the main lode system lenticular veins of quartz in cross fractures are very common, and they may be studied to advantage in the open-pit workings in Gold Creek, where they are sometimes quite isolated; but more frequently they occur in series and are accompanied by stringers lying parallel to the slaty structure, the two sorts together forming complex stringer leads.

In cases where relatively small bodies of massive rock are inclosed between thick beds of flexible slate the former are often thoroughly brecciated by intersecting fractures, while the latter, though they were subjected to the same pressure, have been only slightly broken. The difference in the manner in which the two sorts of rock have yielded is evidently due to the great rigidity of the one when compared with the flexibility of the other.

[a] Spencer, Arthur C., The origin of vein-filled openings in southeastern Alaska: Trans. Am. Inst. Min. Eng., vol. 36, 1906, pp. 1211-1216.

CONJUGATE RELATIONS.

Two sets of fractures having the same or nearly the same strike and dipping in opposite directions, with the included angle approximately 90°, constitute a conjugate system. As thus defined conjugate relations are to be observed in many places in the Juneau belt, though as a rule the two sets of fissures are not equally well developed. Fractures cutting each other at right angles may be observed in the Gold Creek mines, where one set strikes and dips parallel with the country structure, while the other, though it strikes nearly in the same direction, has an opposite dip. In the Douglas Island mines also two corresponding sets of openings are perfectly developed in the igneous dikes which form the ore bodies. Both sets strike approximately parallel with the lode, which in turn conforms to the bedding of the inclosing rocks, and here again they dip in opposite directions at nearly equal angles with the horizontal.

ORIGIN.

The origin of the fractures can not be discussed satisfactorily until the later geologic history of the region is known in much greater detail than at present. Vein openings are always features of deformation and their production involves internal readjustments in rock masses, the equilibrium of which has been disturbed. In the present field various sorts of movement may have been going on, but so far as known the main movements since the great dioritic invasion have been vertical uplifts of regional or continental extent. That such movements should be accompanied by tangential compression in certain regions is to be expected, but the general effect of the more recent earth movements in southeastern Alaska and in this part of the continent at large seems to have involved expansion rather than shortening. In the Juneau district, at least, evidence of tangential compression independent of the vein openings themselves has not been observed, except under conditions pointing to a much earlier date than that to which the fissures must be referred. In general it is believed that the features observed could have been produced either by essentially tangential compression or as a result of vertical uplift, though the real direction of the effective forces can not be determined from the data at hand. Under these circumstances it seems inadvisable to suggest, as is commonly done in accounting for openings in the rocks, that the fractures have been produced as a result of compressing shear due to essentially horizontal movements. It is perhaps more plausible to connect the fractures with known rather than with imaginary movements, and they are, therefore, tentatively regarded as having been produced during general continental uplift.

DATE OF FRACTURING.

No reason has been found to suggest the presence of fractures of more than one date in the region at large, and all are believed to have been opened during the same period of deformation. They were formed after the intrusion and solidification of the Coast Range diorite, and before the deposition of late Mesozoic or early Tertiary strata which are found in an unmetamorphosed condition and in slightly disturbed position on several islands of the Alexander Archipelago.

ORIGIN OF THE VEINS.

AQUEOUS ORIGIN ASSURED.

The general characteristics of the gold and silver bearing veins are sufficient to indicate that they have been formed, as such veins ordinarily are, by aqueous agencies. Schistose structure of the rocks and openings produced by earth movements furnished channels for underground circulation, and waters bearing various mineral substances in solution, taking advantage of these conduits, moved through them and gradually deposited the vein stuff as it is now found.

NATURE OF THE SOLUTIONS.

The nature of these solutions can be arrived at only by considering the materials deposited by them. They are thus known in general to have contained lime, magnesia, soda, potash, gold, silver, iron, lead, zinc, copper, aluminum, molybdenum, arsenic, antimony, titanium, silica, sulphur, carbonic acid, boron, and fluorine. It is suspected also that chlorine may have been present, though this has not been definitely proved.

DEPTH OF FORMATION.

From the erosional history of the region, it is concluded that the veins were formed at a very considerable depth. Erosion has been going on throughout southeastern Alaska with relatively unimportant interruptions since the intrusion of the Coast Range diorites in middle Cretaceous time, and while the amount of denudation can not be estimated with any degree of accuracy, it may be fairly assumed that several thousand feet of rocks formerly lying above the general mountain level of the present have been carried away since the veins were formed.

The range of the veins from an observed depth in the Treadwell mine of over 1,000 feet below sea level to heights certainly above 3,000 feet and probably higher, without any essential change in mineralogical or physical character, also speaks for their formation at great depth, since it can hardly be imagined that near the surface similar conditions for deposition could have obtained for so great a vertical distance as 4,000 feet. Also suggestive of depth is the presence of such minerals as biotite, sericite, tourmaline, rutile, albite, zoisite, and chlorite in the veins and of sericite, biotite, epidote, calcite, albite, and quartz as metasomatic replacements of former minerals in masses of rock which have been altered by the mineralizing waters.

SOLUTIONS PROBABLY HEATED.

If, as is believed, the veins were formed at a depth exceeding 6,000 or 8,000 feet below a former surface, it may be assumed that the solutions from which they were deposited were in a heated condition, especially since the waters probably had their source at still greater depths.

The vertical range of the veins without a corresponding change in their mineralogy may be used as an argument that the vein-forming waters moved from below upward, since it is to be expected that descending waters would produce a progressive differentiation of products in a vertical sense.[a] Moreover, the metasomatic changes in the wall rocks due to the action of the solutions are of the same nature as those observed in California, which Mr. Lindgren concludes could have been produced only by heated ascending waters.[b] On this subject he says:

> Waters which have exercised such a powerful metasomatic influence on the rocks in the vicinity of the veins and contained such large quantities of carbon dioxide as are required by the facts of metasomatism are not known to occur in nature except as ascending, usually thermal, springs.

In the Gold Creek mines the alteration of the diorites which carry green hornblende to a rock composed mainly of quartz, calcite, biotite, and chlorite (see p. 62) is different from any metasomatic change by hydrothermal metamorphism which has been reported in published studies in that the development of biotite in this way has not been described. The change is one which can not be readily conceived of as being brought about by descending meteoric waters, and, it is believed, is one which requires the explanation given in the above quotation. The general nature of the process may be regarded as similar to that described by Mr. Lindgren, but the intensity of the metasomatism would seem to have been even greater than in the California occurrences which he has described.

From these considerations it seems, then, that heated ascending solutions have been responsible for the deposition of the veins.

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[a] Van Hise, C. R., A treatise on metamorphism: Mon. U. S. Geol. Survey, vol. 47, 1904, p. 1134.
[b] Gold-quartz veins of Nevada City and Grass Valley, Cal.: Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1896, p. 173.

MAGMATIC ORIGIN PROBABLE.[a]

The source of the solutions is difficult of determination, because at the best we have here to deal with a problem the elements of which can be only imperfectly known. The fact that the introduction of the veins can be fixed as later than the invasion of the field by the Coast Range diorite suggests a connection between the filling of the veins and the existence of the widely distributed intrusive rocks.

Though this general connection is here assumed, the relation is manifestly not a direct one, since the diorite itself is sometimes the carrier of simple veins, as in the Berners Bay district, or the vein networks, as in the Treadwell deposits. The diorites of the Coast Range type must, therefore, have solidified previous to being fractured, and it is probable that after their intrusion and consolidation a long interval elapsed before they were fractured, preparatory to the formation of the veins. It is clear that if the vein waters were derived from igneous rocks, they were not given off by the particular masses of diorite which are found exposed to view. These waters must, then, have emanated from deeper rock masses, which undoubtedly remained in a magmatic condition after the consolidation of the intrusives which had been forced up into the metamorphic rocks of the region.

At this point direct evidence fails and our reasoning becomes speculative, though it is believed not unwarrantably so. If we admit, as most petrographers are willing to do, that cooling magmas give off water during the progress of crystallization, then the geologic history of southeastern Alaska strongly supports the hypothesis that the vein-forming solutions were in general of magmatic origin.

In all parts of the region dioritic (in some cases granitic) rocks occur in large and small masses, which can hardly be doubted to have been derived from a common source. The great intrusive core of the Coast Range, from 50 to 80 miles wide and not less than 1,000 miles in length, and all of the smaller masses of similar rock which appear on the islands of the Alexander Archipelago are thus conceived to have subterranean connection, probably at a considerable depth below the present surface. Granting such a mass of buried rock essentially coextensive with the coastal Pacific region northward from Washington to beyond the upper end of the Alaska panhandle, the origin of the solutions which have deposited the veins and ores of the region would not be far to seek. That it actually exists is regarded as highly probable, and upon this probability the magmatic hypothesis for the origin of the vein-forming waters is here accepted as the most satisfactory one in explanation of the observed facts and their relations.

Remaining in a magmatic condition long after the intrusions derived from it had solidified, such a reservoir of molten rock as is here assumed would be an adequate source of water and of all the chemical elements which are found in the ore deposits.

All lavas at the time of eruption are known to contain water which escapes during solidification, and there is abundant evidence that the peculiar crystallization of the granular diorites and granites is to be explained by the presence of water in large amounts while the rock was undergoing consolidation. Once crystallized in the form in which we now observe them the granular rocks contain very little water, and the facts of their former wetness and their present dryness lead irresistibly to the conclusion that water must have escaped from the magma during its passage from a liquid to a solid state.

It is this water set free during the crystallization of the minerals of the rocks that is here suggested as the most probable agent in the deposition of the veins of the Juneau district, and the hypothesis is believed to be applicable over a much more extended region adjacent to the Pacific Ocean.

HYPOTHESIS OF METEORIC WATERS.

The hypothesis that waters originating upon the earth's surface have been the principal agent in the deposition of the majority of ore deposits was long a favorite one with students of this subject, and it has only recently been developed in extenso by Prof. C. R. Van Hise,

[a] Spencer, Arthur C., The magmatic origin of vein-forming waters in southeastern Alaska: Trans. Am. Inst. Min. Eng., vol. 36, 1906, pp. 971-978.

who urges its very general application. Those who accept the conclusions of this eminent investigator as presented in the chapter on ore deposits in his recent treatise on metamorphism [a] will naturally accord but little weight to the views here stated in regard to the source of the waters which have formed the veins of the Juneau district.

The magmatic hypothesis as herein presented rests largely upon speculation, but any effort to apply the rival theory becomes even more imaginative. The former accords with many of the essential features of geology throughout the region, and it has been built up in the attempt to correlate the facts which have been observed. There seems, on the other hand, to be no side evidence in favor of the meteoric hypothesis, such as distinct phenomena attributable to concomitant effects of the processes which must be assumed.

On the meteoric hypothesis two sorts of fillings marked by distinct characters would be expected, namely, those deposited during the descent of the waters and those formed on the return journey toward the surface. The complete absence of any fillings which suggest in their mineralogy deposition by descending waters [b] is therefore regarded as being so strongly against the hypothesis as to make it untenable.

ORIGIN OF ROCK IMPREGNATIONS.

In the preceding discussion the general source of the waters which have produced mineralization has been considered in reference to the distinct vein fillings. In addition, impregnated masses of rock deserve brief consideration.

Alteration and impregnation in the wall rock adjacent to stringers or veins of quartz is a common feature of the district, and is strikingly illustrated in the ore deposits of the Treadwell mine and in those of Gold Creek, but on Douglas Island there are several other great masses of rock which have been highly mineralized independently of any vein filling and apparently in the absence of well-defined fractures. (See pp. 24, 91.)

In the mineralized greenstones exposed in Nevada Creek, near the southern end of this island, a certain amount of veining is present, but the filling of seams has evidently taken place since the general alteration and impregnation of the rocks. These veinlets contain albite and rutile, which are characteristic of certain of the veins occurring near Juneau and also of the Treadwell deposits. They are therefore in all probability to be correlated in date with the general veining of the Juneau region.

Though very inadequate for a final decision, the studies thus far made of these mass impregnations lead to the opinion that they must have originated previous to the general fracturing of the rocks. They are believed to have been produced by waters moving through the rocks under some powerful impelling force from below, and, as has been deduced for the later vein-forming waters, a magmatic source would seem to be more likely than any other. If, indeed, the rocks were so deeply buried that openings could not exist in them—that is to say, if they were situated in a zone of rock flowage during the time they were being soaked with metalliferous solutions—a meteoric origin for the latter would seem to be impossible.

RÉSUMÉ OF DISCUSSION.

The hypothesis that the vein waters were of magmatic origin can be fully established or controverted only when the geologic history of southeastern Alaska is more fully known than at present. It can not be too strongly urged that the broad problem of ore genesis presented in this important field depends for its solution upon the establishment of the position which vein and ore deposition has occupied in the geologic evolution of the region considered as a whole.

In the foregoing discussion certain deposits of copper ores which occur on or near igneous contacts in the Ketchikan district are not considered, since they have not been studied by

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[a] Mon. U. S. Geol Survey, vol. 47, 1904, chap. 12.

[b] For a discussion of the mineralogy of the ore deposits thus formed, see Van Hise, op. cit., pp. 1193-1197, 1232.

the writer. Their investigation will undoubtedly furnish important links in the geologic evidence which up to the present tends to show the magmatic origin of the waters which have produced the general mineralization of the region.

PERMANENCE OF THE DEPOSITS IN DEPTH.

From the observable range of the vein fillings from elevations above 3,000 feet to a depth of more than 1,000 feet below tide it may be safely assumed that the same sort of veins must have been removed with the rocks which have been carried away by erosion, and must be present in the existing rocks to a considerable depth. The continental uplifts which have taken place throughout southeastern Alaska and which have brought about denudation by erosion can hardly have been uniform in amount, so that in any district the portion of the rocky envelope of the earth which is exposed between sea level and the tops of the mountain ranges may be regarded as having been revealed by chance. There is every reason to suppose, therefore, that in different parts of the belt here described the veins now exposed may have been deposited at different depths below the surface which existed at the time they were being formed. No suggestion can be made, however, concerning the relative position of any two portions of the field in the vertical scale, and on the whole the presence of veining almost everywhere may be taken as a basis for assuming that the total vertical range of vein deposition was not less than two or three times the 4,000 feet in which veins may be observed in the vicinity of Juneau. In general, then, metalliferous veins and impregnations are probably distributed through the rocks to depths of several thousand feet in very much the same manner as to number and form as in the rocks which are exposed above tide level.

This persistence of general mineralization, however, furnishes no criterion for determining the behavior of individual veins, and in considering the probable permanence of a given vein or ore body its general character must be taken into account. Continuous, well-defined outcrops and wide bodies of quartz may be regarded as indications favorable for continuance in depth, though, as shown by the Bald Eagle vein at Sumdum, this is no infallible rule, and it is regarded as especially liable to fail in soft, flexible rocks like slates. Swells and pinches, both horizontal and vertical, are common features of fissure veins in all regions where they have been followed by the miner. It is to be remembered, however, that every vein must have had feeders, and in one place or another stringers or seams of quartz must lead off from all large ore bodies and in many and perhaps most cases connect with other veins, either near by or at some distance. Overlaps and offsets are to be expected in great variety, no better indication of which need be asked than is furnished by the stringer leads of Gold Creek, in which, though the larger veins are continuous for a few feet only, there are always numerous seams connecting contiguous masses of quartz with each other.

In the Sheep Creek mines, also, the several veins which have been worked clearly overlap each other, so that one is strong and wide adjacent to a pinch in one of the others. The persistence of these veins is, however, sufficient for them to be mined separately, though across the Gold Creek divide on the Perseverance property the veins are very much broken, so that it is impossible to mine the vein stuff separately from the country rock. The change in the nature of the vein fillings which is noted in passing along the lode system from the Sheep Creek mines to those of Gold Creek takes place within a distance of 2,000 or 3,000 feet, and similar variations may very well be repeated in a vertical direction, so that sets of fairly well-defined veins like those in the mine in Sheep Creek may give place to stringer leads in depth, and, vice versa, stringer leads may pass into solid veins.

Throughout the Juneau region the contacts between rocks of different rigidity are regarded as favorable situations for permanence in depth, though even in such cases great changes in the width of veins and their solidity are to be expected.

In the three deepest shafts of the Treadwell mines the ore, consisting of broken diorite recemented by vein stuff, has been followed more than 1,000 feet along the dip. The ore shows no progressive change in appearance or value either along the strike or as depth is gained, and there can be little doubt that the ore-bearing dikes, their broken condition, and the filling of vein stuff all continue downward for a long distance. It is fair to assume also that so long as the rock is filled with close-spaced veinlets values will be maintained, and though variations in gold tenor will be found they can hardly have a wider range than in the ground which is exhausted or is now being mined.

ORES.

GENERAL CHARACTER.

The ores of the Juneau region are mainly those of gold, though silver is usually present in at least small amounts, and in some cases, as in the Sheep Creek mines, the white metal is in excess. In the region which has been studied copper is not known to occur in sufficient amount to make its extraction an object, though chalcopyrite is frequently observed. Elsewhere in southeastern Alaska, notably on Prince of Wales Island, large bodies of copper ore are being exploited.

In general practice gold ores are said to be free milling, when their values may be extracted by a simple crushing and amalgamation. Ores which do not lend themselves to economic treatment in this way and a residual portion of most free-milling ores must be reduced by smelting or by some process of solution and precipitation, such as cyanidation or chlorination. The ores of the Juneau region usually carry more than half of their gold in a free-milling condition, though there is considerable variation in the values which can be saved directly by amalgamation. Practically all the ores now being mined are treated in stamp mills, the free gold being collected by mercury in the mortars and on copper plates coated with amalgam, while the pulp passes over concentrating tables which save the heavy minerals. The resulting concentrates, or "sulphurets," are sent to the smelter at Tacoma, Wash. A general rule, to which a few exceptions could be noted, is that in a given deposit or vein an increase in the amount of sulphides is accompanied by an increase in the value of the ore. The relative amount of sulphide remaining unchanged, it is found also that when the proportion of gold saved by amalgamation increases, the value of the concentrate decreases correspondingly. It seems from this that the gold ordinarily occurs almost entirely in close association with the sulphides. However, visible specks and flakes of the native metal are found in comparatively rare instances in almost all the deposits, and certain quartz veins are characterized by pay shoots or pockets, in which the gold is distributed through the quartz.

Free gold and the gold- and silver-bearing sulphides occur either in veins of quartz and calcite or disseminated through masses of more or less altered rock. In general the vein ores contain the largest values per ton, deposits combining vein and impregnation features are intermediate in gold contents, and masses consisting entirely of disseminated sulphides are of low grade and commonly too poor to be mined with profit.

GANGUE MINERALS.

In the region here considered quartz forms the characteristic filling of the veins and is the principal nonmetalliferous mineral of the ores, though calcite is usually present and certain veins contain considerable amounts of albite. In deposits formed by impregnation the minerals of the rock or their alteration products constitute the gangue.

Quartz.—The vein quartz is usually very white in appearance, except where it has been stained by iron solutions at or near the surface. Between the vein walls it ordinarily forms solid masses, through which the sulphides are distributed, and seldom show drusy cavities, interlocking comb structure, or regularity of banding. This massive quartz is composed of interfering grains, usually of small size, and well-developed crystals are seldom observed. Occasionally, however, there are small cavities into which perfectly terminated prisms project, and these have been found especially in the Crystal mine at Snettisham, where they are intergrown with large cubes of pyrite, forming very handsome groups in open cavities; accompanying these minerals well-crystallized gold in octahedrons is sometimes found.

Rutile.—This mineral is usually present in veins which contain albite, and is characteristic of the Treadwell ores. In the albite veins which have been opened at several points along Gastineau Channel it occurs in drusy cavities in the veins or penetrating the albite, quartz, or calcite.

In the cavities a glass reveals the brilliant luster of its striated prisms and also its characteristic habit of twinning to form crisscross aggregates, though the crystals are very minute. In the Treadwell ores its presence may be readily overlooked in the examination of hand specimens, but the microscope reveals it in fully half of the thin sections which have been studied by the writer. Its occurrence is such as to show clearly that it has been introduced by the solutions which have converted the albite-diorite into ore.

Calcite.—Calcite occurs in subordinate amounts in many quartz veins, but its presence in the near-by walls is more common than in the veins themselves. In the wall rock it is particularly noticeable in parts of the Ebner and Alaska-Juneau mines and in the impregnated portions of the Treadwell diorite. In the Treadwell mines it forms a large part of the reticulating veins which cut through the ore, and occurring in this way gold is somtimes found inclosed in it. When present in considerable amounts it is composed of imperfectly formed crystals of approximately even size, giving a granular appearance like that of coarse marble. In the Silver Queen mine it occurs in small cavities in the form of flat rhombohedrons and lengthened scalenohedrons.

Dolomite.—When well crystallized this carbonate is usually readily distinguished from calcite by the curved faces of its crystals. This characteristic was noted in several instances, particularly in the veins containing albite, rutile, and siderite. No chemical tests have been made to show how generally dolomite may be present, and in many cases it may have been confused with calcite.

Siderite.—Crystallized carbonate of iron occurs in many of the veins, usually, however, in small amounts and commonly confined to included groups of crystals in the quartz near the vein walls. In the Treadwell mines the carbonate showing curved cleavage and slightly tinged with yellow is regarded as sidero-calcite, a mixture of the two carbonates, but it may also contain magnesia.

Feldspar.—Near Juneau several veins occurring in the rocks which lie outside of the slate band of Gold Creek contain albite as a prominent mineral, and in a single instance orthoclase (variety known as adularia) has been found associated with albite. The presence of albite has been noted in veins as far north as Salmon Creek and on the south as far as a prospect on the shore of Gastineau Channel opposite the Mexican mine. In these veins it is associated with quartz, carbonates, calcite, siderite and dolomite, several metallic sulphides, and rutile. In a single instance on Douglas Island it was found associated with zoisite and quartz.

In the Treadwell mines albite is developed in large amounts as a metasomatic replacement of the ore-bearing rock, and it occurs also in smaller amounts in the veinlets which ramify the ore bodies. The minerals associated with it are rutile, metallic sulphides, quartz, and calcite.

In the Nevada Creek deposits, also on Douglas Island, albite is found with the minerals noted above in veinlets which cut the pyritized masses of greatly altered greenstone.

In all of the occurrences given the optical properties of the feldspar are those of pure albite.

Mica.—In Gold Creek a few quartz stringers contain flakes of brown mica having the appearance of biotite, and the same mineral occurs throughout the mass of the diorite where it has been altered by the action of vein-forming waters. The mineralogical change which the rock has undergone involves the subtraction of silica, magnesium, and lime, and the addition of soda and potash, the proportion of the latter being seven times as great in the brown altered rock as in the green diorite from which it has been derived. (See analyses, p. 63.)

Sericite.—Sericite is a frequent but never abundant constituent of vein fillings. It occurs, however, in the mineralized greenstones on Douglas Island and in certain of the metamorphosed sediments throughout the region.

Mariposite.—This is a foliated mineral, which owes its bright-green color to a small amount of chromium. It is closely allied to the ordinary white mica or muscovite and is commonly regarded as a variety of this mineral rather than as a distinct species. It occurs in small amounts in some of the veins.

Hornblende.—Hornblende was one of the original minerals of the Treadwell diorite, and though some of it has survived the alteration of the rock it has been changed for the most part either into a new hornblende of a different variety or to epidote and chlorite.

Epidote.—Epidote is a mineral of very wide occurrence in the region as an alteration product in the metamorphosed lavas and in the granular igneous rocks. It occurs in considerable amounts in portions of the Treadwell ore, where it has been derived mainly from the feldspar of the syenite. It has not been observed in the quartz veins.

Zoisite.—Chemically this mineral differs from epidote in containing little or no iron. It has been observed in a single nonproductive vein on Douglas Island, where it is accompanied by quartz and a little albite.

Chlorite.—This mineral occurs mainly in the wall rocks and in masses of impregnated rock, where it has been formed by the alteration of ferro-magnesian minerals, such as hornblende and pyroxene. In the Treadwell ores it is present only in small amounts.

Tourmaline.—In the quartz veins of Gold Creek small amounts of tourmaline, occurring in minute needles, have been observed in several places. This mineral is characteristic of ore deposits, such as those of tin, in the formation of which gases have played an active rôle. Its presence in some of the gold-quartz veins of the present field suggests the possibility of considering the mineralization of the region as one of the after actions of the great dioritic intrusions.

Graphite.—This soft gray-black mineral occurs in the black slates throughout the region and in mining veins which occur between walls of the slate it finds its way in considerable amounts into the ore. By forming greasy slimes it interferes both with amalgamation and the concentration of finely divided sulphides. This effect has been found very troublesome in the Sumdum and Sheep Creek mills.

METALLIC MINERALS.

Gold.—As already stated, gold occurs in two ways. In some of the veins it is found almost entirely in flakes or spangles of native metal irregularly distributed in pockets or shoots. In the majority of deposits, however, it is invisible and is supposed to be distributed through the sulphides in minute films and particles. In this condition a large part of the gold is still free to amalgamate with quicksilver, and it seems probable that the portion which is not extracted by this process as it is practiced would be attacked if the sulphides were crushed to a sufficient fineness to permit complete contact with the mercury. Free-milling gold is found associated with pyrite, pyrrhotite, and sphalerite, and probably also with chalcopyrite, since in some veins the presence of this mineral is attended by an increase in the amount of gold. When it occurs in this way it is very finely divided and is not ordinarily discoverable by examination with the microscope, though in studying some thin slices of Treadwell ore Dr. F. D. Adams found a few specks of gold inclosed in grains of pyrite. At the Crystal mine the gold occurs in good-sized crystals, and here it is also partly imbedded in the pyrite.

With the gold some silver is usually present, as is shown by the low value of much of the bullion, which in the Sheep Creek product is sometimes as low as $4 per ounce.

No tellurides of gold have been recognized in the region, and they are present probably only in very small amounts, if at all.

Electrum.—This is a pale-colored alloy of gold and silver, containing the latter in excess. It has been noted only in ore from the Reagan shaft in Sheep Creek, where thin films occur in joints apparently much later in origin than the abundant sulphide minerals contained in the quartz.

Pyrite.—Pyrite is the most common ore mineral in the majority of gold deposits. In the Juneau belt it occurs in nearly all quartz veins and independent of them is distributed through the rocks in many places, sometimes impregnating large masses of greenstone or being disseminated throughout the country rock adjacent to the quartz veins. In nearly all cases it is the most abundant mineral in the sulphurets from the concentrating table. In the veins pyrite occurs both in aggregates or bunches and in well formed, though usually small crystals.

In a few instances, as at the Crystal mine, large cubes are found intergrown with rock crystals in cavities. When distributed through masses of rock, the pyrite is usually in small but perfect cubes, the corners of which are sometimes truncated by octahedral faces. On the north side of Endicott Arm, opposite the Sumdum mines, a bed of crystalline limestone contains cubes of pyrite distributed through its mass, and these sometimes measure over an inch.

Pyrrhotite.—Like pyrite, this is a sulphide of iron, but it contains less sulphur, and being attracted by the magnet is commonly called magnetic pyrite. It is present in many of the quartz veins and is especially prominent in the Gold Creek mines, where it occurs both in quartz stringers and in the wall rock between the close-spaced reticulating veinlets. An examination of the Treadwell ores does not reveal its presence, but the concentrates contain it in small amounts. One of its characteristics is the ease with which it gives up any gold associated with it, and auriferous pyrrhotite occurring by itself is ordinarily almost ideally free milling, as illustrated by the ores of the Ebner and Alaska-Juneau mines.

Chalcopyrite.—Compared with the sulphides of iron, zinc, and lead, this copper mineral is present in unimportant amounts, but nearly all of the quartz veins contain it in small quantities, and its occurrence is often accompanied by an increase of gold values. Such is said to be the case, at least, in the Sheep Creek mines. In Nevada Creek, on Douglas Island, it occurs in small amounts in rich veinlets which cut a large mass of greenstone impregnated with pyrite.

Galena.—Galena occurs in extremely variable amounts in the quartz veins. When it is present in considerable quantity, the proportion of silver is apt to increase. It is not commonly noted in well-defined crystals, but is inclosed in the body of the quartz in irregular masses, showing characteristic cubical cleavage, and often intergrown with zinc blende and accompanied by chalcopyrite. At the Crystal mine it was observed as a coating on the large pyrite cubes.

Sphalerite.—This mineral, which is commonly known as zinc blende or blackjack, shows the same variations in occurrence as galena. The two minerals are often associated, though sphalerite is perhaps more abundant than galena. The zinc blende is usually of a dark-brown red or nearly black color, seldom showing crystal forms, and usually inclosed entirely in quartz. It is very abundant in the veins of the main lode system between Silver Bow basin and Sheep Creek, where the silver values are relatively high, but at the Gould and Curry mine spangles of gold may be observed in the nearly black sphalerite.

Arsenopyrite.—Arsenical pyrite occurs in many places in the veins and in some instances carries high values in gold. It sometimes occurs in amorphous aggregates, but usually shows a strong tendency to crystallize and frequently occurs in radiating crystals. It is sometimes associated with quartz, but perhaps is more frequently inclosed in calcite. In the Treadwell ores arsenopyrite can not be separated from the other sulphides by observation, but it is thought to be present in small amounts or else it is mixed with the pyrite, because the presence of arsenic is commonly noted in treating the amalgam from the plates.

Stibnite.—Sulphide of antimony has been observed in the Queen mine occurring in minute radiating needles inclosed in calcite. Its occurrence in the Treadwell mines has been stated by the writer,[a] but further investigation has shown that the needles which are present in much of the ore from these mines are rutile and not stibnite.

Tetrahedrite.—Gray copper ore, as this mineral is commonly called, has been noted in the Queen mine, and very likely it occurs elsewhere in small amounts, though it is certainly not a characteristic mineral of the veins.

Molybdenite.—The sulphide of molybdenite is a soft, flaky mineral with a metallic luster, resembling graphite, but having a bluer tinge. It has not been observed in the quartz veins at large, but occurs in certain zones of sheeting in the diorites of the region and has been found in all parts of the Treadwell ore bodies. When present in amounts notable to the unaided eye, it is said to indicate an increase in the value of the ore, but no constant relations between the molybdenite and the gold of the ores have been established.

[a] Trans. Am. Inst. Min. Eng., vol. 35, p. 503.

Pyrargyrite.—This rich silver mineral, which is commonly called ruby silver, has been noted in the Silver Queen and Glacier mines in Sheep Creek, where it appears to have been formed as a result of secondary deposition from leachings by atmospheric waters.

Arsenic.—A single specimen of native arsenic weighing several ounces has been found in the Alaska-Treadwell mine, but it is not known from what part of the mine it came. It was tested for antimony with a negative result.

Realgar and orpiment.—These minerals occur in small amounts as a coating on the specimen of arsenic mentioned above. Aside from this they are not known, but are likely to occur as products of alteration in veins containing arsenopyrite.

Magnetite.—Magnetic oxide of iron occurs in considerable amounts in the Treadwell concentrates. Its presence in the ores is probably due to its having been an original constituent of the mineralized rock, and to a certain degree to decomposition of the hornblende which the diorite formerly contained.

Large amounts of magnetite are disseminated through many of the greenstone beds in the region, and at Taku Harbor there are some large deposits which are estimated to contain from 30 to 40 per cent of metallic iron.

CONCENTRATES.

Quantity.—The heavy minerals broken out of the gangue by crushing in the stamp mill are separated from the light minerals by treatment on concentrating tables and shipped away for the recovery of the gold and silver which they contain. The percentage of the concentrates varies greatly in different deposits. In the four mills operating on Treadwell ores the heavy minerals average about 2 per cent of the material treated, though even with the high efficiency attained the concentrates are not entirely free from gangue stuff. In the gold-silver ores of Sheep Creek the proportion of the sulphides depends upon the care taken in mining; but when machines are used, the concentrates form from 4 to 6 per cent of the material put through the mill. In the Gold Creek mines, where a large amount of slate and other rock must often be milled along with the quartz, the proportion of the sulphides is greatly diminished, but here the ores are very free milling so far as they have been worked, and it has not been found profitable to concentrate them.

No tests are available concerning the amount of sulphides in the large masses of impregnated rock occurring on Douglas Island, but from inspection the pyrite may be estimated as considerably more abundant than in the Treadwell ore, and it may run as high as from 4 to 6 per cent in many places.

Character.—In many deposits pyrite is the predominating sulphide, as in the Treadwell ores, where, however, a small amount of pyrrhotite and considerable magnetite are present in the concentrates. On the other hand, in the ores from the Gold Creek mines pyrrhotite occurs practically alone, and in these ores the gold is almost entirely extracted by amalgamation. In other cases galena and sphalerite are the principal ore minerals, and their presence invariably marks an increase in the relative amount of silver; for instance, in the ores of Sheep Creek mines these minerals are largely in excess of pyrite and pyrrhotite considered together, and by weight the amount of silver is several times that of the gold. Sphalerite is, however, recognized as a carrier of gold, and in the ore from the Gould and Curry mine specks of gold may be observed embedded in it.

Gold and silver contents.—As already stated, pyrite and pyrrhotite are the main gold carriers, and where only these minerals are present the values may be almost entirely in gold, while the occurrence of galena and sphalerite may ordinarily be taken as indicating the presence of silver, and the larger their amount the greater the proportion of silver will be.

In general the value of the ores varies with the abundance of the sulphides. The value of the concentrates depends partly, of course, upon the total gold and silver in the ore, but varies principally with the proportions of these metals which are removed by amalgamation. In the case of the pyrrhotite ores in Gold Creek the sulphides are not saved because their value of from $8 to $12 per ton is not sufficient to show a profit after meeting treatment charges. The concentrates from the Treadwell ores range from $30 to $60 per ton, these values corresponding, respectively, to an extraction of about 75 and 40 per cent by amalgamation on the plates. In milling the Sheep Creek ores nearly all the gold is saved by amalgamation, and though the fineness of the resulting bullion is low because of the silver which it contains, still most of the latter goes into the concentrates, and these sometimes assay as high as 350 ounces of the white metal, with only 50 cents in gold, to the ton.

TENOR OF THE ORES.

Shoots of high-grade ore have been found in certain of the quartz veins, and pockets are said to have yielded as high as $50,000 (Comet mine, Berners Bay). Instances of this sort are, however, rare and not to be taken into account in estimating the possibility of mining any particular vein. Operations in the past indicate that throughout the belt the average of minable material in the case of quartz veins has not been over $10 per ton, and, outside of the Treadwell mines, probably not over 80 per cent of the values has been realized under the not always perfect methods of reduction which have been employed.

It is reported that mill tests of samples from veins discovered during the summer of 1903 in the vicinity of Eagle River show a yield of over $35 per ton, but an average as high as this can hardly be maintained in actual production, since one of the main conditions for economic working must always be the necessity of producing a high tonnage to supply a stamp mill.

The mines of the Treadwell group have always been the only great producers in the district, and the methods of mining and milling here employed represent about the highest possible attainment in the successful working of low-grade ores under conditions which, though favorable, are still not ideal. For the last few years the average value of all material passing through the mills has been only a few cents over $2 per ton. Formerly the gold contents were somewhat greater, but the difference appears to be chargeable to a policy of keeping up tonnage even when its accomplishment involves the extraction of a great deal of comparatively low-grade rock, and is not to be taken as an indication that the values are decreasing as the mines become deeper.

DESCRIPTIONS BY LOCALITIES.

WINDHAM BAY.[a]

TOPOGRAPHY.

Windham Bay, a narrow inlet 8 miles in length, has its entrance 22 miles above Cape Fanshaw, or 45 miles southeast of Juneau. (See fig. 3.) From its entrance, which is $1\frac{1}{2}$ miles wide, the bay narrows rapidly to a neck one-eighth mile wide connecting with a deep inner basin nearly 4 miles in length and one-half mile wide. At the head of the bay is an extensive tide flat, and all supplies must be landed on a float, which is moored in deep water one-fourth of a mile from the shore. The settlement known as Windham comprises a dozen houses built along the water front on the northeast side of the bay. From the southeast side of this inner bay a broad flat extends southward for 2 miles, its inland continuation being the valley of Shuck River, a stream 7 miles in length. The surrounding mountains are the same that border the south side of Endicott Arm, the peaks ranging from 3,000 to 5,000 feet in altitude.

GEOLOGY.

Windham Bay geologically is located 7 miles southwest of the Coast Range diorite. Its headwaters enter the schist band, the rocks of which are likewise exposed along the south shore of Endicott Arm. At the head of the bay is the band of slate which appears to continue over the divide to Sanford Cove and southward up the valley of Shuck River. West of the slate beds is the slate-greenstone belt composing the shore bluffs at the entrance of Windham Bay. Intruding this latter belt are several outlying masses of diorite, the positions of which have been located on the map.

[a] By C. W. Wright.

ORE DEPOSITS.

The mineral deposits which have been prospected in this area are confined to the schist and slate belts. They occur mainly in the form of stringer leads, which follow the trend of the inclosing rock beds. Three such zones or leads have been defined, within which the sulphide minerals have been irregularly distributed either in quartz veinlets or in the country rock itself. These veinlets, a few inches to a foot or more in width, are individually trace-

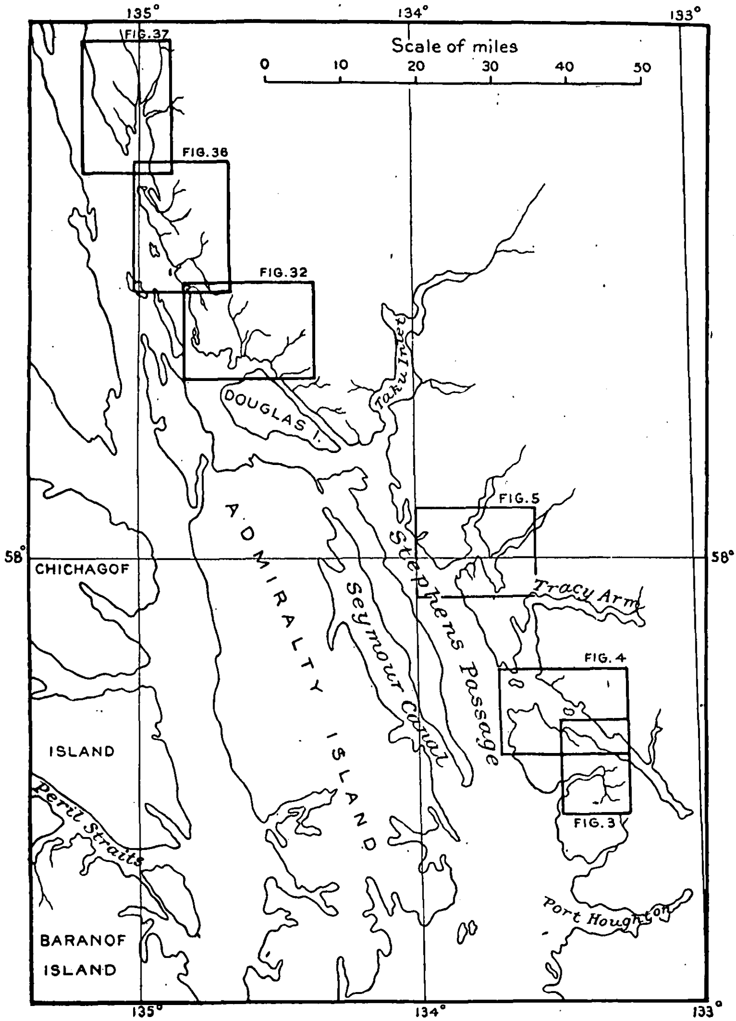

FIG. 2.—Key map of Juneau belt, showing position of local sketch maps.

able for short distances only and are very irregular as to their direction. Though they often carry visible gold, they can not be mined separately and are of significance only when they are present in large numbers.

Here and there dikes of a diabase rock occur within these mineral zones and are usually parallel with the trend of the slate or schist country rock. These dikes appear to have been intruded previous to the ore deposition, as they contain some quartz stringers and are often slightly mineralized. Pyrite is the principal metallic mineral in the ores, which are mainly free gold and pyrite. Small amounts of galena, sphalerite, chalcopyrite, and arsenopyrite also occur, and native gold is frequently found. The gangue minerals are quartz, calcite, and siderite, albite being only rarely noted.

LODE MINING.

The gold-bearing ledges in the proximity of Windham Bay have been known since placer mining began, and many of the outcrops have been staked and restaked, though no impor-

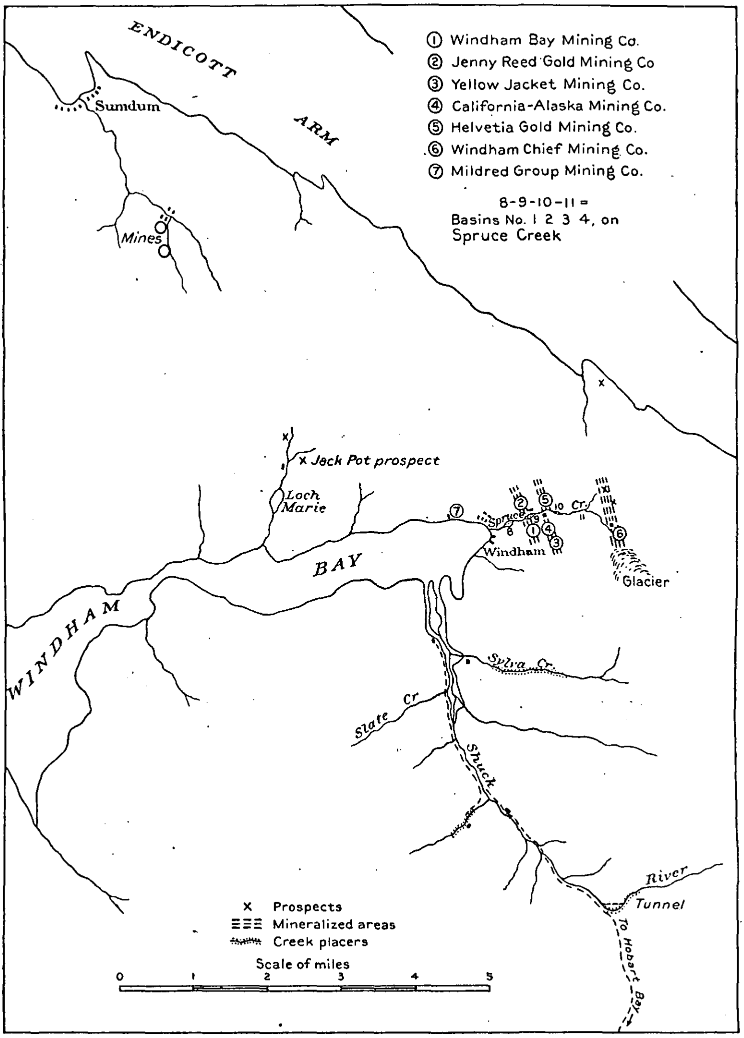

FIG. 3.—Sketch map of Windham Bay and vicinity.

tant developments were made upon these until 1900. About this time several companies were formed, additional claims were located, and investigations were begun.

The only mine which has been on a productive basis is that of the Windham Bay Gold Mining Company, located three-fourths of a mile from the bay, on the south slopes of Spruce Creek. This property consists of nine claims known as the Red Wing group. The ore body, a series of quartz stringers in slate, is sharply limited on the east or foot-wall side by a slightly mineralized diabase dike, whereas the hanging wall is indefinite. The slate itself carries some mineral, but not sufficient to make ore. The zone of marked veining has a general trend parallel with that of the slate beds, but the separate stringers cut across the slaty structure at various angles. Some of these quartz fillings may be followed for 100 feet or more, but most of them are much shorter. They vary in width from mere seams up to 18 inches.

The property has been operated by two tunnels, one 600 feet long and the other, 100 feet above the first, 400 feet long, both of which follow the system of veinlets. Between these tunnels and the surface most of the ore was mined and treated in a 10-stamp mill during 1901–2. The veins themselves are reported to carry high values, but the necessity of mining a large amount of country rock to win this ore appears to have prohibited further operations, and work was discontinued in 1902.

The continuation of the Red Wing group on the west slope of Spruce Creek has a similar diabase dike on the foot-wall side, and the general mineralization is the same as shown on the above-mentioned property. The Jenny Reed Gold Mining Company was developing the mineral belt at this point, but discontinued operations in 1904.

A second mineral belt, a few hundred feet in width, is exposed 1½ miles from the head of the bay. The inclosing rock is a wrinkled talcose schist, rich in silica and intersected by irregular quartz stringers and veins which carry sulphides.

The southeastern portion of this belt, at an elevation of 2,000 feet on the south slope of Spruce Creek, is located by the Yellow Jacket Mining Company. At this point both the country rock and quartz were mined from an open cut and transported by a 3,000-foot cable tram to a mill on the creek below. A crosscut tunnel 25 feet long penetrates the mineral belt, revealing a body of mineralized rock, which, if of sufficient value, could be economically mined by open pits and terraces on the steep mountain slope. Developments were discontinued early in 1904.

On the continuation of the Yellow Jacket belt to the northwest are the properties of the California-Alaska Company, consisting of two claims, the Doctor and the Evening Star. On the Doctor claim, at an elevation of 1,350 feet, 200 feet of tunneling exposes a mineralized band of talcose schist with no distinct lateral limits. Within this are numerous veinlets and pockets of quartz, some with visible gold, which both crosscut and are parallel to the bedding plane of the inclosing rocks. The Evening Star claim, below the Doctor, has been opened by 100 feet or more of tunneling in which the same quality of ore is exposed. Explorations on this belt have shown the necessity of mining large masses of country rock to obtain the ore, and since 1903 no more than the assessment work has been done.

On the west bank of Spruce Creek 13 claims were located along the extension of this belt to the northwest. These are now owned by the Helvetia Gold Mining Company. Explorations have been made by three tunnels 50 to 150 feet in length, and in these the schist country rock is intersected by many quartz stringers said to carry high values in gold. In 1905 developments were continued and a determination of the average values by mill tests was being made.

At the head of Spruce Creek, 3,000 feet above tidewater, is a third zone of mineralization, on which the Apache and Navajo claims, belonging to the Windham Chief Gold Mining Company, are located. The country rock, a siliceous schist, is interbedded with chlorite-schists and crosscut by several dark-colored dikes resembling diabase. Numerous veins of gold-bearing quartz a few inches to a few feet in width intersect the schists, and in both quartz and schist sulphides were noted. In 1903 the developments consisted of two tunnels, 60 and 80 feet long, and several open cuts. The ore exposed in these workings systematically tested by means of a 2-stamp prospecting mill and reported to be of low grade. Since 1903 no important development work has been done.

On the north shore of Windham Bay, situated close to the water's edge, a quarter of a mile west of the town, is the Mildred group of claims. The country rock at this point consists of a very siliceous slate containing narrow interbedded veinlets of quartz and calcite, giving the rock a banded structure. The width of the mineralization sufficient to make ore is considered to be 20 feet. A tunnel close to the water's edge has been driven for 600 feet along the mineralized portion of these slates.

Following up a creek which enters the bay from the north at a point 4 miles west of Windham, prospects have been located 2 miles from tide water. The deposits are auriferous quartz ledges occurring in the slate belt and closely resemble the Sumdum deposits, which are not far distant. But little work has been done on these and the exposures are not sufficient to afford any idea of the probable continuity of the veins.

While in 1905 there were no producing mines at Windham Bay, it seems that some of the properties may yet develop into valuable mines.

PLACER MINING.

The presence of auriferous gravels in the creeks tributary to Windham Bay has been known since the latter part of the sixties, and these have been washed by crude methods for their gold contents at intervals since that time.

The first extensive developments were made by the Spruce Creek Mining Company in 1888. This company obtained possession of the two lower basins of Spruce Creek. The first of these, one-fourth mile from the mouth of the creek, is a glacially eroded depression 300 yards long and 250 yards wide, with a rim rock of hard greenstone at its lower end. The gravel bed is 90 feet deep in its central portion and consists of small gravel wash overlying a layer of blue clay 1 to 6 feet thick next to bed rock. From the shore a drainage tunnel 800 feet in length was driven to a point under this basin. A hydraulic pipe line bringing water from higher elevations of the creek was laid, and with this power the gravels were sluiced. At the second basin, about a mile from the shore, a similar though smaller deposit was worked by the same company. After two years of unsuccessful mining, operations ceased on these deposits and no attempt has since been made to work them. At higher elevations on Spruce Creek are two wide gravel deposits forming benches at sharp bends in the creek bed. . From portions of these deposits miners claim to have recovered with sluice boxes and shovel a few dollars per day in fine gold. Just below the glacier at the head of Spruce Creek, 3,000 feet above tide water, are evidences of old diggings, which are commonly attributed to the first prospectors of the region.

Entering Windham Bay from the south, Shuck River forms a wide gravel-filled valley which narrows to a canyon 100 yards above its junction with its eastern tributary, Sylva Creek, a stream 3 miles in length and 1½ miles from the bay. The gravels of this creek have all been located, though but little has been achieved by way of mining. For a mile above its mouth the creek flows through a canyon-like valley, above which, at 500 feet elevation, it spreads out over a flat a mile wide and 1½ miles long. It has been proposed to work the gravels of Sylva Creek by dredging, but nothing has as yet been done. The gravel wash is small, with but few large bowlders, and the gold is reported to be finely disseminated throughout the deposit. It would seem inadvisable to install a costly plant on this property before the deposit has been more thoroughly tested by pits or drilling.

Three miles above the mouth of Shuck River Slate Creek enters from the west. Here much labor has been expended in developing three placer claims known as the Lost Rocker group. These are located in a basin 400 feet by 800 feet in extent one-half mile from Shuck River. The bed rock in this vicinity is mostly black slate, though at the lower end of the basin there is a rim rock which appears to be intrusive in the slates. The gravel bed has an average depth of 5 feet and consists of slabs of slate and cobbles of greenstone with occasional granite bowlders. It is said to carry 65 cents per cubic yard in gold. A pipe line several hundred feet in length brings water from an elevation of 90 feet to supply a 4-inch nozzle, with which the gravel banks are worked through a series of sluice boxes at the lower end of the basin.

Eight miles from the mouth of Shuck River, at an elevation of 600 feet above sea level, is a horseshoe bend in the river valley, and at this point, where the grade of the river is but slight, a gravel bed half a mile long and several hundred feet wide has been deposited. At its lower end the gravel wash carries a large number of granite bowlders which overlie a deep bed of blue clay, though farther upstream the deposit is composed of smaller material. A group of claims has been located by the Golden River Mining Company in this part of the valley. Several miners were employed during the summer of 1903 to drive a 300-foot tunnel starting at the lower part of the basin and crosscutting the neck of the horseshoe bend. This has been completed, and through it the waters of the river have been diverted, thus leaving the gravel bed accessible. It is reported that work was continued during 1904 and 1905, but that lack of capital prohibited the installation of the hydraulic plant necessary for profitable operation.

HOLKHAM BAY.[a]

TOPOGRAPHY.

Holkham Bay is the extensive inlet from the eastern side of Stephens Passage, 16 miles south from Port Snettisham. (See fig. 4.) Its arms, of which there are two, enter the mainland for 20 miles, penetrating deep into the Coast Range. Tracy Arm, the northern

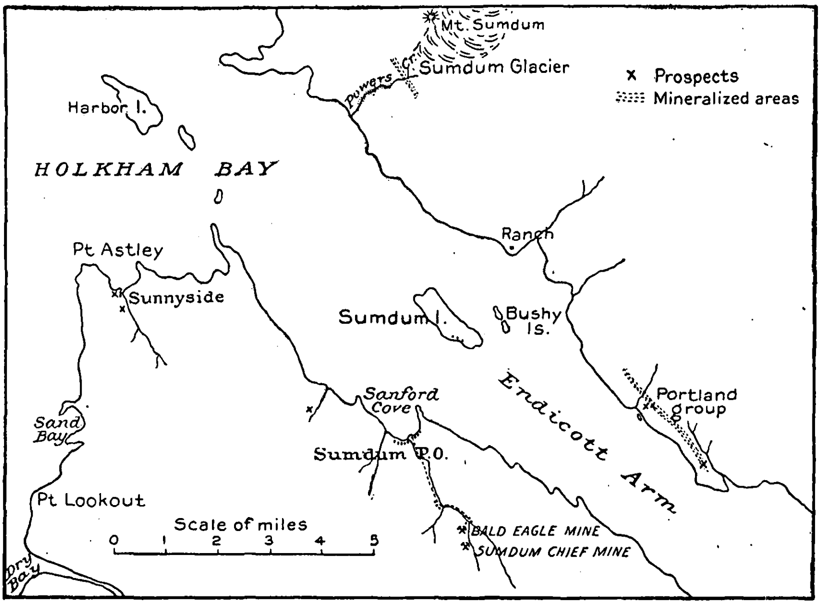

FIG. 4.—Sketch map of Holkham Bay and vicinity.

branch, takes a northerly direction for 9 miles, then turns to the east for 13 miles to its head, where two large glaciers enter the inlet. Its scenery is particularly grand, the shores of granite rising almost perpendicularly and showing the marks of receded glaciers. The southern branch, Endicott Arm, is 25 miles long in an east by south direction, with a width of 3 miles at its entrance, narrowing to less than a mile at its head. At this latter point are the Dawes Glaciers, extending to the water's edge and giving forth numerous icebergs, which completely fill the head of the arm. The mountains between the two arms range from 5,000 to 7,000 feet in altitude, while to the south of Endicott Arm 4,000 feet is the average height of the peaks.

GEOLOGY.

The main line of contact of the Coast Range intrusive may be readily traced on the map. It crosses Tracy Arm at its elbow, follows along the top of the Mount Sumdum ridge, and crosses the head of Endicott Arm. Both the north and south shores of Endicott Arm are essentially of schist. The slate band begins at Sanford Cove and probably extends north-

[a] By C. W. Wright.

westward, joining with the south arm of Port Snettisham. The slate-greenstone belt, intruded by occasional masses of diorite, composes the area west of Sanford Cove and bordering Stephens Passage.

ORE DEPOSITS.

Mineral deposition in the Holkham Bay district has occurred in the schists, in the slate band, and in the outer belt of slates and greenstones, deposits in these rocks being represented respectively by the Portland group, the Sumdum mine, and the property of the Oceanic Mining Company. Of these properties the best developed is the Sumdum mine, which will be described first.

SUMDUM MINE.

The Sumdum mine is located on the south side of Endicott Arm, 2½ miles inland from Sanford Cove, a small embayment where the town of Sumdum is located. The country rock in the proximity of the mine is a black graphitic slate, though the schist belt lies but a short distance to the east. This slate is usually wrinkled, rich in carbonaceous matter, and scattered throughout are stringers and films of calcite, often carrying particles of pyrite.

The mineral deposits are well-defined quartz-filled fissures, striking approximately parallel with the northwest trend of the country rock. They extend for a few hundred feet in a horizontal direction and have been mined to a depth of several hundred feet below their surface outcrops. Two such ledges, which have been largely developed, are known as the Sumdum Chief and the Bald Eagle. The former ledge varies from a surface width of 3 feet to a narrow vein filling at a depth of 1,200 feet. The Bald Eagle ledge, on the other hand, increases from a surface width of 2 feet to 20 feet at a depth of 500 feet. In the latter ledge the vein stuff changes from a free-milling ore carrying $10 to $15 in gold values per ton near the surface to a low-grade ore assaying not over $1 to $2 per ton at 500 feet in depth.

Within the quartz bodies the gold is not uniformly distributed, but is segregated here and there, forming rich pockets, which seem to represent enrichments where the main ledges are intersected by smaller quartz veins. The ore is essentially free gold and gold-bearing pyrite, with small amounts of galena and sphalerite. Quartz and calcite are the gangue minerals, and films of graphite occur between the fillings and the black-slate country. An average value of $8 per ton was obtained from the ore milled, and 75 per cent of the gold content was saved by amalgamation. The concentrates carried $60 in gold and 20 ounces or more of silver per ton. The bullion assay varied from $14 to $16 per ounce. It is stated that the production of this mine has amounted to nearly $500,000.

A tunnel 3,500 feet in length undercuts the Bald Eagle vein 500 feet below the surface outcrop and encounters the Sumdum Chief at a depth of 1,200 feet. From this working tunnel to the surface most of the ledge material has been extracted by overhand stoping, and the stopes have been supported by square sets of timber. Below the tunnel level an attempt was made to mine the ore by underhand stoping, but, as already mentioned, at this depth the ore is below the average value and the investigations appear not to warrant further expenditure.

The mill contains 10 stamps with 4 large Frue vanners, and when running at full capacity 40 tons of rock were milled per day at a cost of 30 cents per ton. An 18-inch pipe 1,200 feet in length brings the water from a flume, the lower end of which is 187 feet above the power plant, and with the aid of two Pelton wheels 170 horsepower are generated. From the mill a wagon road, together with a short tramway, leads to the wharf, and over this the concentrates are hauled, and the conveying wagons return with freight for the mine.

The total cost of production is estimated at $2.50 per ton. During the autumn of 1903 the last of the developed ore was being mined and a diamond drill was in search of other bodies. This evidently failed to reveal anything of importance, for since that time operations on these properties have ceased and a portion of the mining plant has been removed.

PORTLAND GROUP.

Close to the shore on the north side of Endicott Arm, opposite Sumdum, numerous claims have been located upon a wide belt of mineralized rock belonging to the schist belt which lies adjacent to the Coast Range diorite. The ore bodies consist of siliceous schists carrying disseminated sulphides and stringers of quartz and calcite which fill openings along the schistosity. The zone of mineralization follows the strike of the schists and with an average width of nearly 1,000 feet is traceable for a mile or more along their outcrop. The ores are gold-bearing pyrite, galena, and sphalerite and are reported to assay from $0.50 to $3 per ton. A crosscut tunnel 180 feet in length and a few open cuts expose the mineralized rock, but how much of this will eventually prove to be minable can be determined only by more development work and careful sampling.

OCEANIC MINING COMPANY.

The Oceanic group of claims is situated on the small cove just east of Point Astley, at the south entrance to Endicott Arm. The deposits here lie in the slate-greenstone belt, though not far to the southwest is an intrusive mass of gray diorite over a mile in width, which has probably played no small rôle in the deposition of the ores. Around this intrusive mass many of the sediments have been altered to quartzites and calcareous schists rich in mica.

Irregularly distributed along the schistosity of this country rock there has been an introduction of sulphides, accompanied by quartz and calcite, with no apparent channels to which the metalliferous solutions were confined. This sort of filling has produced a mineral belt a few hundred feet in width and several hundred feet in length, within which occasional seams rich in silver and copper are encountered.

The minerals are in the main bornite, chalcopyrite, pyrite, sphalerite, galena, and native silver. The proportions of the metals in these ores do not correspond to those of any other deposits in the Juneau belt.

About 200 feet of underground development work has been done, including several small tunnels and a shaft close to the shore. A small hoist and pump have been installed, and buildings have been erected for the accommodation of a dozen or more miners.

Mineralization of the rocks can be seen in all the openings as well as in the outcrops along the shore, but how much of this will eventually prove valuable or whether that already exposed may be profitably mined and shipped to a smelter can not be determined at present. The prospect, however, appears worthy of further development.

Adjoining the Oceanic property to the west is the Apollo group of claims, located on a similar mineral belt, but with the exception of a tunnel 50 feet in length no work has been done on this property.

HOLKHAM BAY GROUP.

On the south side of Endicott Arm, 5 miles southeast of Sumdum, is the Holkham Bay group of claims, situated at 1,800 feet elevation, 1 mile from the shore. Its ore body is a mineralized quartz ledge in the schist belt carrying gold, silver, and copper values. Nearly 300 feet of development work has been done, and a large tonnage of ore is exposed.

POWERS CREEK.

Placer gold has been known for the past twenty-five years to occur in the creek gravels and banks of Powers Creek, but only a small yield could be realized by prospectors working with shovel and sluice box, and though many claims were located few have been held.

PORT SNETTISHAM.[a]

TOPOGRAPHY.

Port Snettisham has its entrance on the northeast side of Stephens Passage, 30 miles southeast of Juneau. (See fig. 5.) It is a narrow fiord having three branches or arms. At the head of North Arm is Speel River, a swift-flowing stream which enters the Coast Range for a distance of 18 miles. The tributary to East Arm, a much shorter inlet, is Whiting River, traversing the mountain system for 35 miles, though not crosscutting it. This river is navigable in small boats for about 4 miles from the mud flats at its mouth. At the head of South Arm are extensive flats which are bare at low water for a distance of 1 mile, and back of these is a low valley 5 miles in length connecting with Holkham Bay.

From the shore line the land rises abruptly to peaks reaching heights of 4,000 to 6,000 feet. The peninsula of Snettisham, a promontory with peaks averaging 2,500 feet in elevation, is connected with the mainland by a low pass less than 100 feet above tide level. Snettisham post-office is situated on the north end of this peninsula and 3 miles inside the entrance to Port Snettisham.

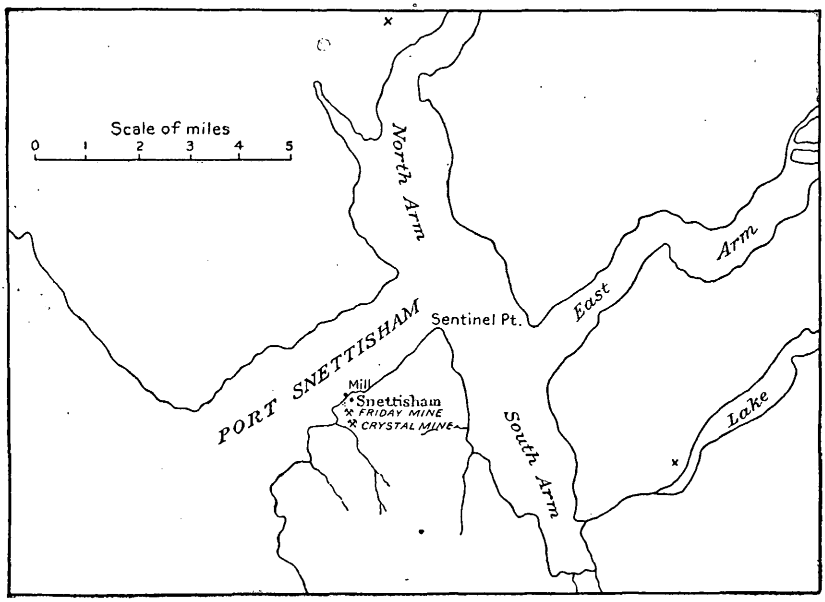

FIG. 5.—Sketch map of Port Snettisham and vicinity.

GEOLOGY.

The rock formations of this area are in a measure reflected by the topography. The eastern portions of the inlet are bordered by the Coast Range intrusives, which extend to the headwaters of the tributary rivers. The schist belt occupies the space between these intrusives and the north and south arms of the bay, while at the heads of these arms the valleys are floored by a black slate which is regarded as the continuation of the slate band occurring farther north in Sheep and Gold creeks. As in the Juneau area, west of the slates there is a broad belt of slates and greenstones, which form Snettisham Peninsula and the shore outcrops of Stephens Passage to the north. A mass of diorite intrudes this outer band and is exposed along the north shore of Port Snettisham for a distance of 1 mile, though on the opposite south shore it is but a few hundred yards in width and appears to wedge away. On this side the edges of the intrusion are marked by segregations of hornblende, and there are many aplite dikes penetrating the bedded rocks near the contact.

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[a]By C. W. Wright.

ORE DEPOSITS.

Several mineral deposits have been prospected within the drainage area of Port Snettisham. These occur in the schists as well as within the area of slates and greenstones. Their distribution, however, is in areas bordering the diorite belts, and from this as well as other facts they are regarded as a result of the diorite intrusion.

The only developed prospects and the only deposits visited are the properties of the Alaska Snettisham Gold Mining Company, situated on the south abrupt shore of Port Snettisham, 3 miles from the entrance. There are two deposits at this locality; one is an irregular quartz ledge near the contact of the intrusive diorite, and inclosed in an altered slate country rock; the other, situated three-fourths of a mile to the south, is a more sharply-defined ledge which is inclosed in a wide dike of apparently intrusive andesite. The strike of the latter ledge is north and south, with a dip of 20° SE. A line following along this strike to the north will pass near the first-mentioned deposit. The intervening space, however, is not sufficiently prospected to determine the existence of a continuous ledge over this distance, and the difference in the values and composing minerals at the two points is opposed to the supposition of their being one identical ledge.

Other deposits of auriferous quartz occur 3 miles west of South Arm, near a lake 6 miles in length. These are located in the schist belt not far from the contact of the Coast Range diorite. The ore carries considerable galena, and on this property assessment work is said to have been done for the past four years.

Another promising prospect is the Beach group, on the north side of Speel Arm, about a mile inland. The ledge exposed is a quartz-filled fissure carrying auriferous sulphides and inclosed in the diorite country rock. Assessment work has been done on the claim for several years.

FRIDAY MINE.

This mine is the first property developed by the Alaska Snettisham Gold Mining Company, which began operations in 1899. The ore body, as exposed in the tunnels, is an irregular ledge varying from 1 to 6 feet in width, and within this the values are also irregularly distributed. It has been developed by two main tunnels, 750 and 600 feet in length and at elevations of 360 and 450 feet above tide water, besides several small pits and open cuts at different points along the surface. The ore is essentially an auriferous pyrite, rich in magnetite, which renders the extraction of its gold contents difficult. This ore, however, is not of a high grade and but little development work was in progress at the time of the writer's visit. It is reported that operations ceased in 1904.

CRYSTAL MINE.

The quartz ledge at the Crystal mine was first discovered in 1895 by B. Heins. It was so named because of the large pyrite cubes which are found in druses occurring in the surface outcrops of the ledge. On the sides of many of these cubes small particles and crystals of gold may often be observed, and this somewhat novel occurrence makes the ore of special mineralogic interest.

The mine workings are situated 1½ miles from the wharf at Snettisham and 700 feet above tide water. The ledge has a width of from 1 to 10 feet, averaging about 4 feet, and is exposed for over a thousand feet in length. Fragments of the inclosing andesite are often included in the vein, and these as well as the quartz carry the gold values.

Operations were first undertaken at this point in 1901–2 and during this time the ore mined, which was separated in a 10-stamp mill on the property, is said to have produced approximately $25,000 in gold. In 1903 the mine was purchased by the Alaska Snettisham Gold Mining Company and rapid development immediately began. At the close of the year 1903 the work done aggregated 1,000 feet of tunneling and drifting along the ledge at different levels. These levels were connected by winzes and much of the intermediate ore was mined.

A well-equipped 20-stamp mill was erected in 1901 close to the shore at Snettisham. Power is acquired by a flume over a mile in length, which follows the mountain slope at an elevation of 400 feet and collects water from the many small creeks. This is connected with a pipe line, which supplies Pelton water wheels at the mill, and a total of 300 horsepower is obtained.

In 1904 mining continued, and most of the developed ore is said to have been stoped out and milled. Early in 1905 this company discontinued operations at Snettisham and plans were being made to remove both mill and mine equipment.

GRINDSTONE AND RHINE CREEKS.

These are twin streams heading against Sheep Creek and flowing in a southeasterly direction to Taku Inlet. The mountain between Gastineau Channel and Grindstone Creek is composed of the same greenstone which is found farther north in the vicinity of Juneau, and along the shore of Taku Inlet this rock extends to beyond Bishop Point. (See general geologic map, Pl. II.)

The black slate which lies between the greenstone and the schist occupies only the basin of Grindstone Creek, but the contact runs diagonally across the mountain separating the two valleys, leaving the upper two-thirds of Rhine Creek in the slate band.

Several years ago considerable prospecting was done in these two basins, but veins sufficiently promising to warrant extensive development were not revealed, and there are at present no quartz claims on which regular assessment work is performed. Such veins as occur are said to be similar to those of Sheep Creek in that they contain more silver than gold, but they appear to be more irregular in occurrence.

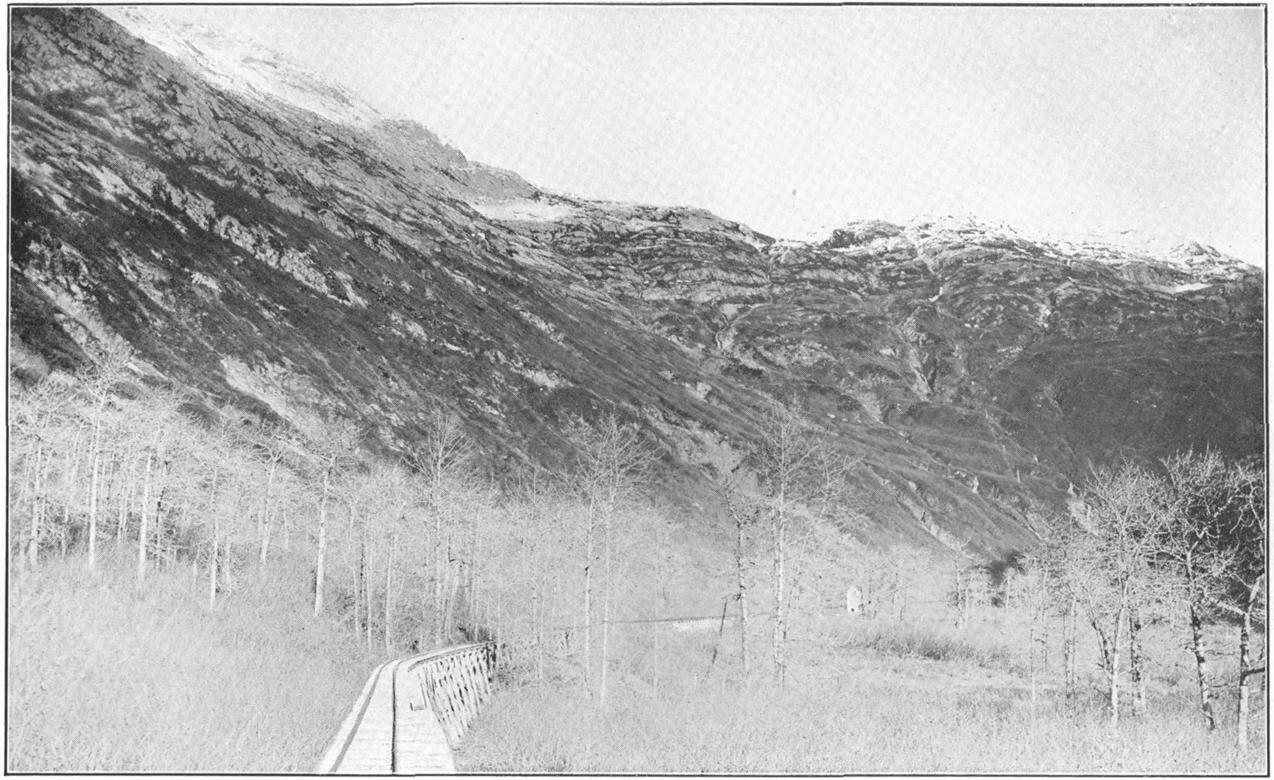
The central portion of Grindstone Valley contains a bed of gravel, below which the creek flows on bed rock. The rim rock of this deposit forms a waterfall 50 or 60 feet in height, beneath which a tunnel has been driven to partially drain the basin, but there have been no extensive mining operations. The deposit has been found to contain gold and some sluicing has been done, but no data are available concerning the average value of the gravel. An unfavorable feature of the deposit is the presence of a stratum of plastic clay below the gravel, which will undoubtedly cause serious inconvenience in any attempt to mine by hydraulic methods.

To ascertain the value of this ground systematic prospecting is necessary. At present the only apparent asset in this vicinity is the water power of the two streams, which could be conveniently harnessed and readily transmitted to Juneau and Douglas Island in the form of electric energy.

SHEEP CREEK.

TOPOGRAPHY.

Sheep Creek, which empties into Gastineau Channel, 4 miles southeast of Juneau, drains an area of about 5 square miles. (See Pl. V and fig. 6.) Flowing from the water parting next to Grindstone Creek, the course of the main valley runs from southeast to northwest. About 2 miles from its head the stream makes a broad turn and in the lower mile and a half flows toward the southwest. The total length of the valley is about 3½ miles. The upper and lower thirds of its course have steep grades, but the middle course is over a gravel flat sloping from 700 feet down to about 550 feet elevation. Below the gravel flat the tributary slopes are very narrow and there are no side gulches. Practically all of the drainage comes into the upper basin, where the walls of the valley are steep, though up to an elevation of about 1,800 feet they are covered with alder brush and grass and are generally sodded nearly to the summit of the surrounding ridges. The latter are nowhere more than 1 mile distant from the stream, though they rise to elevations of from 2,500 to 3,800 feet. As in the case of Gold Creek, the generally smooth, but somewhat corrugated character of the slopes points to the molding action of ice, and the recency of glaciation is indicated by the shallowness of the rills, which collect the drainage from the mountain sides.



SHEEP CREEK BASIN.

Showing topography and vegetation.

GEOLOGY.

The formations of Gold Creek extend without interruption southeastward to Taku Inlet, but only the two outer divisions—namely, the black slate and the group of greenstones and intercalated slates—are cut by Sheep Creek. On the ridge between Gold and Sheep creeks the band of slates with their intrusive dikes of dark diorite is about 6,800 feet across and this width is only slightly diminished in the vicinity of the Grindstone Creek divide, 3½ miles distant. As in Gold Creek, the black slates contain dikes of dark diorite (altered gabbro), which follow the general trend of the formation. Here, however, these rocks have not been greatly affected by vein waters and the brown color which is so characteristic in the Ebner and Alaska-Juneau mines is not found except in the vicinity of the Gould and Curry property, where a little mica-bearing brown rock occurs.

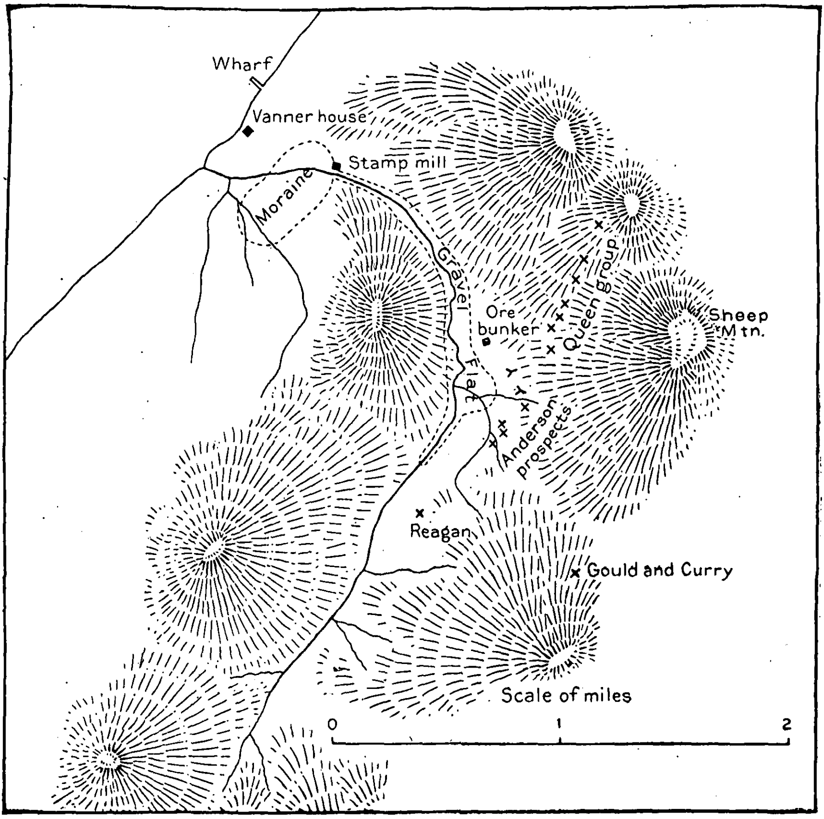


FIG. 6.—Sketch map of Sheep Creek.

On the southeast ridge of Sheep Mountain and extending southeastward for 1½ miles is a somewhat irregular dike of the Coast Range type of diorite. This rock closely resembles in composition the ore-bearing dikes of the Treadwell mines, and here it has been impregnated to a certain extent by sulphides and locally contains stringers of quartz. This intrusion cuts a dike of the dark diorite about 600 feet northwest of the Gould and Curry workings, thus establishing the relative age of these two types of rock.

At the head of Sheep Creek is a considerable thickness of thin-bedded black limestone lying next to the main greenstone contact. At first sight this limestone seems to be but little affected by metamorphism, but close inspection shows that practically all of the carbonaceous material which gives the dark color has been changed to graphite. This mineral occurs in minute flakes lying parallel with the stratification and producing a somewhat schistose appearance. Certain layers contain a great deal of pyrite in minute shining cubes. The boundary between these limestones and the greenstones is much less regular than the corresponding horizon farther north. This is apparently due to the intrusive nature of part of the greenstone in this vicinity. It is, however, impossible to distinguish the intrusive greenstones from the other portions, which are believed to have formed as volcanic flows. On the geologic map this boundary is greatly generalized, so that the irregularity of the contacts does not appear.

The group of greenstones and interbedded slates, corresponding with similar rocks farther north, separates the band of black slates from Gastineau Channel and forms the mountains lying between the basins of Sheep and Grindstone creeks and tide water. The contact with the black-slate band follows a fairly straight course from a point just northeast of Robert Peak to Taku Inlet, just above Bishop Point.

As compared with their attitude in Gold Creek, the rocks stand at considerably higher angles in the region drained by Sheep Creek. From about 60° on the Gold Creek divide the dips increase to 90° in the upper part of the basin, and on the Grindstone divide the beds are slightly overturned, so that the dips are steep toward the southwest. Increasing width of the black-slate band southward from Gold Creek suggests the presence of considerable folding and duplication of the strata, but no direct evidence of this sort of structure has been observed.

OCCURRENCE OF THE ORES.

The concentration of mineral-bearing veins in the portion of the black-slate band lying next to the greenstone is well marked in Sheep Creek. The development of the Silver Queen and Glacier mines has revealed a succession of veins occupying a zone about 400 feet wide next to the greenstone contact. This set or system of leads is prominently developed from the upper part of the slope from the Gold Creek divide to the Reagan group of claims, situated about 8,000 feet to the southeast. Farther along the same course the veins, though present, are smaller and have not been explored underground.

Outside of this main system of lodes many individual veins are found in the black slates on the slopes northeast of the creek, but so far as seen these are never continuous for more than a hundred feet or so and most of them are much shorter than this. These outlying veins are usually transverse to the slaty structure. Some of them contain free gold, but it seems that they can hardly be of any great importance excepting to pocket hunters. A couple of such veins at the Gould and Curry mine have yielded some good ore, but the supply seems to have been insufficient to insure profitable operation. In the summer of 1903 prospecting was in progress just above the Gould and Curry property in a dike of gray diorite where, in addition to considerable quartz veining, the rock has been impregnated with sulphides. The nature of the mineralization is similar to that of the Treadwell ore dikes, but the rock is not altered or mineralized to the same degree and, though gold is reported, it is said that extensive sampling has indicated only low values.

Quartz veins are found here and there in the greenstones occurring between the lode system and Gastineau Channel, but as a rule these are merely gash fillings and, though they may contain gold, are never of sufficient size to be of great value. Both the greenstones and the associated black slates are locally filled by pyrite which occurs without other vein minerals, but mineralization of this sort is likewise regarded as of no economic importance.

So far as present developments show, there appears to be little chance of finding workable mineral deposits outside of the limited zone lying next to the main contact of the black slates and greenstones.

DEVELOPMENT OF THE MINES.

The entire production of Sheep Creek has come from the Silver Queen group of mines, which comprises the Silver Queen, Glacier, and Ascension claims, with several others adjacent. The London, Hartford, Golconda, and Glacier claims were located in 1887; the Silver Queen and Ascension in 1888. After having been developed to a certain extent these claims were brought under a single ownership, and in 1889 the Silver Queen Mining Company erected a 10-stamp mill, which was operated until 1895. In the latter year the property was purchased by the Nowell Gold Mining Company and 20 stamps were added to the mill. Bucket trams were installed and a narrow-gage railroad was construced from the ore bunkers to the mill, about three-fourths of a mile distant. For several years past, under the ownership of the American Gold Mining Company, the property has been worked by lessees and has been a fairly steady producer. The stamp mill is situated about 1 mile from the landing on Gastineau Channel, but the concentrating plant is located on the beach, the wet pulp being delivered by means of covered sluices. The creek furnishes ample water power for operating the dynamos which run the mills and compressors and light the various works.

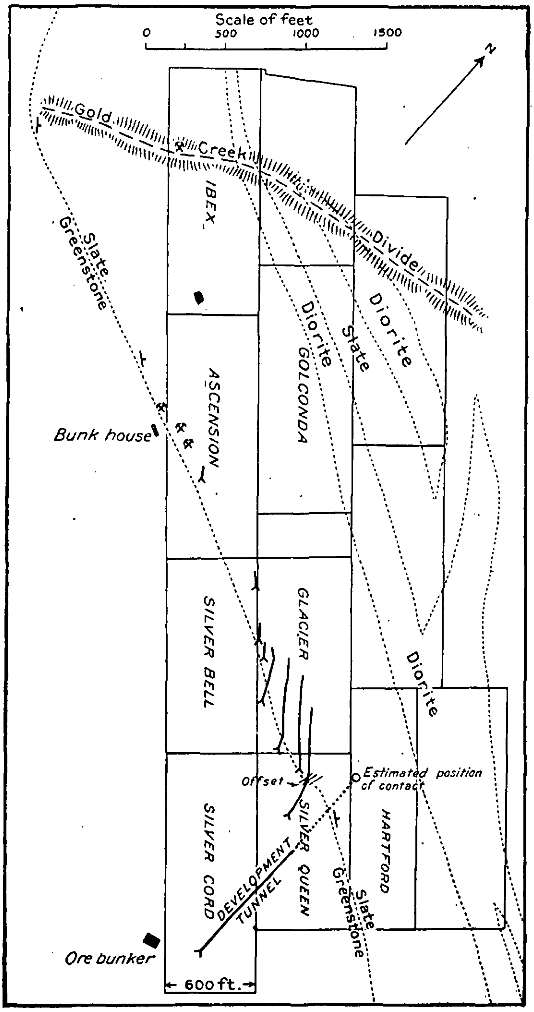


FIG. 7.—Sketch map of Silver Queen group of claims, showing approximate relation of workings to the local geology.

PRODUCTION.

The production of the Sheep Creek mines to the close of 1903 is estimated at $465,000.

SILVER QUEEN GROUP.

Position.—This property is situated on the steep mountain slope northwest of Sheep Creek basin. It extends from the end line of the Alaska-Perseverance group, 1,500 feet northwest of the Gold Creek divide, to Sheep Creek basin, a total length of 6,000 feet, and is three claims or 1,800 feet in width. The group consists of seven full claims and six fractions, having a combined superficial area of about 224 acres.

Development.—The Silver Queen, Glacier, and Ascension claims have been worked independently. In 1903 the Silver Queen workings consisted of about 2,600 feet of drifts and crosscuts on three levels and 500 feet of connecting raises, together with the ore stopes. In the Glacier mine there were 3,200 feet of drifts and crosscuts on four levels and 1,200 feet of connecting raises. The so-called Ibex workings, located on the Ascension claim, amounting to a few hundred feet only, are not now available for examination.

In 1903 connection was made between the Silver Queen and Glacier mines, and ore from the latter is now taken out by way of the Silver Queen workings.

Geology.—The metalliferous veins in this group of mines represent the southeastward continuation of the lode system of Gold Creek. The band of black slates free from greenstones is here nearly 2 miles in width, and more or less veining is present everywhere, but the only veins which are at all persistent occur near the foot wall of the slates next to the boundary with the greenstones. Here they occupy a zone 400 or 500 feet in width, not sharply limited on the northeast or inland side, but definitely bounded on the southwest by the uppermost bed of the greenstone series which forms the mountains next to Gastineau Channel.

The average strike of the bedding as determined from the contact between the slate and greenstone is N. 42° W., and the average dip is about 60° NE. In the mine workings, however, the dip is usually somewhat less. Owing to the inclination of the beds the apex of the slate-greenstone contact is diagonal to the line of strike and trends about N. 75° W. (See fig. 7.)

A vertical section is here given, running through the Glacier mine, to illustrate the attitude of the rocks and the geological position of the mineral zone. (See fig. 8.)

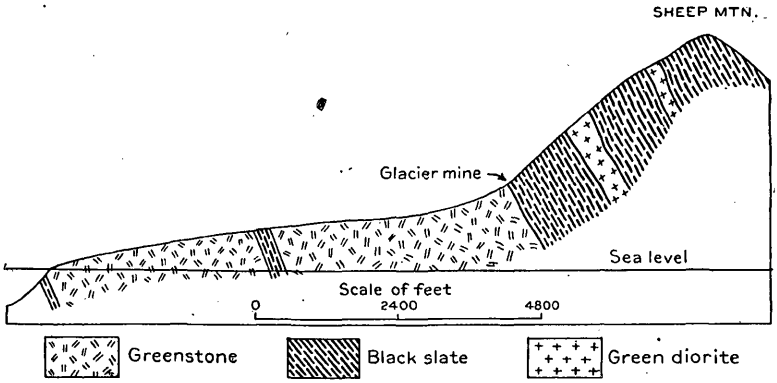
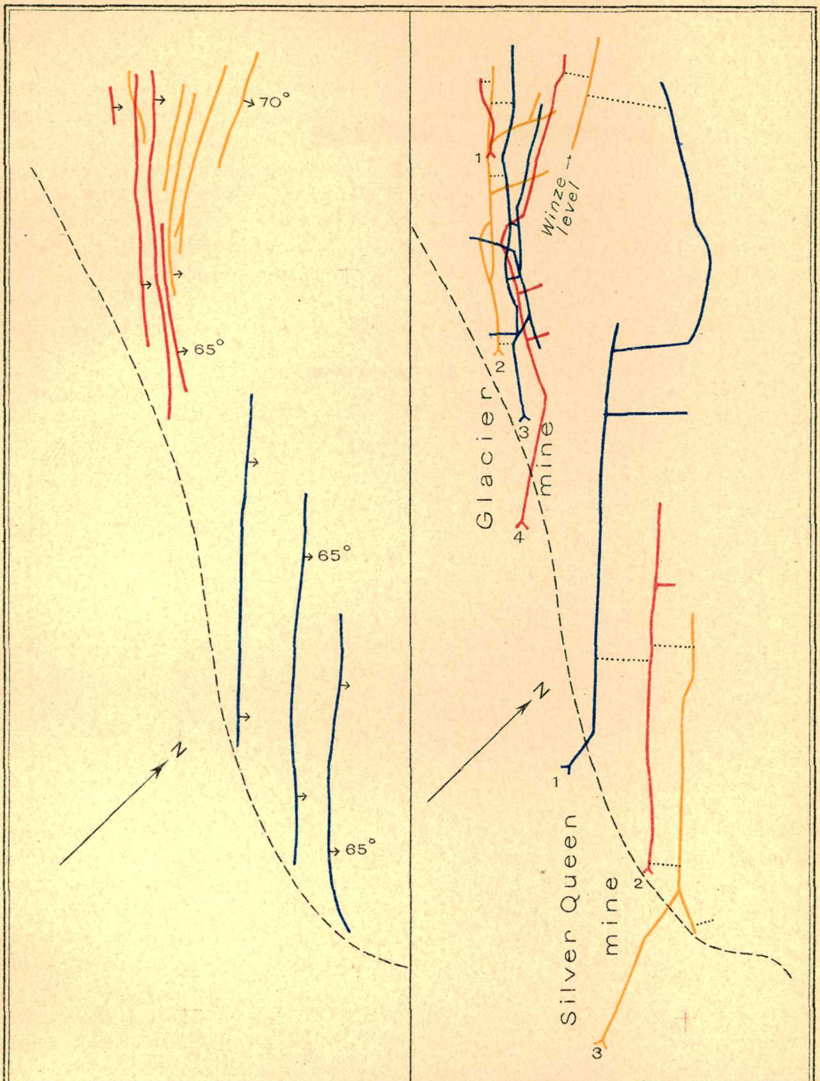


FIG. 8.—Profile section from mouth of Sheep Creek to Glacier mine and Sheep Mountain.

The slates are in every respect similar to those of Gold Creek. They carry considerable amounts of graphite. Their cleavage is practically parallel with the greenstone contact, and this latter is the only key to the bedding in this vicinity, the slates themselves showing no variations sufficient for determining the presence of stratification. Dikes of dark diorite (altered gabbro) are found in the cliffs above the mines, but none of this rock was observed in the zone occupied by the veins except on top of the ridge, where a few small dikes similar to those of Gold Creek are present.

General features of the veins.—In Sheep Creek the quartz veins of the main lode system are stronger and more continuous than in Gold Creek. (See Pl. VI.) They follow in a general way the bedding and cleavage of the slates by which they are inclosed and therefore strike northwest and southeast and dip toward the northeast. (See figs. 8 and 9.)

This correspondence of vein courses and stratification is, however, only approximate, as is proved by variations in the distance between the greenstone contact and any particular vein. In places the Silver Queen vein, which has been followed underground for 900 feet, is only 15 feet above the greenstone, but elsewhere along the outcrop the intervening distance is as much as 30 feet. So also in the case of the Glacier vein a crosscut on No. 4 level reveals the greenstone only 30 feet away, while at the surface above the bunk house (No. 2 level) the interval is considerably more. Another evidence of crosscutting is the fact that the Copper Streak lead has a more northerly course than the Glacier on the three levels where both veins have been encountered, and from No. 4 level upward these veins diverge slightly. The rule covering these observations seems to be that from southeast to northwest and from below upward the veins angle away from the greenstone contact.



PLAN OF VEINS
as shown in mine workings

- – – – – Contact outcrop
- Silver Queen vein
- Copper Streak vein
- Glacier vein

PLAN OF MINE WORKINGS

- – – – – Contact outcrop
- .... Raises and winzes

Scale
0 100 200 300 400 feet

MAP OF SILVER QUEEN AND GLACIER MINES, SHEEP CREEK, ALASKA

JULIUS BIEN & CO. N.Y.

A careful comparison of observations along the mineral zone for a distance of 8,000 feet indicates the presence of three or four nearly parallel veins in the average cross section. Exposures of bed rock are comparatively few, so that the extent to which these veins are continuous can not be determined, but from an examination of the mine workings it is believed that instead of being continuous veins the bodies of quartz have the form of disconnected plates variable in length and depth and arranged in overlapping position.

Silver Queen vein.—This vein has been mined from three levels and found to be continuous for a total horizontal distance of 900 feet. On the dip it has been stoped to a total height of over 400 feet. (See fig. 10.) Above the highest workings the vein is represented by several outcrops along the trail, but here the quartz is evidently not continuous, having the form of disconnected lenses. One of these quartz streaks a few inches thick was encountered in the crosscut portion of No. 4 level in the Glacier mine, so that the total known depth of the vein, including the interrupted portion, is about 600 feet along the dip. The axis of the ore shoot rises toward the northwest, as is shown by the fact that while in the lowest or No. 3 level the ore played out 400 feet from the surface, in No. 2 it was stoped nearly 200 feet farther, and in No. 1, 300 feet beyond the end on the level below. (See stereogram of veins, Pl. VII.)

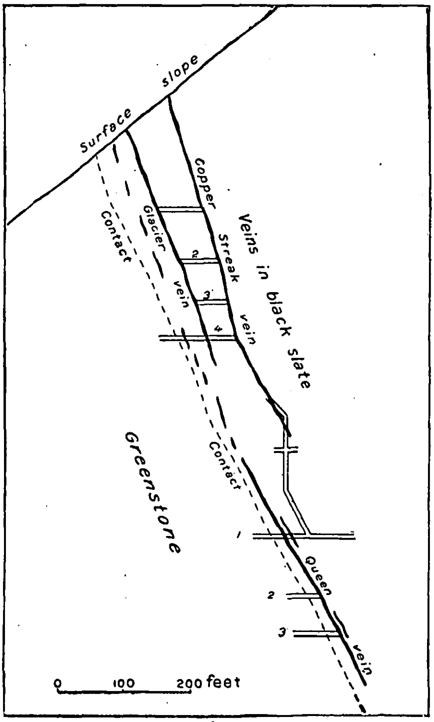


FIG. 9.—Generalized cross section of Silver Queen and Glacier mines, showing dip of veins and relation to slate-greenstone contact.

So far as could be determined from the old workings the Silver Queen vein was usually quite solid, varying in thickness from 2 to 6 or 8 feet, but on No. 1 level, beginning about 100 feet from the outcrop, the vein is double, consisting of two parallel plates of quartz about 6 feet apart. Both veins have an average thickness of 2 feet, varying from 1 to 3 or 4 feet.

From the relative position of the greenstone contact along the trail below Silver Queen level No. 2 and in the ravine about 200 feet to the eastward, it is evident that the strata are displaced by a fault which causes an offset toward the northeast. Exposures of bed rock in this vicinity are very few, but from the best data obtainable the horizontal throw of this fault amounts to about 150 feet. There is evidence of faulting in the crosscut to the vein on No. 3 level, but here the offset appears to be only a few feet, so that the total throw is probably effected by successive steps along several nearly parallel fault planes. The presence of this break must be taken into consideration in any further search for the Silver Queen vein by extending the adit from the basin level. The present length of this tunnel is 870 feet, and if continued in its present direction it should cut the contact between 1,450 and 1,550 feet, provided the dip of the strata is taken to be 45°, as in the Silver Queen workings.

Glacier and Copper Streak veins.—These veins in the black slate lie farther from the greenstone than the Silver Queen vein. The Glacier vein has been worked for a horizontal distance of about 500 feet, and the Copper Streak for 400 feet. The former has been opened from the No. 4 level to the surface above No. 2, showing a length along the dip of 400 feet or so, while the latter has been followed nearly 700 feet on the dip from the winze level below No. 4 to the surface above No. 1 tunnel.

Both veins vary in thickness, being represented in some places by only a few inches of quartz, but elsewhere expanding to 6, 8, or even 12 feet. As a rule they are fairly solid bodies of quartz, but spurs and offshoots are not infrequent, and locally the veins break up

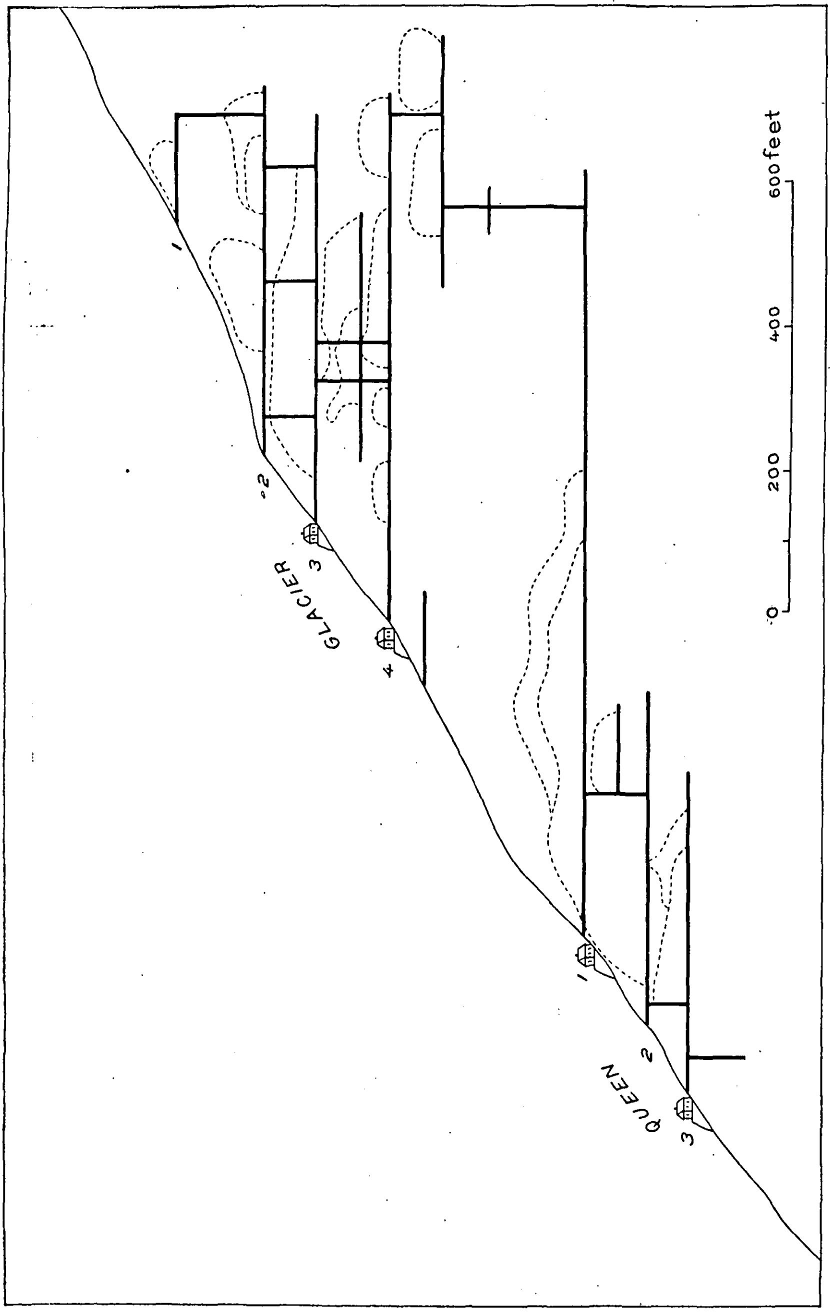
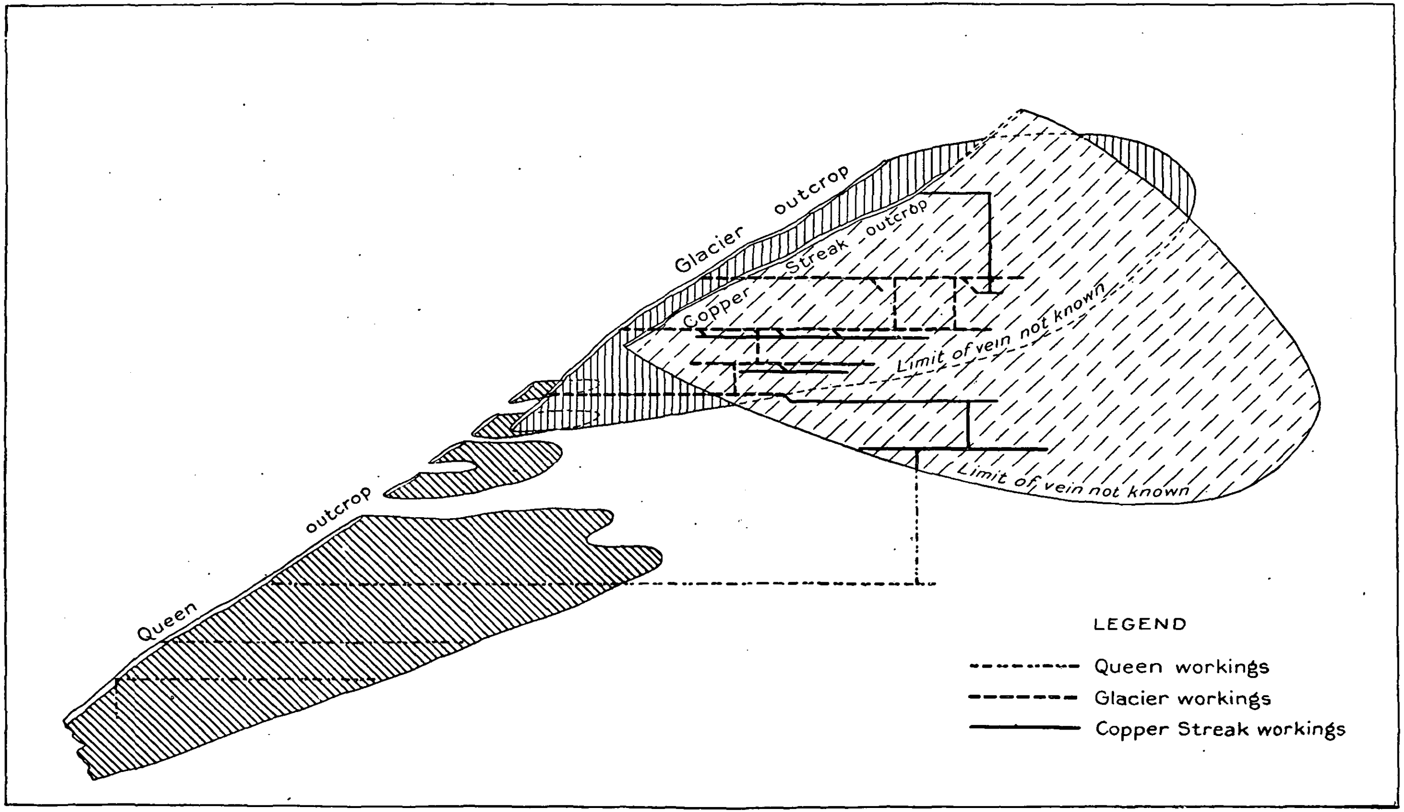


FIG. 10.—Elevation of workings, Silver Queen and Glacier mines.

and take the form of stringer leads. This feature was observed in a breast on the winze level about 250 feet northwest of the raise from No. 1 Queen. At this place the Copper Streak lead, 9 feet in width, is composed of 5 to 7 streaks of quartz separated by graphitic slate and presents the appearance of a typical stringer lead (fig. 11).



STEREOGRAM SHOWING APPROXIMATE RELATIONS OF QUEEN, GLACIER, AND COPPER STREAK VEINS.

The veins overlap and dip toward the observer.

The overlapping of the three veins is well shown in No. 4 level of the Glacier mine, where the relations, so far as revealed, are shown in fig. 12. As the veins are followed toward the northwest they diverge slightly from each other and from the greenstone contact, the distance from the greenstone to the Glacier vein varying from 20 to 100 feet, and the interval between the latter and the Copper Streak being from 30 to about 75 feet.

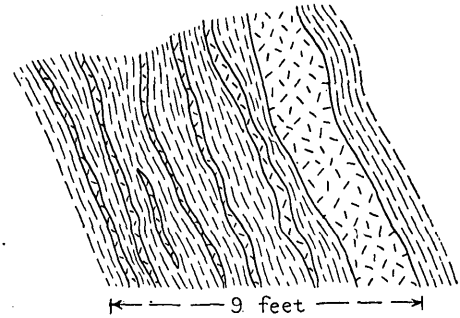


FIG. 11.—Detailed cross section of Copper Streak vein on winze level, Glacier mine.

ANDERSON CLAIMS.

The Anderson group of claims begins at the southeast end of the Silver Queen property and covers the lode system for a distance of 1,500 feet. This property lies at the base of the steep mountain slope and none of the vein croppings rise more than 300 feet above the gravel floor of Sheep Creek.

Continuing toward the southeast the lode system of the Silver Queen group shows the same characteristics in the ground covered by the Anderson claims. The greenstone which forms the foot-wall rock of the ore zone does not outcrop because of the accumulations of talus, but it has been revealed in a crosscut tunnel, where its strike is about N. 40° W. and its dip about 70° NE. The black slates lying next to the greenstone are also hidden, the nearest exposures being perhaps 80 to 100 feet from the contact. Above this, however, there are occasional outcrops and at several points quartz veins have been opened by shallow pits.

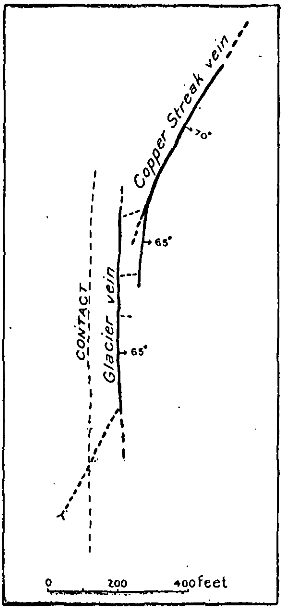


FIG. 12.—Plan of veins opened by No. 4 level, Glacier mine, showing divergence of veins.

On two of these veins there are development tunnels 40 or 50 feet in length, but no other work has been done except to start a crosscut to prospect the ground in depth. The fewness of the openings makes it impossible to judge of the continuity of the veins, but the relative positions of the several prospect openings suggests that the quartz veins are distributed along four horizons in the slate. This impression is given more weight than it might otherwise receive because it corresponds with the occurrence of the veins in the better-developed ground of the Silver Queen and Glacier mines.

The veins are mostly fairly solid and from 2 to 4 feet wide, but at one place a drift 40 feet long shows a typical stringer lead composed of many small separated masses of quartz, some of which follow the structure of the slate, while others, usually the larger ones, cut this structure at an angle of about 45°. The stringers of quartz are very numerous in a band from 3 to 5 feet wide, but are present throughout about 20 feet of the slate.

The metallic minerals of these veins are pyrite, sphalerite, and galena, giving ores which are identical in appearance with those from the adjacent mines.

REAGAN PROPERTY.

Southeastward from the Anderson prospects the extension of the lode system runs through a swampy meadow, where bed rock is covered by a deposit of peat. This ground has never been prospected, though two crosscuts have been started for this purpose from the level of the valley floor. In these tunnels the foot-wall greenstone was encountered after penetrating a considerable mass of loose drift, but the black slate has not been reached. The working depth which these tunnels will afford is not over 150 feet.

The Reagan prospect is located on the slope of the mountain southeast of the upper end of the meadow just mentioned, at an elevation of 950 feet and 250 feet above Sheep Creek. A shaft from the outcrop connects with an adit 40 feet below, and when visited a further depth of 30 feet had been attained in a winze. Drifting on the vein amounts to 250 feet.

The vein follows the structure of the graphitic slates by which it is inclosed, striking N. 45° W. and dipping 75° to 80° NE. It is rather compact, and the walls are well defined and fairly regular, though occasional short spurs are observed. Along the walls a few inches of clay gouge are sometimes present.

The occurrence of sulphides is not uniform, and the workable mineral appears to lie in shoots, though their size and shape can not be estimated from the present extent of the workings. Sulphide minerals observed are galena, sphalerite, chalcopyrite, pyrite, and considerable tetrahedrite (gray copper). Electrum (alloy of silver and gold) also occurs, but only in seams or close fractures, where it has evidently been deposited by the action of surface waters circulating through the vein. Tetrahedrite is likewise of secondary origin, as is shown by the fact that it forms a superficial coating on grains of the primary sulphides.

At the time of our visit several tons of ore extracted during the progress of development work had accumulated upon the dump, but no commercial shipments had been made.

GRAVEL DEPOSITS IN THE BASIN.

Sheep Creek basin is filled by a bed of gravel from 200 to 1,200 feet wide and over a mile long. The surface of the flat slopes from 500 feet elevation up to about 700 feet. No test of the depth of the deposit has ever been made, but it probably reaches a maximum of more than 200 feet, as estimated by comparing the present grade of the stream with the average bed-rock grade of the valley.

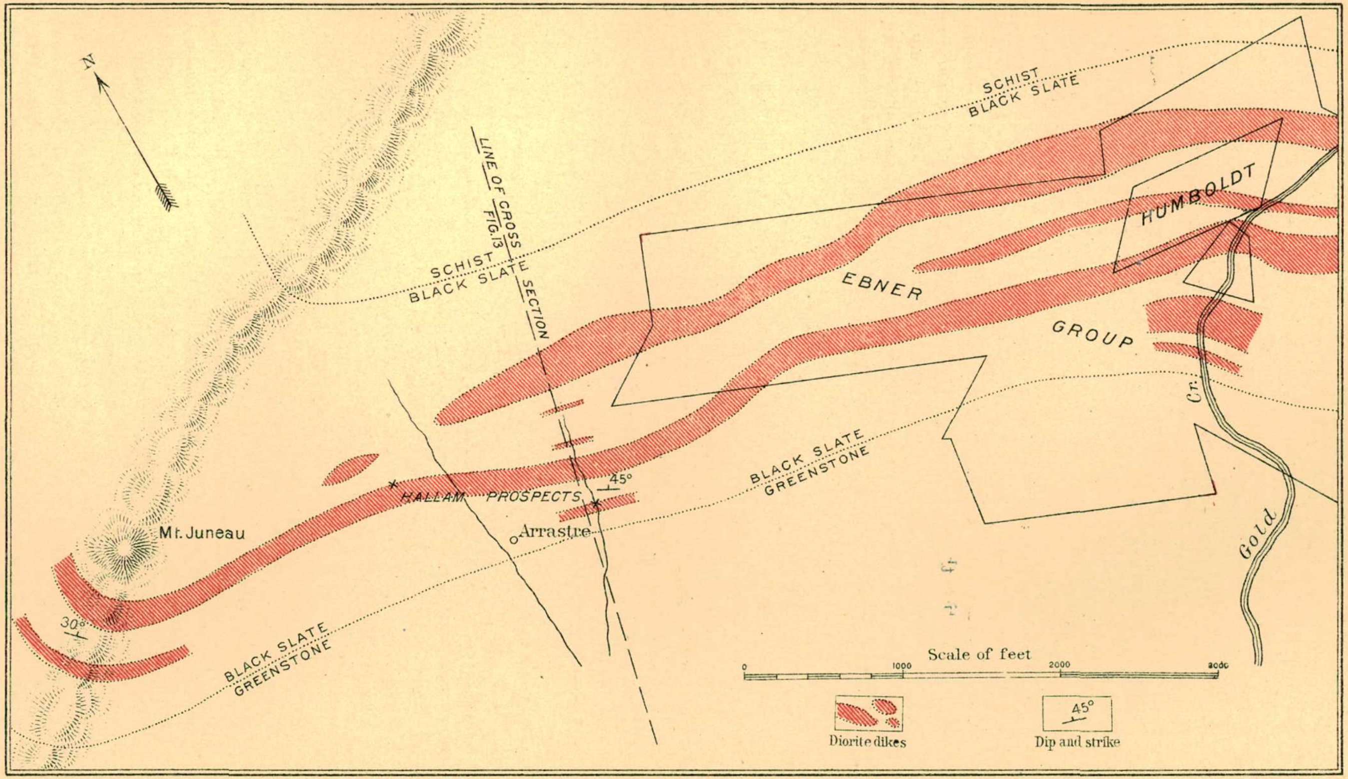
This gravel deposit has accumulated back of a mass of débris dumped into a narrow part of the valley by a former glacier. This material obliterated the lower part of the original channel and caused the stream to take a new course determined by the contour of the morainal deposit and quite out of harmony with the deep, rugged topography. Flowing in this new course the stream first cut through the moraine and afterwards eroded the present canyon in bed rock, but the resistance of the hard formations has thus far protected the accumulation of gravel above from being washed out.

This bed of gravel undoubtedly contains gold, but no confident opinion can be expressed upon the question whether or not it occurs in sufficient amount to warrant exploitation. The slopes which have contributed most of the débris are auriferous to a greater or less extent, but aside from small operations in a gulch near the head of the basin there has been no placer mining within the Sheep Creek drainage.

GOLD CREEK.

TOPOGRAPHY.

Gold Creek, which empties into Gastineau Channel, drains an area somewhat less than 10 square miles in extent. From the water parting at its head to its mouth at Juneau the distance is nearly 5 miles, and the basin of its only important tributary, Granite Creek, has an additional length of about 2 miles. (See Pls. IV, VIII, IX, XIV, and XVII.) Granite Creek and the lower valley of the main stream have the same general course transverse to the strike of the country rock, but the upper portion of the main valley, which is called Silver Bow basin, extends along the strike and has been mainly excavated in black slates. The valley is a deep one and its walls are very steep, the surrounding ridges reaching elevations nowhere less than 2,800 feet, while several of the peaks rise to an altitude of more than 4,000 feet. However, though the declivities are abrupt, vertical cliffs are rare, profiles of the mountain sides are curved instead of being angular, and the whole character of the topography is recognized as having been molded by glacial action.



GEOLOGIC SKETCH MAP, GOLD CREEK TO MOUNT JUNEAU

JULIUS BIEN & CO. N.Y.

The upper end of Silver Bow basin has an elevation above 1,200 feet, but the fall of the stream below this is not regularly distributed. There are several gently sloping floors of considerable length connected by much steeper grades, and these flat reaches have been formed in each case by the deposition of gravel by the stream itself.

GEOLOGY.

Practically all of the rocks which have been distinguished in the Juneau belt occur within the Gold Creek drainage. These have been described in three sets or groups—the dioritic rocks of the Coast Range, a series of crystalline schists, and a series composed of alternating slate and greenstone in beds of various thickness. The local distribution of these rocks is shown on the geologic map of the vicinity of Juneau (Pl. IV).

The larger structural relations are simple. The bedded rocks strike from southeast to northwest and dip toward the northeast at angles varying from about 30° in the vicinity of Mount Juneau to about 60° at the upper end of Silver Bow basin. As a rule cleavage is well developed in the rocks and it always follows the general strike and dip of the formations. (See figs. 15, 16, and 19.)

The mass of the mountain which lies between Gastineau Channel and Silver Bow basin is composed of greenstone and greenstone schist occurring in thick beds separated by thinner strata of black slate. The width of this band is approximately 2 miles, and beyond it is a zone about 1 mile in width consisting of black slates intruded by dikes of gabbro. These two bands constitute the mainland portion of the slate-greenstone series in this vicinity. The boundary between the greenstones and the slates is a simple one and corresponds with the other lines of bedding in the district. The band of slate runs through the axis of Silver Bow basin and may be traced up the slopes of Mount Juneau to its summit and in the opposite direction over the divide into Sheep Creek.

On the inland side of the slates there is a 2-mile band of crystalline mica and hornblende schists containing some beds of quartzite and limestone. These schists have been derived by metamorphism from sedimentary rocks, and the parallel structures which have been developed in them lie mainly parallel with the original stratification, as is shown by the attitude of beds of quartzite and limestone, which can be traced for considerable distances. One group of limestone strata about 200 feet in thickness has been followed for a distance of 10 miles, while another group of calcareous beds which is locally prominent on the western slope of the ridge between Silver Bow basin and Granite Creek and on the Gold-Salmon Creek divide about 1 mile east of Mount Juneau is less constant in its characteristics and can be traced for about 5 miles only, the greater part of its outcrop being in the Gold Creek drainage. The schists have been intruded by dikes of gray diorite, and they are also invaded by, and therefore older than, the main mass of the Coast Range diorite. They also inclose numerous small dikes of dark gabbro, which usually follow the structure of the rocks. These dikes have been altered by pressure metamorphism and in many places they have been converted into schist, which is hardly distinguishable from portions of the inclosing series of sedimentary origin.

The main mass of the Coast Range diorite lies about 4½ miles distant from Gastineau Channel, and its edge is barely reached by the headwaters of Granite Creek. There are, however, two outlying dikes of this rock, and these have contributed a large amount of material to the gravels found in the lower part of Granite Creek and of Gold Creek.

Throughout its length, as studied in the Juneau belt, the main contact of the diorite has a general parallelism with the structure of the metamorphic rocks, into which the igneous rock has been intruded, but in the vicinity of Juneau there is a gradual crosscutting toward the west, as is well shown from the relations represented upon the geologic map (Pl. III).

HISTORY OF MINING OPERATIONS.

Gold Creek was discovered in the autumn of 1880, but no mining was attempted until the following spring In the meantime a recording district was established by the miners, and local rules, which were practically those in vogue in the Cassiar district of British Columbia, were adopted to govern placer locations and water rights. Locations were classed as hill, gulch, and creek claims. Hill and gulch claims were defined as 200 by 300 feet in size, while creek claims were to be 200 feet long and to extend from mountain slope to mountain slope.

Prior to January 1, 1881, no less than 71 placer claims had been duly entered in the books of the recorder, though most of these were located after December 1, when the ground was covered with several feet of snow.

Auriferous deposits on the hillsides consisted of soil nearly in place, derived by the disintegration of the rocks and veins; while the gulch deposits represented the natural wash from the adjacent slopes concentrated along the beds of the streams. These were naturally richer than the larger deposits in the main creek, derived in large part from barren rocks, and they furnished nearly all the output of the first few years. The claims were worked by hand sluicing, as a rule, but canvas hose was also used to wash the pay dirt into the sluice boxes. It is reported that from $5 to $30 per man was realized from many of the claims.

The records of the first recorder of the Harris mining district are preserved in the office of the United States commissioner at Juneau. These show that six placer claims of 300 by 200 feet were recorded by Harris and Juneau for themselves and their employers, Pilz and Fuller, on October 4, 1880. Eight days later they recorded twelve quartz claims of 600 by 1,500 feet in the names of Pilz and Fuller and on the 14th four additional claims for themselves. These sixteen locations cover the best of the ground now held by the Ebner Gold Mining Company and the Alaska-Juneau Company, and early in 1881 practically all of the ground which is at present regarded as of value had been staked.

Arrastres are reported to have been in operation in 1881 and 1882, and in 1883 one on the Fuller claim is said to have turned out $2,000. The first 5-stamp mill was erected in 1882 by W. I. Webster to work the ores from the Humboldt claim. This plant, which was packed in by horses, has been in operation at intervals since August, 1882.[a]

In 1884–85 the Johnson Mill and Mining Company, then owners of the Taku gold and silver group of claims, built a wagon road to the falls on Gold Creek and erected a newly devised grinding machine near the Webster stamp mill. This apparatus, however, proved a failure, and it was not until 1888 that 10 stamps were installed by the Taku Mining and Milling Company. These two batteries are still in operation, and a third, of 5 stamps, has since been added by the Ebner Gold Mining Company, the present owner of the property.

In 1884, 1886, and 1888 arrastres were built upon the Fuller First, Perseverance, and Dora properties.[b] In 1886 two Huntington mills were erected near the Mineral Monument below the Aurora and Fuller First claims at the upper end of Silver Bow basin. In 1890 Archie Campbell installed a revolving Dodge mill on the Fuller First, but in the following year this was superseded by a mill of 5 stamps which had formerly been used in developing the Treadwell mine. After operating with this plant for two years Campbell sold the property to Lane & Hayward, who continued to work it and in 1896 installed 30 stamps. In the autumn of the same year the principal interest was transferred to the Alaska-Juneau Company, which has since been engaged in systematic development with a view to opening the mine upon a large scale.

In 1889 the Eastern Alaska Mining and Milling Company erected a 10-stamp mill at the head of Silver Bow basin and built an overhead tramway nearly 3,000 feet long to the Perseverance group of claims. Prior to 1894 about $70,000 in gold and silver had been produced. From 1894 to 1895 the mill seems to have been idle, and in December of the latter year it was destroyed by a snowslide and has not been rebuilt.

In the upper end of Silver Bow basin, near Icy Gulch, and in the little basin north of the present 30-stamp mill, where in was possible to reach bedrock, placer mining in a small way had been successfully carried on, and perhaps $200,000 had been taken out prior to 1888. During this year a company organized by Mr. Thomas. S. Nowell purchased claims aggregating about 200 acres in the upper part of Silver Bow basin. A tunnel 10 by 9

[a] Rept. Director of the Mint upon Production of Precious Metals in U. S. for Calendar Year 1882, Washington, 1883, p. 27.

[b] The writer is indebted for the statements in this and the following paragraph to Mr. W. Ebner, of Juneau.

feet in cross section and 3,400 feet long was driven to tap the deposit of gravel. This work was completed in the spring of 1891 and sluices and a track were laid through the tunnel. Two hydraulic nozzles were installed and the property was operated during each summer season until 1901, when the company became involved in litigation and work was suspended.

The so-called Red mill of 20 stamps, situated near the lower end of the Nowell placer tunnel, was completed in 1893. It was intended for the reduction of ores from the Groundhog property, located on the eastern side of Icy Gulch above the Perseverance claims. An overhead tramway more than 4,000 feet in length was installed between the mine and the placer pit in Silver Bow basin, where the ore was delivered into cars and run to the mill through the drainage tunnel, a distance of nearly 1 mile.

About 1897 various interests owning property in the lower part of Gold Creek were consolidated through the efforts of Mr. G. W. Garside, and the Last Chance Hydraulic Mining Company was organized in 1898 to work what has been since known as the Last Chance placer. A tunnel 4 by 5 feet in cross section and about 2,000 feet in length was driven through bed rock to tap the deepest portion of the basin, but because difficult ground was encountered after the channel was reached it was found impossible to continue the tunnel in a direct line upstream to bed rock. A turn was therefore made and the rim rock was cut by a raise to the surface on the south side of the basin. In 1903 the company was reorganized as the Jualpa Mining Company, and during the summer of that year progress was made in lowering the outlet, which will eventually be worked down to the bottom of the channel.

In 1903 there were 4 stamp mills in Gold Creek, containing in all 80 heads. The Humboldt mill of 5 stamps was operated for a few days only during the progress of annual assessment work. Twenty stamps in the Red mill and 5 in the Alaska-Juneau were idle, leaving 45 active in all. Of these, 15 were in the Ebner mill and 30 in the Alaska-Juneau, both of which were in operation during the entire summer season.

The recent work at the Ebner and Alaska-Juneau mines has been directed toward the development of the properties with a view to increasing their output, and especially at the Alaska-Juneau a large amount of proving has been done. The only other extensive development work has been that of the Alaska-Perseverance Company, which is now running a crosscut tunnel 8 by 7 feet from a point 275 feet above Gold Creek, to tap the mineralized zone outcropping on the Perseverance group of claims. This work had progressed nearly 2,000 feet in November, 1903, and it was intended to continue 500 feet farther before raising to the old workings, 740 feet above the tunnel level and some 300 feet below the surface. The development of this property previous to the present ownership consisted of about 1,900 feet of tunnels and shafts.

During the summer of 1903 sixty miners and laborers were steadily employed in the three mines of Gold Creek.

PRODUCTION.

No entirely reliable estimates on the total production of the Gold Creek placers and quartz mines can be made. From the reports of the Director of the Mint it is known, however, that during the year 1881 $13,374.70 in gold and $144.36 in silver, coming from the vicintiy of Juneau, were deposited in the San Francisco mint. In 1882 the deposit rose to $34,011, and in 1883 to $85,000. These amounts, however, represent only a fraction of the output for the three years named, which was estimated by R. T. Harris [a] in 1884 to have been $450,000 in all, or an average of $150,000 per year. A less conservative estimate, that of Capt. James Carroll,[b] then engaged in coastwise transportation, places the approximate output for 1883 alone at $400,000, which shows the difficulty of reaching any acceptable figure from recorded data. Through the courtesy of Messrs. William Ebner and Thomas S. Nowell, of Juneau, data have been secured for an estimate which shows a total output between 1881 and 1903 of approximately $1,700,000. An independent estimate based upon

[a] Rept. Director of the Mint upon Production of Gold and Silver in U. S. for Calendar Year 1883, Washington, 1884, p. 21.
[b] Ibid.

the incomplete data given in the annual reports of the Director of the Mint, with proportionate interpolations for the years in which no figures are given, indicates that the production may have been nearly $2,800,000. Possibly a mean of these estimates, or about $2,250,000, may be fairly taken as representing an approximation to the true value of the output from Gold Creek.

The quartz mines have produced about $1,000,000 and the Nowell placer approximately $400,000, which leaves an estimated $850,000 for the small placers, which were mostly exhausted before 1890.

BED-ROCK MINES OF GOLD CREEK.

GENERAL STATEMENT.

The Gold Creek quartz mines are situated on the main lode system of the Juneau gold belt, the general features of which have already been described. The zone which contains the greatest amount of quartz veining and which is consequently of the main interest from the miner's standpoint has a length of nearly 4 miles within the drainage basin and a width of from 1,800 to 2,400 feet. (See Pl. XV.)

SLATE COUNTRY.

The principal rock of the mineral zone is black graphitic and calcareous slate, the cleavage of which strikes northwest and southeast and dips at various angles, but usually steeply toward the northeast. Slaty structure and bedding ordinarily coincide, and as a rule there is no sign of folding or plication in the slates. Locally, however, as observed on the Ebner and Perseverance properties the original bedding shows folding, and in such cases the cleavage cuts across the stratification, following the average inclination of the slaty structure of the district.

The slates are locally bleached, in which condition they have the appearance of fine-grained quartzites and are often spotted, as may be observed in outcrops along the wagon road opposite Ebner's mill. The microscope shows that the spots are composed of quartz, chlorite, and mica (sericite), the rest of the rock being principally quartz in very small grains.

DIORITE DIKES.

Besides the slates the only other rocks of the ore zone are igneous intrusions. Of these there are two types—ancient gabbros, now very much altered, and relatively recent diabases which are practically unchanged by decomposition.

The alteration in the gabbro rocks masks their original nature, for they now consist of feldspar and green hornblende where they have not been mineralized, and near the quartz veins, where they have been affected by water action, they are composed almost entirely of quartz, calcite, brown mica, and chlorite, showing a maximum of metamorphism. The hornblende-feldspar rock, which may, for convenience, be called diorite, usually has a dark appearance and a greenish cast, while the more altered rock has a rusty-brown color in outcrop and a bronzy tone when freshly broken. The latter is commonly known as "brown rock" or "brown diorite."

These rocks are evidently derived from the same material, for they may be observed to grade into each other in several places, as, for instance, in the surface workings at the Ebner mine. They occur as dikes measuring from a few feet up to about 200 feet in width. In the main these dikes follow the cleavage of the slates, though in some instances they leave the secondary structure and follow the bedding, where the two do not coincide. An example of this may be made out at the upper (southeast) pit on the Ebner property. Also on the Perseverance ground there are several instances where the dikes are seen to end blindly, with the strata arching over their blunt terminations. (See figs. 15, 16, and 19.)

DIABASE DIKES.

The narrow diabase dikes cut across the structure of the country. Two of them were observed in the Alaska-Juneau workings, and another may be seen in the cliffs on the north side of Gold Creek, above the Last Chance placer. The dikes first mentioned are composed of fine-grained diabase, in which the feldspar, though somewhat decomposed, appears to be labradorite. The rock contains a good deal of magnetite and some calcite. The dikes cut the quartz veins, and they were therefore injected after the principal mineralization had been accomplished.

The rock of the dikes in the lower part of Gold Creek is minette, composed of brown mica, augite, and feldspar, and similar dikes were observed along the mainland shore of Gastineau Channel.

All these dikes are regarded as belonging to the same period as the leucite-basalt dikes which occur in the Alaska-Treadwell mine.

GREENSTONES OF THE FOOT WALL.

The greenstones which form the mountain between Silver Bow basin and Gastineau Channel are in large part metamorphosed lavas, but it is often impossible to separate the volcanic flows from intrusive material, which is likewise completely altered from its original condition. The complex as a whole is bedded upon a large scale, and the secondary cleavage which has been developed in it is parallel with the original structure, striking northwest and southeast and dipping northeast. In many places the rock is impregnated with pyrite, either irregularly or along contacts between two layers, where movement has permitted ready access to circulating waters. Veins are also found, but for the most part these give little indication of value, though there has been considerable prospecting at several points situated at no great distance from Gastineau Channel.

LIMITS OF THE ORE ZONE.

The ore zone is sharply defined on the seaward side by the foot-wall greenstones, and along this side of the black-slate band the greatest amount of veining occurs. On the other side the boundary of the zone in which the quartz stringers are prominent is more vague, but in the western part of Gold Creek basin the northernmost diorite dike may be taken as approximately defining the ore zone, which is thus from 1,300 to 1,800 feet in width. (See Pls. IV, VIII, IX, and XV.)

In the vicinity of the Alaska-Juneau stamp mill a similar dike of diorite lies about 1,800 feet from the foot wall, but toward the east its distance from the greenstone increases, being nearly 4,000 feet on the Sheep Creek divide. Quartz stringers are present locally in all parts of the intervening slates, but they are more numerous in a zone about 1,800 feet wide along the foot wall than beyond, and even in this zone they are most prominent on the foot-wall side.

The inland boundary of the black slates is formed by crystalline schists, which, like the greenstones, contain comparatively little quartz in the form of veins. This band of rocks can also be traced for many miles in either direction along the hanging wall of the slate band which carries the lodes.

NATURE OF THE ORES.

In Gold Creek there are two sorts of ore material occurring more or less together—quartz veins carrying pyrrhotite, pyrite, galena, zinc blende, and sometimes arsenopyrite, and brown diorite impregnated with pyrrhotite. The quartz occurs both in the slates and in the diorite, and it is only in the neighborhood of extensive veining that the latter has been sufficiently mineralized to become of value.

Mineralization extends through nearly the whole length of the lode system in Gold Creek, and is continued on the Sheep Creek side of the divide toward the southeast. From the Ebner property on Gold Creek to the Silver Queen mine in Sheep Creek the distance is about 5 miles. The Ebner ores contain gold and silver in the proportion of about 7 to 1 by weight, while in those from the Sheep Creek mines the amount of silver is several times that of the gold. It seems that there is a progressive increase in the proportion of silver from northwest to southeast, for on the Perseverance ground the silver is from three to ten times the gold by weight, as shown by a large number of assays made for the Alaska-Perseverance Company. No data are at hand concerning the relation of the two metals in the Alaska-Juneau ores, but the low value of the pulp after amalgamation may be taken to indicate the presence of only a small proportion of silver.

The increase in silver from northwest to southeast accompanies an increase in other sulphides than pyrrhotite, especially galena and zinc blende.

The ores are entirely unoxidized, so that the free-milling quality of those which contain mainly gold seems somewhat remarkable. In this connection, then, it is of interest to note that the sulphide is principally pyrrhotite, a much softer and more brittle mineral than pyrite, which is in general a commoner carrier of gold.

OCCURRENCE OF THE VEINS.

Within the zone of principal mineralization the quartz veins are distributed in the form of stringer leads, which follow the strike of the inclosing rocks more or less closely, but particularly favor the contacts between the black slates and the intrusive diorites. These stringer leads are complex affairs, made up of many veins which fill openings mainly referable to two sets. One set follows the slaty cleavage, striking N. 40° W. and dipping northeast; the other strikes N. 10°–20° W. and dips toward the west. Ordinarily both sets are not developed at the same place in equal prominence, but sometimes they are found together, forming a more or less regular network of veins. Even when only one set is well marked many indefinite connecting stringers are often to be observed forming a complete though less regular reticulation through the rock.

Individual veins are mostly traceable for short distances only, and they are typically lenticular in shape, especially the larger ones. The spacing of veinlets in the stringer leads varies from place to place, but in the mine workings it is ordinarily measured by a few inches or at most by a foot or two.

METASOMATIC ALTERATION.

The black slates show no striking effects of alteration by the vein waters. They hold stringers of quartz in sharp fractures and as a rule no difference can be observed in the nature of the rock next to and at a distance from the fillings. In some instances, however, the microscope shows that considerable amounts of mica have been developed in the slate in places where the quartz stringers are numerous.

The diorite, on the other hand, is greatly altered in many places and this is particularly the case where this rock contains the greatest number of quartz veins along the contacts with the slates. Here the formerly green, rather coarse-grained diorite, itself the result of an eariler alteration of a gabbro, has been changed into a fine-grained substance composed mainly of quartz, calcite, brown mica, and chlorite and commonly called brown rock by the miners. Tourmaline occurs in some of the veinlets, showing that the vein waters contained at least small amounts of the chemically active elements boron and fluorine, but analyses of the brown rock failed to reveal fluorine, though its presence was expected from the alteration of hornblende to biotite, since the micas often contain the element in question. The rock was also tested for chlorine, with negative results.

The presence of brown mica in the altered rock suggested that an addition of potash had been one of the effects brought about by the mineralizing waters, and this inference is corroborated by the analyses which were made of specimens of the green and brown material.

Analyses of green and brown diorite, Gold Creek.

[George Steiger, analyst.]

	No. 208.	No. 60.		No. 208.	No. 60.
SiO_2	47.76	44.69	P_2O_5	0.12	0.26
Al_2O_3	13.98	14.97	SO_3	None.	None.
Fe_2O_3	1.99	.60	Cl	....	None.
FeO	8.72	7.05	F	None.	None.
MgO	9.07	3.92	S	.04	....
CaO	12.71	10.07	MnO	.14	.14
Na_2O	1.65	2.36	BaO	Trace.	.14
K_2O	.20	1.76	SrO	None.	([a])
H_2O-	.22	.36	FeS_2	....	.27
H_2O+	2.06	.20	Fe_7S_8	....	2.25
TiO_2	1.48	2.25	Less O	.02	....
ZrO_2	None.	.02			
CO_2	None.	8.47		100.12	99.78

[a] Not determined.

Specimen No. 208, green diorite from easternmost dike in slate band on the north side of Gold Creek above the Humboldt claim. Green hornblende occurring in felted aggregates composes about 75 per cent of the rock, the rest being principally finely granulated feldspar with some quartz.

Specimen No. 60, brown diorite from Ebner mine. Much of the brown diorite contains considerable chlorite, but in this specimen it is present in very small amount. The rock is somewhat schistose; its mineralogical composition is estimated to be approximately as follows:

Mineralogical composition of brown diorite from Ebner mine.

Quartz	45
Mica	22
Carbonates	20
Titaniferous magnetite	10.5
Sulphides	2.5

Comparison of the analyses shows that if the amount of alumina be regarded as unchanged there has been a slight increase in the amount of soda and an addition of potash amounting to several times the amount present in the sample of green diorite which was analyzed. All of the brown rock contains mica, which is not present in the green phase, and though more extended chemical investigations would be required to prove the point, it seems allowable to conclude that the metasomatic alteration of the green diorite has involved the addition of important amounts of potash. Carbonates have also been developed in large quantities and the general nature of the change corresponds with the alterations which have been set forth by Lindgren in his descriptions of the metasomatic alteration of the wall rocks in certain mining regions of California.[a] The difference to be noted, however, is that in the present case a certain amount of soda seems also to have been added, while in the researches of Lindgren it was found that depletion of soda accompanied the addition of potash.

Metasomatism in the rocks of Gold Creek has been different from that which has been worked out for the Treadwell deposit on Douglas Island, where the potash of the original rock has been almost entirely removed and large amounts of soda have been introduced by the circulating waters. (See p. 111.)

HALLAM GROUP OF CLAIMS.

Position.—This property, part of which was located in the summer of 1901 and the rest in 1902, is situated on the steep slope of Mount Juneau. The easternmost claims begin about 1,000 feet west of the wagon road and together they cover all of the main lode system

[a] Fourteenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1894, pp. 274-278; Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1896, pp. 146-152.

lying between the Ebner property and the summit of the mountain. There are thirteen claims, having a combined area of somewhat more than 250 acres. The situation of the property is shown on the accompanying maps, Pls. VIII and XVII.

Development.—During the summer of 1903 two men were engaged in prospecting and assessment work. Openings had been made at several points, revealing the presence of quartz veins, some of which contain free gold in considerable amounts. A small arrastre was built and rigged with a water power, but the dryness of the season made it impossible to operate it more than a few days.

Geology.—The rocks exposed on the flanks of Mount Juneau, above Gold Creek, comprise the black slates and intruded dikes of the mineral zone and the schistose greenstones forming the foot-wall mass which lies between the lodes and Gastineau Channel. The former occupy a band somewhat more than 2,000 feet in width, rising diagonally across the mountain slope from east to west, while the latter constitute the base of the mountain. Toward the north, beyond the black slates and stratigraphically above them, are crystalline schists and an outlying intrusion of the Coast Range granite, forming a mountain peak back of Mount Juneau. The local geology is shown on the sketch map (Pl. VIII).

The strike of all the rocks is about N. 40° W., and the northeast dips vary from 30° to 40°, their structure being somewhat flatter than that of the same rocks farther east on the Ebner, Alaska-Juneau, and Perseverance properties.

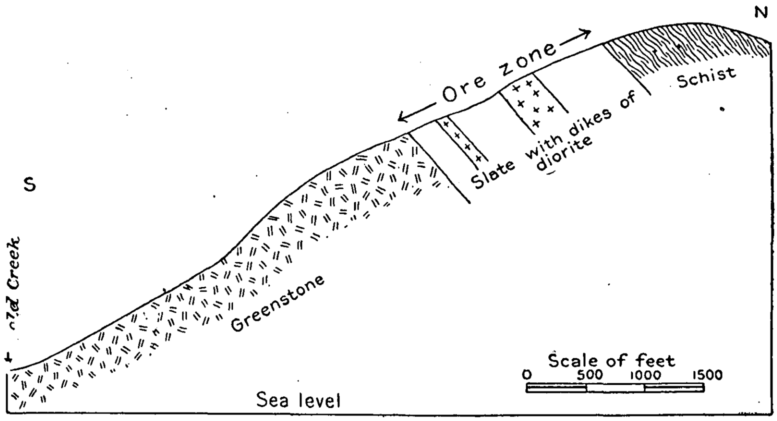


FIG. 13.—Profile section through Hallam claims, showing attitude of the rocks. (Compare Pl. VIII.)

The foot-wall greenstone, so far as known, does not contain promising indications of mineralization, though it is sometimes impregnated with considerable amounts of pyrite along certain well-developed surfaces of schistosity. It is a green rock with a platy cleavage, often lustrous and [illegible] to the touch. It is composed largely of secondary chlorite and calcite, formed by metamorphism from the original minerals of the rock, which is regarded as in large part volcanic [illegible].

In general the black slates have the ordinary characteristics of these rocks throughout the region, but they contain some light-colored, fine-grained quartzites. The intrusive dikes are the metamorphosed gabbros which occur in all parts of the black-slate band, and both the green and brown forms of this so-called diorite are present.

The attitude of the rocks is shown in the accompanying diagram (fig. 13).

The following detailed section exhibits the alternation of slate, quartzite, and intrusive material:

Detailed section at Hallam claims, Gold Creek.

	Feet.
1. Black slates with schists above them, about	600
2. Massive green diorite with lower 15 feet schistose	400
3. Quartz schist	18

	Feet.
4. Outcrops hidden (probably black slate)	25
5. Black graphitic slate	40
6. Slate and quartzite, mostly light colored	60
7. "Brown rock" containing quartz stringers	100
8. Gray quartzite	12
9. Outcrops hidden	20
10. Quartzite	15
11. "Brown rock"	8
12. Spotted slate, light colored	35
13. "Brown rock"	16
14. Spotted slate like No. 11	15
15. Outcrops hidden	30
16. "Brown rock" containing many quartz stringers, exposed	6
17. Quartzite and slate, mainly light colored	155
18. "Brown rock" containing quartz stringers and some pyrrhotite; outcrops on trail	30
19. Quartzite, white and rusty	55
20. Alternating rusty quartzite and black slate	35
Total black slates and diorites	1,675
21. Schistose greenstone, about	1,700
22. Black slates locally impregnated with pyrite	50
23. Schistose greenstone, containing some intrusive gabbro and a few beds of slate, estimated to level of Gold Creek	1,200
	4,625

Six dikes of the intrusive rock are noted—Nos. 2, 7, 11, 13, 16, and 18 of the section. The uppermost dike, 400 feet in thickness, is mainly massive green diorite, but its lower part shows the effects of extreme pressure, which has converted it into green lustrous schist. It has been traced as a continuous feature for a distance of over 5,000 feet from near the boundary between the Alaska-Juneau and Ebner properties, across Gold Creek, and up the mountain side to a point opposite the saddle northeast of Mount Juneau, where it ends. It runs parallel with the line between the black slates and the greenstones below, and most of the veining in this section of the mineral zone lies below it.

The second dike, No. 7 of the section, has an average thickness of about 100 feet, though it is somewhat thinner at the ends, one of which is found east of Gold Creek and the other a short distance beyond the summit of Mount Juneau. Throughout its outcrop it generally has a brown color, due to the large amount of biotite mica which it contains, though in the Ebner ground it is locally green and resembles the diorite of the upper dike. Transitions from green to brown material show that the latter has been formed by secondary alteration of the former, and the brown color is one of the effects of the mineralizing waters which formed the quartz veins cutting it and the slates by which it is inclosed. The dense growth of alders and grass which covers the slopes renders observation difficult, but wherever exposures are found more or less quartz, in the form of stringers, is present in this dike of "brown rock."

Of the other dikes only No. 18, 30 feet in thickness, is of any importance. It shows the same brown color and, like the wider dike above, contains many quartz stringers.

On the west ridge of Mount Juneau there are two dikes, the upper of which is No. 7 of the section given above, while the other may correspond with No. 18 of the section, though exposures are lacking to prove this. (See Pl. VIII.) Only the upper of the two dikes is altered to "brown rock," and the amount of veining is very slight, both here and for at least 1,000 feet toward the east.

Occurrence of quartz veins.—The foot-wall portion of the black-slate band, which has been found elsewhere in the drainage of Gold Creek to be the most valuable part of the mineral zone, outcrops for a distance of over 4,000 feet upon the Hallam property. The veins which have been found lie either in black slate or in the intrusive dikes of altered diorite. Most of them strike more to the north than the country rock and dip much more steeply toward the east. They are particularly numerous along the surfaces between the intrusive rock and the inclosing slates, and have practically the same characteristics as the veins of the same zone in the better-explored ground lying to the southeast.

In the portion of the lode system lying across Gold Creek the minable ore occurs only where quartz veins are present, and there is every reason for supposing that the same will hold true throughout the Hallam property. From the small amount of prospecting which has been done it seems that a good deal of quartz is present in the foot-wall portion of the black-slate band for a distance of about 4,000 feet from Gold Creek, but beyond this the amount of veining to be made out from present developments is not promising. The same may be said for the continuation of the belt toward Salmon Creek, so far as the mountain slopes are concerned, and in the valley itself no evidence of great mineralization has yet been revealed.

The conditions of mineralization on the Hallam property are in every way similar to those in the Ebner mine, and it is therefore believed that exploration of the bands of "brown rock," and especially search along the surfaces between them and the inclosing slates or quartzites, will be the quickest and most economical method of proving the presence or absence of minable ore.

EBNER MINE.

Position and area.—The property of the Ebner Gold Mining Company adjoins the Hallam group on the east and for the length of one [illegible]n on the north, while on the east it runs against the holdings of the Alaska-Juneau Company. (See Pl. IX.) The total area of the Ebner property is approximately 240 acres, which is divided into two nearly equal parts by Gold Creek. It comprises some of the first quartz locations in the creek, where some of the earliest rock mining was attempted.

Development.—Mining has been thus far confined to the east side of Gold Creek, near which the stamp mill and mine buildings are situated.

The nature of the deposit has made it possible to employ the open-pit method of mining to a large extent, but considerable ore has come from stopes above the adit. There are two large pits on one of the mineralized dikes of "brown rock," which has been developed for a distance of 1,200 feet along its strike, and a third has recently been opened on a separate dike lying to the west of the main ore body. (See Pl. IX.)

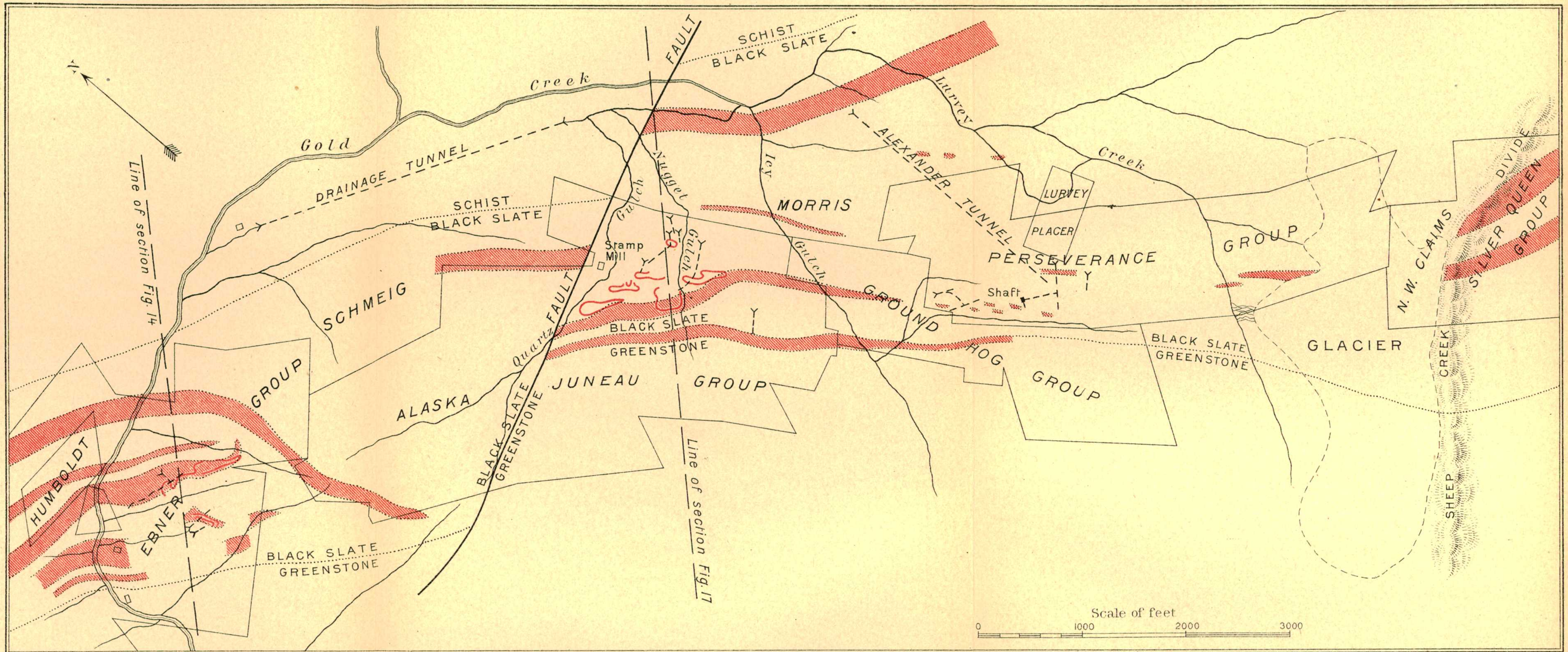
An adit approximately 700 feet in length gives access to the stopes, and all ore, including that from the pits, finds its way through chutes to this level. From the mouth of the adit to the mill the distance is about 300 feet. An older tunnel about 400 feet in length and about 100 feet above the present adit is now abandoned. The total underground development, exclusive of stopes, comprises about 1,500 feet of tunneling.

The stamp mill consists of three batteries with amalgam plates. A Blake crusher is used, and though concentrating tables were originally installed the low value of the sulphides does not make it worth while to save them. The ore treated is said to average not more than $2.50 per ton, and the total expense of mining and milling is from $1.25 to $1.50 per ton. This creditable showing is made on an output of less than 50 tons per day. The output of the mine prior to 1903 has been estimated at about $575,000 by Mr. William Ebner, president of the company. It was operated steadily during the summer of 1903, so that the total production up to the end of that year may be taken as somewhat exceeding $600,000. There is abundant water power for operating the mill during the season from April to December. (Pl. X.)

Geology.—On the Ebner property the zone in which the lodes occur has a width of about 1,500 feet. As in other localities, the lode system follows the foot wall of the black-slate band. The latter is here approximately 2,200 feet wide. (See map, Pl. IX.)

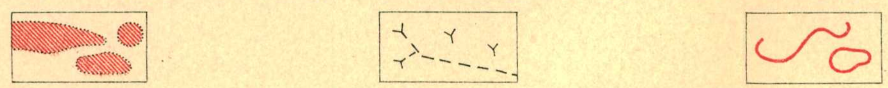
Two well-defined dikes of intrusive diorite run the whole length of the property, and between these a third may be traced for a distance of nearly 2,500 feet. Other masses of similar material are present, but it has been impossible to determine their form or extent, because the outcrops are so few. A general cross section, showing the relations of the different rocks, is given in fig. 14.

The average strike of the slaty cleavage and the course of the diorite dikes is about N. 58° W., or somewhat more westerly than on the Hallam ground. The general inclination

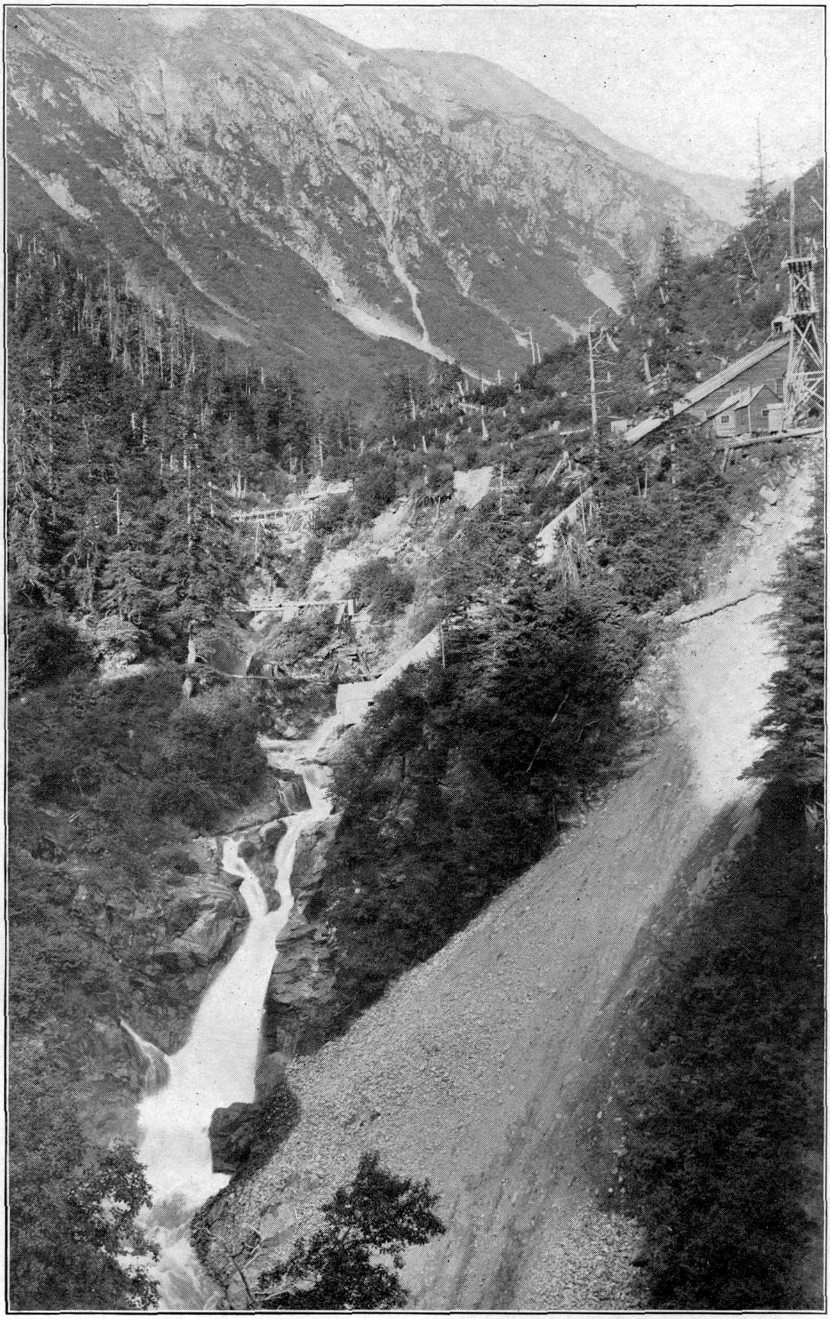


JULIUS BIEN & CO. LITH. N.Y.

GEOLOGIC SKETCH MAP OF UPPER PART OF GOLD CREEK



Diorite dikes Tunnels Open pits



CASCADE ABOVE LAST CHANCE BASIN, GOLD CREEK.

Showing Ebner stamp mill, power house, and waste dump.

of the beds is about 70° NE., but a certain amount of folding exists, so that there are local departures from the average dip. Slaty structure and bedding seem to coincide in the main, but where the beds are arched or crumpled the cleavage crosscuts the stratification.

The shape and position of the diorite dikes furnish the only readily observed evidence of folding in the slates. As represented on the map, only one of them outcrops beyond

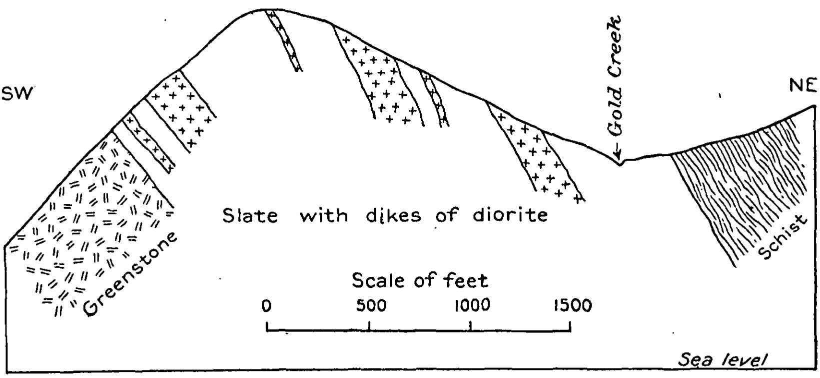


FIG. 14.—Profile section through Ebner workings, showing attitude of the rocks. (Compare Pl. IX.)

the Ebner end lines on the east, and it is apparent that the slate closes over them. Elsewhere, as on Juneau Mountain and on Sheep Creek, the same or similar dikes extend much higher, but in this place we have the top edges of the injected bodies. The wedge end of the middle dike is not exposed, but the south dike bends over sharply to the north, terminating in a hook, while the north dike gradually crosscuts the general strike of the slates and approaches the southwest boundary of the band. In the upper pits the attitude

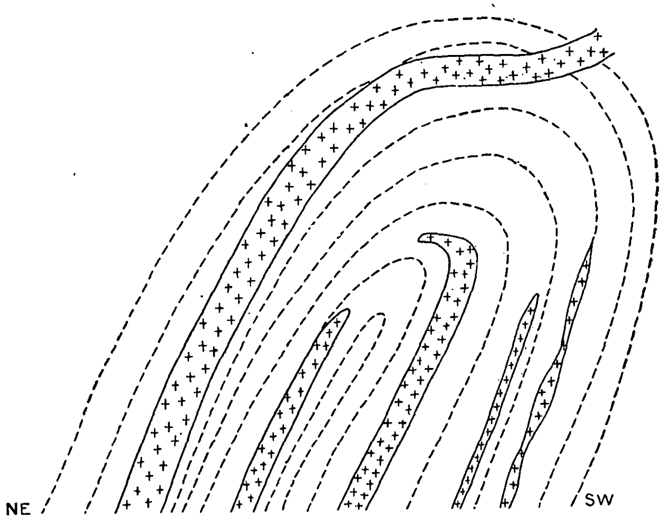


FIG. 15.—Diagram showing the termination of intrusive dikes in Ebner workings and one interpretation of structure.

of the south dike, with the slates capping over its top, is well shown. A simple interpretation of the observed relations would be that there is here an arch in the slates, as shown in fig. 15, but the span of the required fold being over half the width of the entire slate band it is more probable that the structure is better explained by the presence of local crumpling in the slates in some such way as is shown in the second sketch (fig. 16).

The northern or hanging-wall dike is green diorite, composed of hornblende and feldspar, and massive granular in texture, as a rule, though locally schistose. It contains very few quartz veins, and there are relatively few in the slates next to it, so that it may be regarded as the boundary of the system of lodes. Its width varies from 200 to 300 feet.

The middle or Humboldt dike is also mainly green diorite, but it passes locally into the more altered brown form. It is best exposed on the Humboldt property, where it is about 100 feet wide. Here it contains some quartz veins, though the leads which have been worked lie above it in black slates. Near the bed of the creek just opposite the Humboldt mill, where the dike has been uncovered, it is very brown and thoroughly mineralized, and flakes of gold may be found. On the southeast side of Gold Creek it outcrops along the flume, where it is partly green and partly brown, but higher up it is covered by surface débris. On this side of the creek very little prospecting has been done as far north as the Humboldt dike.

The southern of the three main dikes, which lies near the center of the black-slate band, has been followed from Juneau Mountain nearly to the eastern boundary of the Ebner

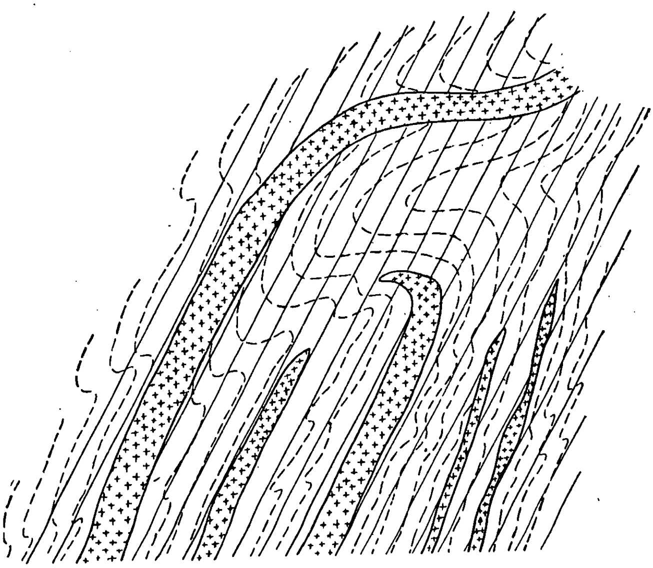
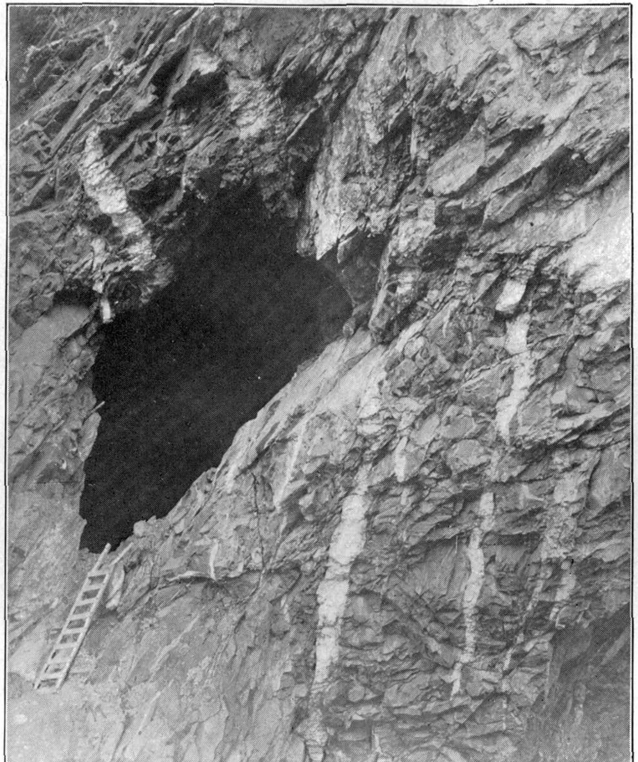


FIG. 16.—Diagram showing termination of intrusive dikes in Ebner workings and probable type of structure in the inclosing slates. Cleavage indicated by parallel lines.

property. Its maximum width is about 150 feet, but it narrows toward the east, where it is capped by the slate. The upper or hanging side of the dike is poorly exposed, but its central portion is green and often schistose. Next to the foot it contains many quartz stringers, and where these are present it has a brown color, becoming rusty on exposure. The veins and the brown color extend from 30 to perhaps 60 feet from the wall of the dike, and as the former become less numerous the color changes to green. The "brown diorite" usually contains considerable pyrrhotite, much of which is auriferous. Most of the mining has been along the foot wall of this dike, but it has not been opened on the northwest side of Gold Creek, where it is covered by deep talus below 2,500 feet elevation.

On both sides of the southern dike the slates contain many quartz veins from place to place, but these are mostly wanting in the immediate hanging wall. Between this dike and the greenstone mass which forms the foot wall of the mineralized zone bunches of brown diorite outcrop at several points, and some of this material has been mined.

A



B

STRINGER LEAD IN BROWN DIORITE, EBNER MINE, GOLD CREEK.

The slate wall of the diorite is seen in the upper right-hand corner of *A*.

Though the southern boundary of the black slates is not well exposed, its position has been determined with a fair degree of accuracy from the crossing of Gold Creek about 150 feet above the new mill building to the saddle between Icy and Quartz gulches.

From 150 to 200 feet south of the boundary of the black slates, and included in the schistose greenstone, is a brown diorite dike over 100 feet thick, which has been traced from Icy Gulch to Gold Creek and across the wagon road, where its outcrops cease. This closely resembles the brown diorite occurring in the slate band, but has a more schistose structure. On the steep slope above Snowslide Gulch it contains many quartz stringers, but the presence or absence of values was not determined.

Occurrence of the ore.—The material which constitutes the ore in this mine is only in part vein stuff. The latter occurs in the form of gash fillings or reticulating stringers inclosed in the country rock, and these can not be separated in mining on a large scale, nor would their separation be desirable on the whole, since the material between the vein fillings is often impregnated with gold-bearing metallic sulphides. The principal mineral of the vein gangue is quartz, but considerable calcite also occurs, or, in its place, dolomite or siderite, and occasional minerals are sericite, biotite, and tourmaline. The mineralized diorite is made up mainly of calcite, quartz, and biotite, with some chlorite.

The vein fillings occur both in slate derived from sedimentary shales and in the altered igneous rock commonly known as diorite. In the early days attempts were made to work some of the more prominent veins of quartz, but though some of these showed good values and strong outcrops they proved too irregular and unreliable to pay for systematic mining. In the slate the veinlets lie either parallel with the cleavage or in sets of parallel gash fractures having nearly the same strike; but dipping in an opposite direction. Veins of this sort are well exhibited in this vicinity on the Humboldt claim, but on the Ebner ground no attention has been paid to them. In the diorite the veinlets likewise lie mainly in two sets, one of which follows the general trend of the country structure while the other dips in an opposite direction. (See Pl. XI.) Locally the stringers of one set may be wider and more continuous than those of the other, but usually the general effect is a mesh work of white vein stuff penetrating the dark country rock. The diorite contains more veins than the slate and the veins are more closely spaced in it than in the slate, especially along the sides of the intrusive masses. Up to 1903 nearly all of the ore mined had been taken from the foot-wall side of the southernmost of the three diorite dikes which traverse the property.

This dike has been mined to varying depths for a distance of 1,100 feet along the strike. Rock of ore grade can be closely judged from the extent to which it is filled by the stringers of quartz. The reticulating veins ordinarily extend from 20 to 30 feet and locally up to 50 or 60 feet into the body of the dike, but they are usually larger and more numerous near the contact with the slate. They seldom, however, penetrate the wall rock of the dikes, and it is evidently to the difference in the physical characters of the two rocks that the persistence of the fracturing along their contact is due.

The principal sulphide present is pyrrhotite, which occurs both in the veinlets and as small grains in the country rock, where it is usually accompanied by magnetite. Galena, sphalerite, pryite, and chalcopyrite sometimes occur in the vein fillings, and flakes of gold are occasionally found in the stringers embedded either in quartz or in calcite.

The alteration of the intrusive dikes by the action of the vein-forming waters is a striking feature of the deposit. The origin of this alteration is indicated beyond all doubt by the fact that the change to brown rock depends on the presence of the vein fillings, being most marked where these are most numerous and becoming less and less apparent as the amount of veining decreases. (See p. 62.)

ALASKA-JUNEAU MINE.

Position and area.—The property of the Alaska-Juneau Gold Mining Company lies on the southeast side of Gold Creek, between the Ebner group and Icy Gulch. (See Pls. IX and XVI.) The steep slope of Icy Gulch between this property and the Perseverance group of claims is included in the Groundhog group. The area of the main group of claims, as shown by the claim map of Gold Creek, is about 209 acres, while approximately 90 acres is covered by an outlying group of claims running over into Snowslide Gulch. In addition to this, tunnel and mill-site locations cover a strip extending from the mineralized zone to Gastineau Channel.

The property includes the Lane & Hayward and the Bennet mines, which have been described by G. F. Becker.[a]

Development.—Though certain of the veins on the Alaska-Juneau property were formerly mined as separate leads, they have proved so unreliable because of irregularity and discontinuity that this practice is no longer followed. At present all mining is done on a low-grade basis, as at the Ebner mine, and practically no attempt is made to separate the vein stuff from the rock which must be mined with it.

The segregation of many small veins forming stringer leads renders operation by open pits the most economical method of mining. At present there are four or five of these pits, from which a large amount of material has been quarried within the last few years. To facilitate handling the ore the pits are undercut by tunnels and are connected by raises serving as ore chutes. These working tunnels crosscut the mineral zone and have thus served the purpose of prospecting the ground which they traverse. In 1903 the total length of the underground workings was about 2,400 feet.

A compressor furnishes air to four rock drills. This machine and the stamp mill are operated by water power developed under a head of 330 feet, the flume being supplied from Icy Gulch. The mill contains 30 stamps and is equipped with Frue vanners. The sulphides are not saved, however, since they have proved too lean for profitable extraction. (See Pl. XII.)

In 1903 the ore treated amounted to about 120 tons per day, the average value being about $1.50 per ton, as stated by the management. The cost of mining was given as 55 cents per ton and that of crushing and amalgamating about 25 cents.

The period of mining extends from the 1st of May to the last of November, being thus limited by the heavy snowfall and the diminished flow of water during the winter months.

The total output from this property up to 1904, aside from placer gold, is estimated at approximately $100,000. More than half of this sum is credited to the operations of the present company during 1902 and 1903.

Geology.—The main group of claims belonging to the Alaska-Juneau Company, about 4,800 feet in length and about 1,600 feet in width, follows the general course of the lode-bearing slates eastward from the Ebner group.

The property may be divided along the line of Quartz Gulch into two parts, each of which shows distinct features of geology. Between the Ebner end lines and Quartz Gulch the country rock is almost entirely black slate, though on the slope toward Snowslide Gulch, which is covered by recent locations, several masses of diorite are present along the southwest side of the slate band and in the greenstones which dip beneath the slates. The boundary between the slates and greenstones can not here be accurately determined, and the position of the line representing it upon the map is therefore only approximately correct. The northeast boundary of the slates with the crystalline schist, though likewise indeterminate, evidently runs through Little Basin. (See geologic maps, Pls. IV and IX.)

Near the stamp mill a mass of green diorite outcrops just above the wagon road and is traceable for several hundred feet northwestward to a point where it finally passes beneath a heavy body of slide rock. A few outcrops of brown diorite were noted at different points in the slate, but none of these represent large or continuous dikes. In this ground lying northwest of Quartz Gulch veins have been discovered at several points, but none of them have been developed to any important extent. They appear to have the same interrupted character as the quartz fillings in the mines, but so far as observed are not sufficiently numerous to constitute workable stringer leads.

[a] Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 72, 73.

ALASKA-JUNEAU MINE AND MILL, GOLD CREEK.

Looking north.

On the mountain slope southeast of Quartz Gulch black slates are also present, but here they are intruded by several dikes of diorite, both green and brown, like those on the Ebner property; southwest of these rocks, above the flume, greenstones and greenstone schists are found.

The difference in the bed-rock formations on the two sides of Quartz Gulch is the result of the transverse fault running approximately N. 72° E. from the saddle between Snowslide and Quartz gulches and following the general course of the latter stream. The precise direction of the movement upon this fault, whether vertical or inclined, has not been made out, but the horizontal displacement of the slate band which has been indicated on the map would result if the southeastern block were either uplifted or thrust toward the northeast. The direction of hade is not known, but the inclination of the fault surface is supposed to be toward the northerly or down-thrown block. The failure to trace the fault toward the west, though possibly chargeable to the lack of exposures, suggests this interpretation, since this structure would carry the line of the break down Snowslide Gulch.

The effect of the fault is to offset the formations horizontally, but the amount of the offset can be estimated only approximately, since it is impossible to find distinctive beds which can be definitely located on both sides of the break. On the foot-wall side of the slate zone not only are the exposures poor, but the greenstones and the intruded diorites

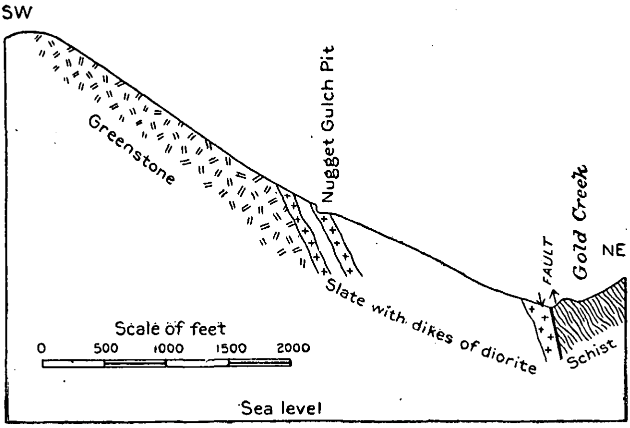


FIG. 17.—Profile section through Alaska-Juneau mine, showing attitude of rocks. (Compare Pl. IX.)

in their altered condition are so similar that the boundary of the slate can not be located within a couple of hundred feet. However, a fairly acceptable measure of the offset may be obtained by assuming that the green-diorite dike outcropping on the road just northwest of the 30-stamp mill represents the dike of similar rock which outcrops at the base of the mountain between the forks of Icy Gulch and Gold Creek. From the point where the latter dike would meet the fault to the outcrop of the diorite on the opposite side of the break the distance is about 1,200 feet. The geologic date of this displacement is not known, but the faulting is supposed to have taken place later than the period of vein formation. The general distribution of the different rocks is indicated on the accompanying map (Pl. IX), though as in the region north of the fault the boundaries of the slate band are only approximately located. The structure is illustrated in fig. 17.

Southeast of Quartz Gulch two dikes of brown mineralized diorite are prominent features of the foot-wall side of the slate band, and minor dikes or decomposed masses occur throughout the exposed width of the slates. Diorite intrusions also occur in the greenstone schist in the vicinity of the slate boundary. The two dikes mentioned above are from 60 feet to nearly 200 feet in width. From Quartz Gulch to Nugget Gulch they appear to lie nearly parallel and are not over 100 feet apart, but from the latter stream to Icy Gulch they diverge and the distance between them increases to nearly 500 feet. The rock is in every respect similar to the brown diorite of the Ebner workings, and its characters have doubtless been produced by the same series of metamorphic changes due to the percolation of mineralizing waters.

Toward the northeast side of the slate band there is a 300-foot dike of green diorite which may be seen in outcrop back of the Perseverance boarding house in the angle between Gold Creek and Icy Gulch. This dike is traceable for more than 2 miles toward the southeast, and there can be no doubt that it extends in the opposite direction as far as the Quartz Gulch fault. Beyond this fault it has been assumed that the dike exposed near the stamp mill also represents it.

The slates of the ore zone are mainly argillaceous and limy, their usual black color being due to graphite, but in places they are very siliceous and gray in color. Though evidently of sedimentary origin, the bedding of these rocks has been almost entirely obscured by the cleavage structure. The latter has an average strike of N. 70° W. and dips about 60° NE. Intrusive dikes follow the slaty structure in a general way, but though the contacts are seldom exposed for observation there must be considerable crosscutting, as is indicated by the variable distance between the two largest dikes. The attitude of the rocks is shown in fig. 17.

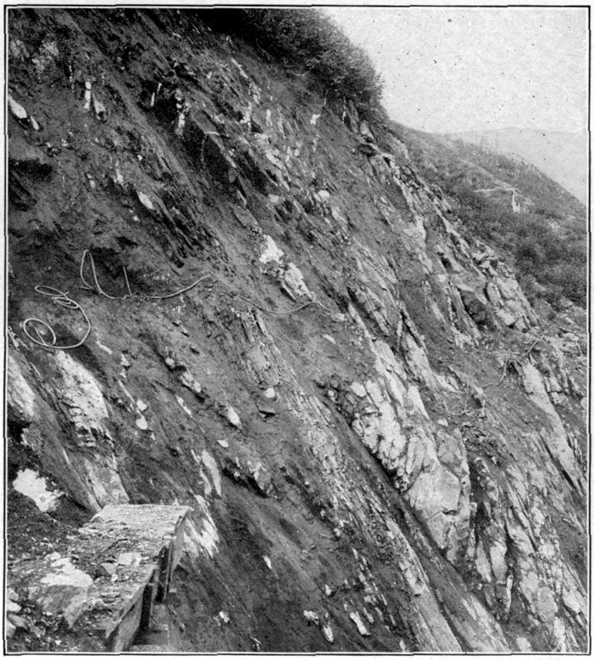
Extent of ore-bearing ground.—The black-slate band is advantageously situated for exploration of the system of lodes which it carries, since it occupies the southwest slope of the mountain to a height of 1,000 feet above Silver Bow basin. As a consequence of this ready access the ore-bearing zone has been more fully developed in the southeastern half of the Alaska-Juneau property than in other parts of the Gold Creek drainage. The mine workings extend along the hillside in the direction of the country strike for a distance of 1,600 feet and are distributed over a zone about 750 feet wide. The entrance to the lowest working tunnel lies about 200 feet above the present channel of Gold Creek in the Nowell placer pit, while the workings farthest up the slope are at an elevation nearly 400 feet higher.

While the developments are as indicated above, there is no reason for believing that the limits of the zone of mineralization have been reached on either side, and above the higher pits the few bed-rock exposures which are to be found show the presence of mineralization in the upper of the two large diorite dikes and also in the greenstone near the boundary of the slate band as this line is marked upon the map. (Pl. IX.) Stringers of quartz in the slate are also to be observed in the vicinity of Mineral Monument No. 2, where bed rock has been exposed by hydraulic operations. It is apparent, therefore, that the zone of marked mineralization extends roughly from the edge of the Nowell placer up the mountain slope to the greenstone boundary, and is thus in the neighborhood of 2,000 feet wide.

Occurrence of the ores.—The ores of the Alaska-Juneau mine occur in irregular and discontinuous but numerous veins of quartz distributed through the country rock, forming typical stringer leads as defined by Becker.[a] The nature of these stringer leads is well illustrated in the accompanying views (Pl. XIII). While the country rock is by no means uniformly filled by veins, still the band of black slates for a width of 2,000 feet or more is intersected by many irregular veins consisting largely of quartz. Most of these have the form of gash veins measuring a few inches to a foot or two in width, and from a few feet up to several tens of feet in length. On the whole these fillings are sparsely distributed in the slate band, but locally they are numerous and closely spaced, and the precious metals which they contain are sufficient to make minable ore of the rock in which they occur.

This mode of occurrence lends itself to mining upon a large scale, so that the open-pit method of working here employed is the only feasible one, since it is necessary to handle large amounts of barren material. During the preliminary development of the Alaska-Juneau property seven open pits have been worked. In five of these the country rock is black slate, while in the others brown diorite is also present, and in the Nugget Gulch pit this is the principal rock.

[a] Becker, G. F., The gold fields of the southern Appalachians: Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1895, p. 283; The gold fields of southeastern Alaska: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, p. 67.



A

B

STRINGER LEAD IN BLACK SLATE, ALASKA-JUNEAU MINE, GOLD CREEK.

In the slates the cleavage strikes about N. 70° W. and the dip averages 60° NE. Numerous stringers lie approximately parallel with the cleavage and others strike about N. 10°–15° W. and dip 60°–70° SW. The largest number of the veins, however, strike N. 25°–35° W. and dip across the cleavage at steep angles. The veins last mentioned, with those which lie in the cleavage, are seen to have conjugate relations, since they cross each other at a high angle. (See p. 28.)

In general the veins which strike about N. 10° W. are of minor importance, but two strong veins having this direction are found on the Aurora claim. These veins have been mined to a certain extent, one of them having been formerly known as the Bennet vein. Each of them measures from 2 feet to 8 feet in width, and one of them has been followed for a distance of several hundred feet and is reported to carry from $10 to $25 per ton. Becker[a] refers to one of these veins and gives its milling value at $13 per ton. At the time of his report the vein had been opened for 200 feet underground and was said to be traceable for an additional 200 feet on the surface.

The two large diorite dikes which occur in the mine workings are like the brown rock of the Ebner mine. (See Pl. IX and fig. 17.) They contain quartz stringers and sulphide impregnations to such an extent that portions of them are mined and milled. The dikes follow the cleavage of the slate and dip with the structure toward the northeast at an average angle of about 60°. The foot-wall dike lying near the boundary of the slate band varies in width from 60 to 80 feet. The other lies from 80 to 400 feet above it and is from 60 to 100 feet wide. Some of the most extensive workings have been in the upper dike, and the best ground opened is along its upper contact with the overlying slates.

In the brown diorite the stringers of vein stuff hold in a general way the same direction as in the slates, though here they are more apt to form networks penetrating the rock. The presence of veinlets in the igneous rock is accompanied by a change in color from green to brown, which is one result of the complete alteration of the rock by the action of the waters which deposited the veins. Between the stringers the brown rock is always impregnated with pyrrhotite, the presence of which seems in most instances to increase the value of the ore, so that the material mined from the dikes runs somewhat higher than that in which the matrix is slate, since the latter is seldom impregnated with metallic minerals.

In the veins the gangue minerals are mainly quartz, but calcite is of frequent occurrence, siderite and dolomite also being present. Sericite is always present in small amounts, and though tourmaline was not observed it is found in other parts of the mineral zone within the Gold Creek drainage.

The sulphides are mainly pyrrhotite and pyrite, but sphalerite and galena are often encountered and chalcopyrite and arsenopyrite also occur.

The greater part of the gold and silver is evidently associated with the sulphides, but the former also occurs in the native form. The fineness of the bullion has been given as 0.856.[b]

GROUNDHOG GROUP.

Position and area.—The claims which are included under this designation are the Alaska Chief and Harris, abutting the end lines of the Alaska-Juneau property and lying on the steep southeast wall of Icy Gulch; the Tremont fraction, above the Harris; and the Groundhog and Summit, still farther to the southeast, adjoining the northwestern claims of the Perseverance group. The total area of the Groundhog group is approximately 76 acres. (See Pl. IX.)

Development.—The Groundhog claim, which lies on the northeast face of the mountain slope above the Perseverance property, is the only one of the group which has been at all developed. In 1893 several tunnels were opened and some pit mining was done. A wire-rope ore carrier was installed to deliver into the Nowell placer pit, from which point the ore was taken to the Red mill, 1 mile distant, through the drainage tunnel. The product of the mine has been only a few thousand dollars.

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[a] Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, p. 73.

[b] Becker, op. cit., p. 72.

Geology.—The boundary between the slate band and the greenstones traverses the claims of the Groundhog group for a distance of 4,200 feet. The claims next to Icy Gulch lie mainly in the slate, but in the latter there are dikes or brown diorite. In the bed of the creek, where a good section of the rocks is exposed, brown diorite also occurs above the highest croppings of slate. This rock and the greenstone which lies next to it have both been altered so that they now resemble each other very closely, and, exposures being very poor, it is altogether likely that there are several separate intrusive masses in the greenstone instead of one, as represented on the map (Pl. IX).

Toward the southeast the relations are even less well exhibited, though the general limit of the slates has been located with a fair degree of accuracy. The Groundhog workings are located entirely within the area covered by the greenstone and the diorite which intrudes it.

The continuation of the next large dike below the one which lies between the slate and greenstone for some distance on the southeast side of Icy Gulch is inferred from its width of nearly 150 feet in the creek bed. The valley slopes are, however, covered by slide rock, and since there is no large body of diorite on the ridge above the dike must pinch out in this direction.

A narrow dike of diorite is exposed at the mouth of the southern prospect tunnel on the Rim Rock fraction of the Perseverance group, and several small masses of the rock are to be seen on the ridge near Groundhog Creek, but these are not connected in outcrop.

Occurrence of the ore.—The Alaska Chief and Harris claims doubtless contain the same sort of veining as the corresponding portions of the Alaska-Juneau and Perseverance ground, but they are not favorably situated for prospecting, and practically nothing is known of their value. On the Groundhog claim, though exposures are few and but little work has been done, the general extent and character of the mineralization can be determined. The rock resembles the brown diorite occurring in the Ebner and Alaska-Juneau mines, and is presumably of the same origin—that is, it is a greatly metamorphosed intrusive rock altered by the action of mineralizing waters. Part of the brown material, however, may be the greenstone matrix of the dikes altered by the same process. The rock is very generally filled with narrow quartz stringers.

Hill placers were formerly worked along the lower side of the claim, where there is a considerable accumulation of rock fragments and red soil, derived from the disintegration of the brown rock. The extent of this soil shows the presence of the brown rock on the upper two-thirds of the Groundhog claim and across its end line toward the head of Lurvey Creek. Elsewhere in Gold Creek the brown alteration is a feature which accompanies the presence of auriferous veins, and though no practical tests were made to corroborate the opinion, it would seem that this ground is fully as worthy of thorough exploitation as the adjacent portion of the slate belt on the Perseverance ground.

ALASKA-PERSEVERANCE PROPERTY.

Position and area.—The claims of the Alaska-Perseverance group adjoin the Alaska Chief and Harris claims of the Groundhog group on the northwest and extend to the northwestern claims of the Silver Queen group, just below the Sheep Creek divide. The length of the group is about 4,800 feet, and it is from 1,100 to 1,600 feet in width. The five full claims and three fractions give an aggregate area of about 132 acres lying athwart the course of Lurvey Creek and well up the steep mountain slope which is drained by this stream. In addition to this group tunnel rights are claimed, giving 30 acres more, or 162 acres in all.

Development.—Only a small portion of the ground has been proved by actual mining, but in the neighborhood of 1,900 feet of tunnels and shafts had been opened on the Perseverance and Rim Rock claims previous to beginning the so-called Alexander crosscut, which, in April, 1905, was reported as 2,500 feet in length. The portal of this tunnel is about 1,400 feet above tide and 275 feet above the valley of Gold Creek, near by.

The old workings were at one time connected with the Eastern Alaska Milling Company's stamp mill by a wire-rope tramway. For driving the long tunnel the mine has been equipped with air drills, the compressor being operated by water power. Mining supplies are raised to the tunnel by a gravity plane. It is reported that the company plans to build a railway from Juneau to the head of Silver Bow basin and to install a 100-stamp mill during the summer of 1905.

Geology.—The rocks occurring on the Perseverance property belong entirely in the black-slate band which carries the main lode system of the region, and as in the Ebner and Alaska-Juneau mines the ground which is under exploitation lies near the southwest or foot-wall side of the band.

The structural trend of the country is about N. 40° W., as is shown by the slaty cleavage, the course of the diorite dikes, and the strike of the foot wall of the slate band in contact with the greenstone. Duplication of the strata by folding is clearly observable in several places, a feature which was not elsewhere definitely determined, though there are reasons for supposing that there must be a great deal of folding throughout the band of slates.

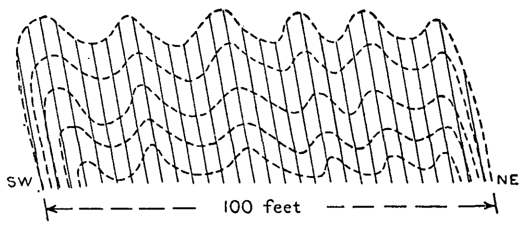


FIG. 18.—Crumpling and cleavage in black slates as observed on Perseverance No. 2 claim, Gold Creek.

Three or four hundred feet from the northwest end of Perseverance No. 2 claim, where the slates are well exposed for a width of about 200 feet, a flat-topped arch is to be made out. Though the rock is very homogeneous in texture, the bedding is revealed by a banded appearance due to slight differences in the color of separate strata a few inches in thickness. These thin beds are greatly crumpled, but a line drawn across the top of the corrugations is nearly horizontal for a distance of about 100 feet. On each side, however, the stratification bands curve over and dip steeply toward the northeast. The cleavage, which is very well developed across the exposure, holds the same course in all parts of the fold, so that on the sides the bedding and secondary structure are parallel, while on the arch they are transverse to each other. (See fig. 18.) The cleavage and the axis of the fold dip about 80° NE.

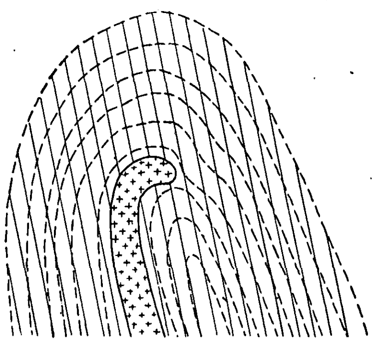


FIG. 19.—Diagram to show folding in the black slates as revealed by the blunt ending of dikes, Perseverance group, Gold Creek.

The way in which some of the diorite dikes terminate also indicates folding in the slates, as already stated in describing the geology of the Ebner mine. These intrusive bodies follow the cleavage structure rather closely, but they sometimes twist and turn aside for short distances to follow folds in the slate. In several places they were observed to end bluntly and to have the strata wrapped about their broad terminations (fig. 19).

There are many different dikes of diorite, but their occurrence is very irregular and they are more inclined to be discontinuous than in the Ebner and Alaska-Juneau mines, or, to speak more accurately, in the latter there are several regular dikes of large size in addition to many small and irregular bodies of the intrusive rock.

Only a few of the diorite dikes are represented upon the map, no attempt having been made to locate the separate occurrences, in view of the impossibility of connecting observed outcrops because of the mantle of soil and grass which covers the greater part of the mountain slope. Several dikes were encountered in the crosscut tunnel, one of which is nearly 200 feet wide, but on the surface there is no such dike and it appears to be represented by several disconnected masses.

Occurrence of the ore.—As in the other mines of Gold Creek, the Perseverance deposits are stringer leads in which the vein stuff is distributed through the country rock in the form of irregular vein fillings. The black slate, which is the principal rock, is intruded by numerous dikes and both of these rocks are cut by the ore stringers.

The gangue of the stringers is mainly quartz, though some calcite is present. Metallic minerals include pyrrhotite, pyrite, galena, and sphalerite. Free gold is sometimes to be noted and on one of the southeastern claims tourmaline associated with pyrrhotite and sphalerite occurs in stringers of quartz.

From the surface showing the most promising ground seems to be a strip 400 or 500 feet wide lying along the foot wall of the slate band on the Perseverance No. 2 and Alta claims. It is in this strip that all the mining was done previous to the opening of the Alexander tunnel by the present company. In this foot-wall strip the slates are greatly crumpled and there is some diorite occurring in small masses. The quartz stringers are very numerous in many places, though they are by no means evenly distributed. Assays of material from this ground are reported by the company to show the general presence of gold and there were formerly placer workings in the wash from the hillside just above the Lurvey placer.

In the Alexander tunnel considerable veining was found and nearly all the rock, including the slate and the diorite, is impregnated with minute grains of pyrrhotite. In addition to this mineral the veins carry sphalerite and galena, and are said to give good assays in gold and silver.

The owners of this property regard it as of exceptional value, and the estimate which has been made by them concerning the richness and extent of the ore-bearing ground indicates that the mine can be developed in such a way that the output will be limited only by the capacity of the reduction plant.

PROSPECTS NEAR JUNEAU.

In the lower valley of Gold Creek there are several prospects or leads which, though undeveloped and therefore of no present economic importance, are of interest because they contain albite and rutile, which are characteristic minerals of the Treadwell ores.

The mountain mass which lies between the black-slate band of Gold Creek and Gastineau Channel is composed mainly of greenstone and greenstone schists, but this highly-altered volcanic rock evidently occurs in beds of various thickness which represent separate lava flows, and between certain of these beds there are layers of sedimentary rock, as is indicated in a general way upon the geologic map and cross section (Pl. IV). The band of sediment which lies next to Gastineau Channel has been traced by occasional exposures from Salmon Creek (see p. 117) to Sheep Creek, and from the mouth of the latter stream a cleft extending diagonally up the mountain slope is supposed to indicate the presence of the same bed for a considerable additional distance southeastward.

At Salmon Creek these strata are greatly metamorphosed and consist of quartz and sericite schists. They are exposed for a width of 60 feet, but are evidently somewhat thicker than this. They dip toward the northeast beneath a bed of dark intrusive diorite, along the contact of which the veins that have been opened occur. In Gold Creek the outcrop is wider, but here diorite is also present above the exposures of slate, as may be seen at the Boston shaft.[a]

In a prospect tunnel on the south side of Gold Creek, just above the wagon bridge, there is a narrow vein carrying albite and rutile, with arsenopyrite and sphalerite. This vein stuff is in every way similar to that from the Salmon Creek vein and the same sort of material was encountered in an opening on the shore of the channel about three-fourths of a mile northwest of the Sheep Creek wharf, nearly opposite the Mexican mine. In this place there is a mineralized band about 6 feet wide in the sedimentary schist. The vein stuff is composed mainly of quartz, calcite, dolomite, with various sulphides, rutile, and albite.

[a] The location of this property is given on Pl. XV. No description is given, because the workings were flooded and therefore not accessible for examination.

In addition to the localities mentioned veining occurs at several intermediate points along the outcrop of the slate band and it seems that the latter must have had a controlling influence in directing the circulation of the waters which deposited the veins along and near it. It is noteworthy throughout the Juneau district that the veins exhibit a marked tendency to follow the contacts between rocks of different physical character. In this case the flexible schists, included between the more brittle masses of greenstone and diorite, afforded favorable conditions for the localization of movement at the time of the disturbance which produced the vein openings in the region.

The similarity of the vein minerals to those found in the ores of the Treadwell mines, which are situated about one-half mile across the country strike from this set of veins, leads to the supposition that the source of the depositing solutions was the same in both instances and the conditions of deposition similar. In the case of the mainland deposits the albite occurs in the vein fillings, so that there can be no doubt that its constituents have been introduced by the solutions which deposited the veins. In the discussion of the formation of the Treadwell ores on a later page this fact is taken as one of the indications that soda was likewise added during the action of the mineralizing waters upon the diorite dikes of the Douglas Island mines, though here the rock appears to have originally contained a large amount of the soda-feldspar molecule in the form of oligoclase and microperthite.

GOLD CREEK PLACERS.

GENERAL STATEMENT.

The placer deposits of Gold Creek have been derived from gold-bearing quartz veins which occur in a band of rocks from 2,000 to 3,000 feet in width, traversing the drainage basin from southwest to northeast nearly parallel with its upper course. From the divide between Gold and Sheep creeks this mineral zone strikes across the lower part of Icy Gulch, rises onto the mountain slope south of Silver Bow basin, then crosses the main valley about 2 miles above its mouth and continues along the southward face of Juneau Mountain. (See map of Gold Creek, Pl. XV.) It is exposed for a length of nearly 4 miles within the Gold Creek drainage.

To distinguish the manner in which the gravels occur the early miners classified their locations as hill, gulch, and creek claims. Hill diggings were those situated between the gulches which drained the mountain slope west of Silver Bow basin; gulch deposits were those found in the beds of the minor streams, including also the dumps of débris or talus where these streams joined the main valley. The creek deposits comprised the broad gravel valleys along Gold Creek.

The hill deposits as thus defined are local masses of soil mixed with fragments of the country rock and veins, accumulated either practically in place or at no great distance from the parent outcrops. They represent the surface wash derived from the gold-bearing rocks, lodged at the base of the declivities and in minor hollows on the hillsides. Locally, where the deposits of soil are characterized by a red color they often contain a greater proportion of gold than is to be found in the rocks from which they were derived. This concentration may be explained by the soluble nature of the rocks from which the red soils have been derived, namely, the brown diorites occurring in the mineral belt. These were highly altered at the time the veins were formed, and through metasomatic replacement of their silicate minerals by the vein waters they now contain large amounts of lime carbonate, which is readily dissolved by surface waters, leaving an insoluble residue containing practically all the values.

In the formation of the gulch placers surface wash from considerable areas has been brought into the gulches from the side slopes and concentrated to a greater or less extent along the stream beds, where the rock and vein fragments are comminuted and the gold set free to lodge in natural riffles in the slaty bed rock.

The materials which compose the creek deposits have been washed in from the side gulches and from the main tributaries of the creek. The tenor of these placers is lower than in the hill and gulch deposits, because the sources of the material are more widely distributed, and large amounts of débris have been furnished from practically barren rocks. Not more than half the area tributary to the Nowell placer lies in the well-defined zone of mineralization, and in the case of the deposits in the lower part of this valley the proportion is even less.

The gulch and hill deposits are no longer of economic importance, but the gravel fillings in the main valley have yielded only a part of the gold which they originally contained.

HILL AND GULCH PLACERS.

Deposits of gold-bearing débris on the hillsides and in the gulches on the west side of Silver Bow basin were the first placer discoveries in the Juneau region. They were worked profitably by various methods of sluicing during the early years of the camp. The available supply of water was ordinarily limited, except during the spring, when the melting snows furnished an adequate flow, so that only a few claims in the same vicinity could be worked at any one time. The general distribution of the small placers is shown upon the accompanying map (Pl. XV). They were practically exhausted and abandoned in 1890, after having produced an amount of gold estimated at between $600,000 and $800,000.

The gold-bearing material of the hill and gulch placers is of very local origin. In the case of the former the deposits are accumulations of rock waste and soil due to disintegration of the rocks practically in place, or at least the material has traveled only short distances, by creeping down the slopes under its own weight or with the assistance of rain and snow. The material in the gulch deposits is of the same origin, but it has been moved farther, so that there has been greater opportunity for concentration of the gold.

CREEK PLACERS.

The deposits of gravel in the main valley of Gold Creek and in a few minor basins located on tributary streams have been worked to only a limited extent. This has been due to engineering difficulties of one sort or another which have not yet been fully overcome, except in the Nowell placer, in the upper part of Silver Bow basin.

The valley gravels occur in three flats or basins, separated by bed-rock reaches. First above Juneau, about 1 mile distant, comes the Last Chance or Jualpa placer, extending upstream for three-fourths of a mile; above its head there is a canyon about three-fourths of a mile in length, followed by a second gravel flat nearly one-half mile long. Above this comes another steep grade of half a mile leading to the upper valley known as Silver Bow basin. The elevation of the first flat rises from about 220 feet at its lower end to 325 feet at its head; the second lies between 600 and 700 feet elevation, and the third lies between 1,000 and 1,100 feet.

Little basin is situated above the second flat, to the right of the main stream, on a small tributary coming in from the south. Its elevation is about 1,000 feet. Lurvey basin, having an area of about 2½ acres, lies well up on the mountain slope adjacent to Lurvey Creek, at an elevation of 2,100 feet above tide. A third minor basin lies at the head of Lurvey Creek between 2,500 and 2,600 feet elevation.

Besides these valley deposits there is an extensive delta deposit at the mouth of Gold Creek, lying partly above and partly below tide water. Just above the head of the delta on both sides of the stream occur large banks of mixed bowlders, gravel, and sand—moraines deposited by a former glacier.

All of these accumulations of loose material are undoubtedly auriferous to a certain extent, for in each case they have been at least in part derived from the mineral zone. No tests of their relative value have been made, and with the exception of the Nowell placer no adequate estimation of the average gold contents has been possible.

ORIGIN OF THE BASINS.

The accumulation of gravels in certain reaches of Gold Creek Valley and not in others has resulted from an irregular distribution of grade along the bed-rock profile. Where the rock floor is steep no gravels have been deposited, because with a high grade the stream has been able to keep its bed clear; but where the grade is low or where depressions exist deposition went on until a slope was built sufficiently steep to allow the current to carry off all material subsequently washed into the stream. The origin of all the basins, except the lowest, dates back to the time when Gold Creek contained a glacier. Evidence of general glaciation throughout the whole region is found both in the character of the topography and in the distribution of erratic bowlders on the highest mountains. The small fields of ice on the northward-facing slopes of Lurvey Creek are undoubtedly the remnants of a glacier which occupied the valley and reached tide water long after the general ice sheet of the region had melted away. The irregular grading of the valley floor can be confidently attributed to unequal erosion of the stream bed by this glacier. Streams of moving ice have the power to gouge their beds, and rock-rimmed basins frequently occur in glacial valleys and are characteristic of them. Slight original irregularities in grade are also augmented by glacial action, and the V-shaped valleys due to stream erosion are commonly broadened.

The basin of the lowest gravel flat was formed after the retreat of the Gold Creek glacier by a great landslide from the steep northern wall of the valley. The avalanche character of the dam is still easily recognized and the scar upon the mountain side is quite distinct, though the slide is certainly ancient. Its age is at least several hundred years, for spruce trees growing on it and upon the deposit above are as large as any in the region, and probably not less than 400 or 500 years old. A similar though smaller avalanche which occurred in 1901 is shown in Pls. XIV, XVIII, and XIX.

GOLD CONTENTS OF THE PLACERS.

For the Nowell placer a computation based on the known total yield, and a rough estimate of the mass of material which has been excavated, indicates an average value of about 14 cents per cubic yard. This is possibly somewhat in excess of the real value of the ground, but no better estimate can be made with the data in hand. It is believed that the richest portion of the deposit has already been removed, because the position of the material which remains indicates its derivation largely from rocks outside of the main mineral belt. This point is more fully discussed later.

None of the other large deposits have ever been adequately tested. It is, however, perhaps sufficiently evident that their average value will be less than that of the Nowell ground. The reason for this belief is that all of these deposits have received a large amount of barren wash from Granite Creek and from the slopes on the north side of the valley above the crossing of the mineral belt. Moreover, a large proportion of the débris from the Nowell workings, minus its original gold contents, has been washed down and lodged over the original deposits. In the case of the Nowell deposit perhaps half of the gravel came from the mineral zone, but for the two placers below fully three-fourths and perhaps more must have been derived from practically barren areas.

LURVEY AMPHITHEATER.

At the head of Lurvey Creek there is a cirque or amphitheater, containing a small rock-rimmed basin filled with shingle from the adjacent slopes and from beneath the small glacier which covers the side of the mountain on the southeast. Amphitheaters and small rock basins of this sort are characteristic of high-glaciated regions, and their excavation is to be attributed to ice erosion.

The area of the deposit is somewhat less than 2 acres, and its greatest depth may be estimated at 20 feet, though the average is probably not over 10 feet. Assuming these figures, there would be approximately 30,000 cubic yards of gravel in the basin. The scour from beneath the glacier has come from the gold-bearing zone, the general boundary of which crosses the upper end of the basin. Consequently the débris undoubtedly contains a good deal of gold, though from the nature of the mineral in this vicinity it is probably alloyed with a high proportion of silver. The expense of draining the basin by means of a trench or tunnel and of installing a small hydraulic outfit would, however, seem to be warranted. A minimum of perhaps 50 miner's inches of water under a head of 100 feet would be available for hydraulicking during the period of most rapid melting, in May and June, and there is an abundance of water for sluicing derived from the glacier.

Any direct determination of the value of the ground by digging test pits will be difficult if not impossible, because the basin has no drainage, except over the rock rim, and the gravels are completely saturated with water. There is no reason, however, why the deposit should not be proved by drilling, a method which has been successfully used in other fields; but it is believed that the final proving of the Lurvey placer, which is described in the following section, may be taken as a safe basis for procedure in the case of the amphitheater deposit, because the material of both placers has come from the same source.

LURVEY PLACER.

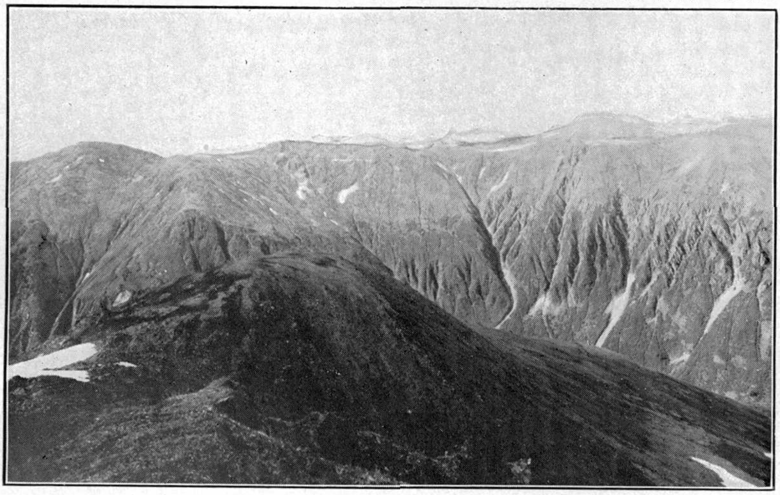
The rock basin in which the Lurvey deposit occurs is a hollow scooped out by moving ice. It is located near Lurvey Creek, at an elevation of 2,150 feet. A former lakelet of about 2½ acres extent, located on a narrow bench on the mountain side, has been filled with gravel furnished almost entirely by Lurvey Creek. This stream formerly flowed into the lake, though its present course lies across one end of the gravel flat and directly across its longer axis. The bench on which the deposit occurs lies at the base of a steep slope several hundred feet in height, which has also contributed some bowlders and a considerable amount of finer stuff. The rocks on this slope are those of the main lode system and contain gold-bearing stringers to such an extent that the talus piles just above the basin were at one time profitably worked by hand sluicing.

Under these circumstances it was assumed that the gravel filling, or at least that portion next to the hillside, would prove remunerative, and in 1889 a tunnel over 350 feet in length was driven to tap the basin. More than an acre of ground of an average depth of 15 or 20 feet was washed through sluices in the tunnel, but according to current reports the yield was inconsiderable. As no steps were taken to locate the deepest part of the basin, the connection from the tunnel, which was made by estimation, emerged near the outer side and above the bottom of the basin. The precaution of running sluices to the face of the bank having been neglected, all the dirt washed into the opening passed over a stratum of gravel which was never excavated. No opportunity was found to interview the parties who did this work, so that it is not known whether any tests were made by panning material from various parts of the deposit during the progress of the work or after the discouraging clean-up. If this was not done with an adverse result, it is reasonable to believe that the gold from the gravel which has been moved was concentrated in the natural sump at the bottom of the rock basin. The additional depth of the deposit below the intake is not known, but, judging from the slope of the basin floor, it can not be very great, certainly not more than 10 feet, and it would seem well worth while to sample the bed-rock gravels.

In a dry season such as that of 1903 it would not be difficult to sink a test pit to the necessary depth, and even to lower the intake would not be a matter of great expense. Also, by working a short distance toward the head of the flat, bed rock would undoubtedly be encountered and a satisfactory test of the undisturbed mass of gravel could be readily made. As already pointed out, this determination could be used as a basis for estimating the value of the deposit in the amphitheater at the head of the creek, from which most of the material in Lurvey basin has been derived.

NOWELL PLACER.

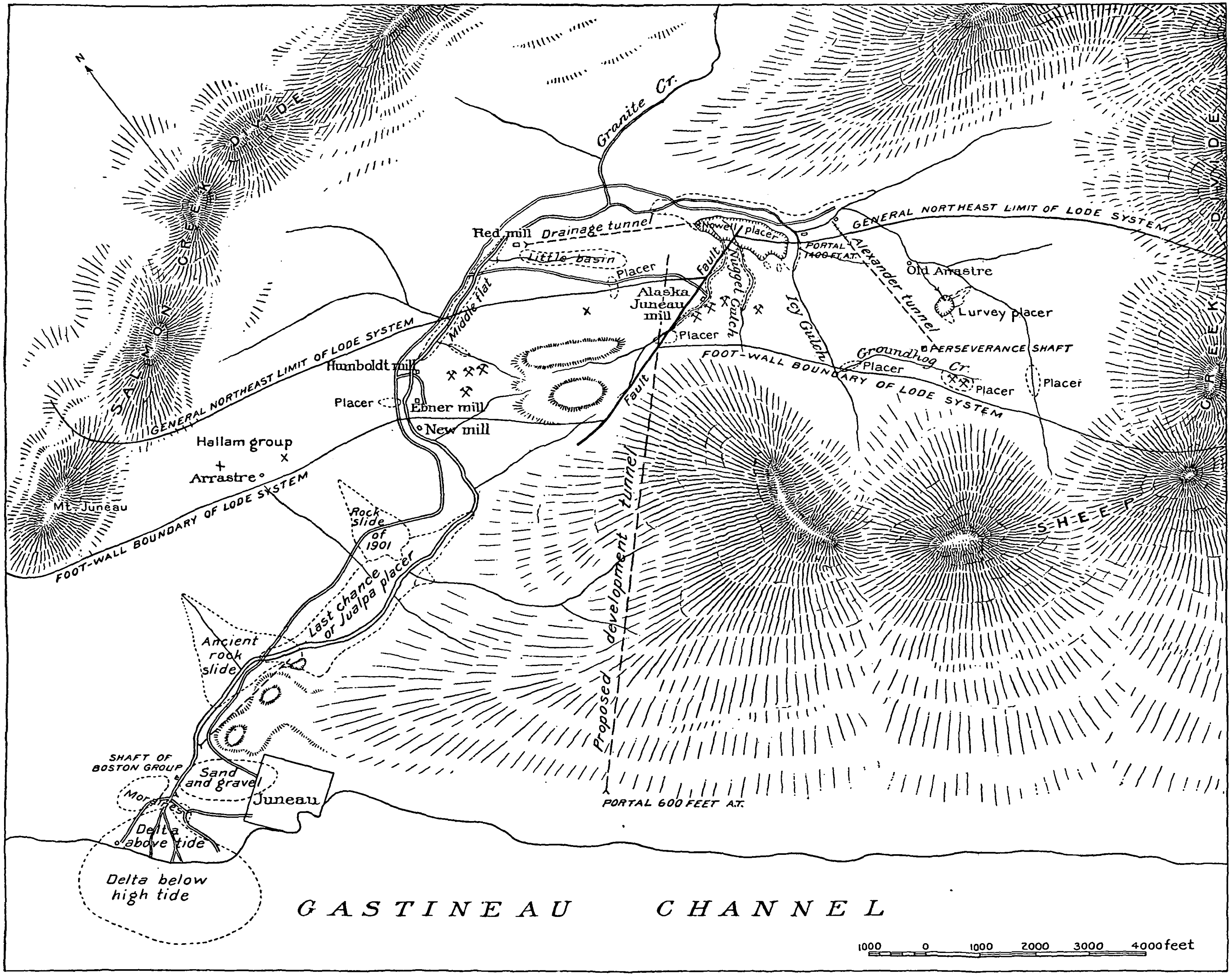
Location and development.—The so-called Nowell placer is situated at the upper end of Silver Bow basin, near the head of Gold Creek (Pls. IX, XV, and XVI). The edges of the deposit were worked in a comparatively small way prior to 1889, when the holders of various claims conveyed their interests to the American Gold Mining Company, which at that time acquired about 200 acres of placer ground in the upper valley of Gold Creek. This company completed a drainage tunnel in 1891 and operated two hydraulic monitors during each summer until 1901, after which no work was done because of litigation concerning the property.



A. UPPER VALLEY OF GOLD CREEK.

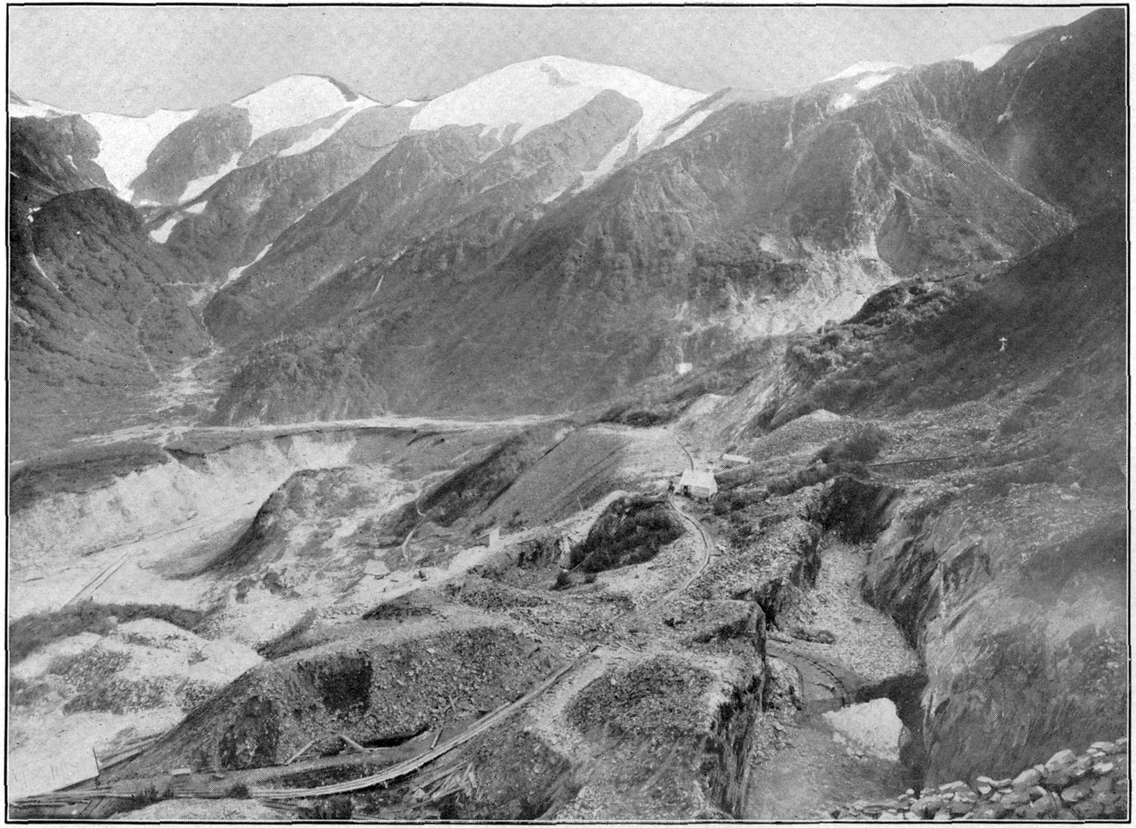
Mount Juneau on the left.

B. LOWER END OF THE ROCK SLIDE OF 1901, LAST CHANCE BASIN, GOLD CREEK.



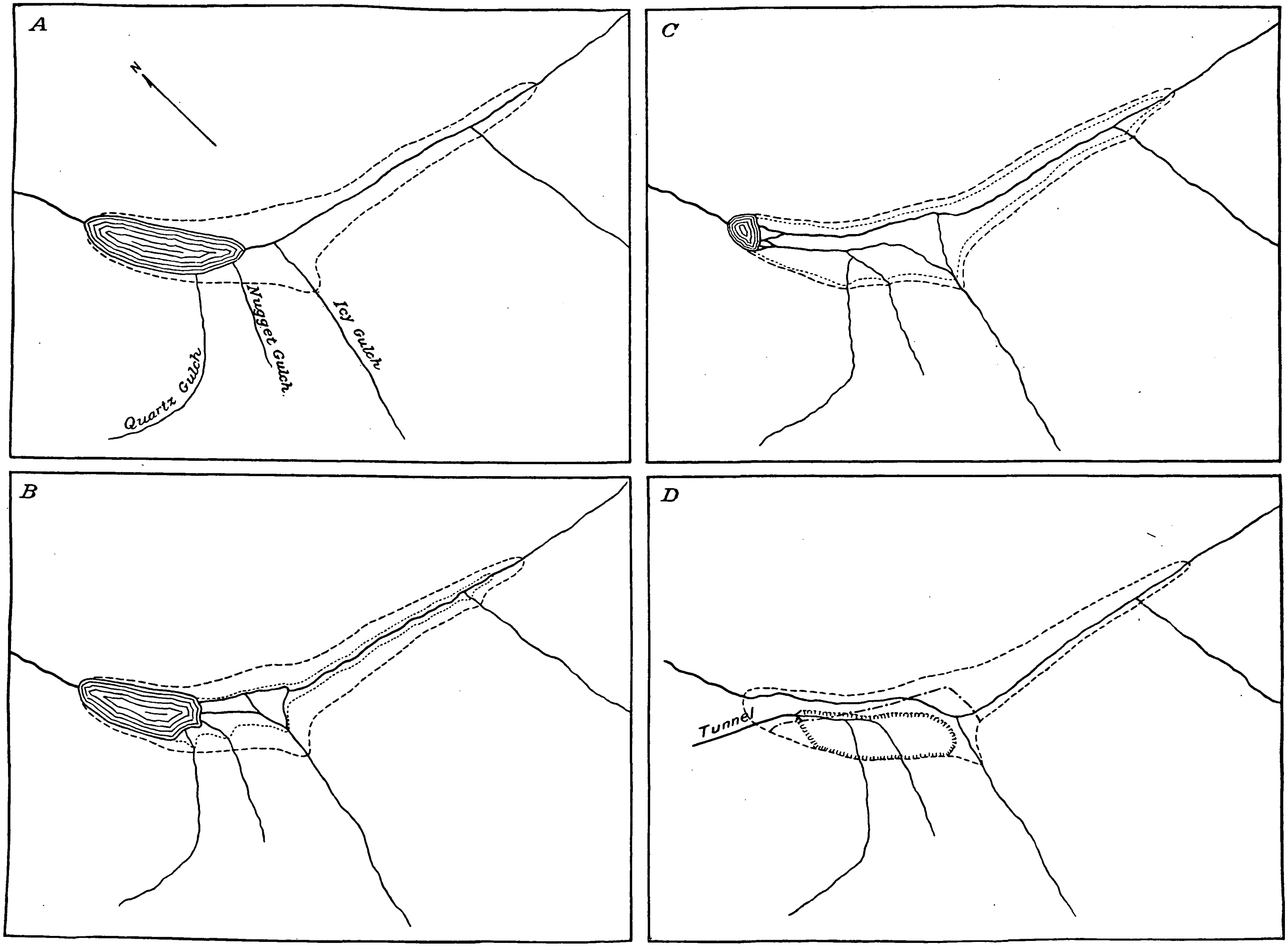
SKETCH MAP OF GOLD CREEK.

Showing position of principal gravel deposits, rock slides, mines, etc., and the general limits of the lode system.



UPPER END OF SILVER BOW BASIN, GOLD CREEK.

Looking southeast toward Perseverance and Groundhog groups and the Sheep Creek divide, showing Nowell placer workings and several open pits of the Alaska-Juneau mine.



SKETCHES ILLUSTRATING FOUR STAGES IN THE GROWTH OF THE NOWELL PLACER, GOLD CREEK.

A. Relative area of former lake and present gravel bed.
B. Showing growth of delta at head of lake and the corresponding extent of gravel filling in valley above.
C. Showing lake nearly filled and gravel bed nearly as large as at present.
D. Present outlines of gravel bed, area worked out, and portion of the deposit in which material derived from southwest side of basin is supposed to rest on bed rock.

In this period of eleven years between $350,000 and $400,000 were extracted from something less than 20 acres of ground, constituting perhaps half the available area of the original deposit, though probably its richest portion.

In working the gravels comparatively few large bowlders were encountered, most of those which the stream was not sufficiently powerful to carry away being of a size which could be handled by wheelbarrows. The wash dirt passed through a long series of sluices set with block riffles and was finally led over undercurrents placed below the outlet of the tunnel.

Value of the ground.—The area of the ground already worked out is about 20 acres, and the average depth of the gravel was approximately 75 feet. Taking these figures and the known product in dollars as a basis for calculation, an estimate of 14 cents per cubic yard is arrived at as the value of the material washed. Of course this estimate is only an approximation, but it is near enough to the truth to indicate that part of the gravel which remains is probably worth the expense of washing, even though its tenor may be lower than that of the ground already excavated. The material in reserve, especially its upper portion, has been largely furnished by streams which do not cross the mineral belt, but, though Lurvey Creek has also contributed its quota of barren débris, it is probable that the bed-rock gravel for a considerable distance above the present workings was derived from the mineral zone by way of Icy Gulch.

Origin of the deposit.—The accumulation of gravel to a depth of 60 to 90 feet was made possible by the presence of a rock basin scooped out by a former glacier. When the ice disappeared from this part of the valley the basin contained a small lake, into which emptied

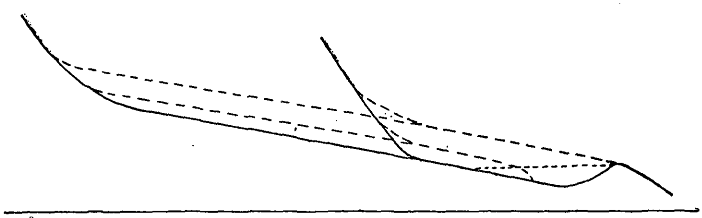


FIG. 20.—Sketched profiles of Gold Creek and Icy Gulch, vertically exaggerated, showing relation of gravel surface to bed rock at present and at stage B. (Compare Pl. XVII.)

the main head of Gold Creek and Icy, Nugget, and Quartz gulches (Pl. XVII, A). These streams were then and are still torrential, capable in time of high water of transporting all the débris furnished to them by rock weathering and glacial scour. It is probable, therefore, that only a short interval elapsed between the abandonment of the basin by ice and its obliteration through infilling.

The first débris deposited in the lake came from Nugget and Quartz gulches, which drain the croppings of the mineral zone on the adjacent hill slope southwest of the basin. Soon afterwards the larger stream flowing in Icy Gulch also became an important contributor of material, but its first deposits must have been thrown into the valley in the form of an alluvial fan at its mouth, where a sharp decrease in grade suddenly diminished its transporting ability (fig. 20). By the building of this fan the main creek was forced over to the northeast side of the valley and its waters were ponded above Icy Gulch. Gravel wash from Lurvey Creek and the headwaters of Gold Creek was thus prevented from reaching the basin below until the dammed valley above Icy Gulch had been filled, and a transportation grade constructed by the deposition of gravel. This filling probably consumed a period sufficient for the construction of a transportation slope over the shorter distance between Icy Gulch and the head of the lake and in addition long enough for the filling of the shallow upper end of the lake itself. (See Pl. XVII, *B* and *C*.)

Up to the time when the Gold Creek wash began to carry over the Icy Gulch barrier the accumulating gravels in the glacial basin had been derived almost wholly from the mineral zone. They had been deposited on bed rock entirely across the valley opposite Icy Gulch and along the western side of the lake basin at the mouths of Nugget and Quartz gulches. Probably the lower portions of the alluvial fans of these streams had then already merged and the upper end of the lake had been filled in. Subsequent to the adjustment of its grade considerable amounts of barren material were brought in by Gold Creek. This wash became mixed with part of the wash from Icy Gulch, but its deposition occurred only on the northeastern side of the basin.

Gradually the lake was silted up and as the place of deposition was forced downstream the surface of the gravel bed was built up to preserve the slope necessary for transportation. When the gravel was finally carried over the rock rim not only had the lake been filled up, but the original level of its surface had also been completely buried. The set of sketches shown in Pl. XVII will aid in understanding the steps which have been outlined.

LITTLE BASIN PLACER.

Below the Nowell placer the wide valley of Gold Creek is divided longitudinally by a rounded knoll of slate and schist rising about 200 feet above the stream bed. The main stream flows in a rather narrow canyon northeast of this knoll, while on the southwest a parallel valley of equal width, known as Little basin, is occupied by a small tributary of Gold Creek which drains the mountain slope northwest of Quartz Gulch. This valley, which is much broader than is required by the small stream which occupied it, is another instance of glacial gouging. The rocks are comparatively soft slates, the strike of which runs parallel with the axis of the valley.

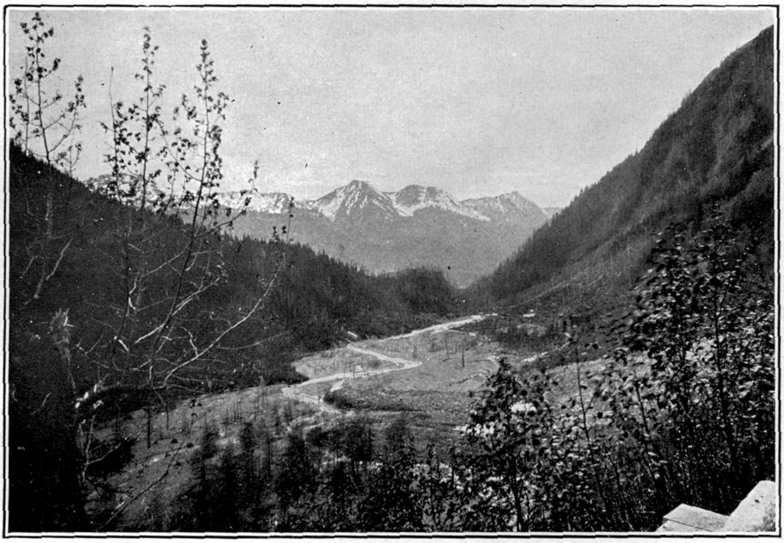
The basin contains several acres of gravel, the depth of which is not known. It may be as deep as 20 feet, or even more if a rock basin exists. The original conditions can not be made out at present, because large quantities of tailings from the Alaska-Juneau Company's quartz mill have been deposited over the natural gravels. The location of the deposit indicates that practically all of its gravel came from the mineral zone near by.

The upper end of Little basin was formerly the site of productive workings which are said to have yielded over $50,000, but the lower part was not touched because it was impossible to secure drainage. If it is ever worked an elevator must be installed.

MIDDLE FLAT.

Description.—The gravel bed which forms the floor of the valley between the lower end of Silver Bow basin and the Ebner dam is about 2,500 feet in length and from 100 to 200 feet in width. Its depth is probably not so great as that of either the Nowell or the Last Chance deposits, but no pits or borings have been made to determine the distance to bed rock. The depth doubtless varies from place to place, as a result of unevenness in the valley floor due to glacial erosion. The surface has a practically uniform slope of about 10 feet in 100.

Origin and probable value of the deposit.—The accumulation of the gravels which form the middle flat is due primarily to the presence of a low bed rock grade above the second canyon of Gold Creek. The débris now lodged in this part of the valley has been derived from the drainage basin above and from the near-by slopes. As the former glacier melted its foot gradually retreated up the valley, and deposits were formed wherever the natural slopes were not sufficiently steep to enable the stream to remove the débris furnished by the glacier. It may be supposed, therefore, that deposition began at the lower end of the flat and continued upstream as the ice gradually disappeared. During this first accumulation the materials must have come from all parts of the upper drainage which contributed ice to the glacier in the main valley, and they were therefore mainly barren of gold. The gold-bearing rocks on the west side of the basin, however, soon began to furnish débris to this side of the deposit, though in relatively small amounts. At least the deeper part of the gravel accumulated before the ice had left the Nowell basin, and while the latter was being filled all the material added to the middle flat must have come from the near-by slopes, only that from the west side of the valley being auriferous to any important extent. Later contributions from Gold Creek were the overwash from the Nowell deposit, and these can hardly have contained any gold except in a very fine state of subdivision. In fact, the gold which escaped concen-



A. LAST CHANCE BASIN, GOLD CREEK.

Looking downstream.

B. LAST CHANCE BASIN, GOLD CREEK.

Looking upstream across hydraulic pit.

tration in the upper deposit must have been too fine to have separated from the sand afterwards.

The conditions under which these gravels accumulated seem, on the whole, to have been unfavorable for bed rock concentration in any part of the deposit. Neither does it seem possible that there can be any valuable amount of gold distributed through the gravels, except along the west side, where a certain amount of gold-bearing débris has been washed down from the neighboring slopes. The latter can, however, hardly compare favorably with the richest part of the Nowell ground, which originated in the same way, because the gulches are smaller and consequently furnished much less débris.

LAST CHANCE PLACER.

Description.—The property known as the Last Chance placer is situated in the lower part of Gold Creek, less than a mile from Juneau. (See map of Gold Creek, Pl. XV, and view of Last Chance basin, Pl. XVIII.) This gravel flat has a length of 4,000 feet and its

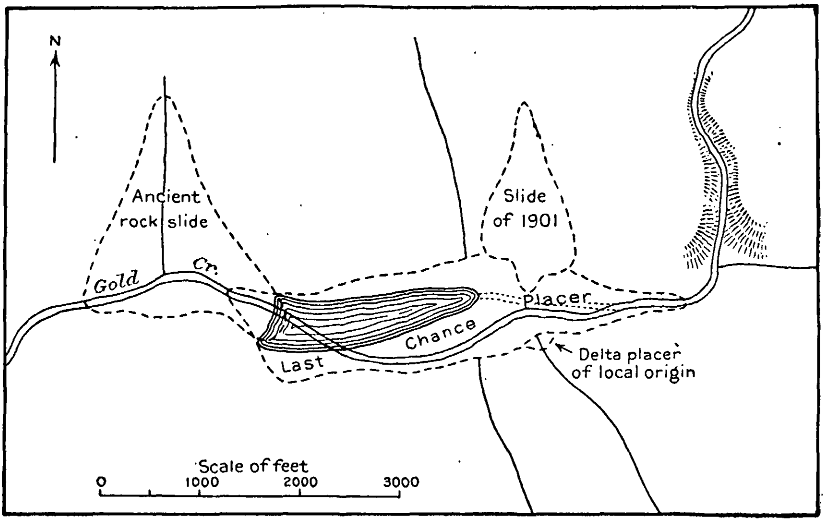


FIG. 21.—Sketch map of Last Chance placer, Gold Creek, showing relative position of rock slides, former pond, and present gravel bed.

maximum width is about 700 feet. The lower end of the flat has an elevation of about 220 feet, its head being approximately 80 feet higher. The depth of the deposit is known to be more than 90 feet at the lower end, where the drainage tunnel as it was first opened failed to find bed rock, though the full depth can not greatly exceed this figure, since rock is exposed in the stream bed at an elevation about 30 feet below the tunnel level.

Development.—The Last Chance placer ground was brought under a single control in 1897, and in 1898 the Last Chance Hydraulic Mining Company was organized. A tunnel of 4 by 5 feet cross section and over 2,000 feet long was driven from a point on the creek about 100 feet above tide, with the object of tapping the deepest part of the channel. The character of the material encountered after leaving solid rock was such that it became impossible either to continue the bore in a direct line upstream to bed rock or to raise through the overlying débris. It was found necessary, therefore, to raise to the surface on the south side of the basin, where rim rock was cut a few feet below the top of the gravel filling. Subsequent operations have been mainly pushed during the summer of 1903 by the Jualpa Mining Company, the present holder of the property. The purpose of the work has been to open a trench back to bed rock and at the same time to gradually lower the intake of the tunnel. To do this it will be necessary to cut through the mass of slide rock which fills the lower end of the basin. This is composed of rock fragments of various sizes, and a considerable proportion are several tons in weight. It is necessary, therefore, to use powder, and all material too large for passage through the tunnel must be removed by the trolley conveyer which has been swung over the pit. Progress in this preliminary work is very slow, and the sluices in the tunnel are in constant danger of being demolished by flooding, as the control of Gold Creek has proved to be a difficult problem.[a]

Origin of the deposit.—The Last Chance basin was formed by an ancient rock slide which came down out of the mountain by way of a small ravine on the north side of the creek. (See figs. 21, 22, and 23.) The material projected into the valley was sufficient to effectually dam the stream, and in the standing water back of the barrier the gravels were deposited, gradually filling the basin. (See Pls. XIV and XVIII.) Before the landslide occurred the slope from the present head of the flat to the head of the delta near Juneau may be supposed to have been practically uniform. If there were alternating flats and cascades, the former were of small importance in accumulating masses of gravel. The fall of nearly 300 feet in a mile and a half gave a slope over which the stream could transport all of the material delivered to it.

From the height of the dam and the present slope of the gravel bed it is known that the lake could not have been nearly as long as the present flat, and between the upper end of the lake and the present rock exposure above, the stream must have flowed on bed rock. Deposition of gravel began in the standing water at the head of the lake, and as the débris was gradually built out into the water, in order to preserve a slope over which the gravel could be transported, the stream dropped part of the material which it carried above the deposit first formed. Part of it, however, was washed down into the pond, and the gravel bed was thus gradually increased in length by additions of material at both ends and in depth by additions to its surface. Under these conditions of accumulation bed-rock concentration could take place only in the portion of the valley above the former lake. Every part of this stretch was temporarily at the head of a growing gravel bed, where for the time being the slope of deposition met or intersected the bed-rock grade. At this place the gravels would undergo sorting, the heavy gold tending to cling to the bottom and lodge in crevices in bed rock, while the rock fragments would be for the most part washed out onto the earlier deposit downstream, a small part, however, being deposited to keep up the necessary grade. Such of the fine gold as passed along with the top gravels would be partly sluiced off into the deposit over which it passed and partly carried into the lake, where it would be dropped with the accompanying gravel. In the area originally covered by the lake, bed-rock concentration would not take place, but the flour gold and gravel would come to rest without any concentration. Here, then, in the completed deposit the values would be distributed throughout the vertical section. Similarly in the upper half of the flat the portion of the deposit formed during the later stages of growth and resting upon the bottom gravels would also contain small amounts of gold throughout, and their tenor would probably be higher than that of the lake beds. On the whole, then, the upper end of the deposit may reasonably be supposed to contain considerably more gold than the lower part next to the slide-rock barrier.

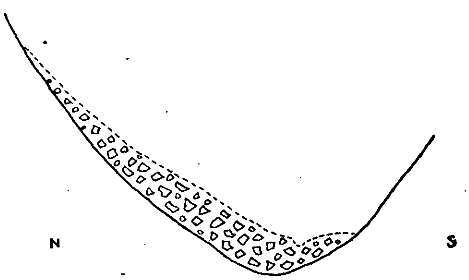
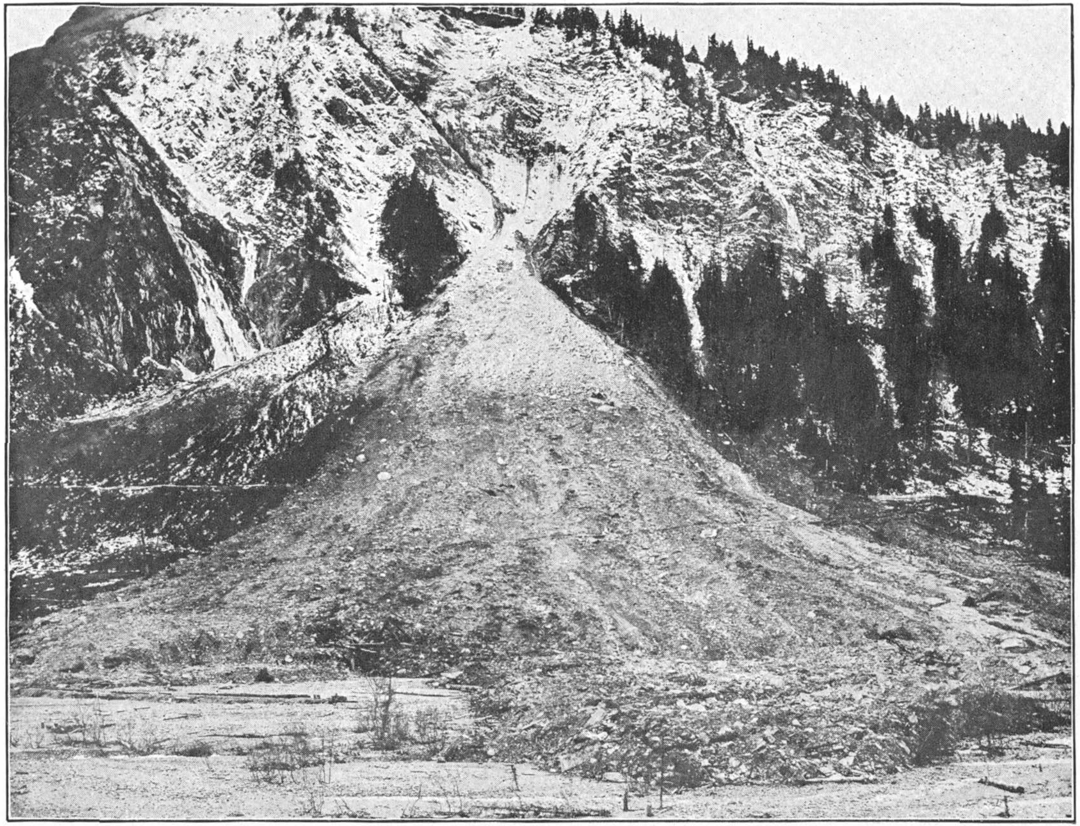


FIG. 22.—Cross section of valley through ancient rock slide, Last Chance placer, Gold Creek.

MORAINE DEPOSITS.

On both sides of the valley below the lower canyon of Gold Creek there are morainal deposits consisting of large banks of sand and gravel, mixed with bowlders. These materials

[a] Since the above was written a large flume has been constructed to control the stream, and the value of the ground will doubtless be known to the owners before this report is issued.



ROCK SLIDE OF 1901, LAST CHANCE BASIN, GOLD CREEK.

Photograph by Winter & Pond.

were dropped from the end of the ancient Gold Creek glacier at a stage when it reached nearly to tide water. (See Pl. XV.)

The material of the moraines has been derived from all parts of the Gold Creek drainage basin, and, reasoning from the known characteristics of glaciers and the methods by which they erode and transport rock material, it is probable that a much greater proportion of the débris has been contributed by the high ridges, composed mostly of barren rocks, than from the middle and lower slopes, where the principal gold veins are exposed. Consequently the gold content of the morainal deposits is probably very low. Some gold is, however, present, as has been shown by sluicing tests on some ground about 500 feet north of the wagon bridge. Here the gravel covers perhaps 2 or 3 acres and forms a hill nearly 100 feet high. It is stated also that on Chicken Ridge colors may be panned from the sands, and it was at one time proposed to hydraulic this portion of the deposit, which is at least 100 feet in depth.

In character the material varies greatly from place to place. The gravels exposed on Chicken Ridge appear to be quite free from large bowlders and could be easily handled if proved of sufficient value, though difficulty would be experienced in securing dumping ground at present, because the residence portion of the town is near by. Farther downstream on both sides of the creek the size and number of the bowlders would render excavation an expensive operation under ordinary conditions. There is, however, plenty of low ground adjacent and with a sufficient body of water the gravel could be moved. On the whole it is believed that these deposits can be of no economic importance.

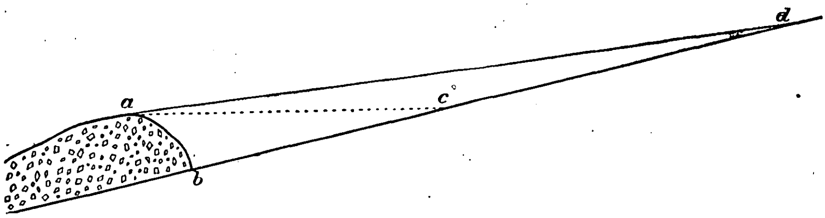


FIG. 23.—Longitudinal section through dam and gravel bed, Last Chance placer, Gold Creek (vertical scale exaggerated). *ac*, Level of former pond; *ad*, surface of present gravel bed; *bdc*, bed-rock grades; *cd*, reach over which coarse gold may be expected on bed rock.

GOLD CREEK DELTA.

The alluvial deposit at the mouth of Gold Creek is by far the largest accumulation of loose-rock material near Juneau. (See Pl. XV.) Its formation has been going on from the time when the glacier front first withdrew from Gastineau Channel into the valley of the creek. During the deposition of the glacial moraines the growth of the delta had already begun, and as the ice gradually wasted away by melting, for a long time practically all of the débris delivered to the creek was carried down to salt water and there deposited.

The material of the delta has all been derived from the Gold Creek rocks, and in the aggregate it doubtless contains much gold. Since, however, the greater part is the overwash from the gravel beds above, the gold may be reasonably supposed to be much finer than that in the valley deposits.

The manner in which accumulation has taken place is quite similar to that outlined for the lake fillings already described, the only difference being that the latter are relatively of much smaller bulk. A certain amount of concentration must have occurred on bed rock as the head of the delta was gradually extended upstream, but no important concentration could have taken place below tide level; in the greater part of the deposit, therefore, the fine gold is distributed through the gravel.

The nature of the deposit would allow of working its lower portion by dredges, but the height of the tides would interfere with the practical operation of the system. The portion of the delta deposit above high-tide level lies too low to permit of its being excavated, since the grade is insufficient to carry off the débris.

DOUGLAS ISLAND.

TOPOGRAPHY.

Lying opposite Juneau, Douglas Island is separated from the mainland by Gastineau Channel, a narrow coastwise passage from one-half to 1 mile in width (Pl. IV). It is separated from Admiralty Island, lying to the west, by Stephens Passage. The length of the island is approximately 17 miles. Northwest of a line from Juneau to Hilda Point its width is about 7 miles, but toward the southeast it narrows rapidly through the eastward retreat of its outer shore line to Tantallon Point, about 9 miles southwest of Juneau.

Tidal flats opposite the northwest corner of the island are laid bare at low water, so that one may walk across the delta of Mendenhall River. It is evident that the wash from this stream has silted up a rock channel of considerable depth.

The island is roughly mountainous, the general elevation of the backbone being above 2,500 feet, while occasional heights rise from 500 to 800 feet higher. The main divide is not symmetrically placed, but lies near the outer side of the island, so that most of the drainage flows into Gastineau Channel. Below Hilda Point the steep mountain wall which rises from Stephens Passage is merely corrugated by the shallow gulches, while on the slope toward Gastineau Channel the drainage lines are well marked and the streams flow in deeply cut trenches separated by bold ridges which run out from the main mountain crest.

Toward the northern end of the island the oblique valley of Fish Creek cuts almost through the range, the pass at its head being in line with the main water parting, but at an elevation 1,500 feet less than that of the neighboring summits. The mountains on the upper end of the island are thus separated into two groups, the larger of which forms the island's western wing.

Fish Creek is more than 7 miles long, the other streams draining into Gastineau Channel varying from 1 mile to nearly 4 miles in length. The waters of all except those near the southwest end of the island are collected for use in the stamp mills at Treadwell, about 18 miles of flume having been constructed for this purpose. The supply, though insufficient for all purposes, still materially decreases the coal consumption by furnishing power during about eight months of the year.

A marked topographic feature of the inland side of the island is a rude bench of irregular height lying in front of the steep mountain slopes which begin half a mile or so back of the shore. Near the Treadwell mines the shoreward edge of this platform, about 500 feet in height, is rather sharply defined, but elsewhere the foreland profile is a graded slope up to 500 or 600 feet, above which begins the abrupt rise to the ridges lying between the streams.

It may be suggested, in explanation of the unsymmetrical development of the drainage on the two sides of Douglas Island, that the controlling factors have been the greater efficiency of erosion on the north slopes during the period of glaciation. The inland side of the island faces northeast and the streams have been eroded as if in obedience to the law referred to. In addition, it is to be noted that no one of the streams on this side of the island has a straight course at right angles to the shore, but each valley turns gradually toward the left as one goes upstream, and their upper courses lie almost invariably in a north and south direction.

GEOLOGY.

General statement.—The rocks of Douglas Island fall naturally into two belts—one characterized by a thick succession of ancient lava flows, here called greenstone; the other by black phyllites or slates. (See geologic map, Pl. IV.) The main mountainous mass of the island is made up of the greenstones, while the slates occur on the inland-facing platform which has been described and rise onto the mountain spurs only northwestward from Douglas city. The belt of greenstone contains nothing but volcanic rock. The slate band, however, is more complex, since it includes several beds of greenstone and many dikes of light-colored intrusive diorite. Along a strip lying next to the main greenstone boundary, black slates and greenstones, the latter usually in a highly altered condition, occur in alternating beds.

The structure of the rocks is simple in its general features, the contacts between the different rock masses striking from southeast to northwest lengthwise of the island and dipping from 50° to 75° NE. (See fig. 24.)

The representation of the different rocks on the geologic map is lacking in many details, only the most general features being indicated. No observations having been made on the western wing of the island, the geology is not known, though the presence of a low platform along Stephens Passage indicates that the rocks are soft, and they are very likely to be slates or stretched conglomerates similar to those which outcrop just west of the greenstones on Point Young, Admiralty Island.

Greenstones.—The rocks here designated greenstones are mainly ancient volcanic rocks extruded as surface flows and later covered by sedimentary strata, with which they have been folded and metamorphosed. On the whole the alteration of these rocks is less extreme than that of the greenstones which occur upon the adjacent mainland, but none of them have escaped metamorphism and it is only here and there that the mineralogical change is so slight that the original nature of the rock can be distinguished. The least-altered material shows a green matrix inclosing dark porphyritic crystals of pyroxene ranging in size up to 1 or 2 mm. in diameter. Observed under the microscope the matrix is always found to be decomposed, though traces of feldspar may be recognized in some specimens.

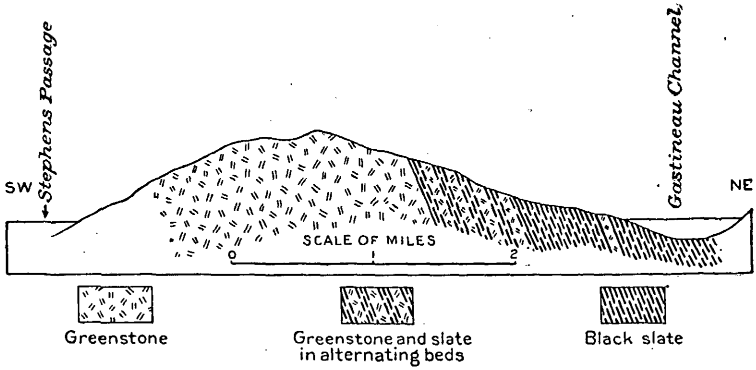


FIG. 24.—Cross section of Douglas Island, showing attitude of rocks.

The alteration products are those of feldspar, such as epidote, sericite, and quartz, with a small amount of calcite. Occasionally serpentine is developed from the augite. The original rock seems to have been andesite of a rather basic composition.

In addition to mineralogical changes, in many places the rock has been converted into a slaty schist.

The altered rock is easily scratched by the knife, giving a white streak. To the unaided eye it presents a fine even-grained appearance. Its color is always green, except in places where it is heavily charged with pyrite, when it is usually bleached to a yellowish tinge. The minerals present are chlorite, calcite, quartz, and epidote, with some limonite and occasional grains of pyrite. That feldspar was originally present in considerable amounts is evident in many specimens from the arrangement of aggregates of secondary minerals in four-sided areas.

Outside of the succession of lava flows which form the main mountain mass of the island, the greenstones occur in the form of intercalated beds or sills in the phyllites which form the principal rock between the mountains and Gastineau Channel. In the mountains the bedded nature of the flows is readily determinable from variations in the texture of different portions of the rock. Some of the layers are made up of angular rock fragments, while others show the amygdaloidal structure so characteristic of many volcanic lavas.

In the slates the greenstone masses are also regarded for the most part as lava flows, though there may be some intrusive bodies, since the various outflows were in all probability fed by fissure eruptions.

Next to the main masses of greenstone the aggregate thickness of the greenstone layers in the slate exceeds that of the sedimentary rock, a relation which has been indicated upon the geologic map by a distinct pattern. In this strip, which is nearly a mile in width, the beds of greenstone are schistose and highly altered. In certain places, as on Ready Bullion Creek, near the Treadwell ditch, the rock is highly impregnated with pyrite.

The body of greenstone which forms the hanging-wall ore zone in the Treadwell group of mines is regarded as a lava flow. It has been traced almost continuously northwestward from the shore of Gastineau Channel for a distance of 6 miles and other outcrops along the line in which it trends have been connected in representing it upon the geological map. From its width on the ridge east of Fish Creek it seems likely that it continues for some distance beyond the northern limit of the area shown on the Juneau map.

Shoreward from the last-mentioned greenstone bed, there are other smaller masses which outcrop along Cowee and Eagle creeks, but the forest covering precludes the possibility of showing the distribution of these bodies upon the map.

Slates or phyllites.—The rocks, which are here called slate in conformity with the common usage of the region, are metamorphosed limy and carbonaceous shales, such as often are designated phyllites. These rocks are black and of fairly uniform fine-grained texture. Their stratification is usually obscure, but is sometimes determinable from variations in color and from slight changes in the character or coloring of the material.

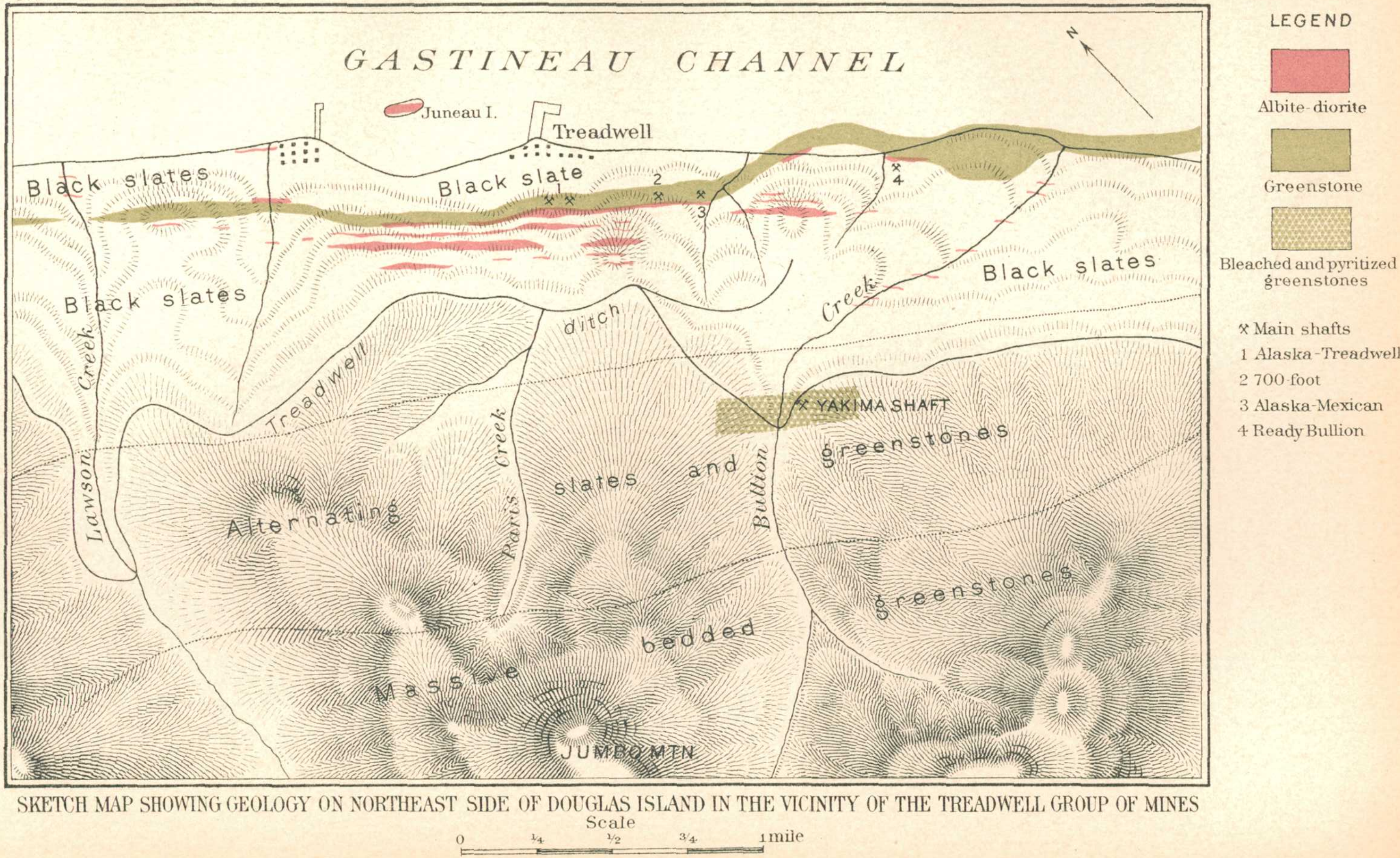
Slaty cleavage is everywhere present, striking parallel with the general course of the band and dipping northeastward with the general structure of the country. No evidence of plication was observed in the slates.

Southwestward from the Treadwell foot wall the slates are free from greenstone intercalations for a width of about 3,000 feet, beyond which the latter predominate as far as the main greenstone contact. This belt of slates which underlies the landward platform of Douglas Island contains, however, many dikes of diorite related to the rock of the ore dikes in the Treadwell mines. Northwestward from the Treadwell greenstone mass occur occasional bodies of greenstone, though none of these are of large size. In this strip there are also a few intrusions of dioritic rock.

Diorite porphyry.—Several dikes of diorite porphyry are found intruding the black slates on Douglas Island. This rock is different from any which has been observed elsewhere in the Juneau belt, but intrusions of similar material are found on Admiralty Island. The rock is fine grained and distinctly porphyritic. Hornblende and feldspar both occur in well-formed crystals set in a finely crystalline groundmass. The feldspar is oligoclase and therefore similar to the principal original feldspar of the ore dikes. The general appearance of this rock is quite distinct from that of the ordinary Coast Range diorite, but it seems probable that it is closely related to this generally occurring type in origin, as it is in mineralogical composition.

The porphyry is best exposed near the southeast end of the island, where it occurs in the form of a dike which outcrops for nearly 1 mile along the inland shore. This dike, which follows the slaty cleavage quite closely, has a width of about 200 feet. Other dikes of the same rock were noted in the bed of Nevada Creek near the Treasury tunnel, and crossing Ready Bullion and Lawson creeks. The Lawson Creek dike has a width of nearly 400 feet.

Albite-diorite.—Irregular dikes of dioritic rock occur in considerable numbers throughout a portion of the black-slate zone of Douglas Island. The largest masses of this rock are in and near the Treadwell group of mines, where they have been highly mineralized and form the ore which is worked. The area in which the dikes are to be found is, however, nearly a mile wide, measured southwestward from Juneau Island, and extends for more than 4 miles in a direction parallel with the general structure of the country and the shore of Gastineau Channel.



SKETCH MAP SHOWING GEOLOGY ON NORTHEAST SIDE OF DOUGLAS ISLAND IN THE VICINITY OF THE TREADWELL GROUP OF MINES

JULIUS BIEN & CO. LITH. N.Y.

In the Alaska-Treadwell mine two dikes, each about 200 feet in width, have been revealed, and as depth is attained these bodies seem to be coming together through the narrowing of the slate horse which lies between them. Still wider dikes occur a few hundred feet back of the mines, and though several of these are mineralized none of them have yet been proved of value. (See map, Pl. XX, and section, fig. 25.)

Of the larger intrusions one forms the greater part of Juneau Island, though a certain amount of black slate is here also present. Most of the large masses, however, occur on the foot-wall side of the greenstone bed which lies above the mine workings and are limited to a zone not more than 1,500 feet wide and about 1½ miles long. To the southeast many narrow dikes may be seen in the bed of Bullion Creek, but none of them occur in Ready Bullion Creek, three-fourths of a mile beyond. To the northwest only a few narrow dikes occur in the bed of Lawson Creek, though in Cowee Creek on the northeast or downstream side of the greenstone there are several dikes of heavy mineralized light-colored rock, which is with little doubt referable to the same set of intrusions as the Treadwell dikes.

The original mineralogical composition of these dikes can not be readily determined, since the rock has nowhere been found in fresh condition. In the larger bodies the rock seems to have been of medium-grained granular texture and to have contained only small amounts of ferromagnesian minerals, though remnants of hornblende are sometimes present. In the smaller dikes porphyritic crystals of only slightly altered hornblende sometimes occur, and feldspar phenocrysts are represented by sharply defined areas of decomposed products derived from this mineral. In the ore material occasional remnants of the principal original feldspar may be determined as oligoclase-albite. This mineral occurs in well-formed crystals from 1 to 3 mm. in diameter, between which is a relatively small amount of interstitial microperthite.[a] The composition of the original rock, as thus indicated, warrants the name albite-diorite, which is here used instead of sodium-syenite, the term chosen by Doctor Becker,[b] since the use of the class name syenite fails to indicate the relationship of the rock to the most common intrusive rocks occurring throughout the Coast Range of southeastern Alaska. The use of one or the other of these names is entirely arbitrary, as is indicated by Doctor Becker, the choice depending upon whether syenite is regarded as a broad term covering all the quartz-free rocks characterized by alkali feldspars or is limited to those which contain potassium feldspar as the metasilicate mineral. Diorite is ordinarily used for the quartz-free rocks characterized by the presence of plagioclase feldspar in addition to mica and hornblende. On this basis albite-diorite is evidently a proper name for the Treadwell rock.

MINERAL LODES.

Douglas Island lies on the outer or seaward side of the slate-greenstone band within the limits of which all the mines of the Juneau belt are located. The bedded rocks of this portion of the band, as already stated, are divisible into two general groups, comprising a zone of massive lava flows which forms the mountain range and a zone of slates containing intercalated beds of greenstone which forms the inland slope of the island. In the zone characterized mainly by slates there are intrusive dikes of diorite which are impregnated with auriferous sulphides in the Treadwell group of mines and also dikes of diorite-porphyry which are not known to be mineralized to any notable extent.

All of these rocks are greatly altered from their original conditions, and all of them, in one place or another, with the exception of the diorite-porphyry, contain considerable amounts of introduced minerals either in the form of fracture fillings or of impregnations of the rock masses. Frequently these two modes of mineralization are observed together. (See p. 91.)

Considering the two sorts of mineralization mentioned in regard to occurrence in the different varieties of rock, it may be said that in all the rocks fracture fillings are prominently developed, at least locally, while mass impregnation is of inconsequential amount in the sedimentary slates, being confined to the rocks of igneous origin and particularly to the

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[a] Microperthite is a minute intergrowth of albite and orthoclase.
[b] Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, p. 38.

greenstones and diorites. In the latter, as exhibited in the Treadwell workings, impregnation goes hand in hand with fracture filling, and both are intimately related in origin, being merely different results of one general process of mineralization.

In the bleached and mineralized greenstones which occur in Nevada Creek and at the Yakima location impregnation and veining are again both present. In this case, however, the veining seems to have occurred subsequent to the general impregnation and to have resulted in a redistribution and concentration of certain of the first-formed metallic minerals, in addition to any essential introduction of new material which may have occurred.

Elsewhere on the island, as, for instance, in the abandoned workings on Eagle Creek, greenstone is heavily impregnated with iron sulphide in the absence of important amounts of fracture filling. No deposits of this type are, however, known to have any prospective value.

The general description here given leads to the same general classification of the Douglas Island lodes as that already given for the Juneau belt at large. They are thus separable into three classes—(1) veins, (2) impregnated masses of rock, (3) mixed deposits in which veining and impregnation are both present.

Veins.—Fractures filled with quartz and other vein minerals are present in many places on Douglas Island, but up to the present no strong or regular veins have been developed. From the manner in which veins occur in the corresponding rocks on the mainland to the northwest it is believed that the most promising situations for the occurrence of strong veining are along the contacts of the greenstone masses with the slates. The only place where any sizable body of quartz was observed outside of the Treadwell mines is at a prospect on the hillside between Lawson and Cowee creeks. The vein here exposed lies near the contact of the greenstone dike and the slate and has a width of from 3 to 4 feet where it has been opened. Sulphides are fairly abundant with the quartz and an assay of a general sample from the material which has been thrown out showed nearly one-third ounce of gold and a small amount of silver.

All of the veins observed in the greenstones which form the mountain seem to be irregular and discontinuous gashes, and even these, though widely distributed, are by no means numerous. In the black slates the veins are still more irregular, but in many places they are numerous and constitute fairly well-marked stringer leads, in which the vein fillings occur mainly in openings along the cleavage of the slates.

Quartz is the principal mineral of these stringer leads, but with it calcite usually occurs and sulphides are nearly always present in greater or less amounts. In a stringer which outcrops on the shore of Gastineau Channel a short distance southeast of Ready Bullion Creek zoisite occurs in considerable amounts with quartz, calcite, and a little albite.

Since these deposits seem to offer little or no inducements to the prospector no study was made of them, and they are mentioned simply to emphasize the widespread occurrence of vein fillings on the island, showing that the Treadwell deposits are only a special localized case of very general mineralization.

Impregnated masses of rock.—In many places on Douglas Island considerable masses of greenstone contain large amounts of pyrite in disseminated crystalline grains. The distribution of this sulphide seems to be entirely independent of the occurrence of fractures or fracture fillings. Some of these bodies of impregnated rock have been prospected in the past, and they are thus known to contain a small amount of gold, though none of them have ever been successfully mined.

When these rocks contain notable quantities of pyrite, the alteration of the material is always extreme, the original minerals of the rocks being entirely replaced by chlorite, sericite, calcite, and quartz, in addition to the iron sulphide. In some cases the metallic mineral is estimated to constitute from 2 to 4 per cent of the rock.

In addition to mineralization in the greenstone, certain dikes which are present along the northwestward extension of the general zone in which the Treadwell ore bodies occur, and which are regarded as originally similar to the diorite in these mines are likewise impregnated with pyrite. Dikes of this sort which have been prospected in the vicinity of Cowee

Creek measure from 20 to 50 feet in width, and are evidently continuous for considerable distances, but since none of these deposits have been proved of economic importance, no attempt was made to study them in detail. Their presence shows, however, that mineral-bearing waters have been by no means confined to the places where profitable ores are found. The latter are only special concentrations in a region very generally mineralized, and while all of the many features which may have determined the difference between valuable concentrations and worthless deposits can not be suggested, it is significant that the presence of vein-filled fractures is always a marked feature in the minable ore bodies, and not generally present in the deposits which have thus far proved to be without value.

The relative age of the general impregnation of the greenstone masses and the fracture fillings which occur throughout the island is a question of no practical importance, though it is one of interest in connection with the general problem of ore genesis in southeastern Alaska. It is also a question which can not be answered at present, though, from the fact that veining seems to have followed general impregnation in the mineralized greenstones which occur in Nevada Creek, it is likely that the former corresponds with the general epoch of vein formation following an earlier period during which mineralizing waters were soaking through the rocks rather than moving in well-defined channels. (See p. 31.)

Mixed deposits.—Combined veining and impregnation was observed in three places on Douglas Island. The valuable deposits consisting of fractured and vein-filled dikes of diorite in the Treadwell group of mines are of this type, and the mineralized masses of greenstone in Nevada Creek and at the Yakima group of claims are given the same classification, though different in several respects as a result of their more complicated genesis. The essential differences between the Treadwell deposits and the others of this mixed type are as follows: At the Treadwell mines the rock which has been filled with veins and impregnated with sulphides and other secondary minerals is intrusive diorite. This rock seems to have been little altered and not at all mineralized before it was fractured. The masses of rock which have been converted into ore or orey material were crushed and fissured, so that they became favorable channels for the passage of ascending vein-forming waters. Through the action of these solutions the rock fragments were not only cemented by the deposition of vein stuff between them, but the fragments themselves were soaked by the circulating waters, their component minerals being largely destroyed and replaced by others. In the other mixed deposits which have been observed upon the island the impregnated rock was originally greenstone belonging to a series of bedded volcanic flows. In these occurrences the general impregnation seems to have originated independently of and earlier than the veins, which are small and by no means generally present. As a whole, the rock exposed over considerable areas contains from 1 to perhaps 3 per cent of pyrite in small, bright crystals. Wherever the iron sulphide is present the original rock has been completely decomposed and altered. The matrix which holds the pyrite has a more or less perfect schistose structure and is of a much lighter color than the ordinary greenstone which surrounds the mineralized rock. The minerals of the latter are sericite, calcite, chlorite, and quartz.

The alteration of the rock, in so far as it exceeds that of the other greenstones in the vicinity, and the introduction of the pyrite are attributed to a process which is conceived to have been comparable to that described by Lindgren in his paper on the Nevada City and Grass Valley districts in California, and designated by him hydrothermal metamorphism [a] In this case, however, large masses of rock have been affected by the alteration instead of limited zones bordering fissure veins.

Veining in these masses of bleached and pyritized greenstone is not a prominent feature by comparison with the Treadwell deposits. The veins are usually narrow and ill defined, and in general they do not seem to occur in extensive networks, but rather in zones of sheeting a few feet in width, which usually cross the northwest-southeast schistosity of the rock. They are often mere seams an inch or so wide filled with quartz, calcite, and albite;

[a] Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1896, p. 94.

these gangue minerals are accompanied by pyrite, chalcopyrite, galena, and sphalerite. Along these seams for a distance of 2 or 3 inches the wall rock often contains all these minerals, but particularly considerable amounts of the sulphides.

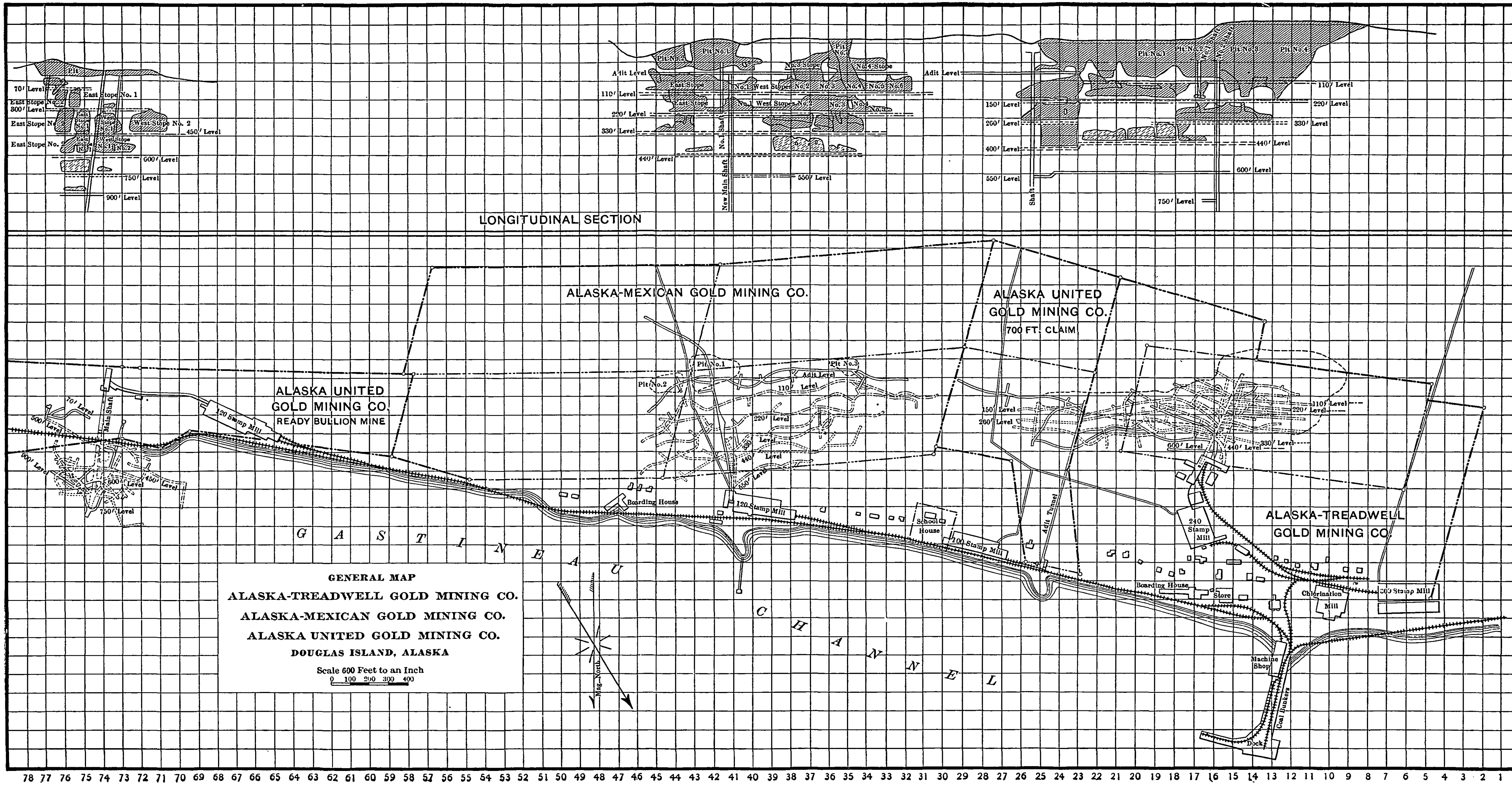
The presence of albite allies these vein fillings with the Treadwell deposits. The veining in the two places is therefore regarded as having been formed by the same sort of solutions and there is no reason for supposing that their formation was other than contemporaneous. The general impregnation of the greenstone must therefore be referred to an unknown but earlier date in the geologic history of the region.

Occurrence of mixed deposits.—The Treadwell ore deposits are described in a following section, and only a short and incomplete account of the other occurrences of mixed ore deposits on Douglas Island is here given, since they are so slightly developed that a detailed study of them was impracticable.

The Yakima group of claims is situated back of the Ready Bullion mine on Bullion Creek, about three-fourths of a mile from Gastineau Channel and approximately 500 feet above tide. (See Pl. XXI.) In this vicinity the exposures along the creek show that the country rock consists of alternating beds of slate and altered greenstone. In classifying the formations of the island for the purposes of geologic mapping these rocks have been assigned to the transition zone between the black slates which lie next to Gastineau Channel and the more massive succession of lava flows which form the mountains. In this portion of the band the amount of igneous rock exceeds that of the slates. The greenstone is almost uniformly altered to a yellowish sericite-schist containing considerable amounts of calcite and quartz, and wherever seen in outcrop the rock is heavily charged with small disseminated cubes of pyrite. The property has been prospected by means of a shaft, and the size of the dump indicates several hundred feet of workings. No details have been gathered as to what was found during this exploration, but the material thrown out is all highly impregnated with pyrite and some of the rock shows that galena and sphalerite are locally segregated in narrow seams containing albite and quartz. The belt of rocks affected by this mineralization, as seen along the creek, is at least 300 feet wide, and along the strike for half a mile or so in either direction occasional exposures show the same sort of bleaching and the presence of pyrite in the greenstone, so that the zone of impregnation is at least 1 mile long in a northwest-southeast direction.

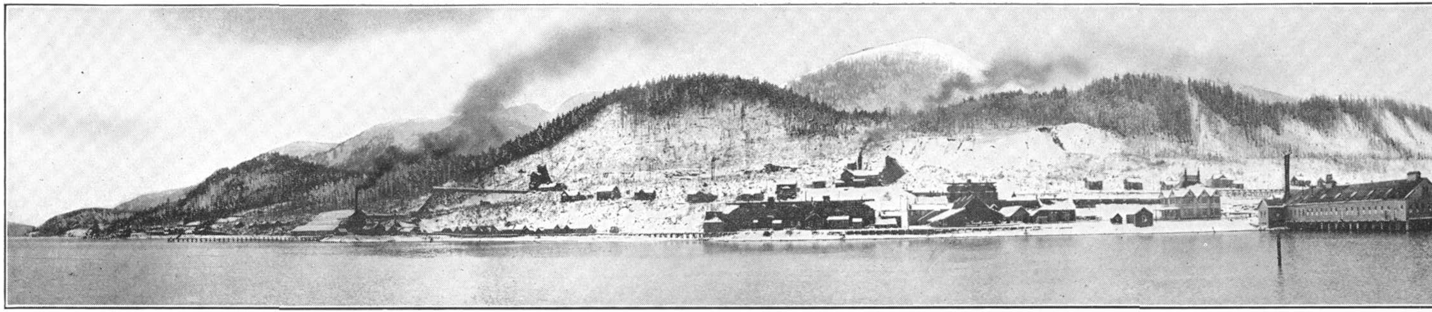
In Nevada Creek the impregnated and vein-filled greenstone belongs mainly to the succession of lava flows which form the mountains of the island and which dip beneath the alternating series exposed near the Yakima shaft. The latter are also present in Nevada Creek and in part, at least, are also mineralized. The schistose greenstones are bleached and mineralized over a roughly elliptical area not less than 1 mile wide where crossed by the creek, and extending nearly 1½ miles in the direction of the country strike. The principal metallic mineral, pyrite, is disseminated in the form of small, bright cubes in amounts estimated to vary from 1 to 3 per cent, and though the distribution of this mineral is by no means uniform it is usually present wherever the rock is bleached. The distinctly schistose matrix is composed of sericite, calcite, and quartz, with some chlorite. Prospecting in this ground has not been extensive, but it has been sufficient to reveal the fact that the generally mineralized rock contains in many places pyrite, galena, sphalerite, and chalcopyrite segregated along narrow seams of secondary origin which usually trend across the schistose structure of the rock. The presence of albite as the principal gangue mineral of these veinlets, together with occasional rutile, is regarded as a favorable indication, so far as the nature of the mineralization is concerned, since it shows a similarity in origin to the thoroughly proved Treadwell deposits. The extent of this secondary veining and the question whether it occurs in sufficient amounts to form minable ore bodies is not yet demonstrated, though the chances that much workable ore exists seem to be sufficient to warrant further systematic exploitation.

The following result of the mill test made by J. D. Davies, of Juneau, on 1 ton of picked ore taken from a tunnel on the property of the Alaska Treasure Consolidated Mines Company, is given by permission of the resident manager:



MAP OF MINE WORKINGS, TREADWELL GROUP.

Reproduced from Trans. Am. Inst. Min. Eng., 1903.

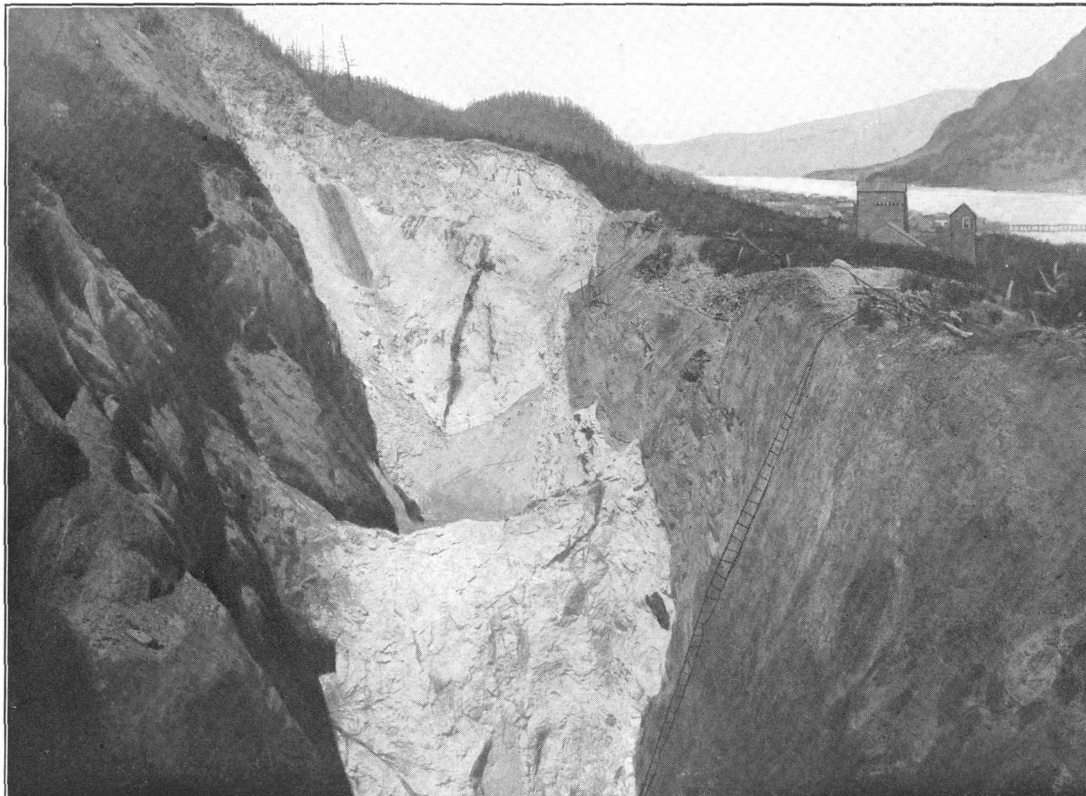


A. LANDWARD SIDE OF DOUGLAS ISLAND.

Showing foothills and mines of the Treadwell group.

B. VIEW OF GASTINEAU CHANNEL.

Looking northward across open pit of Treadwell mine.



OPEN PIT OF TREADWELL MINE.

Looking northwest; showing attitude of ore body.

Mill test of 1 ton of ore from Alaska Treasure Consolidated Mines Company.

Gold, by amalgamation	$2.95
in sulphides	3.92
in tailings	.20
	7.07

The ore was crushed to pass a 26-mesh screen, and the concentrates form 8½ per cent of the material treated.

In addition to the above, assay records in the office of the Treadwell Company[a] indicate that in the so-called Corbus tunnel, which is about 300 feet long, values range from a trace up to $2 in samples, each representing from 50 to 125 feet along the tunnel walls, while a 2-inch streak of "highly sulphureted quartz" gave returns of $8.20.

TREADWELL GROUP OF MINES.

General data.—The mines of this group are owned by the Alaska-Treadwell Gold Mining Company, the Alaska-Mexican Gold Mining Company, and the Alaska-United Gold Mining Company. The mines, four in number, are known as the Treadwell, Seven Hundred Foot, Mexican, and Ready Bullion. The Seven Hundred Foot and the Ready Bullion are owned by the Alaska-United Company, though the former is leased by them to the Treadwell Company.

These mines are situated on the inland side of Douglas Island, near the shore of Gastineau Channel, along which the workings extend for a distance of nearly 7,000 feet. (Pls. XXII and XXIII.) The northwesternmost mine is the Treadwell, and southeastward through the Seven Hundred Foot and Mexican properties the strike of the lode is continuous for a distance of 3,600 feet, beyond which there is an unexplored interval of 2,300 feet between the Mexican and Ready Bullion. (See Pls. XXI and XXIII.)

Although the mining operations have revealed several separate ore bodies and certain distinctions are made in the character and occurrence of the ores, the mines are all located on the same lead and the ore material is practically of one nature and of identical origin throughout. As a whole, therefore, the deposits may be conveniently designated under the name of the first discovered and largest mine.

Previous descriptions.—The present general knowledge of the geologic features of these mines rests on descriptions which have been published by Dr. George M. Dawson[b] and by Dr. George F. Becker,[c] while the microscopical character of the ore material is described in detail by Dr. F. D. Adams[d] and some notes have been recently contributed by Dr. Charles Palache.[e] The general features of the mines and their relations to the Juneau gold belt have been described by the present writer,[f] who has also published a detailed discussion of their geology.[g]

A concise account of the mines from a commercial and engineering standpoint is given by J. H. Curle[h] and the methods and statistics of mining and milling have been treated at length by Robert A. Kinzie,[i] the present superintendent of the mines.

Doctor Dawson's cursory examination was made in 1887, before extensive openings had been made, and while Doctor Becker had better opportunity for observation in 1895, the workings were still rather limited at that time. During the eight years which have intervened since the visit of the latter and the present studies the development of the mines has been very extensive, and the facilities for investigation are now all that could be desired. Additional facts have therefore been secured, and it has been possible to bring to the study of

[a] Courtesy of R. A. Kinzie, superintendent.
[b] Am. Geologist, vol. 4, 1889, pp. 84-88.
[c] Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 7-85.
[d] Am. Geologist, vol. 4, 1889, pp. 88-93.
[e] Alaska: Harriman Alaska Expedition, vol. 4, Geology and Paleontology, New York, 1904, pp. 59-66.
[f] The Juneau gold belt: Bull. U. S. Geol. Survey No. 225, 1904, pp. 28-42.
[g] Trans. Am. Inst. Min. Eng., Lake Superior meeting, October, 1904, pp. 1-38; Bull. U. S. Geol. Survey No. 259, 1905, pp. 69-87.
[h] Gold Mines of the World, 2d ed., New York and London, 1902.
[i] Trans. Am. Inst. Min. Eng., vol. 34, pp. 334-386.

the problems presented by these deposits a fairly accurate knowledge of the general geology of the Juneau region. Under these circumstances it is only natural that some of the conclusions of earlier investigators should be found untenable, and the order of geologic events here given is essentially different from that presented by Doctor Becker.

Development.—The general extent to which the Treadwell ore bodies have been developed may be seen from the map and longitudinal section of the workings (Pl. XXI).[a] The workings shown closely represent the size of the separate ore bodies and the extent of the ore-bearing dikes along the strike. The present depth of the mines is somewhat greater than that indicated by the diagrams, and in every case the lower workings demonstrate the continuance of the ore bodies without decrease in size or in the amount of mineralization.

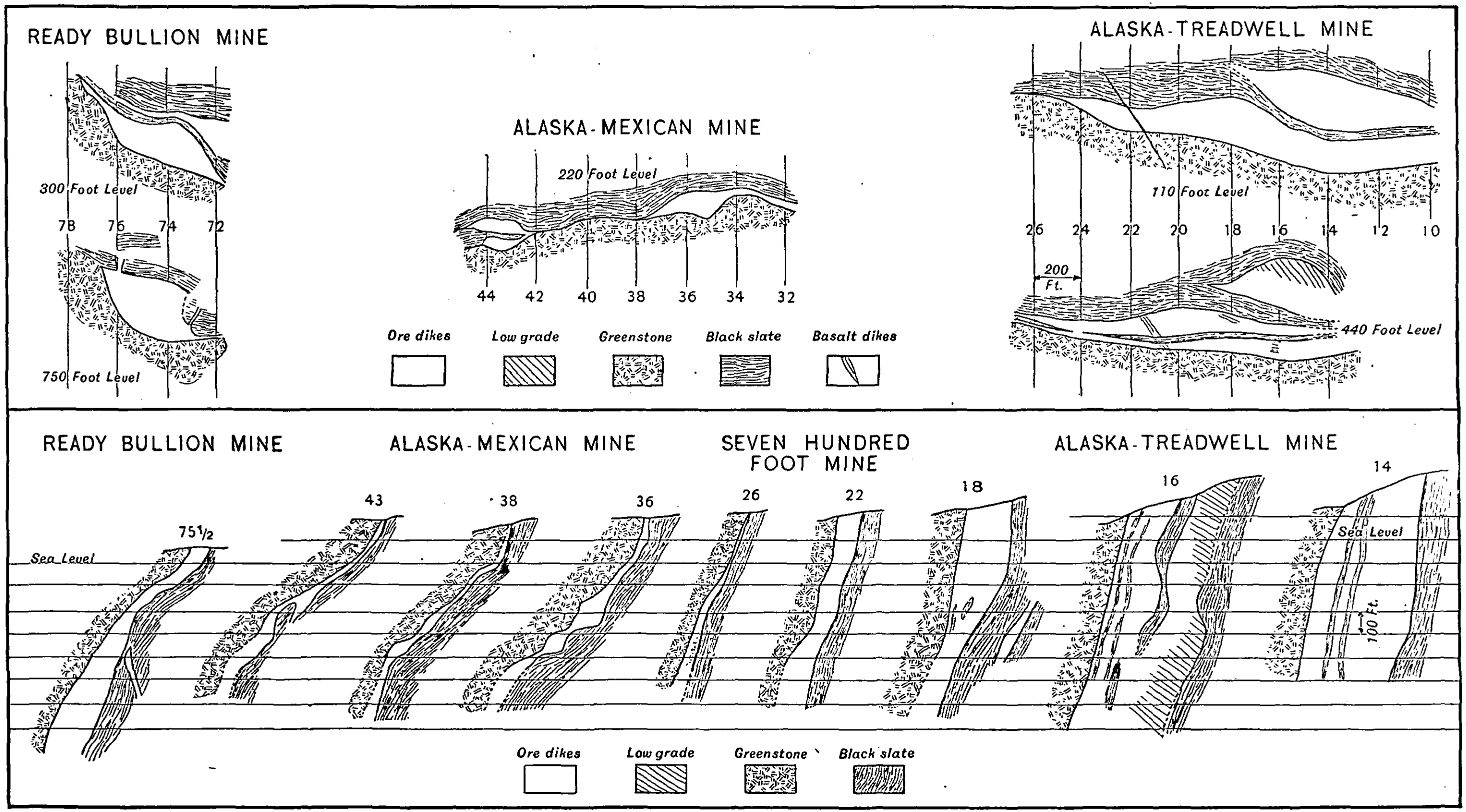
The following table, compiled from the annual reports of the superintendent, shows approximately the linear extent of the workings and the amount of ore sent to the mills up to January 1, 1903:

Extent of workings and amount of ore taken from Treadwell mines to January 1, 1903.

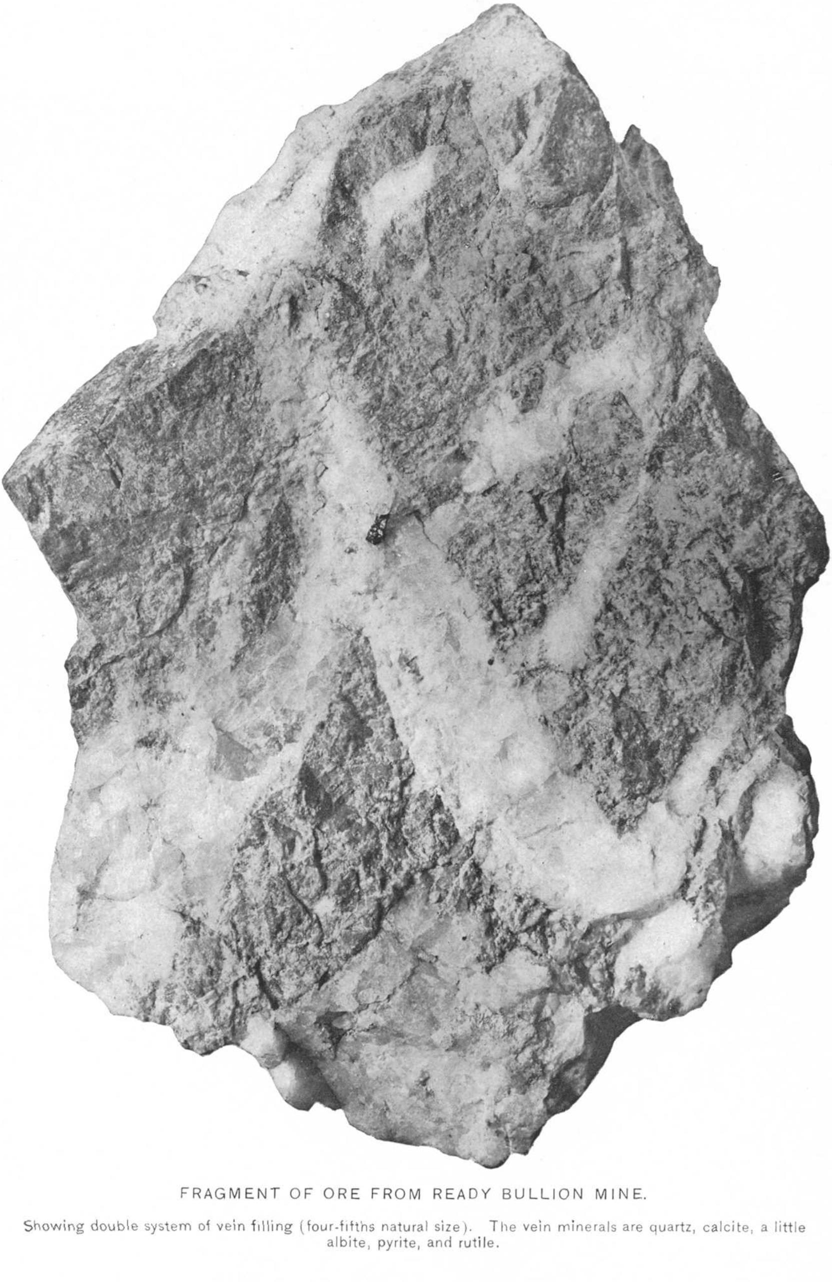
Mine.	Extent of workings.	Ore taken out.
	Feet.	*Tons.*
Treadwell	36,000	4,500,000
Seven Hundred Foot	10,000	400,000
Mexican	27,000	1,300,000
Ready Bullion	24,000	750,000
	97,000	6,950,000

Production of Treadwell group.—The accompanying table of production has been compiled mainly from the reports of the Alaska-Treadwell, the Alaska-Mexican, and the Alaska-United mining companies. The returns from 1882 to 1884, inclusive, and for 1887 and 1888, however, are taken from a table of statistics given by Becker in 1898[b] and the figures for 1885 from the report of the Director of the Mint for that year.[c]

[a] Reproduced from Trans. Am. Inst. Min. Eng., vol. 34.
[b] The gold fields of southeastern Alaska: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, p. 12.
[c] Rept. Director of the Mint on Production of Precious Metals for 1885, p. 30.



PLAN SECTIONS AND CROSS SECTIONS OF ORE BODIES IN MINES OF TREADWELL GROUP.



FRAGMENT OF ORE FROM READY BULLION MINE.

Showing double system of vein filling (four-fifths natural size). The vein minerals are quartz, calcite, a little albite, pyrite, and rutile.

Production of Treadwell group of mines, Douglas Island, Alaska.

Year.	Alaska-Treadwell.	Alaska-Mexican.	Ready bullion+Seven Hundred Foot (Alaska-United).
1882			
1883	$10,902	....	....
1884			
1885	280,479	....	....
1886	366,180	....	....
1887	476,934	....	....
1888	429,889	....	....
1889	652,490	....	....
1890 (January-May)	160,681	....	....
1891 (June, 1890, to May, 1891)[a]	769,765	....	....
1892	707,017	....	....
1893	694,658	....	....
1894	705,948	$204,042	....
1895	626,327	226,258	....
1896	782,829	245,861	....
1897	676,064	335,628	....
1898	586,857	375,882	$47,495
1899	677,655	347,414	586,787
1900	1,153,367	315,005	613,467
1901	860,736	339,452	796,608
1902	1,304,720	426,732	492,058
1903	1,598,963	699,385	[b] 329,458
1904	1,829,508	661,174	[b] 355,311
1905	2,007,842	....	....
	17,359,811	4,176,833	3,222,184

Total, $24,758,828.

[a] After 1891 reports cover period beginning June 1.
[b] Seven Hundred Foot claim idle since 1902.

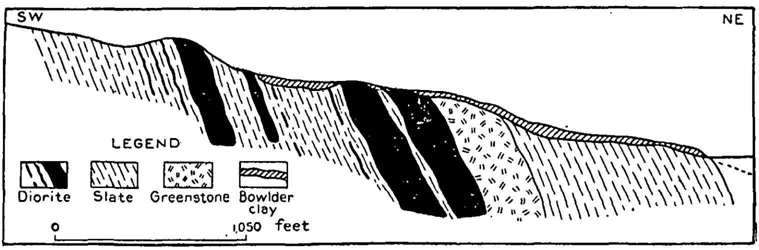


FIG. 25.—Cross section through Alaska-Treadwell mine and northern side of Douglas Island.

In addition to the amounts given in the above table it has been estimated that the Treadwell ground produced $45,000 of placer gold in 1882 and 1883, and the Ready Bullion claim $15,000 in 1881 and 1882.[a] No record has been found of any production from the property last named between 1882 and 1898.

General features of geology.—The Treadwell ore bodies consist mainly of mineralized albite-diorite occurring in the form of intrusive dikes in black slates, the structure of which they closely follow. These slates are metamorphosed shales in which both bedding and slaty structure strike northwest-southeast and dip about 50° on the average toward the northeast (fig. 25). The ore-bearing dikes belong to a series of intrusives which appear interruptedly

[a] Rept. Director of the Mint on Production of Precious Metals, for 1883, p. 30. The population and resources of Alaska: Eleventh Census, 1890, p. 231.

PLATE XXVI.

A. Porphyritic phase of albite-diorite, showing feldspar phenocrysts clouded by decomposition products and surrounded by clear rims of albite. The interstitial groundmass is microperthite, which in other specimens may be seen partially or wholly replaced by albite. In this slide the microperthite has not been attacked, but hornblende originally present is greatly decomposed and replaced by aggregates of fibrous hornblende, epidote, calcite, and pyrrhotite. This feature, however, is not shown in the illustration. Magnification, 10 diameters. Ordinary light.

B. Microperthite forming the groundmass in a porphyritic phase of the albite-diorite. Same slide as *A*, but viewed between cross nicols. A large part of the Treadwell ore consists of rock in which the microperthite groundmass has been replaced by albite, along which calcite, pyrite, and rutile have been introduced. Magnification, 16 diameters. Ordinary light.

A

B

PHOTOMICROGRAPHS OF ALBITE-DIORITE, TREADWELL MINES.

along the strike for a distance of about 3 miles in a zone approximately 3,000 feet wide. In the greater part of this intruded area exposures are few, and only small dikes are found outcropping on the side toward the center of the island. On this side the zone seems to be irregularly limited, but next to the shore of Gastineau Channel the border is defined by a heavy bed of greenstone which runs parallel with the slates and the intrusive dikes and dips with them toward the adjacent channel. Outside of this greenstone no dikes of diorite are known near the mines, though they do occur toward the northwest. (See map, Pl. XX.)

The mineralized dikes which constitute the known minable ore occur just beneath the bed of greenstone, which thus constitutes the hanging wall both of the intrusion zone and of the ore bodies. (Pl. XXII.) Many of the dikes of albite-diorite at a distance from the hanging wall have been greatly altered and impregnated with pyrite, though workable ore bodies have not yet been discovered in them.

The strike of the different rocks is regular in the main and slightly oblique to the channel, so that the outcrops of the ore bodies recede from the shore as they are followed toward the northwest. The base of the greenstone hanging wall strikes the shore of the island about 1 mile below the Ready Bullion mine, at first running inland and then back to a point below high water just beyond the exposure of the southernmost body of diorite in the open pits of the Ready Bullion mine. Reappearing within a few hundred feet, it bends sharply and is next exposed in the southeast pits of the Mexican mine. From this point it is traceable in a nearly straight line through the Seven Hundred Foot and Treadwell workings and for a distance of several miles beyond. Upon the geologic map (Pl. IV) it has been represented as connecting with other outcrops of greenstone toward the north end of Douglas Island.

In the vicinity of the mines there are no dikes of diorite on the south side of the greenstone next to the channel, but about 1 mile to the northwest two croppings have been noted, and Juneau Island, lying in Gastineau Channel about 2,000 feet from the foot wall, is composed in part of similar rock which contains some pyrite impregnations. Farther to the northwest dikes of mineralized rock apparently originally similar to this diorite are found in the vicinity of Cowee Creek, where they also lie above the bed of greenstone.

Besides the mineralization in the igneous dikes, the black slates which lie on either side of the greenstone band contain occasional veins and stringer leads at several points. In general these veins follow the structure of the slate. Veining of this sort may be readily observed along the shore of the island southeast of Ready Bullion Creek, and it is particularly to be noted along the foot wall of the Treadwell greenstone for a distance of several miles northwest of the mines. Assays of material taken from these veins by the writer showed values up to $6 per ton. There has been no systematic attempt to develop them at any point and it is doubtful whether auriferous veins are segregated to a sufficient extent to make them of value.

The rocks occurring in and near the mines which will now be described in greater detail, are the following: The greenstone hanging wall, the slate country, inclosing both the greenstone and the ore bodies, the dikes and lenticular masses of diorite, some of which constitute the ore, and a few small dikes of basalt.

Greenstone.—The hanging-wall greenstone forms a prominent bed or stratum about 300 feet in thickness where measured in the mines, but varying somewhat from this figure in different parts of its outcrop. So far as determinable it follows the structure of the slates, striking with them from southeast to northwest and dipping northeast toward the near-by channel, beneath which it has been followed to a depth of about 900 feet in the lowest working of the Ready Bullion mine. The outcrop is practically continuous for 4 miles northwestward from the point where the greenstone first appears on the shore of Douglas Island. Then the bed thins out and is missing for a few hundred feet, but it soon reappears and may be followed for an additional 2 miles until it is lost beneath a heavy covering of vegetation.

As a rule the rock is greatly altered and in places it is often schistose or slaty, but portions of it are sufficiently unchanged to indicate the original composition and structure. In the vicinity of the Ready Bullion mine the rock is granular, consisting mainly of coarsely crystallized hornblende, though it contains a great deal of magnetite and some pyrite. A specimen from the Mexican workings, which might be called andesite, contains porphyritic crystals of plagioclase and augite in a decomposed groundmass, which seems to have consisted largely of small prismatic feldspar crystals. The secondary minerals in this rock are chlorite, epidote, serpentine, and calcite. Northwest of the workings the greenstone is a fine-grained diabase.

The greenstone was called gabbro by Becker, who regarded it as later than the rock of the ore bodies, but there is now sufficient evidence to establish the opposite age relation, and reasons exist for doubting its intrusive nature. The light-colored rock fragments contained in the greenstone, which form the basis of Becker's conclusions, are represented in his collection by a specimen and a thin section, showing a distinctly outlined fragment of grayish granitoid rock inclosed in greenstone. The diagnostic value of this occurrence, however, is open to doubt, since at several points in the region pebbles and fragments of similar material occur in the volcanic greenstone breccias at different horizons in the series of interbedded slates and greenstones, showing the existence of an available source of granitoid material prior to the deposition of the slates and the outpouring of the contemporaneous lavas.

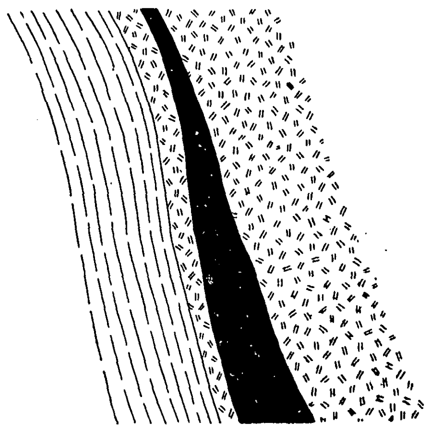


FIG. 26.—Section of narrow dike of albite-diorite observed in surface pit of Seven Hundred Foot mine. The diorite, which is left blank in the sketch, lies between walls of schistose greenstone a few feet distant from the slate, which usually forms the foot wall.

In the open pits of the Seven Hundred Foot and Mexican mines the exposed lower part of the greenstone bed is very schistose, and this slaty rock forms both walls of the ore body. Between the ore and the black slate which usually forms the foot wall is a plate or layer of chloritic schist of somewhat variable thickness, evidently identical with the schistose or slaty greenstone of the immediate hanging wall, and the latter grades off into the massive rock (fig. 26). This relation suggests that the locally developed schistosity of the greenstone existed before the intrusion of the diorite dikes, or was produced at the time of the diorite invasion, and in either case the greenstone must be the older rock. Other evidence tending in the same direction was noted in an old stope above the 220-foot level in the Treadwell mine. Here the main mass of diorite lies below all of the greenstone, but the latter is again somewhat schistose, and a narrow offshoot from the diorite cuts across this secondary structure for a distance of about 3 feet and then follows the schistosity parallel with the wall of the large ore body (fig. 27).

Even without the above proof that the diorite is intrusive in the greenstone, several general considerations would point to the probability of this relation. In the region at large the dioritic rocks invariably cut the bedded greenstones, and on Sheep Creek they are even later than the gabbro dikes, which follow the structure of the inclosing rocks approximately. None of the basic intrusives, which are evidently later than the Coast Range diorites, show any tendency to follow the structural trend of the region, but, like the small basalt dikes in the Treadwell mine, they characteristically hold to transverse courses. The way in which the greenstone limits the zone of diorite dikes and the marked coherence of individual dikes to its lower surface both point to the hanging-wall stratum as a controlling feature in the distribution of the diorite, and therefore suggest its earlier existence. The probability of this relation is well brought out by the detailed map and the cross section (Pl. XX and fig. 25).

Again, if the attitude of the diorite dikes in reference to the slate country rock is compared with that of the greenstone, it is found that the diorite shows all the ordinary structural characteristics of intrusions, while the greenstone exhibits no features which necessarily require an intrusive origin. The diorite bodies change in shape from place to place, branch irregularly, crosscut the stratification locally, and include masses of slate. The greenstone is a single layer or bed which continues along the same horizon for at least 6 miles, showing but slight variations in thickness; it does not crosscut the slates so far as observed, and it contains no slate inclusions. In view of these facts it is strongly believed that the greenstone is not intrusive, but that it originated as a lava flow similar to many others in the same general series of alternating sediments and igneous rocks, while the diorite was intruded at a much later date. In places the greenstone contains stringers of quartz and it is locally impregnated with pyrite, though it has nowhere been found to contain more than small amounts of gold.

Black slate.—The black slates, which constitute the main country rock in the vicinity of the Treadwell mines, are highly metamorphosed, carbonaceous, and calcareous shales of fairly uniform texture. Their stratification is usually determinable from variations in color and from slight changes in the character of material, and so far as observed the bedding and principal slaty cleavage are always in accord.

The cleavage of the slates is regarded as having been produced before the diorite intrusions, the direction of which it largely controls. In this respect the secondary structure corresponds with that of the sedimentary rocks of the general region, all of which were tilted and metamorphosed before the diorites of the Coast Range were intruded. The slates do not appear to have been altered by contact metamorphism next to the intrusive dikes of syenite.

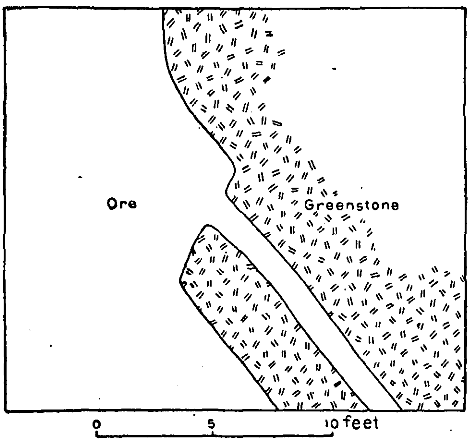


FIG. 27.—Mineralized diorite intrusive into greenstone of hanging wall in Treadwell mine.

Albite-diorite.—Classification of the Treadwell rock is somewhat difficult, because it has been impossible to secure entirely unaltered material. It was described as granite by Professor Adams, but Doctor Becker, from a study of material collected by him, gave it the designation "sodium syenite," to distinguish it from the ordinary syenites which contain potassium as their alkali constituent. However, since the soda-feldspar albite, which is the characteristic mineral of the rock, belongs to the plagioclase series, and these feldspars are the distinguishing feature of dioritic rocks, he suggested the alternative name "albite-diorite," which is here employed, because it indicates the known relationship of the Treadwell rock with the dioritic intrusives of the adjacent Coast Range.

The rock varies in mineralogical composition from place to place, but is always very much changed from its original condition. Most of it shows only small amounts of ferromagnesian minerals, either because they were never present or because they have been decomposed and carried away by the mineralizing solutions which have permeated the rock. Specimens were collected, however, which contain hornblende in apparently original prisms, and biotite is sometimes observed. Secondarily crystallized mica and green hornblende are somewhat common, and with them a considerable amount of epidote is ordinarily found. Feldspar is present in two conditions, original and secondary.

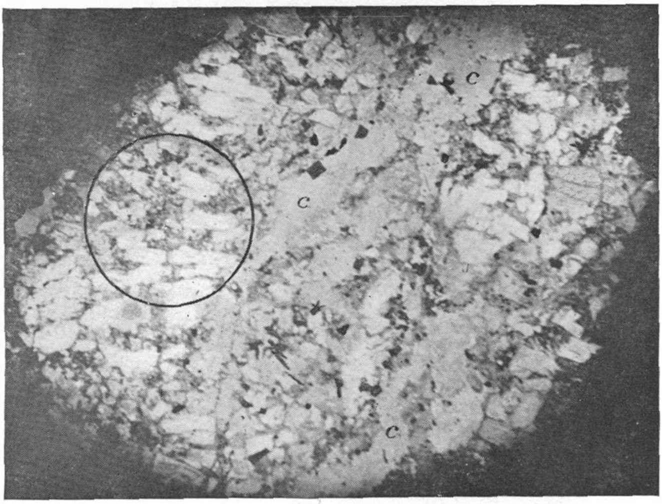
The primary feldspars of the magma were albite-oligoclase—occurring in phenocrysts now always clouded by decomposition products—and microperthite, with some pure albite,

PLATE XXVII.

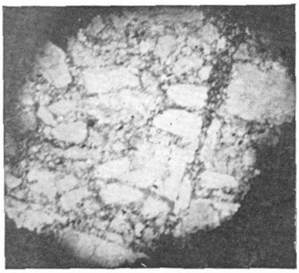
A, Albite-diorite with groundmass replaced through the action of mineralizing waters. The oblong areas showing white in the photograph are the decomposed clouded feldspars of the original rock, which are less transparent than the surrounding albite and calcite. Calcite (*c*) is present in several areas the shape of which suggests that this mineral occurs in veinlets, but if so the walls are not well defined, because the calcite and secondary albite are intercrystallized and the latter continues into the walls. Pyrite and rutile are present in considerable amounts and are confined to the secondary filling between the old feldspars. (See Pl. XXVIII, *A*, showing area marked by circle.)

B, *C*, Illustrating the appearance of specimens of the ore in thin section. The white areas are the clouded feldspars of the original rock, the groundmass being replaced by secondary albite. The latter also occurs in minute veinlets and in both situations is accompanied by minute crystals of pyrite.

D, Specimen of ore from the Alaska-Mexican mine, illustrating the occurrence of minute ramifying veinlets of albite in the fractured rock. The veinlets are more transparent than the body of the rock, and therefore show dark because of the black background.

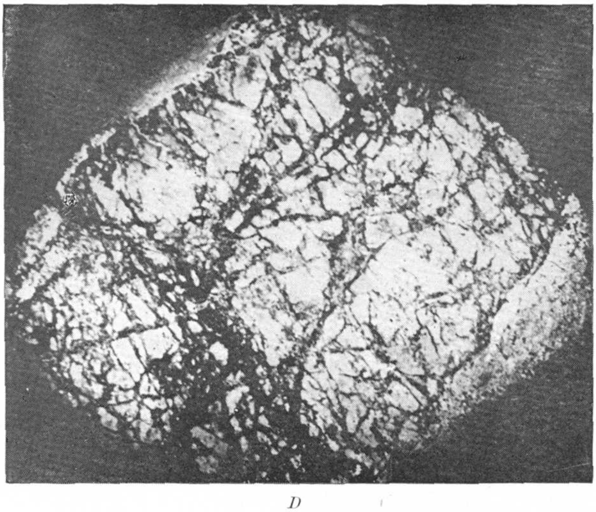


A



B

C



D

THIN SECTIONS OF TREADWELL ORE.

These sections were placed against a dark background and photographed by reflected light. Magnification in each case 2 diameters.

forming a granular groundmass of distinctly later crystallization. The composition of the phenocrysts is inferred in general from the presence of epidote or zoisite as one of the minerals formed by the alteration of the feldspars, but this has been checked by the optical characteristics of relatively fresh material occurring in several specimens, and is indicated by the chemical analyses which have been made. The appearance of these clouded feldspars under the microscope is shown in several of the accompanying photomicrographs (Pls. XXVI to XXXI).

The interstitial microperthite is present in varying amounts in the fresher examples of the rock (see Pl. XXVI), but in the mineralized rock it can not be detected by the microscope.

The secondary feldspar is always albite. It is usually quite free from decomposition, and when it occurs in considerable amounts the rock presents a very fresh appearance. This mineral has been formed mainly at the expense of the original microperthite, which it replaces in part, but frequently it also fills narrow seams which cut across the original feldspar crystals of the rock. (See Pls. XXVII, *D*, and XXX, *A*.)

Quartz seems not to have been an original mineral in the albite-diorite. It is never observed in the body of the rock associated with the secondary albite, but is confined to the veinlets which intersect the dikes. Calcite is common, both in the veins and distributed through the rock itself along with the albite of secondary generation.

Original accessory minerals noted are apatite, zircon, titanite, rutile (?), and magnetite. The secondary minerals which have been noted are uralite (secondary hornblende), green mica, chlorite, epidote, zoisite, calcite, quartz, sericite, rutile, pyrite, pyrrhotite, with molybdenite, galena, sphalerite, chalcopyrite, and arsenopyrite occurring exceptionally. Some of the magnetite seems to have originated from the breaking up of primary iron-bearing minerals, but since it sometimes surrounds cubes of pyrite it has apparently also been deposited from the mineral solutions.

Three analyses which have been made of relatively fresh specimens of the rock are given in the following table:

Analyses of albite-diorite from Treadwell mines.

[George Steiger, analyst.]

	I.	II.	III.
SiO_2	63.01	58.53	64.36
Al_2O_3	18.48	17.74	18.18
Fe_2O_3	.06	1.58	.64
FeO	.32	1.46	.43
MgO	.06	1.71	.28
CaO	2.66	5.08	2.56
Na_2O	10.01	5.69	8.96
K_2O	.39	3.90	.89
H_2O-	.05	.18	.18
H_2O+	.27	1.18	.55
TiO_2	.13	.81	.17
ZrO_2	....	.06	.03
CO_2	2.01	.90	1.62
P_2O_5	.06	.27	.06
SO_3	....	None.	.07
MnO	.06	.11	.11
BaO	.02	.07	.06
SrO	Trace.	.05	.04
FeS_2	2.10	.96	.97
	99.69	100.28	100.16

PLATE XXVIII.

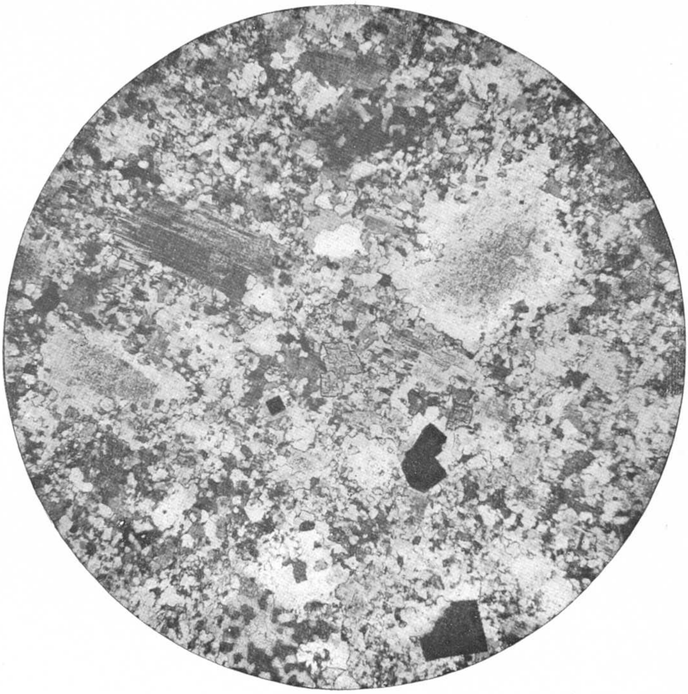
A. Clouded feldspar of the original rock surrounded by fresh transparent albite intergrown with calcite and accompanied by pyrite and rutile. The metallic minerals never occur in the clouded feldspar, but are confined to the interstitial filling, which is regarded of secondary origin through the metasomatic replacement of the original groundmass under the action of vein-forming waters.

f. Original feldspar.
a. Secondary albite.
c. Calcite.
r. Rutile.
p. Pyrite.

Magnification 8 diameters. Ordinary light. (Compare with Pl. XXVII, *A*.)

B. Feldspar phenocrysts of the albite-diorite with interfilling of secondary albite. Viewed between crossed nicols. Of the three old feldspars shown in the photograph two may be readily distinguished by their clouded centers, while the third is the banded individual nearly in position of extinction. In this case the original groundmass has been entirely replaced by albite; the phenocrysts have also been strongly attacked and some of them have evidently disappeared. The clear rim of the individuals with clouded centers is albite, which is probably secondary. Pyrite and calcite are both associated with the albite. No distinct veinlets are present in any part of the thin section. Magnification 16 diameters.

A



B

PHOTOMICROGRAPHS OF TREADWELL ORES.

I. Apparently fresh rock from 110-foot level, Treadwell mine. (No. 95 of Becker.[a]) A thin section of this rock shows an aggregate of irregularly banded feldspar phenocrysts, mostly plagioclase, set in a granular matrix composed of smaller feldspar crystals. With the striated feldspars there are some unstriated grains, which are probably albite or possibly orthoclase. The larger crystals are usually clouded by decomposition products, while the interstitial material is always clear. Embedded in the latter are a few small cubes of pyrite, and some calcite is present. The interstitial feldspar, which is always albite, is evidently secondary and was formed at the same time as the calcite and pyrite.

II. Specimen No. T 5, Treadwell mine. The main constituent is albite-oligoclase, considerably clouded by decomposition products. Microperthite occurs in considerable amounts as an interstitial filling between the phenocrysts of striated feldspar. Hornblende, though present, is mostly not original, but the shape of the areas filled by secondary minerals is characteristic for hornblende. Considerable epidote, evidently derived from the hornblende, is present. There is only a small amount of secondary albite, but calcite is present and pyrite occurs with it. The specimen contains both rutile and titanite.

III. Specimen No. 425, Treadwell mine. The main constituent of this rock is albite-oligoclase, clouded by decomposition products. A considerable amount of hornblende is present, part of it secondary and part of it as evidently representing original phenocrysts. Interstitial microperthite occurs in small amounts. There is practically no secondary albite, but the partial decomposition of the hornblende has resulted in the formation of epidote. Calcite and pyrite are present.

From these analyses the mineralogical composition of the rocks has been estimated, with the result shown in the table below:

Mineralogical composition of albite-diorite from Treadwell mines.

	I.	II.	III.
Quartz	2.34	0.84	7.18
Orthoclase	.00	20.57	2.61
Albite	84.36	47.68	74.41
Anorthite	1.11	5.36	3.89
Hornblende	....	9.16	.86
Epidote	....	7.22	.94
Zoisite	.91	....	....
Muscovite	3.03	3.03	3.83
Calcite	3.80	1.20	2.70
Magnesite	.11	.58	.38
Siderite	.57	....	.58
Titanite	....	1.97	....
Apatite	.13	.55	.13
Zircon	....	....	.07
Rutile	.13	....	.17
Sulphates [a]	....	....	.17
Pyrite	2.10	.96	.97
	98.59	99.12	[b] 98.89

[a] SO_3 assigned to barium and strontium.
[b] Pyrrhotite, trace.

The minerals given in each case are those determinable in the respective rocks as seen in thin section under the microscope, except that it has been assumed that the calcite carries a certain proportion of other carbonates than that of lime.

The composition of muscovite (sericite) employed is that represented by the formula $2H_2O,K_2O,3Al_2O_3,6SiO_2$. In order to balance the alumina it was found necessary to assume different formulas for the hornblende in the two rocks which contain this mineral. In No. II hornblende is given the formula $CaO,3(MgFe)O,4SiO_2$, with the ratio $Mg:Fe=3:2$; and in epidote the ratio $Al:Fe=3:2$ is employed. In No. III hornblende is given the formula of syntagmite — $3(Na_2CaMgFe)O,(AlFe)_2O_3,3SiO_2$, in which $(CaO+Na_2O):(MgO+FeO)=3:4$; and in epidote the ratio $Al:Fe=4:1$ is used.

[a] Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, p. 39.

In the vicinity of the mines dikes of albite-diorite occur in the black slates and are distributed throughout a zone about 3,000 feet in width and extending along the strike for a distance of 3 miles. Thus far only bodies near the hanging wall of this zone have been mined, though several others are strongly mineralized. The dimensions of the different dikes are extremely variable, the larger ones having a maximum observed width of over 200 feet in surface exposure and in the mine workings. The sizes vary from this down to the width of one's hand. Toward the ends of the intrusive area only small dikes occur, as may be observed along the bed of Bullion Creek. The sketch map (Pl. XX) indicates the general distribution of observed dikes. Undoubtedly a still larger number, principally of small dikes, are hidden by gravel beds and by the deep mat of decaying vegetation which covers much of the ground. In many cases, and this is particularly to be noted in the dikes which have been mined, the individual intrusions are made up of a series of lenses formed by alternate bulging and pinching of the intrusive mass. In places the structure of the slate follows these irregularities, while elsewhere there is local crosscutting. Pinching and swelling of the diorite is shown in both vertical and horizontal cross sections of the dikes, though in general it is to be noted that the variations are more frequent and the changes take place within shorter distances on the dip than on the strike. These features are illustrated by the plans and cross sections of the ore bodies (Pl. XXIV), which, with the addition of a few details, have been selected from the working maps and stope sections of the different mines.

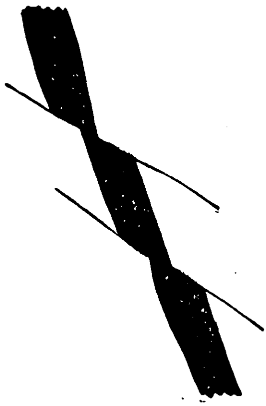


FIG. 28.—Ideal sketch showing manner in which faults of low dip may displace an inclined dike to give appearance of alternate swelling and pinching.

The greater frequency of the variations on the dip, which has been mentioned, may be due to faulting, for in the west end of the "Glory Hole" at the Treadwell mine, and in one or two other cases underground where observations have been less readily made, the ore bodies are offset by movement along surfaces which strike nearly parallel to the veins, but dip at a lower angle. A series of such faults would produce the effect of alternate swelling and pinching (fig. 28).

Outside of the ground which has been worked the details of the various diorite masses are unknown, but their general distribution is shown upon the geologic map of the vicinity, and the generalized cross section through the workings of the Treadwell mine indicates the relative number and size of the dikes which outcrop (Pl. XX and fig. 25). Considerable work was done several years ago in prospecting adjacent bodies of diorite, many of which are as thoroughly impregnated with pyrite as the developed ore bodies. So far as known the gold values are mostly very low, and while mines may yet be discovered, explorations have not thus far resulted in important discoveries.

The occurrence of the sulphide-bearing diorite which forms the Treadwell ore deposit has been described by Dr. G. M. Dawson, who visited the mine in 1889. This geologist states his impression that the deposit represents the upper portion or "feather edge" of a granitic intrusion, probably contemporaneous and connected with the granites of the neighboring Coast Range. The structural relations presented by this view are entirely in accord with present observations, for, while the rock can not be strictly classed as granite, neither can a large part of the rocks which form the core of the Coast Range be so classed, since their composition is usually dioritic. The diorite of the Douglas Island mines doubtless belongs to the Coast Range period of intrusion, and if the small dikes of basalt which are found from place to place throughout the region be excepted, it is the youngest of the bed-rock formations in the vicinity. At the time of its intrusion the rocks which now appear at the surface occupied a position deep within the shell of the earth (lithosphere), and while many masses of the Coast Range diorite were forced through to the surface, it is doubtful whether any of these particular dikes ever extended as far as the surface which then existed. Taken together, they represent intrusive material which was arrested en route, while larger masses of related rocks in the region are regarded as the once deep-seated portions of intrusions which probably had actual surface exit. In the underground workings the blind endings of certain of the dikes show that some of them do not extend even to the present surface. How much farther the larger ones may have penetrated the slates now removed by erosion can not be estimated.

Basalt dikes.—In several places in the mine workings basalt dikes, which cut all the other rocks, have been encountered. They are narrow, usually from a few inches up to 3 feet in width and have sharply defined walls. Locally the dikes occur in pairs, and in several places are seen to divide, particularly when they occur in zones of sheeted rock. The fissures in which they occur are transverse to the strike of the rocks and trend from N. 10° W. to about north and south true meridian, with a rather steep dip toward the west. As a rule, they are not mineralized to any important extent, though a small amount of pyrite sometimes appears and occasionally they contain a considerable amount of this mineral. In several places veinlets of calcite occur along the selvage, but these are readily determinable as of later origin than the greater part of the quartz and calcite which form a reticulation throughout the mass of the ore material.

General description of the ores.—The occurrence of the albite-diorite dikes which constitute the Treadwell ore bodies has already been described. The ore is of the class which has been called mixed ore in the general part of this report. It consists mainly of rock impregnated with sulphides, principally pyrite, and in part shattered and filled by reticulating veins of calcite and quartz, which also carry sulphides. The ore-bearing dikes are considerably mineralized throughout, and often the whole mass can be mined. Locally, however, the values are too low to pay for extraction, and portions of the rock must be left.

Three sorts of ore are recognized by the miners—"quartz," "brown ore," and "mixed ore." The so-called quartz ore, which constitutes the bulk of the workable material, is essentially altered and mineralized diorite cut by a network of small veins of quartz and calcite. As a rule its color is white or light gray, but in many places it has a greenish cast. The brown ore is derived from a comparatively small amount of productive mineralization occurring in the walls or in the narrow horses of slate, where the presence of gold-bearing sulphides is commonly recognized by a brown color, which leads to the designation of this ore. The brown material grades into the ordinary black slate, and its color is apparently due to decarbonization of the carbonaceous rock by percolating sulphide solutions. Impregnation of the slate is by no means always present, and where it occurs it seldom extends for more than 2 or 3 feet from the walls of the main ore mass. The mixed ore, which is more abundant than the brown, is composed of slate intricately intruded by small dikes of very fine-grained diorite, the whole being impregnated with sulphides in the same way as the ordinary ore.

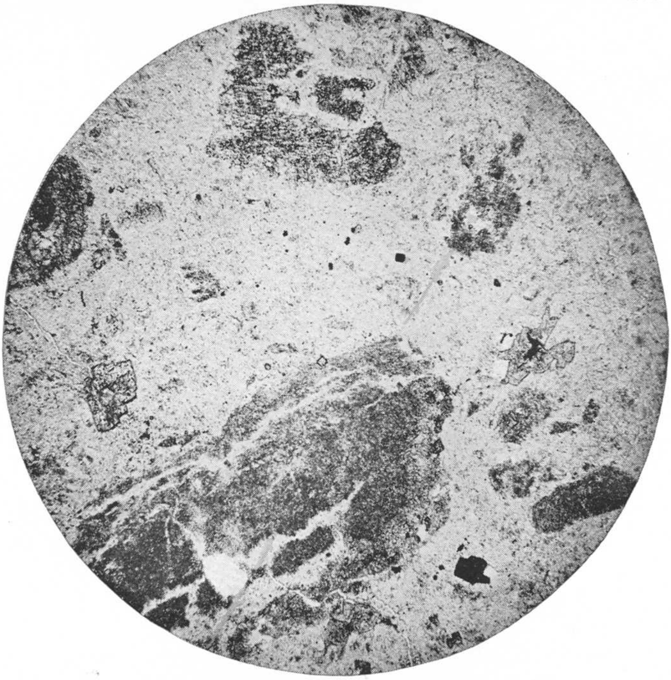
The value of the material mined varies from, say, $1 to $5 and even $10 or more per ton, though in the course of development a great deal of less valuable rock is extracted, and in working the open pits large amounts of worthless slate must be moved, much of which goes with the ore to the stamps. In general the average value of the rock has been a few cents over $2 for the past two or three years. From 60 to 75 per cent of the gold is free milling, and the concentrates, which the mill records show to be about 2 per cent of the material treated, assay from $30 to $50 per ton.

Shape of the ore bodies.—The impregnation of the dikes in which the ore occurs is, for the most part, so general and the presence of at least small amounts of gold is so constant that it is impossible to recognize any well-defined masses which may properly be distinguished as ore shoots. Though the values are by no means uniformly distributed, from the assay plan they do not appear to occur in any regular way, and indeed the distinction between ore and rock too lean to pay for extraction is often the matter of only a few cents. The actual differences in gold tenor of several contiguous samples taken from the ore are usually much greater than the difference between the average of any considerable block of ore and the contents of intervening masses of poor rock. In several places mere joints or seams

PLATE XXIX.

A. Another part of the thin section illustrated in Pl. XXVIII, *B*. Viewed by ordinary light. This photograph brings out the greater transparency of the secondary albite by comparison with the clouded phenocrysts. A crystal of calcite containing an aggregate of rutile needles is marked *r*. Magnification 16 diameters.

B. Same as *A*. Viewed between crossed nicols. The transparent groundmass is resolved into a granular aggregate of albite accompanied by calcite, pyrite, and rutile. Here the albite replaces the original groundmass, but the phenocrysts have been only slightly attacked. Magnification 16 diameters.



A

B

PHOTOMICROGRAPHS OF TREADWELL ORES.

may be noted separating the ore and the poor material, and it frequently happens that blocks of the latter, which show assays from a trace up to $1, are entirely surrounded by ore averaging $2 or more. Structural limitations, such as joints, however, are difficult of observation, because the sides of the drifts are everywhere covered with dust.

The plans and cross sections given in Pl. XXIV represent the shape of the ore dikes and their variations in form from place to place. These diagrams are taken from the working maps and stope sections compiled by the engineers of the company. The sections are numbered to correspond with the lines 100 feet apart on the general map of the mine workings given in Pl. XXI.

In general the best ore is that which contains the greatest number of quartz and calcite veinlets, and though their absence is not an infallible indication of valueless material, it seems that the irregular distribution of the gold has resulted mainly from original differences in the amount of crushing and the consequent varying permeability of the rock. Where there is no metasomatic replacement of the diorite by secondary albite, the sulphides usually replace such minerals as hornblende or mica, and it is suspected that in these cases the gold content is ordinarily low.

In planning the position of stopes the assay charts often enable the location of pillars in relatively poor material, but as a rule the low-grade rock is not found to persist for the whole distance between two mine levels. The largest masses, which have been left because of their leanness, are on the foot-wall side of the south dike in the Treadwell workings, but even here there are great variations in the gold tenor at different places. On the 110-foot level all the rock was minable; on the 220-foot level from 10 to 40 feet of low-grade stuff was left on the floor, excepting for a distance of about 150 feet. On the 330-foot level good values were found up to the slate, excepting for 200 feet along the west end, where 20 feet or so were left; while on the 440-foot level not over half the rock gave assays over $1. The relative position of the high-grade and low-grade material in this part of the mine is shown in the plan of the 440-foot level and in section 16 (Pl. XXIV).

Veining in the ore bodies.—In almost all parts of the Treadwell deposit reticulating veinlets of calcite and quartz are prominent features of the mineralized dikes (Pl. XXV). Aside from the small amount of sulphides which they contain the veinlets are often composed entirely of calcite, but this mineral is usually accompanied by quartz, though the latter seldom if ever occurs by itself. Albite has been noted only in fillings which are less than an inch in width, though there is every reason to believe that careful search would reveal it in small amounts in many of the larger stringers. The veinlets rarely measure more than a few inches across, while many of them are much narrower. The microscope shows the presence of minute fracturing between the veins visible to the unaided eye. The veins are usually closely spaced, and an estimate based on a study of all the mine workings indicates that infiltrated materials make up nearly one-fifth of the mass of the ore.

The boundaries of the veinlets against the inclosing rock are sometimes distinct, but in many cases there is an apparent gradation from the vein matter into the wall rock. In small specimens it is often difficult to distinguish the vein stuff from the rock when the amount of introduced minerals is large in proportion to the mass of the matrix, though in large fragments or on the stope faces the general extent of the different portions of the ore material is exhibited. The microscope shows that the merging of the veinlets with the rock cut by them is due either to penetration of the latter by calcite which is intercrystallized with secondary albite formed at the expense of the original feldspar, or, in the case of some of the smaller veins, to the fact that albite formed in the vein or along the side of the fractures is intergrown with the feldspar of the rock, making a closely welded boundary.

In the minute veinlets quartz seldom occurs, the filling being albite with some calcite, pyrite, and occasional rutile. Under the microscope these narrow fillings, which may be traced across several mineral grains, have the same finely granular appearance as the mosaic of the same minerals which occurs between the clouded phenocrysts of the rock as a replacement of microperthite. (See Pl. XXX, *B*.) Where it fills narrow cracks the appearance of the albite mosaic and the manner in which it comes in contact with the walls suggest that it may have been formed by granulation of the original feldspar. To what extent this suggestion may apply can not be determined, but it is to be noted that the calcite and pyrite of the mineralized rock never penetrate the clouded feldspars, but are always confined to these mosaics except in portions of the ore where hornblende has been replaced by sulphide. The presence of calcite and pyrite shows that there has been an introduction of material during the formation of the ore, so it may be that part of the feldspar substance was found ready at hand, while another part of it has been contributed by the mineralizing waters.

Veinlets traverse the rock in different directions, but the greater part of the filling occurs in fissures constituting two well-marked systems. One set of fractures strikes and dips approximately with the structure of the inclosing slates; the other, which is the more prominent, strikes slightly oblique to the structure of the country rocks and dips in the opposite direction—that is, toward the southwest. The fractures in the diorite have been so completely healed by the combined replacement of the rock minerals and by the deposition of vein stuff that in blasting the ore breaks like a massive rock.[a] The nature of the veining is well shown in the photograph of a specimen of ore which is reproduced in Pl. XXV, and also in Pls. XXVII, *D*, and XXVIII.

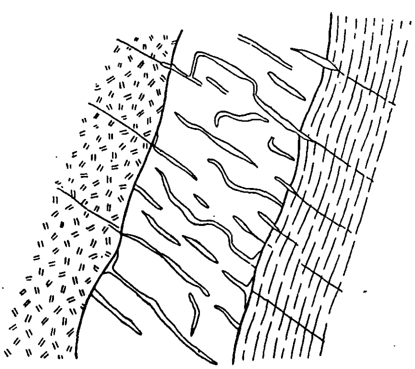


FIG. 29.—Dike of albite-diorite in open cut of Ready Bullion mine. This dike, about 3 feet wide, is cut by veinlets of calcite and quartz, which fill transverse fractures. The breaks extend into both walls, but the filling never extends far beyond the dike itself.

In places where the mineralized dikes are narrow, the set of fissures parallel to the country structure usually diminishes in importance, and often only the cross fractures have been developed. This may be explained on the supposition that the tendency to motion parallel to the walls of the intrusions was taken up outside of the massive rock in the slates, while the transverse strain affected both the slate and the intrusive rock, the latter being specially susceptible to cross fracture because of its small mass and brittle nature. Cross fractures, filled with vein stuff and limited to a narrow dike in the slates, may be seen to good advantage at the east end of the Ready Bullion pit, near the southernmost outcrop of the diorite (fig. 29). Throughout the mines it is the rule that all transverse gash veins stop at the walls of the diorite, and while there are a few exceptions the quartz seldom penetrates the country rock to any great distance, and when it does it diminishes rapidly in thickness. However, this is not always due to the noncontinuance of the fissures, for they may be frequently observed continuing from the diorite into the slate in the form of well-marked joints.

Occasionally veins or lenticular masses of quartz are found which measure a foot or two or rarely more in width, but these are by no means common in the diorite dikes. In the upper workings of the Ready Bullion mine, however, there was a large body of quartz which is described by Palache as a well-defined vein 40 feet in width.[b]

In a few places where the edges of the ore dikes have been revealed strong veins of quartz are found running out between the walls of the slate to form extensions of the ordinary mixed ore. Values in these veins are said to exceed the average tenor of the ore, but none of them have been mined because of their relatively small size.

A feature of the Mexican mine mentioned by Becker,[c] who visited the property during the early stages of its development, is the occurrence of ore in the form of stringer leads in

[a] Kinzie, Trans. Am. Inst. Min. Eng. vol. 34, p. 16.
[b] Harriman Alaska Expedition, vol. 4, 1904, p. 61.
[c] Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, p. 70.

the foot-wall slates next to the ore dike, but this feature was not observed in the workings which were open at the time of our visit.

Gangue minerals.—Feldspar, calcite, and quartz are the three important nonmetallic minerals of the Treadwell ores. Part of the original feldspar of the intrusive diorite remains in the ore and with a considerable amount of secondary feldspar forms the principal gangue mineral. Other minerals of the unaltered rock were hornblende and mica, but these are now present in relatively small amounts, as is also epidote, which has been formed as a product of alteration from them. Calcite and quartz occur in veinlets penetrating the diorite and make up perhaps one-fifth of the material which is mined. Calcite is also found disseminated irregularly in the more altered parts of the diorite, unaccompanied by quartz. When sulphides and calcite are both present, they are almost invariably in contact with each other, but the secondary feldspar also carries a great deal of pyrite.

Ferruginous calcite occurs commonly in the superficial workings, where some of it may have been formed by the action of iron-bearing solutions upon the primary calcite of the deposit. It occurs also in deeper parts of the mines, where it is evidently a primary mineral of the ore. A small amount of pink carbonate, probably a mixture of calcite and rhodochrosite, was observed in the open pits of the Ready Bullion.

Rutile occurs in aggregates of minute crystals, and though seldom visible to the naked eye the microscope shows that it is widely distributed in various parts of the mines. As a rule it occurs embedded in calcite, but it is sometimes found in the secondary albite and has been noted in the quartz fillings.

Metallic minerals.—As shown by the mill records, the metallic minerals or "sulphides" constitute about 2 per cent of the Treadwell ores. They consist mainly of iron pyrites, but considerable amounts of pyrrhotite and magnetite are also present.

Pyrite occurs both in the rock and in the veinlets, but the position of the sulphides has no apparent influence on the gold content. In the rock it invariably has the form of minute cubes, from a size scarcely visible to the unaided eye up to about 1 mm., rarely larger. It is distributed sparsely through the diorite accompanying the secondary minerals, especially the albite and calcite, though where these are not present it is associated with epidote and uralitic hornblende. In the reticulating veinlets the pyrite occurs either as separate cubes, often several millimeters across, or in bunchy aggregates, forming "turkey-egg rock," which usually contains more than average values.

Magnetite occurs only in the form of minute grains outside the veinlets. Part of it appears to have been an original constituent of the diorite, but much of it was deposited secondarily along with the pyrite, perfect cubes of which it sometimes surrounds.

Pyrrhotite often accompanies or takes the place of the pyrite and may be readily isolated from the concentrates by means of a magnet. Chalcopyrite, galena, and sphalerite occur sporadically, and native arsenic, realgar, and orpiment have been noted in small quantities. Assays are said to indicate the arsenical nature of much of the pyrite, though the presence of true arsenopyrite has not been recognized. Molybdenite is frequently noted, though it is irregularly distributed.

Occurrence of gold.—Visible gold sometimes occurs in veins of coarsely crystalline calcite inclosed in the ore bodies and has been observed associated with pyrite and scales of graphite.[a] This mode of occurrence is, however, not usual, and in general even the microscope does not reveal the form in which the precious metal exists. I have not been able to distinguish gold in the thin sections studied under the microscope, but Prof. F. D. Adams, who examined the material collected by Dawson in 1887, observed gold mechanically inclosed in crystals of pyrite.[b] It is evident that a considerable amount of gold must be in the metallic condition, because a large proportion is saved by amalgamation, the amount sometimes being as high as 75 per cent of the total assay value.

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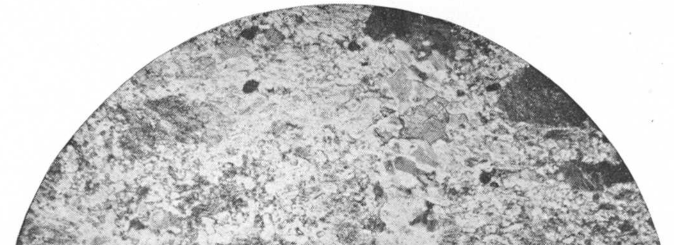
[a] Palache, Harriman Alaska Expedition, vol. 4, 1904, p. 63.
[b] Am. Geologist, vol. 4, 1889, p. 92.

PLATE XXX.

A. Crushed albite-diorite cut by reticulating veinlets composed mainly of albite, but containing a little calcite and pyrite. Ordinary light. Magnification 8 diameters. (Compare with Pl. XXVII, *D*.)

B. Crushed albite-diorite cut by reticulating veinlets of albite and calcite, viewed between crossed nicols. The darker areas between the veinlets are the decomposed feldspars of the original rock. Magnification 16 diameters. Same thin section as Pls. XXVII, *D*, and XXX, *A*.

A



B

PHOTOMICROGRAPHS OF TREADWELL ORES.

The gold is perhaps mainly associated with pyrite, but rather coarse crushing is the present mill practice,[a] and so much of the pyrite passes the screens in comparatively large grains or unbroken crystals that it seems open to doubt whether from 60 to 75 per cent of the gold could be free milling if it were all associated with the iron sulphide. The nonamalgamating portion undoubtedly does occur with the pyrite, because the concentrates contain only pyrite and magnetite, with a small amount of pyrrhotite. The portion which amalgamates readily probably occurs largely in the gangue minerals. Molybdenite can hardly be an important carrier of gold, because it seems to be somewhat limited in distribution, although its presence in visible quantities is said to indicate high values.

As a rule the values vary with the amount of vein filling, but the position of the pyrite in the rock or in the quartz and calcite seems to have no influence upon the amount of gold. In some places, where the ore is of average grade, all the metallic minerals seem to be in the rock, and careful search is necessary for the discovery of any sulphide in the quartz or calcite. Elsewhere the sulphides may be almost entirely confined to the veinlets. A limited amount of material is mined which contains practically no stringers of quartz or calcite, the sulphide being disseminated through the mass of the rock—for instance, in the crosscut on the 440-foot level and in stope No. 1 of the 330-foot level in the Treadwell mine. In other places material of similar appearance, containing an equal amount of pyrite, yields only a very small amount of gold.

Metasomatic alteration.—As already stated, the Treadwell ore bodies are dikes of albite-diorite, fractured and filled with reticulating veinlets of sulphide-bearing quartz and calcite and permeated with metallic sulphides, the whole carrying small amounts of gold.

From the structure of the ore it is evident that the dikes were subjected to pressure which caused fracturing, whereby they became porous, affording channels of easy circulation for underground waters. The minerals in the ores and their mutual relations suggest that carbonated, mineral-bearing solutions, probably in a heated condition, found the broken dikes and continued to move through them for a very long period. In transit these waters attacked the minerals of the albite-diorite, decomposing them and in some cases effecting more or less complete metasomatic replacement. As a rule, where the rock contained hornblende and mica these original minerals have entirely disappeared, their places being taken by aggregates of secondary minerals, including epidote, chlorite, calcite, sometimes pyrite or pyrrhotite, and more rarely magnetite. Ferromagnesian minerals seem, however, to have been absent from the greater part of the rock, and the nature of the ordinary alteration is of a different sort.

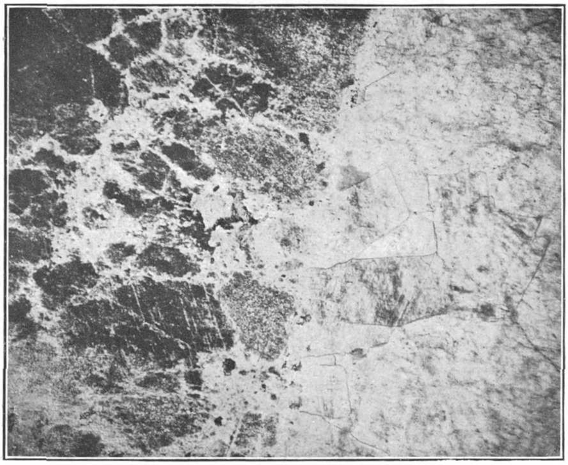
Though the rock is usually badly decomposed a few specimens of relatively unaltered material indicate that the original rock characteristically contained two sorts of feldspar—namely, albite-oligoclase and microperthite. The first occurs in phenocrysts of fairly definite form, often showing concentric structure and always clouded by decomposition products, except that they frequently have narrow rims of clear material which are probably secondary. The microperthite, which has the characteristic mottled appearance of this minute intercrystallization of albite and orthoclase, is entirely interstitial as regards the albite-oligoclase. It is nearly free from decomposition inclusions and is ordinarily accompanied by some clear albite (Pl. XXV). The metasomatic replacement of this interstitial microperthite by albite is the most striking feature presented by the alteration of the rock. In most of the specimens studied under the microscope the substitution has been complete, and the interstitial mosaic of albite seems to be an integral part of the rock (Pls. XXVI to XXXI). In a few specimens, however, the process of replacement has been only partially completed, and the comparison of all the material available leaves little doubt of the fact that metasomatism has actually taken place. In some cases the replacement has gone so far that the crystals of albite-oligoclase have been attacked, as shown by their corroded contacts with the albite mosaics (Pl. XXVIII, *B*). Another conclusive evidence that the albite is of secondary origin is the fact that the mosaics contain calcite and pyrite and some-

[a] Slot screens equivalent to 18 and 20 mesh wire screens are used.

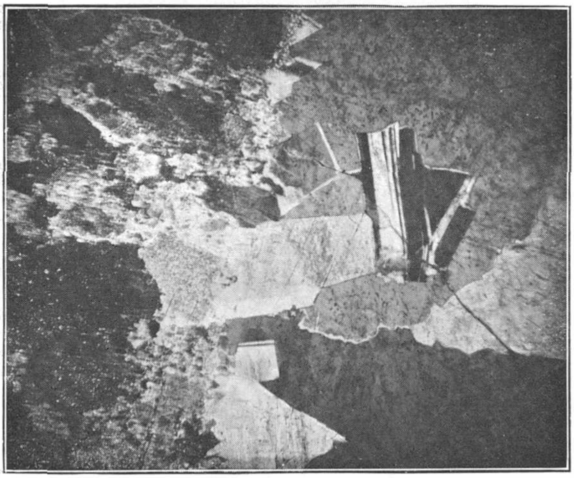
PLATE XXXI.

A. Edge of narrow vein composed of quartz and albite, viewed in ordinary light. The vein on the right is more transparent than the clouded feldspar of the wall rock. The latter, however, is penetrated by seams of secondary albite, which show white in the photograph. Magnification 10 diameters.

B. Same as *A*, viewed between crossed nicols. Several crystals of albite are shown, most of them being attached to secondary albite developed about the old phenocrysts in the wall rock. The oblong crystal in nearly horizontal position near the center of photograph lies partly in the vein and partly in the wall. The clear portion is pure albite, evidently deposited by the vein-forming waters; the portion on the left which is clouded by decomposition products is a fragment of one of the original phenocrysts of the rock, and it has determined the orientation of the secondary growth. The old fragment has an extinction corresponding to the composition $Ab_9 An_1$, but regarding the separate products of decomposition as sericite and zoisite it is probable that the original mineral contained somewhat more lime. Magnification 10 diameters.



A



B

PHOTOMICROGRAPHS OF TREADWELL ORES.

times rutile, all of these minerals being intercrystallized and evidently contemporaneous. Furthermore, albite sometimes occurs in small veinlets in which the principal filling is quartz.

In a preliminary description of the geology of the Treadwell deposit [a] the belief was expressed that the secondary albite had formed almost entirely out of the elements present in the original rock, for the reason that this mineral is not ordinarily found in any veinlets except those of very small size. The opposite view now held takes into consideration the very common occurrence of albite as an actual vein filling at other places on Douglas Island and at several points along the mainland shore of Gastineau Channel. In these veins it is accompanied by metallic sulphides, together with rutile, quartz, carbonates of lime, magnesia, and iron, all of which are characteristic minerals of the Treadwell ores. Since these facts have been recognized, albite has been discovered in a veinlet less than an inch in width which forms part of a fragment of ore from the Ready Bullion mine. A thin section of this narrow vein shows quartz as the most abundant mineral occupying the central portion, while albite, accompanied by some calcite, occurs on the walls. A portion of the albite in the vein is separated from the feldspar in the rock by an extremely narrow mosaic of minute albite grains, but some of the crystals are knit to the old feldspars and are crystallographically continuous with them, as shown by the parallelism of cleavage cracks on the two sides of the boundary. The old and new portions of crystals which exhibit this secondary growth, brought about by the deposition of feldspar material from the vein waters, may be readily distinguished under the microscope by the presence of decomposition products in the former and their absence from the latter. Under crossed nicols the old and new portions of the mineral grains become equally illuminated in certain positions, but there is a slight difference in the angle of extinction. In one case where a crystal can be oriented with a fair degree of accuracy the clear feldspar of the vein gives an extinction angle corresponding with that of pure albite, while the extinction of the old mineral is that corresponding with the composition Ab_9An_1. This composite crystal, lying partly within the rock and partly within the vein, is illustrated in Pl. XXXI.

It is commonly observed that where both calcite and quartz are present in the filled fractures, the former usually occurs next to the walls and it always permeates the rock to a greater or less extent, recalling the relations described by Lindgren in his papers on the gold-silver veins of Ophir and of Grass Valley and Nevada City, Cal.[b] Doctor Becker suggests in this connection that the process of selection by the diorite of certain substances from the vein-forming waters would be equivalent to osmotic separation, and that a tendency to such a separation seems almost inevitable when solutions are in contact with dense rocks.[c]

The alteration of the Treadwell diorite is regarded as having accompanied the formation of the veinlets which intersect the rock, and the metasomatic action is attributed to the same solutions as those which deposited the quartz and calcite in the vein fillings. Both quartz and calcite appear to have been almost entirely introduced by the circulating waters, while the secondary albite, though probably formed mainly from added materials, has also been formed by the rearrangement of materials contained in the original minerals of the diorite.

According to Lindgren [d] alteration of the sort which has been described has not been previously recorded, for though albite occurs as a vein mineral in California, Australia, the Alps, and probably many other places, it has not been detected among the metasomatic minerals of the wall rocks in any veins which have been carefully studied by geologists. In this connection, however, reference should be made to pseudomorphs of albite after adularia (orthoclase) from St. Gotthard. These are described by Bischof,[e] who gives an extended discussion of the probable chemical reactions involved and suggests the competence of waters

[a] Trans. Am. Inst. Min. Eng., October, 1904, p. 33.

[b] Fourteenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1894, pp. 274-278; Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1896, pp. 146-152.

[c] Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, p. 68; Mineral Resources U. S. for 1892, U. S. Geol. Survey, 1893, p. 159.

[d] Metasomatic processes in fissure veins: Special volume on Genesis of Ore Deposits, 2d ed., Am. Inst. Min. Eng., 1901, pp. 520, 533.

[e] Chemical Geology, English edition, vol. 2, 1855, pp. 170-171.

containing sodium chloride to effect the observed replacement of potash feldspar by soda feldspar.

As a result of his careful estimation of the alteration which has taken place in the wall rocks of the California veins, Lindgren has found that soda has been extracted and potash has been added during the process of metasomatism caused by the action of the vein-forming waters.[a]

In the present case the result of alteration has been quite different. A study of the mineralized rock under the microscope shows very clearly that albite has been formed in the rock at the expense of the original potash-bearing feldspar, and reasons have been given for believing that part of the soda contained in the secondary albite has been introduced by the waters which likewise deposited the calcite quartz and metallic sulphides. It is to be supposed also that potash has been carried away, since the microscope shows no orthoclase in the ore material and the chemical analyses of the latter give only small amounts of K_2O. The nature of the replacement which has been worked out suggests that specimen No. 95 of Doctor Becker's collection[b] does not represent the fresh albite-diorite, since it contains more than 2 per cent of pyrite and a considerable amount of albite mosaic, which is probably secondary. If it is regarded as a completely altered form of the rock, comparison of its analysis with that of specimen No. 425, which is only partially changed and contains less pyrite and less calcite, shows not quite half as much as K_2O. Another specimen of ore in which the calcite amounts to 8.7 per cent showed 21 per cent of K_2O and 7.83 per cent of Na_2O and here the potash is only one-third as much as in No. 425.

Quantitatively these estimations are of little value, since it has not been possible to determine the average composition of the original rock for comparison with that of the ore material, but the direction of the change is definitely indicated and the estimations correspond with the facts indicated by microscopic study. The wide difference in the amounts of potash and soda in the two examples of relatively unaltered rock suggests considerable variation in the original rock from place to place, an inference which is likewise to be drawn from the presence of ferromagnesian minerals in some of the dikes and their absence from others.

Rôle of the basalt dikes.—In his discussion of the genesis of the Treadwell-Mexican ores, Doctor Becker leaves some doubt as to the importance which he desired to assign to the basalt dikes as mineralizers. He first says that the genesis of the ores is probably connected with the dikes, but afterwards suggests the relative unimportance of their influence.[c]

In the Treadwell and Seven Hundred Foot mines two narrow dikes of the basalt are observed in a zone of sheeting, which is undoubtedly later than most of the veinlets in the ore mass (fig. 10). A small amount of calcite is found along their selvages, but they contain little or no pyrite. Upon the west or hanging-wall side the ore is somewhat richer than it is between and beneath them, but it seems that this variation in gold tenor can not be attributed to the dikes as mineralizers, because the rock between them is not enriched, as might be expected had they been an actual source of gold. It seems likely that a rearrangement of values by relatively recent circulation has been going on, and the course of the currents may well have been controlled by the zone of sheeting in which the dikes occur; but secondary migration of this sort must be distinguished from the original mineralization, the extensive results of which in the neighborhood are entirely beyond comparison with the effects directly or indirectly attributable to a pair of narrow dikes of this sort. It is now believed that they have no connection with the formation of the ore.

Other basaltic dikes occurring on Gold Creek are regarded as practically of the same age as those on Douglas Island, and these are also unmistakably younger than the gold-bearing quartz veins of that neighborhood.

Origin of the fractures.—The complex fracturing of the Treadwell dikes, by reason of which they became favorable channels for the passage of vein-forming and mineralizing waters, is to be attributed to some important movement in the earth's crust. All the rocks through-

[a] Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1896, p. 148.
[b] See table of analyses on p. 101.
[c] Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, p. 69.

out the Juneau belt have been broken and fissured, and a study of the region has led to the general conclusion that nearly all the vein openings belong to one period of deformation, the date of which is to be placed subsequent to the invasion and solidification of the Coast Range diorite, which occurs both on the mainland belt and on the islands of the archipelago.

Outside the Treadwell mines no evidence was found that open fissures or cavities of any sort have been filled with vein stuff at different dates, no instances of early veins crossed by others of later formation having been observed, and in all cases where intersecting fractures were noted it is evident that both were filled contemporaneously, so that they were presumably formed at the same time.

The deformation was so general throughout the region, as shown by the extensive occurrence of vein-filled fractures, that the dikes which now constitute these important ore deposits could hardly have escaped its effect. Though the manner in which the dikes have yielded to the pressures is different from that of common occurrence, this is readily explainable by their distinct physical characteristics in comparison with the general run of formations and by their mode of occurrence with relation to the rocks which they intrude. In the ore bodies themselves it is found that a few veinlets cut across others of earlier formation, a feature which could hardly fail to be developed in a mass so thoroughly broken, but this is the exception and not the rule, and it is strongly believed that all of the secondary filling of these dikes belongs essentially to one period and that the rock has suffered only one important deformation.

Beyond the ore dikes along the strike of the inclosing formations stringer leads and irregular veins, following the structure of the rocks, are found, and the openings which they fill are in every respect similar to those in the same sort of rocks in other parts of the belt.

No facts have been noted which suggest a separate origin for these fractures and the others occurring in the general belt. All of them are therefore regarded as contemporaneous.

The question of the nature and direction of the deforming forces is considered on another page. Here it need only be said that the fractures in the diorite bodies must have been produced by compressive stress which may have been applied either in a direction nearly horizontal, as first suggested by Becker,[a] or in a nearly vertical direction, as thought likely by the present writer.

Nature and source of the depositing waters.—The problem of the nature and source of the vein-forming waters has been considered in the general part of this report (see p. 29). The formation of the Treadwell ores is assigned to the same general cause as the other mineral deposits of southeastern Alaska, namely, to waters of magmatic origin ascending through channels opened by a general fracturing of the rocks.

The deep-seated source of the depositing waters is accepted from the nature of the alterations which they have produced in the now mineralized dikes of the Treadwell mines. The derivation of the waters as emanations from a deep-seated magma is held as the most plausible working hypothesis in the present state of geologic knowledge concerning southeastern Alaska at large, but the merits of this hypothesis must be settled by future studies in the region.

Persistence in depth.[b]—The ore dikes have been developed along the dip for a distance of approximately 1,000 feet in all three of the mines now operated. The Treadwell workings reach about 700 feet below sea level, the Mexican 600 feet, and the Ready Bullion 800 feet.[c] In no case has it been possible to make out any progressive change in the character of the ore as depth was attained. The assay charts show the ore in the lowest levels to be quite as good as in the upper workings, and it is evident that variations along the dip are not greater than those observed from place to place along the strike. It is true that the mine records for a period of years show a gradual decrease in the value per ton of the material which has been treated. This is especially noticeable in the case of the Treadwell mine, which has been the

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[a] Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, p. 67.
[b] Compare the general discussion of permanence in depth on p. 32.
[c] 1903.

longest in operation, but it is the result of increasing the tonnage by mining low-grade rock, rather than an indication that the average value is decreasing with depth.

It seems fair to assume that the ore will continue to at least a considerably greater depth without important change in average value. There is nothing in the character of the ore to indicate any important secondary concentration of values by oxidizing waters near the surface. On the other hand, the characteristics of the deposits are believed to indicate that it was formed in its present condition by the direct action of ascending waters, and that practically no subsequent or secondary concentration has taken place. If this idea is correct there can be little doubt that mineralization and the values will continue to a much greater depth than has been reached, and it may be fairly anticipated that the limit of deep mining will finally depend more upon increased costs attendant upon hoisting and pumping than upon exhaustion of the ore.

SALMON CREEK.

TOPOGRAPHY.

Salmon Creek empties into Gastineau Channel 2½ miles above Juneau (Pl. II). This valley, which is nearly 5 miles in length and 2½ miles across, has the same general features of topography as that of Gold Creek. Its drainage area is, however, somewhat greater. The surrounding ridges average about 3,500 feet in elevation and the mountain peaks rise from 500 to 1,500 feet higher.

The grade of the stream bed is more evenly distributed than in Gold and Sheep creeks, but in the upper end of the valley there is a gravel floor nearly a mile in length which lies between 1,000 and 1,100 feet elevation. This basin resembles that of the Nowell placer in Gold Creek in that it is entirely surrounded by bed rock. It is therefore regarded as another case of glacial erosion. Below it there is a cascade somewhat over 100 feet in height.

GEOLOGY.

Salmon Creek cuts through the same formations as Gold Creek. The headwaters extend across the schist band nearly to the main mass of the diorite. The black-slate band is nearly a mile in width, its outer edge lying about 2 miles from tide water, while the greenstone series, which characterizes the inland shore of Gastineau Channel, occupies the lower part of the valley. The strata strike about N. 40° W. and dip upstream about 30°.

The geology of this valley has not been examined with as much detail as has that of the two creeks lying immediately to the southeast, so that it has been impossible to represent the distribution of several dikes of dark diorite which are known to be present.

ABANDONED PLACERS.

At several places along the lower end of Salmon Creek abandoned workings give evidence of former attempts to find gold-bearing gravel. These operations, however, can not have been extensive, and it seems doubtful that they could have been remunerative in any important degree.

The large bed of gravel in the upper valley has not been prospected, so far as could be ascertained.

EXTENSION OF THE MAIN LODE SYSTEM.

The band of black slate which carries the gold-bearing lodes in Gold Creek extends from Mount Juneau diagonally down the steep slope to the easterly fork of Salmon Creek, crossing the main stream above the forks and continuing in the ridge which separates this drainage basin from that of Lemon Creek. The walls of the valley are covered with timber and shrubbery up to 2,500 feet, and consequently the slates are nowhere clearly exposed. For this reason the amount of quartz veining which they contain is not readily observed, but in the upper slopes next to Mount Juneau outcrops are numerous and here very few veins are present. Considerable pyrite and occasional stringers of quartz are found in the slates themselves, but there is nothing to compare with the amount of veining observed near the Gold Creek mines. Prospecting was begun during the summer of 1903 along the right fork of the creek, where some quartz veins are found, but there seems never to have been any adequate or systematic exploration of this band of slate, which elsewhere carries the main lode system of the region.

WAGNER PROSPECT.

The Wagner property is situated just below a waterfall, where the bed rock is first exposed, at the head of Salmon Creek delta. (See fig. 33.) Openings have been made on both sides of the stream, but the principal workings are on the south side, where a crosscut 70 feet long has been run to the vein, and on the latter there is a drift 110 feet in length.

The vein, varying in width from a mere stringer up to 8 feet, follows along the contact of highly metamorphic sericite slates and a bed of greenstone, which is probably an altered dike of gabbro and not the ordinary volcanic andesite forming the usual rock of the greenstone series. The average strike of the rocks and of the vein is about N. 20° W., and the dip is about 40° NE.

Beneath the vein the slates have been exposed by stripping to a thickness of about 60 feet The greenstone hanging wall has been penetrated by a 60-foot tunnel and is exposed to a much greater thickness in the bed of the creek above the falls. In the tunnel the foot wall, in some places at least, is schistose greenstone, evidently a greatly crushed layer of the gabbro, which forms the hanging wall. The foot wall of the vein, being slate or schist, is smooth or regular, while the upper side next to the more massive greenstone is extremely irregular and the wall rock is gashed by many short stringers running out from the vein.

The gangue minerals of the vein are quartz, calcite or dolomite, and albite, with a small amount of white mica and rutile. The sulphides are mainly arsenopyrite, pyrite, and chalcopyrite, though sphalerite and galena occur in small amounts and there is a little gray copper (tetrahedrite). The presence of albite and rutile allies this vein with the Treadwell deposits and with the veins which have been opened up in the lower part of Gold Creek and on the mainland shore of Gastineau Channel along the same band of slate which is exposed at the mouth of Salmon Creek.

In the present state of development little can be made out regarding the distribution of values in the vein, though from the nature of others in the region it is probable that vein stuff of low grade will be found to occur in shoots, leaving portions of the vein comparatively barren. On the south side of the creek the land is comparatively low, and a drift on the greenstone and slate contact would gain a depth of only 300 feet in a length of 1,200 feet. To the north the strike of the vein carries it into the mountain, so that depth is gained more rapidly in this direction. Should future exploration reveal the presence of workable ore, it is anticipated that a shaft would be one of the first necessities in properly developing the vein. A small hand-power stamp mill has been used in testing ore from this property, and the owners seem pleased with the results obtained.

LEMON CREEK.

TOPOGRAPHY.

Lemon Creek empties on the tidal flat at the head of Gastineau Channel 5 miles northwest of Juneau (Pl. II). Its drainage area is about 30 square miles, and its valley penetrates the Coast Range for a distance of about 8 miles. From the south there are several good-sized tributaries, and the uppermost of these side valleys contains a large glacier, which merges with the ice from the head of the main valley and extends to a point only 6 miles from the mouth of the creek.

The valley is a deep one, the surrounding ridges rising to 3,500 and 4,000 feet, with peaks above 5,000 feet in the headwater region. The stream bed lies north of the central line of the valley, and on this side the tributaries are closely spaced and their channels only slightly incised in the mountain flank.

The grade of the main stream is somewhat irregularly distributed. The mouth of the valley is filled by a delta deposit raised only a few feet above high tide and extending upstream for something over a mile. Above this there is a short rock-cut canyon with a low waterfall or cascade at its head. Next comes a narrow stretch of gravelly bottom land extending upstream for nearly a mile and a half, with a grade of perhaps 200 feet per mile. Then comes a cascade, giving a rise of several hundred feet in a distance of half a mile, and above this the grade is somewhat more gentle, and short gravelly flats occur from place to place, separated by reaches of steeper slope extending to the foot of the glacier.

GEOLOGY.

The continuance of the rock bands of Gold and Salmon creeks into the Lemon Creek drainage is indicated on the geologic maps, though here the boundaries have been less accurately determined than farther south. The average strike of the rock is about N. 40° W., as in Salmon Creek, but the dips are considerably less steep, averaging not more than 20°.

The glacier at the head of the creek lies almost entirely in the Coast Range diorite, the boundary of which against the schist band crosses just above the foot of the ice stream. The belt of schists carrying mica, hornblende, and garnet extends from the glacier down to Mill Creek, where the upper camp of the Lemon Creek Company is situated, thus having a width of 2½ miles. There are occasional dikes of altered gabbro in these schists, many of which are themselves so schistose that their original nature is recognized only with difficulty. Outside of the schist comes the black-slate band 1½ miles wide, in which dikes of the altered diorite are more numerous than in the same slates where they cross Salmon Creek. Just below the placer workings a ledge of greenstone, which forms the waterfall, is probably the uppermost bed of this rock, and the boundary between the black-slate band and the zone of alternating slates and greenstones has been drawn here. The ridges which lead down to salt water on either side of the valley are formed by the greenstones and slates which correspond with those forming the mountains along Gastineau Channel.

OCCURRENCE OF VEINS.

There has been very little prospecting for mineral lodes in the Lemon Creek Valley. At two localities only were veins carrying metallic sulphides observed during the present investigation. On Mill Creek, at an elevation of about 900 feet, is the Clark prospect, where several veins have been discovered. The country is black slate and diorite (altered gabbro), the latter occurring in dikes which locally crosscut the slates. The intrusive rock is very massive in comparison with the slates, and veins occurring in it are more regular than in the flexible slates. However, they were noted in some cases passing from one of these rocks into the other. The country trends about N. 40° W., and dips about 40° NE., while the veins strike N. 60° W. to east and west, dipping in the same direction as the inclosing rock, but rather more steeply.

The vein on which the most work has been done shows solid quartz containing considerable pyrrhotite, the whole vein having a thickness of 3 or 4 feet. It has been exposed for over 200 feet horizontally and to a height of about 100 feet. The only other sulphide noted is chalcopyrite, of which there is but a little. The appearance of the vein stuff is much like that of some of the ore from the Gold Creek mines, but the owners of the property report that no assays have been obtained above $1 in gold.

About one-fourth mile below the foot of the glacier two parallel veins are exposed on the south side of the creek. The inclosing rock is a banded diorite occurring in an outlying dike. In it there are a few small irregular lenses of fine-grained aplite, which trend with the banding of the rock in a northwest-southeast direction. Striking N. 60° E. across the country structure, the two quartz veins occupy well-defined, but somewhat irregular, fissures following a secondary schistose structure in the gneiss. These veins are from 8 inches to a foot wide and they have been followed with occasional interruptions for several hundred feet.

Metallic sulphides—pyrrhotite, galena, sphalerite, and chalcopyrite—are abundant in the quartz, but the size of the veins offers but little encouragement for further prospecting.

In addition to the veins noted others are reported as occurring on the north side of Lemon Creek, above the mouth of Mill Creek. These are said to be quite as unpromising as those which were visited.

Though no steps were taken to determine the value of the placer deposits, the work which has been done by the owners of the property indicates that there must be a considerable amount of gold in the gravels of this stream. The study which was made of the region was not sufficient to show the source of this gold, and possibly future prospecting may yet reveal lode deposits of some importance.

PLACERS.

Abandoned sluice boxes found near an old cabin in the first basin below the glacier are taken as evidence that sluicing has been carried on at this place, and it is reported that gold has been found at different points along the creek.

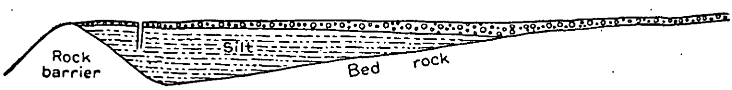


FIG. 30.—Longitudinal section, Lemon Creek placer, showing relations of bed rock, glacial silt, and gravel bed.

In 1902 the Lemon Creek Company, of Pittsburg, prospected a portion of the gravel flat by means of pits and was encouraged to install a small hydraulic plant about 1½ miles above the mouth of this stream. After six weeks preliminary work the installation was found to be inadequate, and operations were suspended until a larger supply of water could be made available by means of a flume from Mill Creek. This flume was partially finished the same year, but no progress has since been made. The company has operated its own sawmill and plenty of good spruce timber is available for all needs.

At the foot of the gravel plain, which extends along the creek for 1½ miles, the valley is very much restricted by two hills which approach from either side. Between these hills

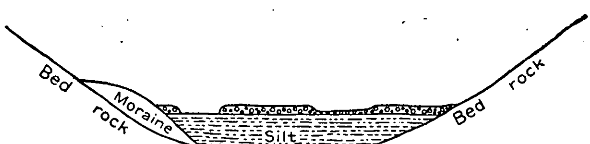


FIG. 31.—Cross section near lower end, Lemon Creek placer, showing relations of bed rock, moraine, silt, and gravel.

the stream flows in a narrow canyon, in which hard greenstone is exposed. This resistant rock forms a barrier above which the soft black slates were scooped out by the glacier which formerly occupied the valley. The basin thus produced was first filled with fine silt deposited by the stream from the glacier. The clay formed by this deposit has been penetrated by a shaft to a depth of 40 feet without striking bed rock, so that the fact of a rock-rimmed basin is fully established. On top of the clay the stream has deposited gravel and a transportation grade has been built up. At different points on both sides of the valley there are banks of sand and small gravel, rising 20 feet or more above the gravel bottom. These are probably morainal material deposited by the glacier, and they are said to contain no gold.

The gravel bed extends from the rock barrier where the lower camp is located to Mill Creek camp, 1½ miles up the valley. Its width varies from 100 to about 500 feet, and its depth, which has been determined only near the lower end, is 8 or 10 feet. The relations of the different material and their positions in the rock basin are illustrated in the accompanying diagrams (figs. 30 and 31).

The gold contents per cubic yard have never been adequately estimated, but the ground was prospected by a series of shallow pits, the material from which is said to have shown values distributed through the gravel. Operation during the period of six weeks developed the presence of the clay bed mentioned above, which forms a very unsatisfactory bottom and when it finds its way into the sluices seriously interferes with the process of washing the gravel. Another difficulty encountered in working the deposit is the slight grade of the false bed rock, which necessitates the installation of an elevator before operations can be continued. If the lower end of the deposit is ever worked in this way, some special means must be devised to prevent erosion of the clay bottom by the action of the elevator. If this difficulty can not be overcome, it will be necessary to abandon the lower end of the deposit and to begin work above the upper end of the clay bed.

The gold of the creek is reported to be mostly fine and flaky, with occasional nuggets of a few dollars' weight. Discussion of the source of the gold is impossible from the few data at hand. No prominent system of lodes has been found in the valley. While there are occa-

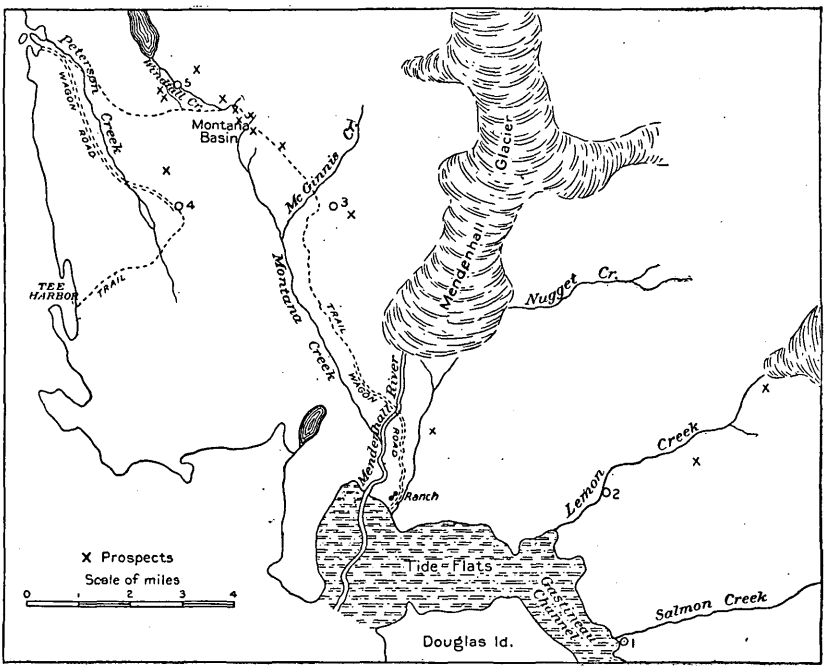


FIG. 32.—Sketch map, Salmon Creek to Windfall Lake.

sional veins, so far as noted these are not numerous, and for the most part they are mere stringers, many of them, at least, containing no important amount of gold. Should the Lemon Creek placer eventually prove a remunerative adventure, further lode prospecting will doubtless follow.

NUGGET CREEK.

The valley of Nugget Creek joins that of Mendenhall River about $1\frac{1}{2}$ miles above the foot of the glacier. (See sketch map, fig. 32.) Its basin, about 3 miles in length, trends east and west, and there are several tributary gulches which head against the Lemon Creek divide. The rocks of the valley belong to the group of schists which lies next to the main diorite, except at the headwaters, where the edge of the intrusive rock appears.

Several years ago some excitement was aroused by the discovery of small nuggets of gold in shallow gravels along the middle course of this creek. The active prospecting which followed failed, however, to reveal anything of great value, though annual assessment work is still done on a few claims. The gold occurring in this valley is necessarily derived from the schist formation, and it has probably come from small gash veins, since it is not known that any strong leads have been located. From a very cursory examination of the placers it would seem that only the shallow deposits favorably situated for sluicing can be expected to yield returns.

There is an extensive gravel flat which is judged from the topography to have a considerable depth, but this deposit can hardly be supposed to contain gold in workable quantity. This conclusion is, however, based on the general impression that the rocks of the schist band are not auriferous to any great extent and the evident fact that conditions have not been favorable for any great amount of concentration. The successful mining of the Lemon Creek placer would be the only contingency which, in the opinion of the writer, would ever warrant extensive prospecting of the Nugget Creek gravel bed, though drilling methods could undoubtedly be used effectually in prospecting the deposit.

MENDENHALL RIVER TO BERNERS BAY.

TOPOGRAPHY.

In the strip of country 25 miles in length lying between Mendenhall River and Berners Bay the topographic features are somewhat different from those of the more southerly portion of the Juneau belt.

From Port Houghton to Mendenhall River high mountains rise directly from the waters of the coastwise channels, but to the north the main front of the Coast Range lies several miles back of Favorite Channel and the lower end of Lynn Canal. Reference to the topographic map will show that this mountain front falls in line with the mainland shore of Gastineau Channel, while in front of it there is a foothill country from 3 to 6 miles in width.

Summit elevations in the foothills are mostly below 2,000 feet, while farther inland the mountains rise from 4,000 to 6,000 feet above tide. Snow fields connecting with those which feed the Taku glaciers occupy the high mountain area, and three large ice streams, known as Mendenhall, Herbert, and Eagle glaciers, descend nearly to the line of the main mountain front, where their gravel-strewn floors are less than 200 feet above sea level. North of these three glaciers two minor ice streams are drained by branches of Kowee Creek.

The foothill strip is drained mainly by streams flowing parallel with the mountain front and with the coast line, the only large transverse ones being the three rivers mentioned above, of which Herbert and Eagle rivers have a common outlet through the bed-rock barrier which lies next to Favorite Channel. Along this coastwise barrier are situated the highest summits of the foothill region, in one case reaching an elevation of nearly 2,800 feet. All of the streams have broad flood plains in their lower courses, which have apparently been formed by the silting up of former embayments through the deposition of material furnished by the streams themselves. In order to maintain their transportation grades the streams, and especially those which drain the glaciers, are still building up their gravel plains, and in the case of Herbert River this process has resulted in damming the lower part of Windfall Creek. The formation of a gravel barrier across the valley of the latter stream has taken place so recently that the dead trees along the flooded creek bottom are still standing.

GEOLOGY.

A cross section from any point on Favorite Channel to the mountains lying north of Mendenhall River shows all the lithologic bands that have been encountered in the Juneau belt. (See fig. 33.) The peaks which rise above the great ice fields are composed of the Coast Range diorite, and this rock forms the principal portion of the mountains between the several glaciers. The outermost mountains forming the front of the range are composed mainly of schist and black slate, though greenstones are found upon their flanks. The schist band, which is over 2 miles wide in the region south of Mendenhall River, is reduced to one-half mile at the head of McGinnis Creek, just north of Mendenhall River, and wedges out entirely in the headwater region of Kowee Creek. In this vicinity there is a tabular mass or broad dike of diorite lying between the schist and the band of black slate.

The slate band may be traced continuously from Mendenhall River to the ridge north of the middle fork of Kowee Creek, where it is also cut out by the gradual crosscutting of the main diorite, so that farther north the latter comes in contact with the slates and greenstones. In the upper part of Mill Creek, which is the first prominent stream entering Berners Bay above the mouth of Kowee Creek, two detached slivers of the slate formation are found, while in the diorite and still farther back in the range the existence of intruded fragments of the schist is suspected from the fact that with a field glass well-defined structure may be seen in the high peaks which rise out of Eagle Glacier. The apparent bedding of these rocks trends in the same general direction as the bedding of the metamorphic rocks outside of the boundary, and the dips are likewise toward the northeast.

Along this black-slate band are located the placer workings on McGinnis Creek, the placers and lode prospects in Montana basin and in the basin at the head of Windfall Creek, the lode mines of Eagle River, and several prospects at the head of the middle branch of Kowee Creek. (See fig. 32.)

The foothills stretch between the high mountains and Favorite Channel is occupied mainly by alternating beds of slate and greenstone, which strike parallel with the main lines of drainage and dip in common with all the other rocks of the region toward the northeast. At Tee Harbor volcanic breccias composed largely of coarse fragments of andesite are apparently

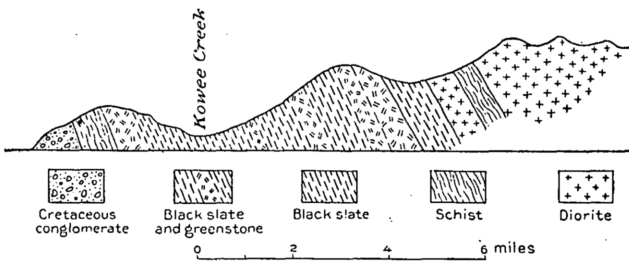


FIG. 33.—Geologic cross section from vicinity of Yankee Cove to the high mountains of the Coast Range.

interbedded with the slates and greenstones. These beds are quite similar in appearance to those exposed along the shore of Gastineau Channel above the wharves at Juneau. From their position, however, it is thought that they are less likely to correspond with the latter than with some portion of the greenstone beds which compose the mountains of Douglas Island.

At Yankee Cove there is a considerable development of conglomerate which somewhat resembles the breccia just mentioned, but which is regarded as quite distinct from it. This rock forms the outer flanks of the ridge which separates the drainage of Kowee Creek from Favorite Channel in the immediate vicinity of Yankee Cove, but whose extent along the strike has not been determined. Where observed it contains many pebbles of slate which are usually much flattened, so that the rock has a slaty cleavage. Conglomerate similar to this and likewise different from that at Tee Harbor is found on Portland Island, about 18 miles south of Yankee Cove; and the same sort of rock occurs on Admiralty Island at the head of Young Bay, from which place it has been traced by Mr. Wright along Seymour Canal to the lower end of Admiralty Island, where lower Cretaceous fossils have been found in it.[a]

The main channels of Montana, Windfall, and Kowee creeks occupy a general depression which follows the northward prolongation of the axis of Gastineau Channel. The valleys forming this longitudinal chain are eroded in soft shales which contain no thick beds of greenstone, while the harder and more massive volcanic rocks are found on either side in beds of considerable thickness. In the band of slates and greenstones as a whole, in this

[a] See "A reconnaisance of Admiralty Island," in this Bulletin, pp. 138–154.

region, the amount of the former rock is much greater than in the corresponding portion of the geologic cross section in the vicinity of Douglas Island, but nevertheless the two sorts of rock are present in many separate beds. This alternation of strata of greater and less rigidity has been a favorable condition for the opening of fissures, and this portion of the slate-greenstone band contains many more strong veins than are to be observed in corresponding rocks either on Douglas Island or on the mainland south of Mendenhall River. The presence of strong quartz veins is particularly noteworthy in the upper part of the series, and throughout this portion of the Juneau belt the main lode system may be regarded as lapping over the foot-wall boundary of the black-slate band, which in the vicinity of Juneau limits the zone in which most of the lodes occur.

Besides the greenstones other igneous rocks occur in this belt, such as sills or dikes of altered gabbro corresponding to similar rocks in the region nearer Juneau. These rocks were observed along the ridge between Windfall and Peterson creeks, but no adequate determination of their distribution was possible.

M'GINNIS CREEK.

POSITION AND GEOLOGY.

This stream, which is a tributary of Montana Creek, takes its rise in the high mountains which lie just west of Mendenhall Glacier (fig. 32). Its valley, about 3 miles in length, runs across the country structure, cutting the edge of the Coast Range granite at its head and traversing the thin remnant of the schist series or black-slate band which carries the lode system and the inner edge of the band of the slates and greenstones. The average strike of the rocks is northwest-southeast, and the northeasterly dips vary from 45° to 60°.

MANSFIELD GOLD MINING COMPANY.

Present interest in McGinnis Creek centers about the placer workings of the Mansfield Gold Mining Company, which are located on the east side of the creek 750 feet above tide and 1½ miles above its junction with Montana Creek. (See fig. 32.) To reach this property one goes by boat to a landing situated on the east side of the Mendenhall delta about 8 miles above Juneau. From this place a wagon road extends about 2 miles along the river bottom to a bridge, one-half mile beyond which begins a trail leading to the camp.

Placer deposits.—Gold-bearing débris of two sorts is found on the Mansfield property. The gravels which form a wide and thick bed along the valley bottom are said to be auriferous, though their value has never been determined by adequate prospecting and no attempt is at present being made to work them. The material which is being mined corresponds to that taken from the so-called gulch diggings in the early days of Gold Creek. It consists of débris derived from the steep mountain side which has lodged in the lower parts of steep, shallow ravines, forming a series of talus cones. These piles of débris flatten out and also flare at the bottom so that they merge with the gravel bed of the creek. In their lower portions they also coalesce with each other, being entirely separate only at the top, where they extend to greater heights in the wider ravines because these have naturally received more loose material than the narrower drains.

The pile of débris which had been attacked for mining is the one situated farthest downstream; none of the others have been thoroughly prospected. The preliminary work to determine its value consisted of opening fourteen pits from 12 to 36 feet in depth, some of which were carried to bed rock; in addition the slide rock was penetrated by a tunnel for a distance of 50 feet. In order to operate the deposit by the hydraulic method the creek was diverted by a flume nearly a mile in length reaching a point near the top of the deposit and giving a head of over 200 feet above the main creek. An estimate of the value of the deposit based on investigations previous to 1903 was said by the owners to have been satisfactory, but subsequent development in 1904 and 1905 established the impossibility of working the deposit with a profit.

The gold of the deposit has been derived from the numerous quartz stringers which occur in the black slates of the high mountain which towers above the camp. The gold, which is mostly fine, occurs in rough grains, as is natural from its local origin.

Quartz veins.—The lode system from which the gold of the McGinnis Creek placers has been derived lies in the band of black slates which carries the Gold Creek veins. Here, however, quartz veining is not so prominent as in parts of Gold Creek, and the values appear to be less concentrated. Stringers and gash veins are found both following and crosscutting the structure of the country rock, varying in size from mere seams up to a width of 2 feet or rarely more. So far as observed, single bodies of vein stuff are never more than 100 or 200 feet in length or depth. The exploration of these lodes has attracted the attention of the Mansfield company, and considerable prospecting was done by them in the hope of discovering workable veins. Underground exploration was, however, abandoned after the placer operations were taken up.

MONTANA CREEK.

TOPOGRAPHY.

The main valley of Montana Creek trends from northwest to southeast, parallel with the geologic structure. The divide separating it from the drainage of Windfall Creek lies about 2 miles above the mouth of McGinnis Creek, but half a mile or so below this divide it receives a transverse tributary which rises in Montana basin, located upon the flank of the high mountains west of McGinnis Creek (fig. 32). This basin is a steep-walled amphitheater which lies approximately 2,200 feet above sea level.

GEOLOGY.

The northwest-southeast valley of Montana Creek lies in slaty rocks belonging to the slate-greenstone series, while the lower courses of the stream, which drains Montana basin, traverse beds of greenstone and greenstone schists which extend to the shoulders of the ridges on either side of the wide, gently sloping basin floor. The basin itself is excavated from the black-slate band, the boundary between which and the schists lies entirely back of its drainage. (See Pl. II.) The rocks strike directly across the basin and dip toward the mountains at an angle of about 50°.

PLACERS.

The first placer work on Montana Creek is reported by John Olds, of Juneau, to have been done in 1882, two years after the discovery of Gold Creek. The claims were located in the basin (see fig. 32), where sluicing was continued in a small way for several seasons, yielding fair returns. Nothing has been done, however, for many years and these old diggings were not examined.

In the portion of the valley between the mouth of McGinnis Creek and the junction of the basin tributary there is a gravel flat containing a large amount of débris similar to that forming the floor of McGinnis Creek; but, as in the case of the valley gravels of the latter stream, these have never been thoroughly prospected, though it is reported that colors are always to be found by panning. This portion of the valley was not visited and no data are available concerning the situation of the gravels and the character of the valley with refer ence to the possibilities of hydraulic mining.

QUARTZ VEINS.

The graphitic slates of the black-slate band have been prospected to a considerable extent because of the quartz veins which they contain. In Montana basin, as in Gold Creek, the veins are mainly stringer leads and gash veins, and so far as development shows there are no continuous bodies of quartz. In the outer portion of the slate band, where the veining is most conspicuous, the ground is generally hidden by a heavy growth of grass; but the presence of gold in the surface débris, as determined by the early prospectors, indicates that this zone is the principal source of the placer gold along the creek. Outside of the slate foot wall certain veins lying in the schistose greenstone seem to be more continuous than any in the slate. No detailed study of these veins was made, but observation during the necessarily hasty reconnaissance of the district indicates the possibility that at least one lead may be traced from the ridge southeast of Montana basin to the northwest side of Windfall basin, a distance of somewhat more than a mile.

PETERSON CREEK.

TOPOGRAPHY.

Peterson Creek is a stream 6 miles long, running from southeast to northwest at a slight angle with the coast line. Its headwater divide, nearly 2,000 feet in height, lies against Auk Cove, and its valley is separated from Favorite Channel by a high ridge cut by a single defile lying nearly opposite the lower end of Tee Harbor. The summit of this ridge is about 1,200 feet above tide. The valley contains a good-sized lake just below the pass mentioned. Below this lake the stream falls about 1,200 feet in 3 miles, affording an excellent water power during a large part of the year. The lower end of the valley contains a wide meadow only a foot or so above high tide, traversed by tidal sloughs leading into the landlocked embayment known as Salt Lake. The ridge between Peterson and Windfall creeks rises to a height of over 1,000 feet.

GEOLOGY.

The geology of the area drained by Peterson Creek corresponds with that of the inner side of Douglas Island in its general features. The ridge next to Favorite Channel is composed mostly of massive greenstone, but along the shores, being particularly well developed at Tee Harbor, there is a fragmentary greenstone tuff resembling the volcanic agglomerate exposed along the shore at Juneau. However, from the general structural relationships in the intervening country, these two occurrences can hardly correspond, and the Tee Harbor agglomerates are therefore regarded as a thicker development of certain layers having a similar nature and origin which are interbedded with the massive greenstones in the Douglas Island mountains. These agglomerates are distinct in appearance from the conglomerate strata of Point Young, Portland Island, and Yankee Cove, which correspond to each other in lithologic characteristics and at Point Young are known, from the fossils present, to be deposits of Cretaceous age.

The relation between the massive greenstones mentioned and the black slates which occupy the valley depression has not been observed, but along the strike on Douglas Island are alternating beds of slate and greenstone constituting a transition between the massive lava rocks of the mountains and the slates occupying the landward portion of the island. Along the bed of Peterson Creek the slaty rocks are phyllites resembling those which underlie the platform back of the Treadwell mines. No intrusive light-colored diorite is present to correspond with the mineralized dikes which constitute the Treadwell ore bodies, and so far as observed there are no greenstone layers in this zone short of the middle slope of the ridge between this valley and the Montana-Windfall depression. In this high ground the igneous rocks are of two sorts—andesitic flows, like those in the mountains between Gastineau Channel and Silver Bow basin, and intrusive sills of altered gabbro, similar to the dark dikes which penetrate the slates and greenstones of Gold and Sheep creeks. Some of these intrusive masses extend along the strike for several miles.

The physical conditions attendant upon many alternations of flexible slates and rich beds of greenstone or dikes of diorite seem to have been particularly favorable for the production of fissures, and throughout this belt and its continuation toward the northwest between Favorite Channel and Kowee Creek many quartz veins occur, some of which are characterized by more than ordinary continuity when compared with the individual veins of the main lode system.

PETERSON GROUP OF CLAIMS.

This property is situated on the northeast side of Peterson Creek, nearly opposite but half a mile distant from the head of the lake and perhaps 200 feet above its level. (See fig. 32.) The elevation of the lake is less than that indicated on the contour map, being nearer 600 feet than 800 feet, as shown. A trail from Tee Harbor was formerly the only feasible route to this lake, but the owners of the property devoted the summer of 1903 to grading a wagon road from a point on the beach about 1 mile south of Salt Lake.

Prospecting has been in progress in this district for several years. The presence of large masses of quartz has been determined and openings at numerous points indicate the presence of a stringer vein which seems to be continuous for several hundred feet at least. The country rock is seldom exposed, and the relations of the vein and inclosing rocks can not be satisfactorily determined. So far as seen, the walls consist of slate, though both greenstone and altered gabbro are found in the vicinity. Near the larger veins there are many stringers, some of which occur in gashes which cut across the structure of the slates. The strike of the main lead is about N. 30° W., but its dip was not ascertained and it may prove to stand nearly vertical, as seems to be the case at one of the openings. The only sulphide mineral observed in the material on the mine dump is arsenical pyrites. The vein is said to contain some free gold.

Shallow workings at several places have encountered vein stuff of ore grade, a considerable amount of which has been treated by means of an arrastre. Also, some of the surface material derived from the vein has been sluiced each year, and the property has thus, in part at least, paid the expenses of preliminary development.

Because of the topographic situation no depth can be attained by tunneling, so that for future exploration a shaft must be sunk, which will require the installation of hoists and pumps. Enough prospecting has been done along the country strike, for a distance of a mile or so northwest of the Peterson property, to show the presence of veins at various points. Several strong leads of quartz containing good amounts of sulphide minerals were discovered on the Windfall side of this ridge during the summer of 1903, and all things considered this belt of the slate-greenstone series appears to be favorable ground for prospecting.

WINDFALL CREEK.

TOPOGRAPHY.

The waters of this stream rise in a high basin contiguous to that at the head of Montana Creek. This upper drainage flows transverse to the country structure down to the base of the steep mountain front, where it turns toward the northwest and finds outlet by way of Herbert and Eagle rivers. The main valley, which is a continuation of the Montana Creek depression, has a length of nearly 5 miles. Just below its middle it contains a lake 1 mile in length, which has been formed by the filling in of the lower valley by gravel washed from Herbert Glacier. Below this lake the stream is sluggish and is bordered by a wide, forested gravel plain. Above the lake is another wooded flat, which has been formed by the accumulation of débris furnished by the stream itself. The two principal forks of the creek come together on this flood plain, arms of which extend up both branches half a mile or so. Above the larger of the gravel beds the stream grades increase rapidly, and in the case of the main fork the slope amounts to about 700 feet per mile up to the broad summit on the main divide, while above this the grade to the basin is almost twice as steep.

The lode claims located in the basin may be reached by trail from the placer camp on McGinnis Creek by way of Montana basin or preferably by a more gradual ascent from Salt Lake or Peterson's landing to the broad divide between Windfall and Montana creeks and thence up the south side of the gulch.

GEOLOGY.

The formations of Windfall Valley are the same as those described for Montana Creek. The high basin taps the black-slate band, and the gulch which drains it traverses the inner edge of the slate-greenstone series, while the main valley is excavated in black slates which are believed to correspond with the rocks along Gastineau Channel.

The inner band of slate, which carries the main lode system of the general belt, is here about 1 mile in width and, being separated from the remnant of schist lying next to the main diorite by an outlying wedge of this intrusive rock, it forms the prominent ridge between Windfall Creek and the first tributary to Herbert Glacier above the foot of the ice stream. North of Windfall basin there has been almost no prospecting in this belt, and nothing can be said of the extent of veining, because personal observations are lacking.

PLACER OPERATIONS.

The discovery of gold in the gravels of Montana and Windfall creeks dates back to the early eighties, and evidences of small-scale sluicing operations are to be seen at several points. On Windfall Creek some work was done below the junction of the basin stream, where the

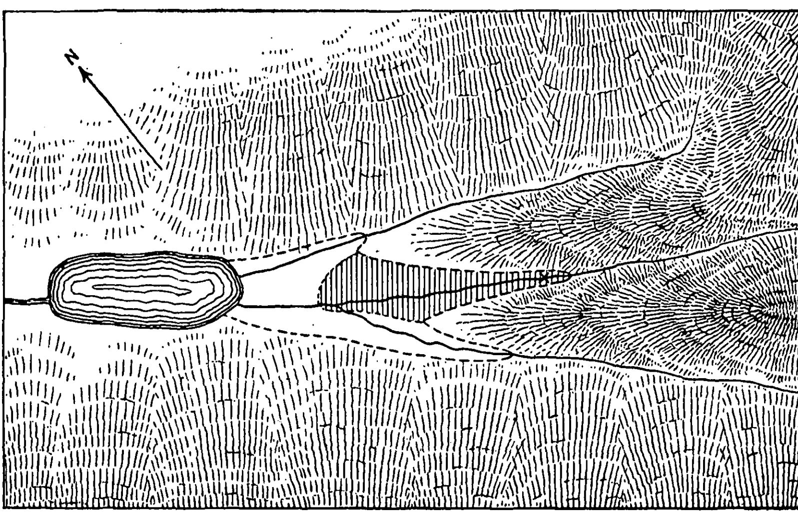


FIG. 34.—Sketch map of gravel deposit along Windfall Creek. The portion derived entirely from the auriferous middle fork is shown by sketching. Location of placer workings is shown by cross (X).

creek bed is relatively flat. Along this reach the gravel is rather thin, but there are many large bowlders, the presence of which doubtless rendered a great deal of pay dirt unavailable. Below these old workings the stream flows on bed rock, and its grade is steep down to the head of the gravel flat lying above the lake. The upper end of this gravel deposit has been worked from time to time by shovel and sluice-box methods, but apparently with only indifferent results, since the gentle slope of the stream below the workings makes it difficult to dispose of tailings.

In 1903 a hydraulic plant was installed on this ground just below the bed-rock exposures. (See fig. 32.) A large amount of the overburden was removed, but before bed rock could be cleaned up the water supply failed, owing to the exceptional dryness of the season. In spite of these adverse circumstances an encouraging amount of gold was taken from the sluices in September, though the disproportion of returns to expenses seems to have at least temporarily embarrassed the company, since no work was done during the season of 1904.

The work accomplished in 1903 at the head of the gravel flat showed the presence of values sufficiently encouraging to lead to the consideration of the question whether gold in workable amounts may be expected to occur throughout the mass of gravel between this place and the upper end of the lake. The ground could be tested with moderate expense by drilling, but any work of this sort should be preceded by a careful estimate of the relative contribution which the two forks of the creek have made to the deposit, since only the débris furnished by the more easterly of the two large branches carries gold to any important extent. The small stream which lies immediately northeast of the main fork is said to be practically barren of values. The accompanying sketch map (fig. 34) illustrates the manner in which the relative extent of the material derived from the stream which is the recognized feeder may be estimated. Probably the best values will be found in a more or less definite channel lying near the axis of the deposit of the central stream. Below the junction of the main forks the gravel would be of mixed origin, and probably not rich enough to pay for working.

As already noted in the topographic description, the origin of Windfall Lake is due to outwashed material deposited across the lower end of the valley by the river flowing from Herbert Glacier. The formation of this dam is so recent that the lake has not been filled, though this is gradually being accomplished by the growth of the delta at the mouths of the tributary creeks. A sounding in the center of the lake would give the approximate depth of the bed rock below, and from this and the height of the first bed-rock exposures above the lake level the depth of the gravel bed can be estimated with a fair degree of accuracy, assuming that the bed-rock slope is fairly constant. In fig. 35 a equals the depth of the lake, b equals the height of the bed-rock exposures above the lake level. The average bed-rock grade is given by the ratio $(a+b)$ to c, and the surface slope is given by the ratio b to d. The difference

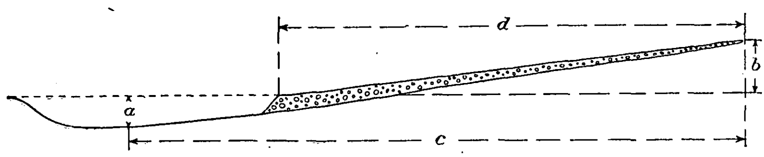


FIG. 35.—Diagram showing method of estimating thickness of Windfall gravel bed. (See text for explanation.)

between the two surfaces at any point can be readily calculated or determined graphically from a diagram drawn to scale.

An estimate of the depth of the deposit by some such method as that given above or by drilling to bed rock will be necessary in determining specifications for a dredge, by means of which these gravels could undoubtedly be handled so far as their physical character is concerned. The presence of large bowlders is not to be anticipated, because the feeding streams have never been capable of transporting them. On the other hand, logs and stumps buried during the growth of the deposit will probably be encountered, and their presence in numbers would prevent the successful operation of any dredging machinery. All things considered, the point can not be too strongly urged that any comprehensive scheme for working this gravel bed should be taken up only after thorough prospecting by means of drill holes reaching to bed rock.

QUARTZ VEINS.

Observation on the ground leaves no doubt that the auriferous débris which has accumulated in Windfall Valley has come almost entirely from the basin at the head of the creek. The gravels contain large amounts of vein quartz, many fragments of which carry various metallic sulphides, and the latter, together with magnetite, also collect in the sluice-boxes, all of which indicates the presence of considerable veining in the area which has contributed this loose material.

In Windfall basin the conditions are evidently similar to those in Montana basin, where more prospecting has been done. In the former the most promising leads which have been opened lie in the upper part of the slate-greenstone series, the northeastern edge of which lies well toward the head of the gulch. So far as known, no stringer veins have been discovered in the belt of graphitic slates which carries the main lode system in the vicinity of Juneau. The only workings visited are on the Smith & Heid property, where development amounting to the annual working required by law has been in progress for several years. Openings have been made at several points along what seems to be a fairly continuous or at least a reappearing lead. This vein, which is the one mentioned in the description of Montana Creek, as extending toward the northwest, follows the country structure, dipping steeply into the mountain. The nature of the rock which forms the immediate walls was not observed. Above this lead there are other openings, from one of which several tons of ore showing free gold have accumulated on the dump. It is said that the vein from which this ore was taken is very irregular and discontinuous, and that the values are bunchy. The inclosing rock is greenstone schist.

Outside of the basin some prospecting was in progress during the summer of 1903, and locations were made on the mountain slope above the placer mine and also on the west side of the valley along the base of the ridge next to Peterson Creek. In the place last mentioned several strong croppings of quartz were seen by the writer, and encouraging assays are reported. The principal country rock is black slate, but in this district dikes of dark rock following the general country structure are known to be present. Of course the persistence of the veins is as yet undetermined, but this ground would seem to be worthy of more attention than it has received up to the present.

EAGLE RIVER.

TOPOGRAPHY.

Herbert and Eagle rivers are streams of glacial origin which flow into Favorite Channel through a single mouth, located about 22 miles northwest of Juneau. The converging ice streams in which they take their rise approach to within about 3 miles of the channel shore. At their lower ends these glaciers are about 3 miles apart, and they are separated by a mountainous mass more than 6,000 feet in height, the seaward slope of which lies nearly in line with the general front of the high mountains. Below this dividing mountain the merging of the valleys forms a broad gravel-floored plain sloping gently toward the sea. The gravel filling beneath this plain is probably deep, and presumably a former landlocked bay of considerable dimensions has here been filled up by the outwashed débris from the two glaciers.

From the south Herbert River is joined by Windfall Creek, the lower valley of which is likewise deeply filled by gravel. Also from this direction a broad depression separated by bed-rock hills, on the one hand from Windfall Creek and Herbert River and on the other from Favorite Channel, connects the flood plain of the combined rivers with the low-lying area about Salt Lake. This passage gives ready approach to Eagle River valley from a favorable landing place in the cove north of Salt Lake, and through it a tramway has been laid by the Eagle River Mining Company.

Northeast of Eagle River there are no large streams, the divide to the drainage of Cowee Creek being nowhere more than 2 miles distant from the main channel of the river. Next to Favorite Channel this divide is about 2,600 feet above tide, from which elevation it rises gradually as the main mountains are approached, so that the slopes on this side of the river are very steep, and the mountains are cut by many gulches. In common with the larger part of the valley floor the mountain flanks are heavily forested.

GEOLOGY.

The distribution of the several rock bands which have been distinguished throughout the Juneau belt is shown upon the geologic map. As in the adjoining territory, the dips of stratification and of intrusive contacts in the vicinity of Eagle River are toward the northeast. The Coast Range diorite forms the greater part of the mountain between the two glaciers and of the high ground lying west of Eagle Glacier. The same rock also occurs in a tabular body separated from the main mass by a wedge of schist which crosses the lower end of the glacier. In this vicinity this included band of schist, which contains some massive beds of crystalline limestone or marble, appears to be the only representative of the series which covers a much wider zone in all the region south of Mendenhall Glacier. However, it may be that certain red or rust-colored rocks occurring in a high peak which rises out of the ice field near the head of Eagle Glacier are to be regarded as another portion of the same series, torn off during the intrusion of the diorite. The narrowing of the schist band and its final disappearance a few miles farther to the north is taken as evidence that the main boundary of the invading diorite gradually crosscuts these sedimentary formations of the Juneau belt, and, as will be shown under the description of the geology of Kowee Creek, this transgression toward the west soon brings the diorite into contact with the slate-greenstone band.

The schist and marble are very well exposed in the valley wall northwest of the glacier. Intercalated with these metamorphic sediments are several narrow intruded bands of more or less gneissic diorite. The schists and marbles are also injected to a considerable extent by stringers of aplite, and occasional veinlets of quartz are present. All of these beds, including the diorite, are cut by a few small dikes of basaltic rock.

Next to the main diorite contact some tremolite is developed in the marble, but no other characteristic minerals of contact metamorphism were observed and the outlying masses of diorite have not notably altered the sediments. Certain of the sedimentary bands contain large amounts of disseminated pyrite, but none of this mineral has been tested for precious metals by us.

The outlying mass of diorite which crosses the foot of Eagle Glacier lies along or near the boundary between the schists and the great band of graphitic slates which has been separated throughout the Juneau belt because of its prominence as a vein carrier. In the vicinity of Eagle River the limits of this band have not been accurately determined, but the representation on the map is approximately correct, since the location of the first greenstones is known at the head of Yankee basin. The mine of the Eagle River Mining Company is located in this graphitic slate.

Outside of the black-slate band comes the usual series of slates and greenstones occurring in alternating beds, but no detailed study of these rocks has been made in this vicinity.

QUARTZ VEINS.

The steep mountain slope north of Eagle River is covered by a thick growth of vegetation which entirely hides so much of the ground that prospecting is carried on under great difficulties. Here and there, however, veins have been discovered, and during the past three or four years considerable development work has been done. Operations have been carried on for several seasons at a group of claims situated opposite the main head of Kowee Creek in the belt of slates and greenstones, but this property was not visited. Another group which has been under development for three years is said to have produced $75,000 in gold during 1904. This property is owned by the Eagle River Mining Company. (See fig. 36.) In the autumn of 1903 the vein had not been reached by the adit then being driven, so that only the surface showing was available for examination. The country rock is black slate belonging to the band between the schist on the northeast and the alternating slates and greenstones on the northwest, so that this property is regarded as being located upon the main lode system of the Juneau belt, though in this northern region the lode system is less well defined than in the vicinity of Juneau.

The outcrop was originally revealed by the overturning of a large spruce tree, but in 1903 the vein, though afterwards opened at various points, had not been uncovered sufficiently to reveal the walls. The exposed portion was from 3 to 8 feet wide, and at the main prospect the quartz was apparently continuous for at least 50 feet along the strike, which was taken to be approximately N. 30° E., true meridian. So far as noted the gangue is all quartz, the metallic minerals observed being pyrite, arsenopyrite, galena, and free gold. Native copper has been noted. Mr. C. D. Mallory, president of the company, is authority for the information that a mill test of 900 pounds of ore, made by J. G. Davies, at Juneau, from various openings on the property returned in free gold $22 and in the sulphides $15 a ton. The degree of concentration was about 25 into 1.

Mr. C. W. Wright, who visited the mine in 1905, reports that the vein strikes N. 30° W. and dips 50° NE. Three ore shoots had been opened and found to pitch about 30° NW. in the plane of the vein. At different levels the shoots measure 25 to 100 feet from edge to edge, and are from 5 to 15 feet thick. The length of the shoots along the line of pitch has not been determined, though one of them has been followed for more than 300 feet.

A horse tramway extends from the 20-stamp mill to the company's wharf at Eagle Cove.

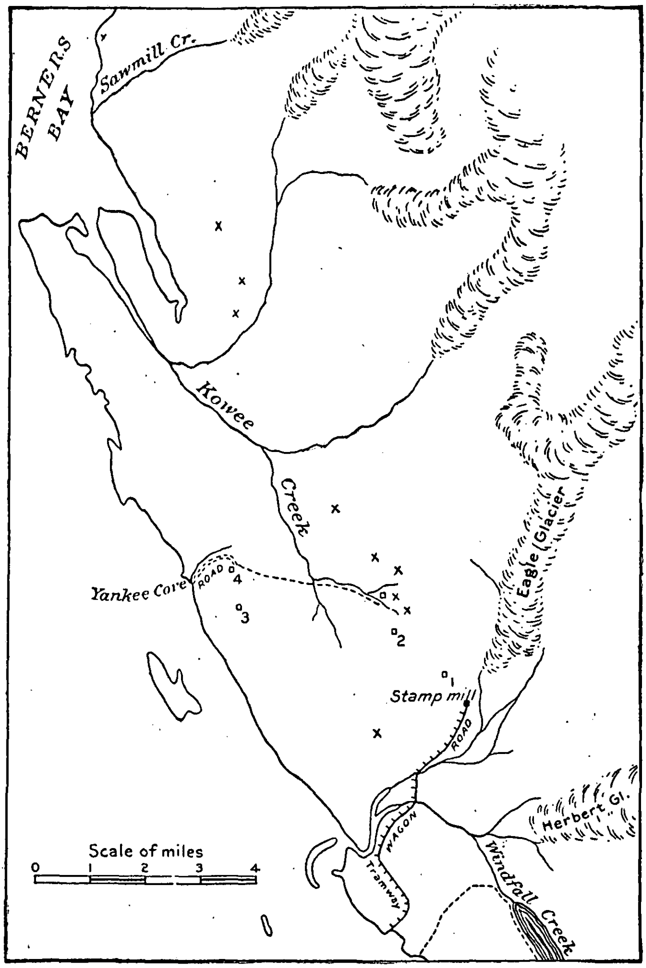


FIG. 36.—Sketch map, Windfall Lake to Berners Bay. 1, Eagle River Mining Company; 2, Rex; 3, Alaska-Washington; 4, Bessie and Aurora Borealis; X, other properties.

YANKEE BASIN.

This basin lies directly opposite the Eagle River mine at the head of the main forks of Kowee Creek. (See fig. 32.) The axis of the depression runs from southeast to northwest, parallel with the strike of the country structure, and the boundary between the slate-greenstone band and the black-slate band lying to the northeast traverses the mountain side several hundred feet above the main drainage line. (See geologic map, Pl. XXXVII.) Several fairly continuous or recurring veins which have been located in the neighborhood of this contact would seem to warrant further exploration, but up to the present the only development work which has given favorable returns is on the Rex claim, located several hundred feet west of the slate-greenstone boundary, at an elevation of about 2,800 feet. Here a small but rich vein which was opened in 1903 is said to have yielded $3,000, though subsequent work has not revealed a continuous vein. The rock is greenstone, in which the irregular vein crosscuts the country structure. The vein is composed mainly of calcite, but there is some quartz. Arsenopyrite is the only sulphide present; it is highly auriferous and apparently carries all of the values. Weathered portions of the vein show the reddish-chocolate color characteristic of oxidized arsenical pyrites and throughout the decomposed material rough, spongy gold occurs from mere colors up to 10 or 15 cent nuggets.

YANKEE COVE.

POSITION AND GEOLOGY.

This indentation is situated about 6 miles above the mouth of Eagle River at the outlet of a small transverse stream which heads in a meadow back of the high ridge separating Kowee Creek from Favorite Channel. A plank road 2 miles long has been built from the beach to the head of the small creek mentioned, where the 5-stamp mill of the Bessie group is located. The outer side of the ridge is composed of beds of conglomerate and slate apparently interbedded with each other and with the beds of greenstone and slate which occupy the top and inner slope of the ridge next to Kowee Creek. These conglomerates resemble closely those of Portland and Admiralty islands and are regarded as probably corresponding with them, in which case they are very much younger than the rocks with which they are infolded, and are to be correlated with the Mariposa beds of California. They are not represented on the geologic map, since their distribution has not been worked out.

The veins which are under development occur mainly in greenstone, but in part they are inclosed in the slates which separate the different bands of igneous rock. Some of the greenstone seems to be an altered form of massive andesite, but certain layers are evidently volcanic tuff or breccia, though in this locality the fragments which make up the rock are much smaller than in the agglomerate occurring near Juneau and at Tee Harbor. These bands of igneous material are found on the upper part and on the inland slope of the ridge, down to the broad platform of Kowee Creek, where no prominent beds of greenstone were noted, black slates being the prevailing rock.

QUARTZ VEINS.

Considerable general prospecting has been done in past years, but those interested in this district have settled down to the development of a few promising veins, the best explored of which are the Aurora Borealis, Bessie, and Alaska-Washington. (See fig. 36.)

The Aurora vein outcrops in a shallow northwest-southeast ravine where the steep slope of the ridge meets the edge of the Kowee Creek meadow. It follows near the contact between black slate and a heavy bed of greenstone which strikes northwest and dips rather steeply toward the northeast. The strike of the vein carries it along the base of the slope, so that surface prospecting is rendered difficult by the presence of much débris and by the heaviness of the forest. Very little depth can be gained by drifting on the vein, and since large masses of débris are to be anticipated no shaft has been sunk; consequently the vein has been very inadequately explored. From its position between a massive rock on the foot wall and flexible slate above, it seems fair to anticipate that the vein will show considerable persistence, though in the light of other localities where quartz veining occurs in black slate it is more likely to break up into a complex stringer lead than to persist as a solid body of quartz. The property is equipped with a 5-stamp mill and has produced several thousand dollars' worth of gold, but the workings were caved in 1903 and therefore not available for examination. As exposed in an open cut, the vein has a width of 3 to 4 feet, but contains occasional slivers of slate. The walls are irregular and occasional spurs or stringers extend into the country rock. The vein stuff, which is here considerably crushed, is thoroughly oxidized, and specks of gold are to be seen here and there, so that good prospects may be obtained by crushing and panning rusty portions of the quartz.

The Bessie vein strikes across the bedding of the country, running approximately N. 75 °E. and dipping steeply toward the south. The lode has been opened at many points and appears to be continuous entirely across the band of andesitic tuff or greenstone in which it lies, having been traced for a distance of about 1,600 feet. The strike of the formation is approximately N. 30° W., so that the vein runs slightly diagonal to the edges of the greenstone bed. The vein lies in a very favorable attitude for mining, the steepness of the slope on which it outcrops permitting rapid gain in depth, and all levels can be readily opened from the surface without dead work. The vertical extent of the vein above the Aurora mill is roughly estimated at from 600 to 800 feet. Its width varies from a foot or so up to 5 or 6 feet, probably averaging 3 feet. Arsenopyrite is the principal sulphide, though ordinary pyrite also occurs and free gold is present in many places, apparently in the form of a primary mineral not set free by oxidization of the sulphides. The property was too little developed in 1903 to afford any basis for determining the manner in which values are distributed, but past experience in southeastern Alaska leads to the expectation of irregular distribution in a vein of this sort.

The Alaska-Washington vein is similar in its general features to the Bessie. Openings have been made for a distance of nearly 3,000 feet along the same general course, bearing a few degrees north of east, true meridian, and the vein or at least the fissure in which it lies is apparently continuous for this distance. The eastern half of the vein is inclosed in the same bed of andesitic breccia as is the Bessie, but the western portion lies in a distinct bed of this rock separated by a band of black slate 200 feet wide. The vein has been developed by 600 feet of drifting at three levels. Thus far no large pay shoots have been encountered, though in places values as high as $8 have been reported and small amounts of gold are invariably present. The owners of the property report that the values are independent of the amount of sulphides present. Though this vein evidently contains less gold than the Bessie, it is of the same general type and it is to be expected that pay shoots will be found in it.

KOWEE CREEK.

TOPOGRAPHY.

Kowee Creek has a catchment area of about 50 square miles and drains the main mountain front for a distance of nearly 10 miles. The main stream runs parallel with the shore of Favorite Channel, heading in the high divide near Eagle River and entering into Berners Bay (Pl. XXXVII and fig. 36); but its collecting ground lies principally northeast of this depression, where its two large tributaries are transverse streams fed by glaciers connected with the Eagle River snow fields. The lower reaches of the stream are bordered by a broad, swampy flood plain, but the upper valleys are narrow, with very steep walls. The spruce forest extends somewhat higher than is usual on the mainland, being continuous up to 2,500 feet and locally straggling to an elevation of nearly 3,000 feet.

GEOLOGY.

The two transverse tributaries of Kowee Creek cut back several miles into the Coast Range diorite, the main boundary of which from Eagle River northward to Berners Bay is nowhere more than 5 or 6 miles distant from Favorite Channel. The wedge of schist, which was noted on the west side of Eagle Glacier, can be readily traced across the divide into the valley of the neighboring fork of Kowee Creek, but it is apparently cut out at no great distance beyond this stream. The ridge between the two transverse forks was not visited, but in the interval between the northern stream and Sawmill Creek there is no corresponding band of schist. Here, indeed, the diorite is bounded by greenstone, so that the black-slate band has also been cut out somewhere in the Kowee drainage. Beyond the main contact, lying well back in the diorite and traceable by the eye from this ridge across Sawmill Creek, are two strips of evidently bedded rocks, which are regarded as part of the black slate.

The slates and greenstones occupy the outer parts of the ridges between the transverse streams and extend to the seaward slope of the ridge which separates Kowee Creek from Favorite Channel, where the conglomerates regarded as of Lower Cretaceous age are folded in with them. No detailed examination of the district having been made, the extent and distribution of the individual beds is not known, but it would be a comparatively simple task to distinguish and map the conglomerate strata, the several bands of slate, and the igneous rocks, and even to separate the breccias and tuffs from the massive lava flows and certain intrusives which somewhat resemble them.

VEINS.

The veins occurring on the west side of Kowee Creek near Yankee Cove and those in Yankee basin have already been described. Even in those localities there is still room for careful prospecting, but in other parts of the drainage basin there has been very little exploration and almost no development. This is due to the inaccessability of the district, the rough character of the topography, and the heaviness of the forest and undergrowth, all of which add to the difficulty of prospecting and developing. Such work as has been done indicates that there is a grouping of veins along the inland edge of the slate-greenstone band and in the adjacent portions of the black slates. The veins follow the country structure for the most part, and taken together they may be regarded as essentially a continuation of the main lode system of the Juneau belt.

The strip of country lying northeast of the main longitudinal valley of Kowee Creek, extending from Yankee basin to Sawmill Creek and the shore of Berners Bay, would seem from very cursory examination to be one of the most favorable fields for prospecting within the general region. Many of the veins are strong and well mineralized, the sulphides observed being pyrite, pyrrhotite, arsenopyrite, and galena.

Quartz lodes have been located along the east shore of Berners Bay, and though this locality was not visited there can be little doubt that the veins are similar in nature to those occurring in the corresponding rocks in Kowee Creek.

In Sawmill Creek some prospecting has been done and considerable mineralization is said to exist in the strips of slate which are included in the diorite a mile or so back of its main boundary.

BERNERS BAY DISTRICT.

GENERAL DESCRIPTION.

The region usually spoken of as the Berners Bay district lies between Lynn Canal and the rivers which enter Berners Bay. The peninsula separating these two bodies of water has a comparatively low elevation and forms a foreland in front of the high mountains, corresponding topographically with the foothills which border Favorite Channel in the region between Mendenhall River and Berners Bay. The high mountains rise above timber line (see Pl. XXXVI), but the southern portion of the peninsula is well forested. It is drained mainly by small longitudinal or strike streams, but on the north is crossed by Sherman Creek, heading in the high mountains, which a short distance farther north rise directly from the shore of Lynn Canal (Pl. XXXII).

On the northeast the foreland extends to Johnson Creek, which is a strike stream heading against Sherman Creek. In the upper basins of these two streams all the mines of the district are located, with the exception of the Greek Boy group. The last-named property is situated on a small stream about 5 miles above the head of Berners Bay, on the west side of the large unnamed river which penetrates the diorite of the Coast Range for nearly 20 miles in a direction parallel with the trend of Lynn Canal and 5 miles distant from its shore.

Some of the locations are at elevations above 2,700 feet and most of the veins which have been opened outcrop above 1,500 feet. Exceptions to this are the Greek Boy, the lowest opening of which is perhaps not more than 100 feet above tide, and the Jualin mine, the buildings of which are situated at about 600 feet elevation. (See fig. 37.)

GENERAL VIEW, BERNERS BAY DISTRICT.

Looking north across the head of Sherman Creek.

DEVELOPMENT OF THE MINES.

The mines of Sherman Creek are accessible by way of a narrow-gage railway from Comet landing to the stamp mill erected by the Berners Bay Mining and Milling Company, about 3 miles above the mouth of the creek and about 800 feet above tide. Above the mill there is a gravity plane several hundred feet in length and wire tramways have been installed to handle the ores of several mines, though none of these were in operation in 1903. Three mills have been built. One of 10 stamps belonging to the Portland-Alaska Gold Mining Company is located on the shore of Lynn Canal northwest of Comet; another of 20 stamps owned by the

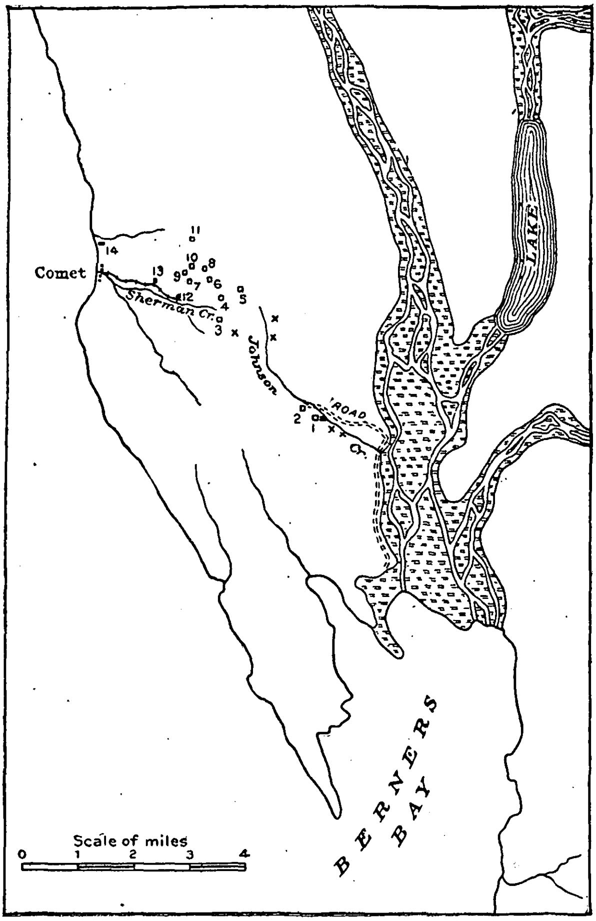


FIG. 37.—Sketch map, Berners Bay and vicinity. 1, Jualin mine; 2, Indiana tunnel; 3, Comet mine; 4, Northern Belle; 5, Johnson prospect; 6, Eureka; 7, Bear; 8, Kensington; 9, Savage; 10, Horrible; 11, Mellen; 12, Comet stamp mill; 13, Mellen mill; 14, Horrible mill; X, other prospects.

Mellen Mining and Manufacturing Company is situated near the railway about 2 miles from the steamboat wharves; the third is the 40-stamp mill of the Berners Bay Mining and Milling Company. The property of the last-named company has recently changed hands, and plans for a much larger milling plant are said to have been made. Up to the present all of these mills have been operated principally by water power, extensive flumes having been constructed to concentrate the flow of the several tributaries of Sherman Creek. In some cases, however, auxilliary steam engines have been employed. The wharf at Comet is adequate for the use of coastwise vessels, and a general store is maintained at this point. The total amount of development work in the Sherman Creek group of mines is estimated at about 13,000 feet of crosscuts, drifts, and winzes, half of this being in the Comet mine, which has been the principal producer.

The Johnson Creek mines are less readily accessible than those on the west side of the peninsula. One of them—the Johnson prospect—is most easily reached from the head of Sherman Creek, but the others have been made accessible by a fairly good wagon road about 3 miles long, leading from one of the sloughs at the head of Berners Bay to the Jualin mine and the workings of the Indiana Company. The lower end of this road is about 3 miles from the nearest safe anchorage or landing place for steamers, so that the interval must be covered by small boats or barges. Besides this route there is a direct foot trail from the cove where the steamers stop to the Jualin camp. The mine workings in the several properties located on Johnson Creek aggregate about 4,000 feet. There is a 10-stamp mill at each of the two principal properties.

The Greek Boy property is reached by a boat or barge to the head of the slough, thence by a wagon road about 1 mile in length. The vein is developed by several hundred feet of drifts at three levels, which are connected by a raise. The property has no milling plant.

PRODUCTION.

The production of the Berners Bay district has been about $1,000,000,[a] something less than one-half this sum having been taken from the Jualin mine and something more than half from the Sherman Creek mines. Of the latter, the Comet has contributed the greater part, other productive veins having been the Kensington, Bear, Mellen, Savage, Northern Belle, Horrible, and Mexican.

GEOLOGY.

In the Berners Bay district slate, greenstone, and diorite are the three main types of rock, other sorts being present only in the form of small dikes (Pl. XXXVII). Slate underlies the greater part of the foothills, though here there are some interbedded greenstones. These rocks occupy a strip from 3 to 4 miles wide, extending inland on the southeast to the lower course of Johnson Creek, and toward the northwest including the lower slopes of the mountains beyond Sherman Creek. Back of the slates and greenstones, which contain no developed veins, there is a wedge of massive diorite which is 2 miles wide in Johnson Creek, about a mile wide on the divide between Johnson and Sherman creeks, and about one-half mile wide where it strikes Lynn Canal 3 miles above Comet. All the mines of the district, except the Greek Boy, occur in or near this band of rock.

The general limits of the diorite band may be traced with a fair degree of accuracy, but outside of the main mass there are numerous small parallel dikes of the intrusive rocks, following the structure of the slates, a feature which may be seen to advantage in the long crosscut of the Comet mine. The rock varies from place to place, particularly in the size of grain, but it is mainly diorite characterized by andesine feldspar, hornblende, and brown mica, though certain phases may be termed granodiorite or granite, from the presence of orthoclase and quartz. Some of the rock is considerably altered, the feldspar being clouded and the hornblende largely changed to chlorite.

The height of land north of Sherman Creek, together with the basin at the head of Johnson Creek, is composed of massively bedded greenstone, forming a band 2 miles in width, which runs diagonally across the trend of the mountain range. Between this rock and the main mass of the Coast Range diorite there is a narrow band of black slate, which is exposed in the vicinity of the Greek Boy workings. This vein lies in the slate, but appears to follow the contact with the diorite. In the greenstone band there are a few narrow dikes of fine-grained white aplite and others of dark-green basaltic rock younger than the

[a] 1903.

aplite. The white dikes which occur well away from the edges of the greenstone band follow an obscure bedding in the volcanic rock, with which the diorite contacts on either side are likewise essentially parallel. The basalt dikes usually run across this structure.

OCCURRENCE OF VEINS.

In the Berners Bay district all the veins which have been considered worthy of development are included in or occur along the contact of the wedge of diorite, which occupies the valley of Johnson Creek and the basin at the head of Sherman Creek and extends along the base of the steep mountain to the shore of Lynn Canal. The single exception is the Greek Boy lode, which lies along the contact of the main diorite a mile or so inland from the northeast boundary of the diorite wedge.

None of the veins have been thoroughly studied, but several properties were cursorily examined and some of the more general geologic relations of the veins may be discussed.

The veins or lodes may be divided into three varieties, distinguishable by the manner in which they occur in the country rock. Most of them are contained in well-marked fissures running transverse to the general country strike. Mining and prospecting on these veins has shown that most of them strike in a northerly direction, varying from N. 20° E. to N. 20° W., with dips from 60° to 75° E. They are usually solid bodies of quartz from 2 or 3 up to 8, 10, and 12 feet, rarely more, in width. The walls are usually perfect and frequently show the presence of soft gouge. The veins of this type are limited horizontally by the closing of the vein walls, though in some instances at least the fissure continues beyond the end of the filling. Where the walls come together the diorite is always much altered and passes into chlorite schists, evidently produced by the mashing of the rock and the recrystallization of its minerals.

The gold occurs both native and associated with sulphides, the proportion of free-milling metal varying, however, greatly in different veins and to a less extent in different portions of each vein. On the basis that the ore must contain about $4 per ton to pay for mining and treatment, it has been found that pay shoots are rather well defined. Commonly the shoots are small, so that in several of the veins the values are said to be bunchy. In the case of the Comet mine, which has so far been the largest producer, a well-defined pay shoot lying diagonally in the vein was mined to a depth of about 1,000 feet, but even in this shoot much of the gold occurred in nests or bonanzas.

A second type of occurrence is shown in the Kensington and Eureka lodes, which are stockworks or fracture zones in the diorite, filled with vein stuff and comparable in a way with the Treadwell deposits on Douglas Island. These zones of broken rock filled with intersecting veins of quartz carrying sulphide minerals vary in width up to at least 100 feet, and one of them was reported in 1904 to have been opened at a depth of 1,400 feet for a length of about 200 feet.

The third sort of lode is distinguished from the other two by occurring along the contacts of the intrusive bodies of diorite. The two examples noted are the Johnson lode, at the head of Johnson Creek, where the rock next to the diorite is greenstone, and the Greek Boy, which is a complex aggregate of veins occurring in black slates next to the boundary of the main diorite. At the Johnson property there is a zone of mineralization following the somewhat irregular contact of the greenstone and diorite, but lying mainly in the intrusive rock. Quartz occurs in many sharply defined veins which run diagonally out from the contact, and while these are irregularly spaced the rock between them often contains a network of intersecting veinlets. The rock carries considerable pyrite, and this mineral also impregnates much of the diorite where it is broken and filled with quartz.

The Greek Boy is a good example of a strong stringer lead, since it is composed of many small, nearly parallel or branching veins separated by plates of the slate country rock.

The examination of the Berners Bay district in 1903 was made in three or four days, mainly for the purpose of determining the desirability of more detailed study in the region, and as Mr. C. W. Wright plans to study this district during the season of 1905 descriptions of the different properties are not given here.

A RECONNAISSANCE OF ADMIRALTY ISLAND.

By Charles W. Wright.

INTRODUCTION.

In preparing the following report upon Admiralty Island the principal aim has been to point out the general distribution of the mineral deposits and their commercial importance, to describe the different rock formations exposed on the island, and as far as possible to provide a geologic guide for the prospector.

The field work bearing upon this report was done in July, 1904. At this time all of the important mines and prospects on the island were visited, as were also the coal deposits at Kootznahoo Inlet and Murder Cove. Notes were gathered, mainly from the shore exposures, for a general geologic map of the island, and when time permitted topographic sketches were also made.

The writer wishes to express his gratitude for the many valuable suggestions of Mr. Alfred H. Brooks, under whose supervision this work was carried on; also to Dr. Arthur C. Spencer and Dr. Fred. E. Wright for their hearty cooperation and help.

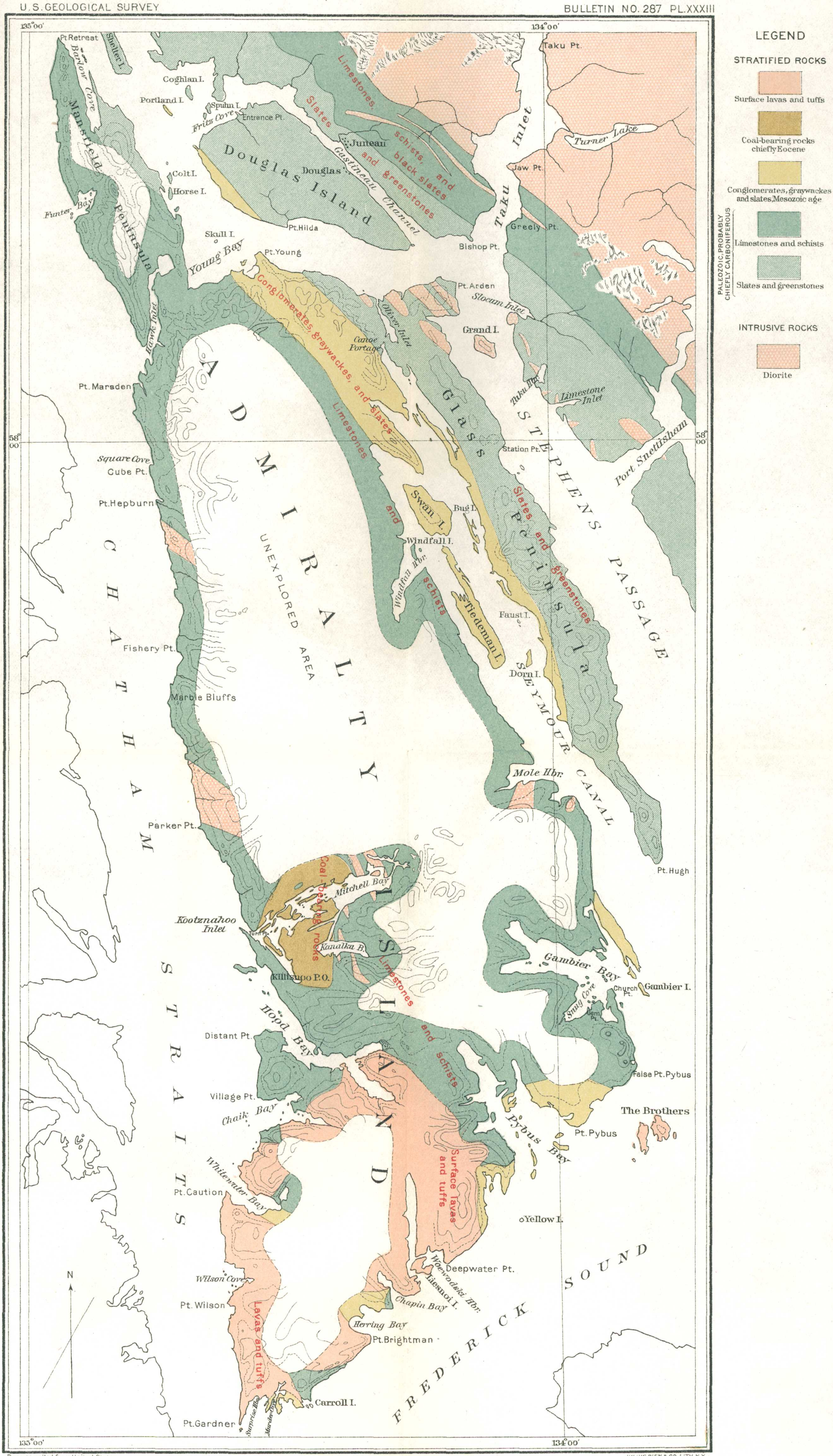
GEOGRAPHY.

Admiralty Island, one of the largest islands of the Alexander Archipelago, lies adjacent to the mainland south of Juneau. Its latitude ranges from 57° to 58° 30′ and longitude from 133° 50′ to 135°. The island is completely surounded by inland channels, no portion of it beng directly exposed to the Pacific Ocean. It is a mountainous mass of very irregular outline, separated from the mainland by Stephens Passage and from the seaward islands by Chatham Strait. Its shore line is indented by numerous bays and inlets, characteristic of the entire coast. (Pl. XXXIII.)

The island as seen from the channels presents a bold and rugged relief. Within short distances of the coast the land often rises to elevations of 2,000 to 4,000 feet. Dissecting these mountain ranges are fiords which form narrow inlets and bays in the coast line. There are no glaciers on the island and snow remains during the summer months only in the gulches leading to the highest altitudes.

A northward view from a summit in the central portion of the island reveals a relatively flat area dotted with many lakes; to the south the general aspect is that of rugged, precipitous mountains forming spurs of strikingly uniform height. Low passes traverse the island from Mole Harbor and Windfall Harbor to Kootznahoo Inlet. To the north comparatively narrow valleys are prominent between the declivities of the small mountain ranges, which follow a general northwesterly direction. The mountain peaks average 3,000 feet in elevation, though a few ascend to over 4,000 feet.

Rocks of varying structure and hardness occur distributed in narrow belts or occasionally broader zones trending northwest-southeast. This disposition of the formations has largely controlled the erosive processes. The upturned edges of resistant schists, limestones, and occasional intrusive masses persist above the general level and form the hills, ridges, and mountain peaks. The areas of soft shales, sandstones, and other less resistant rocks are marked by lowlands, deep valleys, and ravines.



Base compiled from United States Coast and Geodetic Survey map.

JULIUS BIEN & CO. LITH. N.Y.

GEOLOGIC SKETCH MAP OF ADMIRALTY ISLAND, ALASKA

By C. W. Wright
1903

Scale
5 0 5 10 miles

Contour interval 1000 feet
Dotted line 500-foot contour

1905

In common with the greater part of southeastern Alaska, this island has been covered during a recent epoch by glacial ice, to the action of which many of the minor topographic features, such as lake basins and rounded mountain summits, can be attributed.

The general northwest-southeast trend of the valleys and small mountain ranges on the island corresponds to that of the entire coast of southeastern Alaska, and to the broader structural features of the rocks.

GENERAL GEOLOGY.

The component rocks of Admiralty Island are of many sorts and occur in very complex associations. They have been formed in part by deposition beneath the sea and in part by intrusion of igneous masses, as well as by eruption from volcanoes. All of them except the youngest have been subjected to metamorphism of greater or less extent.

The division of these rocks is based in the main upon their lithologic and structural differences. A complete classification can not be attempted until the stratigraphic succession of the rocks in southeastern Alaska is better known than at present.

GEOLOGIC MAP.

For purposes of description and cartographic representation the rocks of Admiralty Island have been thrown into somewhat arbitrary groups, which are designated by different colors or patterns on the accompanying geologic map. (See Pl. XXIII.) The base of this map is chart No. 8050 of the United States Coast and Geodetic Survey. Since the observations on which this report is based were almost entirely confined to the shores, the distribution of the various groups of rocks in the central portion of the island can not be given. Localities of metalliferous deposits and of coal prospects are indicated by appropriate signs.

STRATIFIED ROCKS.

The stratified rocks of Admiralty Island may be divided into two groups, separated by a conspicuous unconformity. The first group—the metamorphosed rocks—includes the bedded rocks which have been intricately folded and in general highly metamorphosed. The second group—the nonmetamorphosed rocks—is made up of relatively flat-lying and practically unaltered beds which rest upon the upturned edges of the older rocks. These main groups have been subdivided in accordance with their lithology. In the older, closely folded complex there are two Paleozoic divisions—one composed of slate and greenstones, the other mainly of limestones, cherty limestones, and schists—and one Mesozoic division, composed of conglomerates and slates. In the second group the coal-bearing series of late Mesozoic and early Tertiary age has been separated from lava flows which lie above it.

Surficial deposits of glacial and stream origin have no areal importance on the island, and in no place have they been found to carry gold. They will, therefore, not be considered in this report.

A comparison between the geologic formations and the occurrence of ores in southeast Alaska and northern California shows a striking likeness. In the United States Geological Survey folios on the California district by Lindgren, Turner, and Ransome,[a] two main divisions of the stratified rocks have been made, namely, the "Bed-rock series," which corresponds to the metamorphosed rocks of Admiralty Island and the "Superjacent series," which is equivalent to the group of nonmetamorphosed rocks, as here defined.

UNCONFORMITIES.

Two important geologic unconformities are exhibited in the sedimentary rocks of Admiralty Island. The older of these is shown by the great difference in age between the fossils in the conglomerates and slates and those in the underlying rock beds; also by the structural relations of the former to the latter as exhibited on the southeast side of the island at Herring Bay, and by a somewhat greater amount of general metamorphism in the limestones and schists than in the conglomerates and slates.

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[a] Geologic Atlas U. S., folios 51, 63, 66, etc., U. S. Geol. Survey.

The second unconformity is at the base of the coal-bearing strata. These relatively recent nonmetamorphosed rocks rest upon the upturned and eroded edges of both the Paleozoic strata and the Mesozoic conglomerates and slates. This relation is well exhibited at several points in Kootznahoo Inlet, near the central portion of the island, where the Tertiary coal beds are in contact with the Paleozoic limestones. The lavas which cover the greater part of the south end of the island may also be regarded as unconformable in a way, since they have flowed out over an eroded surface and in different places rest on strata belonging to nearly all of the sedimentary groups.

STRUCTURE.

The simplicity of arrangement of like rocks in parallel bands, which is found on the mainland, is not so apparent on Admiralty Island, though the wider features still show this relation. The older schists have been closely plicated and compressed, and the resulting isoclinal folds, a thousand feet or more in width, are well exposed along the shore line. The axial trend of these arches is ordinarily N. 30° W. and their pitch is usually 10° to 20° SE. A characteristic schistose or slaty structure has everywhere been developed along with this wrinkling. The planes of schistosity on the sides of the folds correspond closely with the bedding planes of the original sediments, but near the arches the secondary cleavage cuts across the bedding and in certain sorts of rock the latter is often completely obliterated. The strike of the bedded rocks is in general northwest-southeast, with steep northeasterly dips, though the direction of strike may vary widely within small areas, especially in the vicinity of igneous intrusions.

An epoch of erosion followed this period of intricate folding, after which other sedimentary rocks were deposited, and still later flows of lava were extruded. Thus the older upturned beds are locally concealed and their continuity across the island is interrupted.

In the following pages the areal distribution of the rocks composing Admiralty Island will be briefly described, but because of the incompleteness of the data obtained the grouping of the rocks here given is only tentative. Investigations must be made on the neighboring islands and on the mainland to the northwest before the extent and age relations of these rocks can be definitely established.

METAMORPHOSED ROCKS.

Under the general heading of metamorphosed rocks is included all of the older bed-rock complex, which is made up of strata varying considerably in appearance, composition, and origin. The rocks comprise both igneous and sedimentary beds, originally deposited in a horizontal position, which have been greatly disturbed and for the most part considerably metamorphosed. The limestones have been crystallized into marble; the clay and shale beds have been changed to slate and graphitic mica schists, usually termed "black slates;" the sandstones have been altered to graywackes and quartzites, and the beds of massive greenstone and tuff have often been rendered schistose, and their primary constituents are invariably replaced by secondary minerals. Portions of these beds, however, have not been subjected to this extreme metamorphism, so that fossil remains are sometimes found. The paleontologic evidence has been sufficient to determine that the geologic age of these older strata ranges from Silurian to lower Cretaceous.

These altered rocks are disposed in bands parallel to the general northwest trend or long axis of the island and to the mainland of southeastern Alaska. Frequently changes in the dip of the beds are caused by the presence of alternating anticlines and synclines. The intricate folding of these strata is a striking record of compressive forces in the earth's crust acting in a northeast-southwest direction. From the structural relations between the Mesozoic rocks and those of upper Paleozoic age it is apparent that folding along practically the same axes must have taken place both before and after the deposition of the conglomerates and slates, which in some places are so closely interfolded with the older rocks that they appear to be interbedded with them.

Intruding this older complex are wide masses of coarse-grained grey diorite similar to that of the Coast Range on the mainland; also dikes of andesite, basalt, and related rocks. These are described below under the heading of "Intrusive rocks."

The metamorphosed rocks compose by far the greater portion of Admiralty Island and also of southeastern Alaska. To the prospector they are of the greatest interest, since they form the inclosing rock of most of the important ore deposits.

SLATES AND GREENSTONES.

The slate and greenstone group comprises the rocks occurring in close association on the eastern side of Admiralty Island, where they cover almost all of Glass Peninsula. These rocks form a prominent feature along the coast of the mainland and on Douglas Island, just north of Glass Peninsula. The group is made up mainly of greenstone, which is altered andesite, or diabase, but there are some beds of volcanic tuff and occasionally beds of carbonaceous shale now altered to graphitic sericite schist.

On Douglas Island these greenstones are usually massive, but on Glass Peninsula they are ordinarily rather schistose, though massive and schistose bands are often found in alternation. The strike of the secondary structure is northwest-southeast, and the dip, though steep, is usually inclined to the northeast. From fossils occurring in limestone beds associated with similar interbedded greenstones and slates at Taku Harbor, just across Stephens Passage from Glass Peninsula, the slate-greenstone aggregation is regarded as of Carboniferous age.

Slate.—The rocks here designated slate might perhaps be more properly termed phyllite or even schist, since the metamorphism which they show exceeds that of ordinary roofing slates and their cleavage is irregular or wavy, rather than straight. The name is, however, a convenient one, and being in general use throughout the region, is here retained for the black laminated argillaceous or clayey beds, which alternate with the limestones or greenstones of Admiralty Island and compose a considerable part of the bed-rock complex both here and on the adjacent mainland. These black slates were originally carbonaceous shales, but graphite and mica have been developed in them as a result of metamorphism. In many places they carry numerous veins or stringers of quartz or calcite and they are locally impregnated with pyrite. Both sorts of mineralization are accompanied by gold in greater or less amounts, though up to the present no mines have been developed.

Greenstone.—A bedded rock of either massive or schistose structure, of porphyritic to fine-granular texture and green in color, is here designated by the general term "greenstone." The component minerals, most of which are secondary, are in the main amphibole, epidote, chlorite, calcite with some quartz, and magnetite. The original plagioclase feldspar is usually altered to zoisite and muscovite, and the pyroxenes are changed to amphibole. These minerals vary greatly in amount, and so the rocks themselves range from a comparatively massive though altered andesite to amphibolite, actinolite schist, and calcareous chlorite schist.

The occurrence of the greenstones, intercalated as they are with the sedimentary beds, suggests that they represent extrusions of igneous material thrown out over the sea bottom as a molten lava and in the form of loose fragments or volcanic tuff. In no place does the rock occur unaltered, and in many cases it is impossible to determine whether the schistose beds were originally of massive or fragmental character. Often, too, the strata of tuff have become indurated, so as to greatly resemble truly massive rocks.

Under the microscope the less-altered amphibolite shows plainly its derivation from igneous rocks of the type of augite-andesite or diabase. Under the influence of pressure the augites become converted into amphibole and the whole rock is filled with minute needles of the same mineral.

A rock type intermediate between black slate and amphibole-schist is of common occurrence and has been designated as slaty amphibole-schist. An intimate mingling of igneous and sedimentary particles in this rock indicates the addition of volcanic material during ordinary sedimentation. Narrow beds of much squeezed schistose conglomerates are interstratified in the greenstone schists. These were observed outcropping at but one locality and, so far as known, are of no great areal importance.

The greenstones of Admiralty Island occur mainly in a belt including the greater portion of Glass Peninsula, but rocks of similar appearance are also irregularly involved with the limestones and schists in other portions of the island, though for the most part these latter are intrusive.

LIMESTONES AND SCHISTS.

The group of limestones and schists is made up of complexly-folded strata, which can not be divided at the present time. Their separation from the slates and greenstones which lie to the northeast is based on differences in the predominating rock types. No contact of these two divisions was observed, but their relative distribution is shown on the map.

Mica-schist, phyllite, and limestones are the principal rocks in this division, though quartzite is found in many places in relatively small amounts.

The presence of many anticlines and synclines in the structure of these beds is a prominent feature. The axial trend of these folds is N. 20°–40° W. and they vary in width from 500 to 2,500 feet. Along the west shore north of Killisnoo each of several small coves marks the position of a synclinal fold, giving a topographic expression of geologic structure. This feature is most strikingly shown at Point Hepburn, Square Cove, Point Marsden, and along the east shore of Hawk Inlet.

Limestone.—The limestones are all metamorphic—that is, they have been altered from their original condition. In most cases both the bedding planes and the included fossil remains have been destroyed and the rock is changed to a white, fine-grained marble. This crystallized limestone forms more or less extensive strata in the midst of other metamorphic rocks. It occurs both in narrow beds and as lenticular areas several miles in width. In many places the limestones pass by insensible gradation into calcareous and siliceous schists. Along the west shore of the island beds of marble are exposed for a distance of 5 miles, and similar occurrences may be observed at many other points. This marble is accessible to transportation and, though not of uniformly good quality, some of it may prove of value as a building stone.

Quartzites.—Quartzites are metamorphosed siliceous sandstones and differ from the latter principally in their greater hardness. In some cases, however, they are closely associated with the limestones and may be due to siliceous replacement of calcareous material. Their occurrence is similar to that of the limestone, being interstratified with other metamorphic rocks, though they are found in much narrower belts. They were particularly noted along the shore north of Pybus Bay, at Herring Bay, and on Carroll Island.

Schists.—Under this general term are included rock beds varying greatly in composition and appearance. They are in the main of sedimentary origin, though some—the gneissoid rocks and occasional strata of amphibole-schist—have probably originated from granites or diorites. They have been formed by the thorough metamorphism or recrystallization of sandstones, shales, and igneous rocks under pressure. These schists embrace a series from rather coarsely crystalline varieties to others that are excessively fine grained and resemble slates. The most prominent and abundant minerals in the mica-schists are quartz, calcite, muscovite, biotite, and chlorite, with considerable amounts of feldspar, variable proportions of garnet, magnetite, and numerous other minerals. These minerals are present in all degrees of relative abundance. Quartz sometimes largely predominates, so that the schists grade into quartzite; again calcite or dolomite becomes abundant and the beds are classed as calc-schist, which may grade into schistose marble. The micaceous minerals, either muscovite, sericite, biotite, chlorite, or talc, invariably lie in irregular layers parallel to the schistosity. These schists occupy the greater portion of Mansfield Peninsula and are prominent along the north shore of the island.

Phyllite.—The fine-grained mica-schists which approximate slates are usually termed phyllites and are distinguished from the slates in that they show the development of a finely crystalline texture because of the extreme metamorphism they have undergone. These beds are often finely wrinkled. Phyllites are distributed over the greater portion of the island, being particularly noteworthy along the west shore of Seymour Canal.

Age.—The determination of the age of these oldest stratified rocks rests upon fossils gathered at Pybus and Herring bays.

The following is an abstract of a report upon the Paleozoic fossils from Admiralty Island by Dr. G. H. Girty:

> The fauna from point at southeast entrance to Pybus Bay, Admiralty Island, which also seems to occur at point on divide between Chapin Bay and Herring Bay, Admiralty Island, is without doubt Upper Carboniferous in age, and probably can be designated Permo-Carboniferous. This fauna is known to be at but one other point in Alaska—Porcupine mining district—where some of the same species were obtained last year. This fauna also is entirely dissimilar from those of the Mississippi Valley and Appalachian region and finds nearer affinities in those of western United States and of eastern Europe (Russia).

On the west side of Admiralty Island, at Marble Bluffs, 10 miles north of Killisnoo, is a wide belt of limestone in which no organic remains were found, though numerous fossils, both of upper Silurian and of Lower Carboniferous age, were obtained from the probable continuation of the belt on the west side of Chatham Strait. At Taku Harbor on the mainland, fossils of Carboniferous age were collected from a limestone belt, associated with slates and greenstones supposed to correspond with those of Glass Peninsula.

CONGLOMERATES, GRAYWACKES, AND SLATES.

Between the two foregoing rock divisions and the one classified under the present heading there is a considerable unconformity. This important fact, bearing upon the geologic history of the whole region, is recognized by a lesser degree of metamorphism in the conglomerates and associated beds than in the members of the older divisions; by the very common occurrence in the conglomerates of pebbles derived from the underlying rocks; locally by the resting of certain beds of the conglomerate upon the eroded edges of limestone strata, and by the presence of lower Cretaceous fossils in the younger beds.

The rocks of the conglomerate-graywacke-slate divisions are folded in with the older formations, but the relations which have been stated indicate, first, that the older rocks had been considerably folded, compressed, and metamorphosed before the younger were formed; and, second, that similar though somewhat less intense folding and compression followed the deposition of the lower Cretaceous beds.

The fossils which are mentioned in the following pages show that this series corresponds in age with the "Mariposa beds" of the "Mother Lode District" in California, a fact which furnishes a key for correlating the geologic events which have a bearing upon the deposition of the metalliferous veins in the two regions.

The strata of conglomerate, graywacke, and slate occur at Pybus and Herring bays and on the lower end of the island, but they are mainly developed along the shores and on the islands of Seymour Canal. Their northern continuation is found on Point Young, and they are also present on Portland Island, northwest of Douglas Island. At Yankee Cove, on the mainland, about 8 miles south of Berners Bay, rocks of similar appearance are found which may belong to the same series, though they seem to be interbedded with the slate-greenstone division. No similar beds were observed along the north shore of Kupreanof Island.

Conglomerates.—The conglomerates of this division appear to represent ancient beach gravels and consist of an assemblage of greenstone, granite, quartz, slate, limestone, and schist fragments interbedded in a dark-colored siliceous groundmass. In some cases pressure has flattened the smaller rock fragments and pebbles of these conglomerates, though the larger pebbles or cobbles do not show distortion. The conglomerate varies from a coarse sandstone to one with cobbles 4 to 6 inches in diameter. Followed along their strike, the beds of conglomerate often pass irregularly into sandstone and slate. The component pebbles are of course older than the conglomerate itself, and this fact proves that such igneous rocks as granite, greenstone, and melaphyre were present in the region previous to the lower Cretaceous period of deposition. Fragments of limestone, slate, and greenstone are recognized as having come from the underlying formations which are now exposed in the region.

Graywacke.—The term graywacke is here employed for a metamorphosed sandstone composed of quartz, feldspar, slate, and other rock and mineral fragments. It is generally a tough, compact rock of a dark-gray color. The difference between it and the quartzite of the older strata is in the degree of alteration. If this same sandstone had been subjected to the same dynamic and other forces which produced the quartzite, a similar rock would probably have resulted.

Slate.—As the sandstones during metamorphism pass into graywackes or quartzites, so the shales and clays become slates when not so thoroughly recrystallized as to yield phyllites or mica-schists, which are characteristic of the older strata. The distinctive difference between slates and shales is the possession by the former of a new cleavage that may lie at any angle with the original bedding of the rock. Slates predominate in this series. and in Pybus Bay and west of Point Young, on the north end of the island, they are exposed for a width of nearly a mile. In Seymour Canal they occur interstratified with the conglomerates and graywackes.

Dike rocks.—Dikes, usually of small size, are abundant intruding the conglomerate, graywacke, and slate strata both along the bedding plane and cutting it. Their width ranges from 2 to 12 feet, and apparently they have no general direction of trend or dip. They vary from acidic andesites to basic basalts and are of a light-gray to black color. Their texture is always porphyritic, and often feldspar or amphibole crystals occur as phenocrysts in the groundmass.

Age.—The geologic age of these beds is known from fossils occurring in the slates on the north shore of Pybus Bay and in the conglomerate beds a few miles to the north. The determination of these fossils was made by Dr. T. W. Stanton, who reports as follows:

> The specimens of *Aucella* from Pybus Bay, Admiralty Island, are apparently referable to species that in California and adjacent States are characteristic of the lower Cretaceous, *Aucella piochii* occurring in a lower zone than *Aucella crassicollis*. The Alaskan specimens probably also come from the lower Cretaceous, although strict correlation is rendered somewhat hazardous by the fact that the genus *Aucella* with similar specific forms ranges down into the upper Jurassic.

These beds are thus open to the same question of exact age as the Mariposa beds of California, but the two can be directly correlated with something more than probability.

NONMETAMORPHOSED ROCKS.

The nonmetamorphosed rocks are the youngest on the island. They comprise an assemblage of conglomerates, sandstones, and coal seams, together with recent volcanic outflows lying unconformably upon the metamorphosed rocks. The presence of the coal beds indicates that the conditions which obtained during this period of deposition were those of a shallow sea, alternating here and there with swampy land on which accumulated the vegetation for the coal beds. That these beds were laid down subsequent to the main folding of the region is argued from the unchanged condition of the rocks and the slight amount of distortion to which the beds have been subjected. Since their deposition movements of the earth have caused breaking and tilting of the beds, but this deformation of the original horizontal structure is trifling when compared with that of the underlying strata.

COAL-BEARING STRATA.

Conditions favoring the deposition of coal beds with accompanying shales and conglomerates began before the close of the Cretaceous period and continued apparently without interruption through the Eocene epoch or later. This is inferred from the similarity of the upper Cretaceous beds on Kupreanof Island and the Eocene beds of Admiralty Island, comparison of which reveals no lithologic or structural differences, though the contained fossil plants are distinct.

The rocks of this formation have no definite strike or dip, but are characterized by frequent and great deviations in the attitude of their stratification, though the amount of flexing and faulting is moderate. The coal-bearing strata occupy an area of approximately 36 square miles at Kootznahoo Inlet, in the west-central portion of the island.

On the southern end of the island, at Murder Cove, coal beds also occur, but at this locality a basaltic lava or tuff forms the inclosing rock. The relative age of these strata was not determined, but if the lava flows of this area are younger than the Eocene beds of Kootznahoo Inlet—which fact is indicated by the occurrence of the basalt dikes cutting these latter beds and by their almost horizontal position—then the coal beds at this point represent post-Eocene deposits. Occurring in this way the coal would seem to be of limited extent, as it was probably deposited in local basins in the area of lava flows. In all probability the woody material from which the coal has been found either grew in these depressions or was brought in by streams from some near-by source. Mr. Collier [a] describes similar deposits occurring on the Yukon, where the volcanic tuffs which contain the coal are more recent than the Cretaceous beds upon which they rest.

Conglomerates.—The conglomerates of this formation consist, essentially, of slate fragments with pebbles of granite, greenstone, and limestone, varying to several inches in diameter. All of the component rock fragments can be traced to a local source. These beds alternate with those of sandstone and occasional strata of shale.

Sandstones.—Sandstones predominate in the coal-bearing strata and, like the conglomerates, they are made up of rock fragments such as slate and limestone, rather than of mineral fragments. They are generally soft, containing but little quartz, and of a gray color. Cross-bedding—that is, a subordinate bedding inclined to the general stratification—is a characteristic of its structure.

Shales.—As sands give rise to sandstones, so, on hardening and drying, muds and silts yield shales. The shales of this series contain a high percentage of clay and bituminous matter. A small percentage of iron gives them a brown to rusty color upon weathering. They contain numerous fossil plants and in places they grade into beds of bony coal. These shales never form wide belts, and the beds are separated from one another by layers of sandstone.

Coal.—The occurrence of coal on Admiralty Island, except at Murder Cove, is in beds from 3 inches to 3 feet in thickness, interstratified with seams of carbonaceous shale or sandstone. The coal varies from a black lignite to a bituminous coal. Its commercial qualities will be discussed under "Economic geology" (p. 147).

Age.—The age of these beds was determined by Dr. F. H. Knowlton, who makes the following statement on fossils gathered at Kootznahoo Inlet:

> So far as I am able to judge from the fragmentary nature of the leaves they * * * indicate the so-called Arctic Miocene as the age.

The "Arctic Miocene" is equivalent to the Eocene epoch.

Beds lithologically similar outcropping in Keku Strait on Kupreanof Island were determined by the same authority as follows:

> These plants indicate beyond question that the age is Cretaceous, and I would place them in the lower part of the upper Cretaceous, or approximately of Cenomanian age.

This determination furnishes the later age limit for the period during which the great folding of southern Alaska occurred, the earlier limit being indicated by the presence of lower Cretaceous (*Aucella*) fossils in the youngest rocks involved in the disturbance.

SURFACE LAVA FLOWS.

Subsequent to the Eocene epoch of deposition basaltic eruptions occurred. The greater portion of these basalt flows were extruded over the southern portion of the island, filling the then existing valleys and submerging the highest mountain tops. These eruptions form a series of lava sheets and bedded tuffs having a maximum thickness of 2,000 feet. The area thus covered has doubtless been greatly reduced by erosion, but at present approximates 240 square miles. The source of this volcanic material was deep seated, the molten rock reaching the surface through hundreds of vents and craters. These vents are now occupied by the many basalt dikes, which may be observed throughout the area cutting the Eocene and

[a] Collier, A. J., Coal resources of the Yukon, Alaska: Bull. U. S. Geol. Survey No. 218, 1903.

the older strata and sometimes even the lava beds themselves. The positions of the volcanic craters were not observed, though that such did exist is highly probable because of the interstratified beds of volcanic breccia and scoria, the occurrence of which would be difficult to explain otherwise. The lava beds are not folded, but they show a general dip of 5° to 10° NW. The individual layers, which may be recognized on the mountain declivities by their difference in color, vary from a few feet to tens of feet in thickness.

The post-Eocene lavas of Admiralty Island are porphyritic rocks varying in color from gray-green to gray-black and in composition and texture from that of a basic andesite to a normal basalt. Porphyritic textures are usual, although other textural phases have been developed locally. Amygdaloidal structure, with fillings of delessite, chalcedony, calcite, and a zeolite which is probably stilbite, is characteristic of some beds.

The only mineral components visible to the unaided eye are phenocrysts of plagioclase and occasionally pyroxene. The microscope reveals further magnetite and rarely olivine and quartz; also a brown zeolitized glass in several of the thin sections. Alteration products are calcite, epidote, muscovite, chlorite, and serpentine. The phenocrysts of feldspar often show marked zonal structure and grade in composition from acidic andesine to basic labradorite. In the groundmass the plagioclase is usually more acidic. Compared with the pyroxene the feldspar occurs in larger amounts.

The red surface weathering is a feature which distinguishes these lavas from other rocks in the region.

INTRUSIVE ROCKS.

The principal intrusive rocks of southeastern Alaska are diorites, which invaded the field during middle Cretaceous time, after the earlier rock beds had assumed their present folded condition. They were formed under deep-seated conditions, and have been exposed as the result of great erosion. These diorites occupy extensive areas on Admiralty Island, forming belts which interrupt the regular structure of the bedded rocks. The period of invasion is determined by the fact that the diorites cut into the lower Cretaceous beds, and because the structure of the sedimentary rocks has in so great a measure determined the boundaries of these intrusive masses. The nonmetamorphosed rock beds are known to have been deposited after the intrusion, and numerous pebbles of the diorite are scattered throughout the upper Cretaceous and Eocene conglomerates.

This rock corresponds in composition and probably in age to the Coast Range intrusives which are described by Doctor Spencer elsewhere in this bulletin (p. 13).

The areal distribution of the diorite, so far as observed, is represented on the map, though other masses may occur in the unexplored portions of the island. This rock is prominent along the west shore of the island, where, in two instances, outcrops extend 4 to 8 miles. The long axes of these belts are usually parallel with the trend of the inclosing formations, and some of them probably extend for many miles in a northwest-southeast direction.

Other intrusive rocks of much less areal importance are gabbro, diabase, andesite, and basalt, occurring usually in small dikes. While some of these dike rocks are probably older than the diorite masses, many of them are younger, but their relations are not definitely known.

SUMMARY.

The rocks of Admiralty Island, aside from those of intrusive origin, fall naturally into two broad divisions, based upon the degree of metamorphism which they show. The older, greatly folded and highly altered rocks, which cover all but a small part of the island, range in age from Silurian to lower Cretaceous and comprise schists, limestones, slates or phyllites, and greenstones in the Paleozoic section, and conglomerates, sandstones or graywackes, and slates in the Mesozoic portions. Both the Paleozoic and the Mesozoic beds are closely folded and considerably metamorphosed, but the latter have been altered somewhat less than the former and there can be no doubt that an important unconformity exists between them. The lower Cretaceous rocks occur in a strip along Seymour Canal and at Pybus Bay. Fossils which they contain justify their correlation with the Mariposa beds of California.

The nonmetamorphosed rocks rest upon the upturned and eroded strata of the older formations, occurring in two separated areas, about Kootznahoo Inlet and on the island's southern end. As shown by fossil plants, the Kootznahoo rocks are of Eocene age and correspond with the Kenai beds of other parts of Alaska. They comprise conglomerates, sandstones, and shales and contain several beds of coal. The rocks of the second area are entirely different in character from those just mentioned, consisting almost entirely of bedded volcanic tuffs and lava flows, though at Murder Cove coal deposits are intercalated with the accumulations of fragmental volcanic material.

Coarse-grained granitic or dioritic rocks, large masses of which invade the metamorphosed formations of Admiralty Island, are regarded as contemporaneous with the intrusive complex of the mainland Coast Range. Everywhere throughout southeastern Alaska the invasion of these rocks appears to have followed the last important folding, and on Admiralty Island the date of this disturbance can be fixed as later than lower Cretaceous. The period of intrusion was also earlier than Eocene and thus corresponds with the period of granodiorite invasion in the Sierra Nevada.

ECONOMIC GEOLOGY.

GOLD.

Although gold associated with sulphides is widely distributed over Admiralty Island in quartz veins, there are but few known localities which show such a concentration of the metal as to make valuable deposits. At only one locality have mining operations been advanced beyond the prospecting stage, or, in other words, beyond the annual assessment developments required by law. The prospects are few and scattered, and the mineralization is widely and irregularly distributed. Along only one line has it been possible to designate a mineralized zone of noteworthy continuity. This supposed belt includes the Funter Bay mines and the Mammoth group of claims, 12 miles to the southeast, on the divide between Young Bay and Hawk Inlet. Some 15 miles farther southeast, on the west side of Seymour Canal, 4 miles north of Windfall Harbor, is a prospect which is a possible continuation of the same belt, though the intervening ground has not been prospected.

Other prospects occur at Gambier Bay and on the west side of the island 20 miles north of Killisnoo. In the outcrops of the older rock series along the shore numerous mineralized quartz stringers and veins are exposed, but in the main these are too small to be of economic importance.

The origin and the date of fissuring, the vein systems, and the classification of the ore deposits of the Juneau district have been discussed in detail by Doctor Spencer in the foregoing pages, to which the reader is referred. Most of the mineral deposits on Admiralty Island occur in quartz-filled fissures, usually of no great lateral or vertical extent, or in quartz stringers or small veins, interlacing the country rock and constituting stringer leads. The permanency of the vein fillings in depth has not been determined by mining, but from the nature of the vein fractures it is believed that the leads will not change essentially within the depths ordinarily attained in mining operations.

The properties under development are favorably situated, most of them being easily accessible from tide water. The availability of water power and the abundant supply of timber on the island are favorable to mine development.

The mines on Admiralty Island have been prospected since 1885. The irregularity with which they have been operated and the small returns obtained from them make it impossible to state the production of this area. However, it probably has not exceeded $15,000.

DESCRIPTION OF LOCALITIES.

FUNTER BAY.

TOPOGRAPHY AND GEOLOGY.

Funter Bay forms a harbor on the east side of Chatham Strait, 10½ miles south of Point Retreat, the northernmost point of Admiralty Island (fig. 38). At its southeast entrance and in the bay are several small islands. The largest is Station Island, about 75 feet in elevation; the second in size is Gauge Island, at the head of the bay; the others are mostly bare islets and reefs. The surrounding land is densely wooded and hilly, though there are some comparatively flat areas. To the southeast are mountains which rise nearly to 4,000 feet, and on their slopes many of the prospects are located. A cannery, a store, and a post-office with weekly mail service via Juneau are situated at the head of the bay on the northeast side. The principal mines all lie south of the bay.

The geology of the region, as noted from the exposures along the shore, is comparatively simple. The rocks are essentially highly metamorphosed and intricately folded limestones and interstratified greenstone schists belonging to the old metamorphosed complex. Intruding these schistose rocks is a series of diabase and andesite dikes from 5 to 10 feet in width,

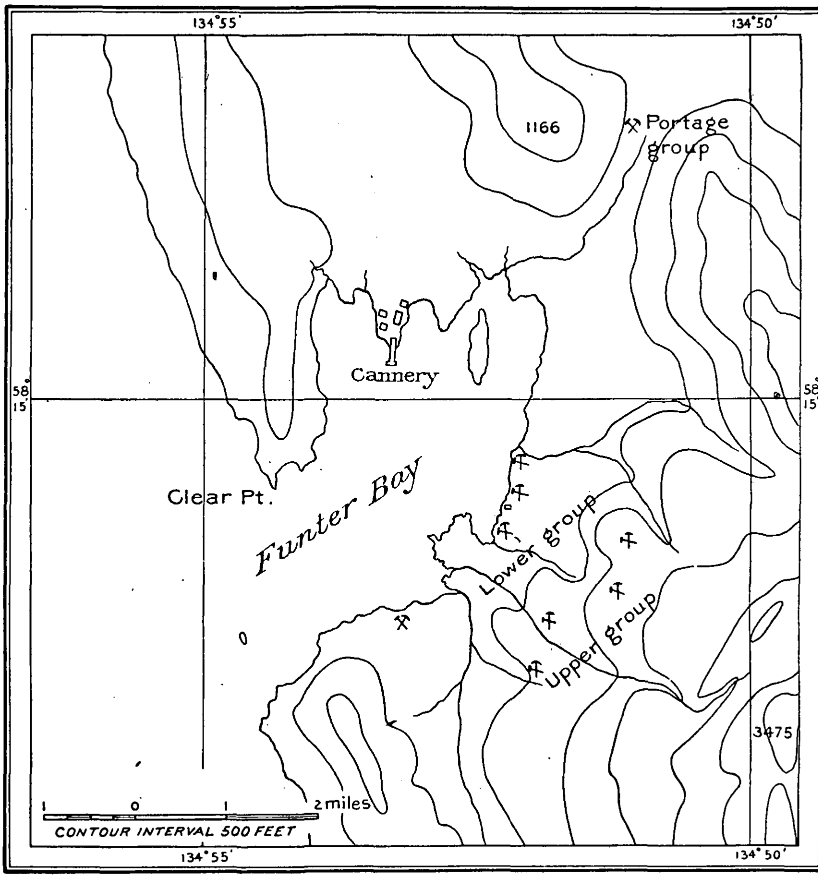


FIG. 38.—Map showing location of mines and prospects at Funter Bay.

striking generally N. 60° E. Near the contact of these dikes quartz stringers are common. Folds striking N. 20°–40° W. and pitching at a low angle to the southeast are prominent in the bedded rocks. Fracturing has accompanied flexing of the beds and frequent faulting is observed displacing the strata for a few feet.

Two systems of quartz veins are prominent. The one on which most of the prospecting has been done consists of quartz stringers and narrow fissures striking N. 60° E., with nearly vertical dips. The much larger ledges of the second system strike N. 10° W., as shown at the Portage group of claims, 1½ miles from the head of the bay and in the prospects on the southeast side of Funter Mountain. The quartz ledges are confined principally to the phyllites and greenstone schists. In the belts of limestone quartz veins are not of common occurrence and at one point a quartz vein which was well defined in the schist pinched out in a short distance after passing into the limestone. Following along their strike the ledges often change from a vein several feet wide to a thin stringer.

FUNTER BAY MINING COMPANY.

The holdings of the Funter Bay Mining Company include most of the prospects located on the south slope previous to 1902. They embrace two large groups aggregating 58 claims. The lower group borders the shore line and includes the Tellurium, Uncle Sam, King Bee, Lone Star, and other claims. The upper group, about 1 mile from the shore, includes the Mountain Queen, Washington, Heckler, Patterson, and other less important claims. Most of these represent separate quartz ledges which have been developed to a greater or less extent.

The first discoveries at Funter Bay were the Tellurium group made in 1887 by R. Willoughby and C. Wier, of Juneau, but development in excess of the minimum legal requirements was not begun until 1894. In that year a Huntington revolving mill and a Frue vanner were installed at the Tellurium mine in order to thoroughly sample the ore, and favorable returns were reported from this experiment. In the following year the Alaska Willoughby Mining Company bonded the property and installed a 10-stamp mill with four Frue vanners. They continued operations in 1895–96 and later sold their properties to the Funter Bay Mining Company, which continued developments on the many claims. In 1904 this company failed to do assessment work and many of their holdings were relocated by outside parties.

The Tellurium ledge, located close to the water's edge, is a quartz-filled fissure crosscutting an amphibole-schist country rock. It varies from 3 to 10 feet in width and has been traced for several hundred feet in a N. 65° E. direction. The greater part of the gold contents is in a free state, the rest being associated with pyrite and pyrrhotite. Calcite occurs with the quartz as a gangue mineral. Telluride minerals are not known to occur. On the Lone Star claim, to the east, a quartz vein parallel to the Tellurium ledge has been opened by a 60-foot tunnel. Two other ledges on adjoining claims have been exposed by short cuts, but their extent and value are still undetermined. The underground workings of the lower group of claims have been confined principally to this Tellurium ledge. It has been opened by two shafts, each a hundred feet in depth, with a connecting drift. It is reported that 1,800 tons of ore of a good average value have been mined from the ledge in open trenches and underground.

A wagon road more than a mile in length leads from the lower group over a swampy tract 60 feet above tide water to the foot of the steep mountain slope where the claims of the upper group begin. The uppermost workings of the Heckler group lie somewhat more than 2,000 feet above tide level. The developments of these upper ledges consist of various open cuts and prospect shafts. On the Patterson claim a 70-foot shaft has been sunk on a quartz ledge several feet wide. The work on the Washington claim consists of a short tunnel following a 2-foot ledge. On the Heckler claim a tunnel 50 feet in length exposes a narrow ledge at 900 feet elevation. At an altitude of 2,000 feet on Heckler No. 2 claim a large cropping of quartz has been explored by a tunnel and open cut, and at one point this vein is said to be 30 feet in width. Its length has not been determined.

Adjoining the upper group of claims of the Funter Bay Mining Company on the south is the Geyser claim, with a tunnel 275 feet long, and the Tingwalla claim, with a tunnel 125 feet long—both on narrow ledges which in places are represented only by thin seams of quartz.

KEYSTONE GOLD MINING COMPANY.

The property of this company, generally known as the War Horse mine, is located 1 mile southeast of the Tellurium group, close to the shore of Funter Bay.

The Keystone Gold Mining Company undertook the development of this property in 1897 and again in 1900, but since that time no important improvements have been made. The quartz ledge, which averages about 2 feet in width, is rich in free gold finely disseminated throughout the quartz. The workings consists of two shafts 48 and 125 feet deep, besides 320 feet of drifting along the vein. Shipments of sorted ore are said to have yielded over $100 per ton.

PORTAGE GROUP.

The Portage group is situated about 2 miles from the head of Funter Bay, from 400 to 700 feet elevation. At the lower workings is an irregular vein apparently composed of a succession of lenticular quartz masses inclosed in slate. The strike of the lead corresponds with the northwest strike of the slaty structure, the dip being nearly vertical. The vein carries considerable pyrite and chalcopyrite with small amounts of galena, but assays are said to show that the ore is of low grade. A small shaft and open cuts expose the quartz at several points. Up the hill above these workings prospecting was being done on a belt of mineralized schist similar in appearance to that which has been more fully exposed at Young Bay. This is exposed across a width of 30 feet and has a N. 10° W. strike and dip NE. 65°, the foot wall being defined by an unmineralized and massive greenstone, the hanging wall by a gradual decrease in mineralization.

YOUNG BAY.

The continuation of the Funter Bay mineral belt is probably represented by the Mammoth group of mines, situated 12 miles southeast of Funter Bay and 4 miles south of Young Bay, at 2,600 feet elevation (Fig. 39). The ore deposit, however, differs from most of those at Funter Bay in that the schist country rock is heavily mineralized, while quartz-

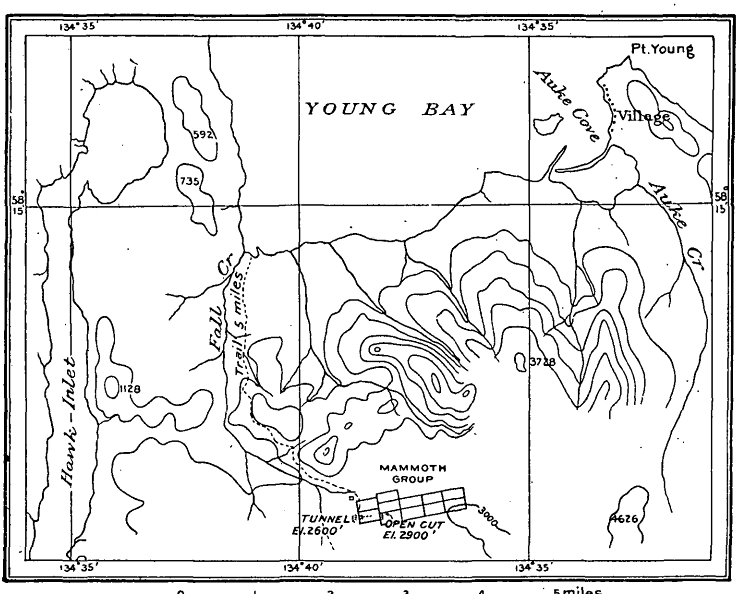
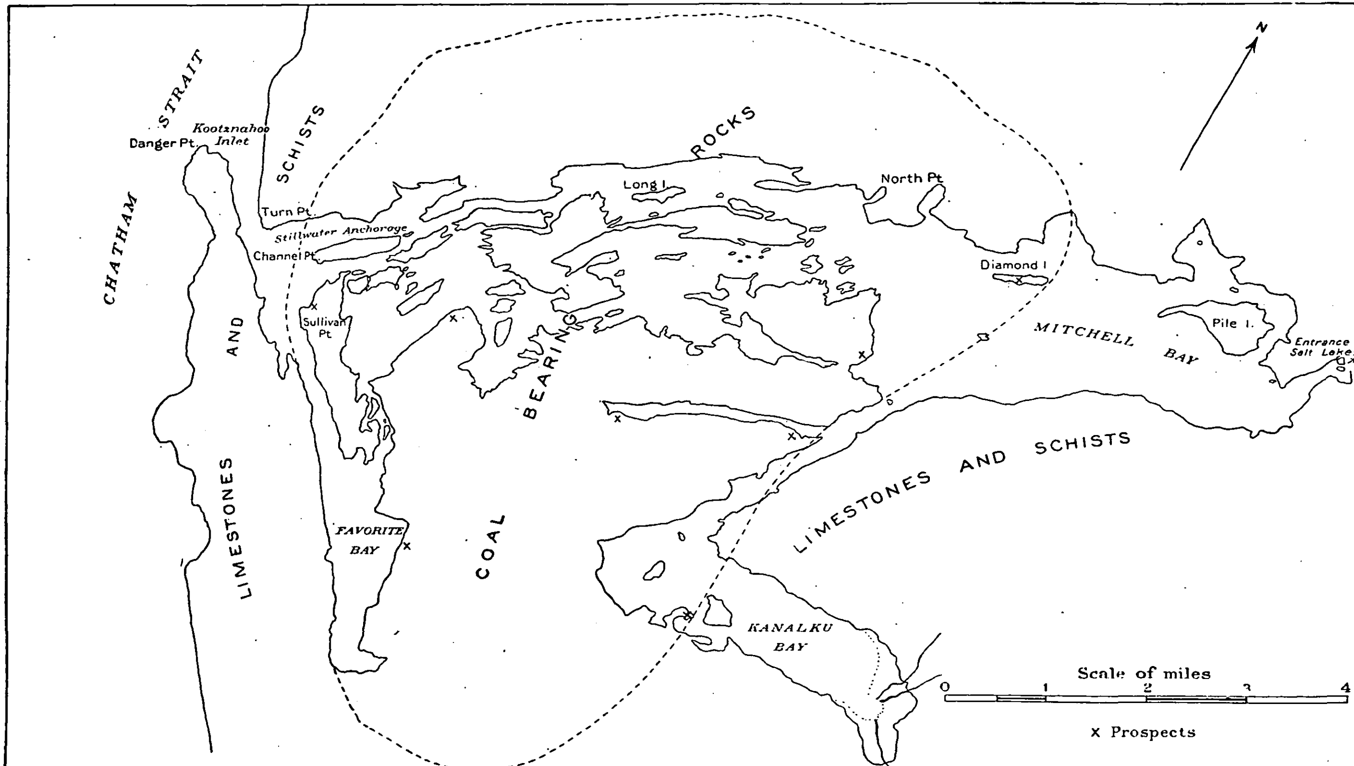


FIG. 39.—Map showing location of Mammoth group, Young Bay.

filled fissures are of very minor importance. The strike of the schistosity is N. 25° W. and dip NE. 75°. The schist is heavily impregnated with pyrite across a width of a few hundred feet, and in addition the rock is traversed by many narrow seams filled with galena and sphalerite. With these minerals native gold is sometimes observed. Developments comprise a tunnel 165 feet in length and many surface pits and trenches. During the summer of 1905 a careful sampling of this mineral belt was made, but the results are reported as unfavorable.

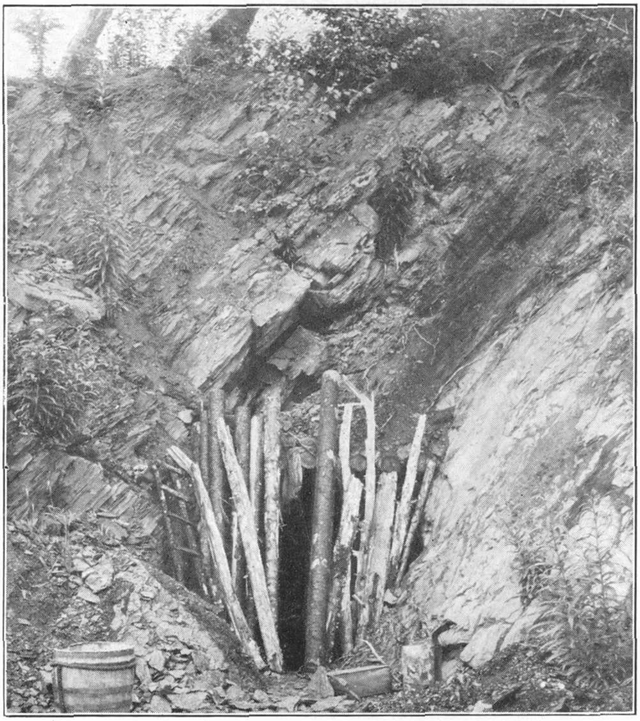
SEYMOUR CANAL.

On the west side of Seymour Canal, 4 miles north of Windfall Harbor, a deposit of copper-bearing pyrite is exposed in a quartz-mica schist of sedimentary origin. These sulphides have been introduced with veinlets of quartz along the strike of the schist and form a mineral



MAP OF KOOTZNAHOO INLET, ADMIRALTY ISLAND.

Showing location of coal prospects (X).



A. COAL PROSPECT ON EAST SIDE OF DIAMOND ISLAND, MITCHELL BAY.

B. COAL PROSPECT ON SOUTH SIDE OF MITCHELL BAY.

zone 20 feet in width. This is located close to the water's edge and has been prospected by a 60-foot shaft and a 25-foot drift crosscutting the ore body. The low percentage of copper and small gold values in the ore have not encouraged further developments. The extent of the mineralization along the strike has not been determined.

GAMBIER BAY.

At the head of Gambier Bay, a wide inlet south of the entrance to Seymour Canal, several mine locations have been made. On the north slope of Cave Mountain, which forms the divide between the two arms, is the Brown prospect, located 1,000 feet above tide water. The ore deposit is inclosed in a calcareous schist country rock and consists of a ledge in places several feet in width, striking northwest, parallel with the side of the mountain. The ledge has been exposed by an open cut 25 feet in length and also by several smaller cuts, which show that it is continuous for more than 200 feet along its strike. The ore body has the appearance of a brecciated limestone partly replaced by quartz stringers and by small masses of pyrite and chalcopyrite. A few assays were reported which gave small values in both gold and copper, but an average sample of the vein has not yet been tested.

On the south slope of Mount Gambier, opposite the Brown prospect, locations were made on both copper- and gold-bearing ledges by Mr. F. Cook, but the development is slight, and nothing has been done upon the claim during the past few years.

FISHERY POINT.

Southwest of the Funter Bay mineral belt is a second zone, along which ore deposition appears to have occurred. This is exposed at Point Hepburn and 1 mile east of Fishery Point, where the President group of four claims is located. On this group, situated 250 feet above sea level, three ledges composed of quartz and mineralized schist have been discovered. These are reported to average 30 feet in width and are separated from one another by two narrow belts of barren schist. The ledges follow the trend of the country rock, striking northwest and dipping southwest. The sulphides contained are principally pyrrhotite, pyrite, and chalcopyrite, accompanied by small amounts of galena and sphalerite. Several cuts expose the ledges on the surface and a shaft has been started to investigate them in depth.

COAL.

The existence of coal beds on Admiralty Island has been known for many years, and early though unsuccessful attempts were made by the Navy Department to locate workable deposits here. Later in the nineties considerable private prospecting was undertaken in Kootznahoo Inlet, north of Killisnoo, and at Murder Cove, east of Port Gardner, resulting in the location of various coal seams. In 1895 Dr. W. H. Dall visited the prospects in Kootznahoo Inlet and has given a detailed description of them.[a] At this inlet (see Pl. XXXV) the coal beds are interstratified with conglomerates and sandstone, and vary from a few inches to a few feet in thickness. The physical character of the coal varies with the locality. As encountered in mining it is usually crushed and of a somewhat granular structure. Large masses break rapidly into small fragments and disintegrate after short exposure to the air. The coal is of a brown-black to black color; it usually has a dull luster and an uneven to semiconchoidal fracture. As noted by Dall, grains of fossil resin or amber are abundant in some of the coal seams, and it is stated that the extraordinary heat generated by the combustion of this resin rapidly destroys grate bars and boiler pipes.

The following table of analyses is taken from Doctor Dall's report:[b]

[a] Dall, W. H., Coal and lignites of Alaska: Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, pp. 769-908.
[b] Op. cit., p. 783.

Comparison of Kootznahoo coals.

Claim.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.
McCluskey	2.44	44.75	47.93	4.88	0.67
Sepphagen	1.66	35.40	31.80	31.14	.32
Point Sullivan	.82	21.83	41.80	41.80	.51
Mitchell	2.37	31.73	35.01	35.01	.47

It will be observed that the percentage of both moisture and sulphur is very low. This low percentage of water is due to the fact that the coal samples were not sealed. The high percentage of ash is noteworthy, and with but one exception—namely, that from the McCluskey mine—the supposed coal seams may be regarded as carbonaceous shales. From the character of the coal noted by the writer at the McCluskey mine it appears that the above analysis does not represent the quality of an average sample and that the percentage of ash should be higher.

Many thousands of dollars have been spent prospecting the Kootznahoo deposits, some of the miners having the idea that the narrow coal seams would become wider in depth or that the small beds were derived from more extensive deposits below. There is, however, no foundation for this supposition, and the contrary is more likely to be the case. Most of the properties have been abandoned, and no work was done during 1904-5.

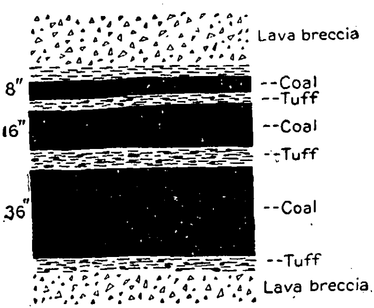


FIG. 40.—Section of coal bed at Murder Cove.

At Murder Cove the inclosing rock of the coal beds consists of basaltic tuff and lava. On the surface this volcanic tuff and breccia is much decomposed, and is locally termed a sandstone or conglomerate. This occurrence has already been described under the heading "General geology," and a discussion of the economic conditions follows.

DESCRIPTION OF LOCALITIES.

MURDER COVE.

Murder Cove forms a narrow inlet 2 miles in length in the southernmost portion of Admiralty Island. Just inside the entrance of the bay are several islands, beyond which the channel contracts to a width of 100 yards and then opens to form a sheet of water which at high tide is half a mile wide and a mile long. This inner bay forms a well-protected harbor for vessels of moderate size.

The first discovery of coal in this vicinity was reported in 1868 by Capt. J. W. White, of the United States revenue steamer *Waywanda*, but it was not believed to exist in commercial quantities. Later, in 1885, the coal seam now exposed was discovered and opened by two tunnels over a hundred feet in length, but the beds proved to be broken and faulted, though the coal was of good quality. This deposit is located 500 feet above sea level and 2 miles from the head of the bay. In 1900 developments were again renewed by the present owners. The coal is bituminous, with a low percentage of ash and no visible amount of "sulphur." The beds have been slightly folded and crushed and in mining the coal breaks into small fragments. The coal lies in three benches, separated by narrow seams of tuff and impure coal. The total width of the seam averages 5 feet and that of the partings about 1 foot. Both the floor and roof of the coal beds are of an indurated basaltic tuff, so that but little timbering is necessary (fig. 40).

The above section through the coal bed was taken at the head of the inclined shaft. The trend of the bed follows the curvature of the drift shown in the diagram of the workings, but it has not been traced beyond these limits (fig. 41). The inclined shaft followed it at an angle of 25° for a distance of 100 feet, at which point the coal bed was found to be displaced. The shaft was continued at a somewhat steeper angle for 80 feet and at this depth the surrounding rocks were crosscut and the coal bed was relocated. During the writer's visit to this property the shaft was filled with water, no work having been done within the past three years.

It is very doubtful whether this property can ever make a profitable mine. The crushed nature of the coal and the irregularity of the structure are unfavorable, as well as the situation of the deposit. Before shipments of the coal can be made a tramway from the mine to the shore must be built and a wharf erected. These conditions do not encourage further development at Murder Cove.

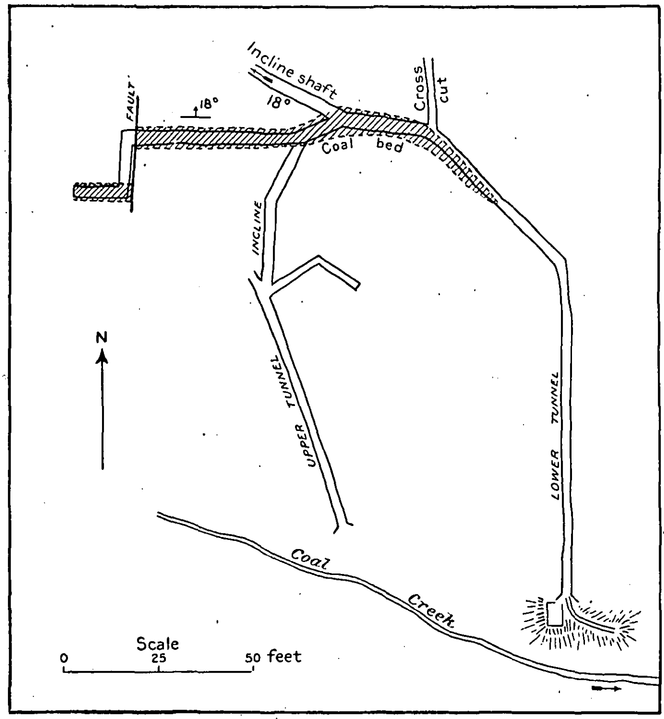


FIG. 41.—Plan of mine workings at Murder Cove.

KOOTZNAHOO INLET.

TOPOGRAPHY.

Kootznahoo Inlet, comprising an area of about 15 square miles, is an intricate group of narrow passages, lagoons, and bays, on the eastern shore of Chatham Strait, having its entrance 3 miles north of Killisnoo. (Pl. XXXIV.) It is full of rocks and reefs, and the tidal currents rush with great velocity through the narrow passages. Navigation should be attempted only by small vessels of short length and ready turning qualities, and by them only at slack water, under the guidance of a pilot thoroughly acquainted with the inlet. The accompanying map, for which the writer is indebted to the Coast and Geodetic Survey, presents the shore line and reefs of Kootznahoo Inlet with much accuracy. On it the location of the coal seams and prospects has been designated.

The general elevation of the surrounding land is less than 100 feet, and the channels seldom exceed 20 fathoms in depth. At the head of Mitchell Bay is a narrow entrance to several salt lakes, which, because of the tidal currents, can be entered only at high slack water. These continue inland for some miles, and from the northernmost lake a low area extends across the island to Mole Harbor.

The areal extent of the coal-bearing rocks is represented on the map by a dotted line. They are underlain and surrounded by rocks of the limestone-schist series, previously described.

MITCHELL BAY.

There are two coal prospects in this bay. On the east side of Diamond Island an inclined shaft 30 feet in depth exposes a bed 2 to 3 feet in width, interstratified in the sandstone. The strike of the bedding plane is N. 52° W. and the dip 45° SW. (Pl. XXXV, *A*). The coal is of poor quality because of the slate mixed with it.

In a small bay just north of the entrance to Davis Creek a 3-foot bed of coal containing several shale partings has been prospected by a tunnel 28 feet in length. (Pl. XXXV, *B*). The strike at this point is N. 40° W. and the dip 35° NE. In the shale many fossil plants were obtained.

Lighter Creek forms a narrow arm southwest of Mitchell Bay. Near its mouth the Meade and Mitchell seams are exposed by short tunnels, and 1½ miles to the southeast is the Brightman and DeGroff seam. None of these are of value, and all of them have been abandoned.

KANALKOO BAY.

The only locality in Kootznahoo Inlet where coal has been found in beds of considerable thickness is in a small cove on the south side of Kanalkoo Bay. This is generally known as the Firestone or McCluskey claim. The surface croppings are along the beach, where the beds were first prospected by narrow ditches. These exposures are now mostly concealed by sand and gravel wash. The developments include an inclined shaft 180 feet in depth at an angle of 35°, following the coal bed. At this depth the deposit is reported to have a total width of 12 feet, containing about 7 feet of coal and 5 feet of interbedded shale. When this property was visited the shaft was full of water, no work having been done during the last few years.

FAVORITE BAY.

At Sullivan Point, near the entrance to Favorite Bay, a shaft was sunk on a coal seam from 2 to 3 feet thick. At a depth of 80 feet the width of the vein did not increase, and work was stopped.

On the east side of Favorite Bay is the Sepphagen claim, which consists of a worthless coal seam exposed close to the water's edge. A small shaft was sunk here, but the property has been abandoned since 1895.

SUMMARY.

The coal deposits of Admiralty Island have no present or prospective commercial value. This statement is based on the thinness of the coal beds, their irregularity of structure, the crushed character of the coal, and its poor quality.

MARBLE.

The limestone belts of Admiralty Island have been noted on the geologic map. Certain parts of these masses have been converted into marble, some of which is sufficiently massive and even grained to make an excellent building stone, even if not fit for ornamental purposes. Large slabs or columns probably can not be obtained owing to its systems of joints. On the west side of Admiralty Island, opposite Tenakee Inlet, a mass of marble forms the shore rock for a distance of 8 miles. It is easily accessible, and for this reason it may prove to be of economic value. The marble is not a pure limestone, but contains bands rich in dolomite. It has a fine granular texture, a white to light-gray color, and often a banded appearance.

Other smaller belts of marble occur at Chaik Bay to the south, and at Gambier and Pybus bays, on the southeast side of the island.

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