COPPER MINING AND PROSPECTING ON PRINCE WILLIAM SOUND.

By U. S. GRANT and D. F. HIGGINS, Jr.

INTRODUCTION.

In 1898 two geologists of the United States Geological Survey visited Prince William Sound; one examined the extreme northwestern part of the district,[a] and the other made an examination of a considerable part of the sound and described several copper prospects.[b] In 1900 further information concerning the geology and copper deposits was obtained.[c] In 1905 a more detailed reconnaissance of the general geology and mineral resources was made, a preliminary report of which has been published.[d] In 1907 further information concerning the progress of mining and prospecting was obtained.[e] In 1908 the writers continued the work of 1905 and completed a detailed topographic and geologic map of part of Latouche Island. A report on the general geology and mineral resources of the sound is now in preparation.

Prospecting for copper on the shores of Prince William Sound dates back for some years, but it was not continuous until 1897, when the recent period of activity may be said to have begun with the staking of the claim on which is now situated the Ellamar mine. Prospecting was especially active from 1903 to 1907, but declined in 1908, after the fall in the market value of metallic copper, comparatively little development beyond the necessary assessment work being undertaken except at some properties on Knight Island, on Fidalgo Bay, and in the vicinity of Copper Mountain.

The following descriptions are confined chiefly to properties on which considerable development work has been done since the report

[a] Mendenhall, W. C., A reconnaissance from Resurrection Bay to the Tanana River, Alaska, in 1898 Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 265-340.

[b] Schrader, F. C., A reconnaissance of a part of Prince William Sound and the Copper River district, Alaska, in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 341-423.

[c] Schrader, F. C., and Spencer, A. C., The geology and mineral resources of the Copper River district, Alaska; a special publication of the U. S. Geol Survey, 1901, 94 pp

[d] Grant, U. S., Copper and other mineral resources of Prince William Sound: Bull. U. S. Geol. Survey No. 284, 1906, pp. 78-87.

[e] Moffit, F. H., Notes on the copper prospects of Prince William Sound: Bull. U. S. Geol. Survey No.: 345, 1908, pp. 176-178.

of 1905. There are, however, numerous prospects which are not mentioned in that report nor in the present one. In 1906 and 1907 many claims were staked at various places on the sound, especially on Knight Island. New discoveries were made on the south side of Fidalgo Bay and on and to the east of Cordova Bay, but on the latter little work was done. Only two properties—the Ellamar mine, at Ellamar, on Virgin Bay, and the Bonanza mine, on Latouche Island—are making regular shipments of ore. Each of these mines has been in operation for a few years.

A preliminary map of the mineral resources of the Prince William Sound region constitutes Plate IV of this volume.

LATOUCHE ISLAND.

Bonanza mine.—This mine has continued shipping since 1903, steadily increasing its output. A dock, ore bunkers, an office, and mess and bunk houses have been constructed, and two tramways have been built from the dock to the mine, about half a mile distant. The mine is in the main a large, open hill face, from which the ore is quarried and run down to two tunnels, one 30 feet and one 120 feet below the quarry floor. The ore is then trammed from these tunnels to the dock. Aside from the open quarry the development work includes about 3,700 feet of tunnels.

Latouche Copper Mining Company.—This company's property is situated about half a mile north of the Bonanza mine. A dock, ore bunkers, mess houses, and a tramway from the dock to the tunnel, a distance of a quarter of a mile, have been built. The property has been developed by numerous shallow pits and trenches, and by a 700-foot tunnel which strikes the ore-bearing ground 200 feet below the surface. The ore is rock charged with chalcopyrite and some pyrrhotite and pyrite. Most of the ore removed has come from one stope, which is 45 by 15 feet in area and 5 to 10 feet in height. Several hundred tons of ore are reported to have been shipped in 1907, and there is some ore remaining in the bunkers.

Chicago-Latouche Mining and Power Company.—At the head of Wilson Bay this company has installed a pipe line and an electric power plant and is engaged in running a tunnel east-southeastward, with the expectation of cutting a continuation of the Bonanza ore bed to the south-southwest. In July, 1908, this tunnel had reached a length of about 1,400 feet.

Reynolds-Alaska Development Company.—On Horseshoe Bay this company has built a small town, installed a pipe line and electric power plant, and constructed over a mile of corduroy road from its dock eastward to its shaft and tunnels. The shaft, reported to be 100 feet deep, with a crosscut at its bottom to an ore body, was full of water at the time of the writer's visit. About half a mile northeast

PRELIMINARY MAP
SHOWING
MINERAL RESOURCES OF
PRINCE WILLIAM SOUND REGION, ALASKA
AND ADJACENT TERRITORY
FROM
RESURRECTION BAY TO THE COPPER RIVER DELTA

Compiled from United States Coast and Geodetic Survey charts; published maps of the United States Geological Survey; and material sketched by U. S. Grant and D. F. Higgins, Jr., for the United States Geological Survey, comprising most of the west and north sides of the sound. Solid lines indicate more definite information; dotted lines are approximate.

5 0 5 10 15 20 miles

1908

LEGEND

- ✕ Copper mine or prospect with extensive developments
- ● Copper prospect
- □ Gold prospect
- △ Antimony prospect

KEY TO PLATE IV.

COPPER MINES AND PROSPECTS.

Ellamar district.

1. Ellamar mine.
2. McNaughton.
3. Rua & Frodenburg; Wagner; Falck; Schage.
4. Reynolds-Alaska Development Co.
5. Fielder & Hemple.
6. Simonstad & Hendrie.
7. Galena Bay Mining Co. (Millard).
8. Galena Bay Mining Co. (Millard).
9. Tibbits & Wilson.
10. Copper Crown.
11. Standard Copper Mining Co. (Bourke & Steele); Grove.
12. Hemple.
13. Reynolds-Alaska Development Co.; Spaulding; Barre.
14. Three Man Mining Co. (Dickey).
15. Three Man Mining Co. (Dickey).
16. Three Man Mining Co. (Dickey).
17. Three Man Mining Co. (Dickey).
18. Dolan & Ryström; Dolan & Wagner.
19. Chisna Consolidated Copper Co. (Griffith).
21. Fidalgo Alaska Copper Co. (Schlosser).
22. Neversweat; Manhattan.
23. Shamrock; Arley; Bratton.
24. Merchant, Bell & Larson; Roosevelt; Birdie.
25. Fidalgo Mining Co. (Blakney); Simonstad & Larson.
26. Whalen & Nelson.
27. Bratton.
28. Guthrie & Bellola.

Cordova district.

29. Ellis, Boone & Ibeck.
30. Ellis, Boone & Ibeck.
31. Ellis, Boone & Ibeck.
32. Kelly & Macormac.
33. Flynn & Scott properties.
34. Kippin & Co.; Kinney; Diggs.
35. Flynn & Co.
36. Flynn & Co.
37. Revenue.
38. Tansey groups.
39. Tansey groups.
40. ———.
41. Flynn & Co.
42. Armstrong.
43. U. S. and Mountain groups.
44. Dalton, Boswell & Lowe.
45. Cordova Copper Co.; Rioux.
46. Emerald.
47. Boswell & Lowe.
48. Rosencrans & Co.
49. Shepard & Macpherson; Kelly & Van Slack; Diggs & Tremble; Brown & Collins; McKenna & Kiffin; Flynn & Co.
50. Flynn & Co.
51. Hanson & Co.; Flynn, Holt, Brown & Collins; Kelly, Diggs, McKenna & Tremble.
52. Hanson & Co.; Flynn, Holt, Brown & Collins; Kelly, Diggs, McKenna & Tremble.
53. Wash & Waskey.
54. Wash & Waskey.
55. Boswell, Holt & Flynn.
56. Boswell, Holt & Flynn.
57. Ibeck, Ellis & Boone; McMurphy; Diggs.
58. Scott & Ibeck.
59. Harris; Ibeck; Richards.

Latouche Island district.

60. Latouche Consolidated Copper Company (Tibbits).
61. Seattle-Alaska Copper Co.
62. Latouche Island Copper Mining Co. (Murphy).
63. Latouche Island Copper Mining Co. (Murphy).
64. Reynolds-Alaska Development Co.
65. Reynolds-Alaska Development Co.
66. Chicago-Latouche Mining and Power Co. (Bazard).
67. Chicago-Latouche Mining and Power Co. (Bazard).
68. Bonanza Mine.
69. Latouche Copper Mining Co. (Barrack.)
70. ———.
71. Hogg.
72. Hogg.

Knight Island district.

73. Happy Jack Copper Mining and Development Co.
74. Hogan, Hemple & Egan.
75. James Mullins Coal Co. (Wilson).
76. James Mullins Coal Co. (Wilson).
77. Kilbourn.
78. Schultz.
79. Harvey.
80. Harvey.
81. Hendrix, Reavley & McMasters.
82. ———.
83. Graham & Harrison.
84. Graham & Harrison.
85. Bettles.
86. Sponberg, Sanberg & Simpson.
87. Larson.
88. Ericksen & Allen.
89. Moore.
90. Hubbard & Elliott.
91. Russell Ball Copper Co.
92. Grove & Walters.
93. Knights Island Copper Mining Co. (Hemple).
94. Twentieth Century Knight Island Copper Mining Co.
95. Knights Island Alaska Copper Co.
96. Hemple.
97. Knights Island Consolidated Copper Co. (Hubbard & Elliott).
98. Knights Island Consolidated Copper Co. (Hubbard & Elliott).
99. Copper Bullion (Rua).
100. ———.
101. Wallace, McPherson & Valentine.
102. Fergusson, Johnson & Harvey.
103. Kaczanowski & Wilson.
104. Wallace, McPherson & Valentine.
105. Big Passage Copper Mining Co.
106. Knights Island Mining and Development Co.
107. Crown Copper Co. (Bradford).
108. Crown Copper Co. (Bradford).
109. Malack.
110. Boyle.
111. Malack.
112. Von Gunther.
113. Singletary.

Glacier Island district.

116. Glendinning Mining Co.
117. Byers.
118. Gilnow.
119. Chamberlain.
120. ———.
121. ———.
122. Nelson & Ryström.
123. Jensen.
124. Jensen, Walace & Kilbourn.
125. Nelson.

Seward district.

126. Leitzke.
127. Pitman & Gould.
128. Ellsworth; Reynolds-Alaska Development Co.
129. Peterson.
130. Pitman & Gould.
131. Pitman & Gould.
132. Reynolds-Alaska Development Co.
133. Likes & Frazer.
134. Likes & Frazer.
135. Likes & Frazer.
136. Redman & Guyot.
137. Shaw, Deubruel & Bouchaert.

GOLD PROSPECTS.

Fidalgo Bay.

20. Benzer.

Jackpot Bay.

114. Evans, Cooper & Matson.

Seward.

138. ———.

ANTIMONY PROSPECT.

Port Wells.

115. Bratten, Daniels & Coch.

of the shaft and 400 feet above sea level 2,000 feet of tunneling has been done, most of which is on the Duchess claim. Here a body of ore has been encountered which strikes north-northeastward and dips 70° W. It is only a few inches thick where first encountered at the south-southwest, but thickens gradually toward the north for 500 feet along the strike until a thickness of 45 feet is reached; beyond this point exploration has not gone. The ore body consists of pyrite and some chalcopyrite mixed with bands of slate and graywacke. Considerable sorted ore is on the dump, and small shipments are reported to have been made from this tunnel.

Other prospects.—The above-mentioned properties are on the northwest side of Latouche Island. Other but much less extensive work has been done elsewhere, especially by the Latouche Consolidated Copper Company, which has sunk a few pits near the southeast end of the island; by the Seattle-Alaska Copper Company, which has installed a steam plant and begun the sinking of a shaft on the southeastern shore of the island, a mile and a half from its southeastern point; and by the Latouche Island Copper Mining Company, which has sunk a 60-foot shaft and run a 100-foot tunnel near the southeastern shore of the island, about 4 miles from its northeastern point.

KNIGHT ISLAND.

On Knight Island a considerable amount of development work has been done, mainly in 1906 and 1907. Much of this work was done on or near Drier Bay, on the west side of the island.

DRIER BAY.

Knights Island Consolidated Copper Company.—This company, locally known as the Hubbard-Elliott Company, has installed a wharf, offices, ore bunkers, and a steam power plant at the northeast corner of Drier Bay. Work has been done on a number of claims, but the main development has been on two tunnels called the Monarch and the Bald Eagle. At the Monarch, a mile and a half northwest of the dock and about 600 feet above sea level, about 350 feet of development work has been done. At the Bald Eagle tunnel, which is about 900 feet above sea level and three-fourths of a mile northeast of the dock, is a northwestward-facing cliff with an iron-stained surface. The rock is greenstone with irregular schistose zones that wrap around masses of nonschistose rock. The schistose zones carry chalcopyrite and pyrrhotite, and in some of them these sulphides are abundant and form ore bodies, from one of which a few hundred tons of ore have been mined. Connecting the Bald Eagle tunnel with the dock is a wire rope aerial tramway, the upper station of which was unfortunately somewhat damaged by a snow slide in the early part of

1908. Shipments of ore have been made from this tunnel, and some ore remains in the ore bunkers.

Knights Island Alaska Copper Company.—About 900 feet above sea level and half a mile northeast of Northeast Cove of Drier Bay, this company is running a tunnel to intercept a vein which outcrops on the hill 360 feet above the mouth of the tunnel. In July, 1908, the tunnel had reached a length of 300 feet, and it was thought that the vein would be reached 100 feet beyond. The vein consists of a schistose zone in the greenstone, carrying quartz, pyrrhotite, and chalcopyrite.

Twentieth Century Knight Island Copper Mining Company.—This company has staked nine claims south of Northeast Cove of Drier Bay. The property is developed by a small floating wharf, a bunk house, and two tunnels. The lower tunnel is about 250 feet above sea level and has been driven for 30 feet in greenstone and chlorite schist. A few stringers of chalcopyrite have been revealed. The upper tunnel is about 350 feet above sea level and in July, 1908, was 390 feet long and was still being extended. It follows a 6-foot shear zone containing numerous lens-shaped bodies and stringers of chalcopyrite. At 230 feet from the entrance a raise of 70 feet has been made on this shear zone. The upper tunnel is expected to cut several ore-bearing zones whose outcroppings appear on the hill above.

Knights Island Copper Mining Company.—Development work has been done by this company half a mile southeast of Barnes Cove of Drier Bay. Sidney Paige examined this prospect in 1905 and reported a lens of ore (chalcopyrite and pyrrhotite in greenstone) approximately 30 feet wide and 40 feet high.[a] A tunnel, about 100 feet below this lens, is now being run with the expectation of cutting it. Another tunnel, over 100 feet in length, has been run along a schistose zone carrying quartz, chalcopyrite, pyrrhotite, and pyrite.

Russell Ball Copper Company.—This company's prospect is located on the south side of Drier Bay, between Barnes Cove and Mallard Bay. The company has located six claims, four on Drier Bay and two over the ridge from Drier Bay toward Snug Harbor. The property on Drier Bay is developed by four openings. A wire-rope aerial tram operated by a windlass has been rigged from the upper tunnel to the shore. This tunnel is 520 feet above sea level and is 60 feet long on a vein of nearly solid chalcopyrite with a little pyrrhotite. The vein averages 8 inches in width. Good outcroppings were reported above at an altitude of about 1,000 feet, but these were covered with snow when visited in July, 1908. The other three openings are below and vary from 12 to 30 feet in length. They are intended to cut the vein mentioned above, but have not been driven far enough to strike

[a] Bull. U. S. Geol. Survey No. 284, 1906, p. 85.

it. Some ore is sacked ready for shipment, and a small amount was shipped in July, 1908.

MUMMY BAY.

Mummy Bay is on the southwest side of Knight Island. At H. J. Harvey's prospect, near the northwest corner of the bay, some strippings near the shore have exposed irregular quartz lenses carrying pyrrhotite, chalcopyrite, and pyrite. Three-fourths of a mile from the shore are a few small areas of diabase containing disseminated pyrrhotite and chalcopyrite. These have been prospected by two tunnels, each about 150 feet in length. Near the center of the north shore of the bay, at Charles Schultz's prospect, is an opening 10 feet wide and 30 feet long on a schistose zone containing chalcopyrite and a little pyrrhotite. A few tons of ore have been taken from this opening.

EAST SIDE OF KNIGHT ISLAND.

Happy Jack Copper Mining and Development Company.—This company's property is located on the south side of Hogan Bay, just at the entrance. A steam plant, an office, and mess and bunk houses have been constructed. The main work has been done on a tunnel at the shore, which in July, 1908, had reached a length of 986 feet. It is being run to intersect a vein that outcrops higher up and to the southeast and extends along a fissure, cutting across the strike of the country rocks, which are slates, graywackes, and greenstones. The vein, where examined, varies from 1 foot to 4 feet in thickness and contains quartz, chalcopyrite, and pyrrhotite. Two tunnels have been run on this vein, one 398 feet and the other 535 feet above sea level. The upper tunnel is 85 feet in length and the other, with its branches, is about 450 feet in length. A number of tons of ore are now on the dumps from these two tunnels, and some ore has been shipped.

Wilcox prospect.—This prospect is located near the head of Hogan Bay, Knight Island. It is being opened by the James Mullins Coal Company, of Cleveland, Ohio. Six claims and a fraction are staked. The property is developed by four substantial log buildings and three tunnels. The longest of the tunnels is 1,500 feet from the head of Hogan Bay, at an elevation of 315 feet. It is about 500 feet in length and has one side drift of 50 feet on which work was being done in July, 1908. A few veins and some disseminated chalcopyrite are shown. The second opening is about three-fourths of a mile up the main left-hand gulch at the head of Hogan Bay and about 1,000 feet above sea level. This tunnel is 70 feet long and is designed to crosscut leads whose outcroppings appear in the hill above. Several small veins of solid chalcopyrite were encountered. The third opening was not visited, as it was small and difficult of access.

Hogan, Hemple & Egan prospect.—This prospect is one-fourth mile west of the head of Hogan Bay and has about 130 feet of tunnel, which reveals an irregular vein of chalcopyrite with a little pyrrhotite. Other showings, on which very little work has been done, occur on the mountain side above this tunnel.

Discovery Bay.—On the north side of the entrance to Discovery Bay J. J. Bettles has a prospect on two iron-stained zones that appear at the water's edge. These zones strike north-northeastward and apparently reappear on the south side of the entrance to Delight Bay. The eastern zone is 12 feet in thickness and has on its hanging-wall side 10 to 15 inches of fairly solid ore consisting of pyrrhotite and chalcopyrite. Northeast of Snug Harbor, at the head of Discovery Bay, Graham & Harrison have a 60-foot tunnel in greenstone. Higher up, on the divide between Snug Harbor and Delight Bay, and about 1,300 feet above sea level, they report a vein from 4 to 11 feet in thickness, which has been traced for several hundred feet. The ore shown to the writers from this vein is brecciated and schistose greenstone carrying chalcopyrite and a little pyrrhotite.

Copper Bullion claims.—These claims, locally known as Rua's claims, are situated on the east side of Knight Island, and the development work consists of a tunnel, which had reached a length of 360 feet in July, 1908. This tunnel is about half a mile from the east shore of the island and a mile and a half north of the entrance to Marcia Harbor. The rock excavated in the tunnel is greenstone with a few stringers of pyrrhotite and chalcopyrite, but at the end a brecciated zone cemented by quartz and these two sulphides has been encountered. As far as the workings show, this zone is about 60 feet in width and strikes in a northeasterly direction. About 400 feet above this tunnel, at the base of a southward-facing cliff on the south side of Iron Mountain, is an exposure of ore 65 feet in width. All of this width, except about 10 feet of mixed ore and rock, is practically solid pyrrhotite with a small percentage of chalcopyrite. About 200 feet farther up the cliff the ore body appears to be 30 feet in width, and at the top of the ridge, 150 feet still higher, there is reported to be 12 feet of ore. It seems probable that the tunnel cuts this same ore body.

Bay of Isles.—Near the northwest side of the Bay of Isles is the Snowstone group of claims, and west of the head of the south arm of the bay is the Pandora group of claims. On the Snowstone group are two tunnels, 55 and 25 feet in length, a fourth of a mile from the shore and about 200 feet in elevation. On the Pandora group, half a mile from the water and about 500 feet above sea level, a schistose zone in the greenstone is exposed along a small creek. This zone is 50 feet in width and contains scattered through it a few small stringers of ore and three smaller zones, 5 to 24 inches in width, in

which the ore stringers are abundant. The ore is chalcopyrite with some pyrrhotite. A tunnel here intersects three ore-bearing zones, 2 to 6 feet in width, in the larger schistose zone. A small shipment of ore has been made from this place.

NORTH END OF KNIGHT ISLAND.

Near the head of Louis Bay there are a few prospects. At one of them, controlled by the Knights Island Mining and Development Company, a small steam sawmill and electric plant have been installed at the extreme southeast corner of Louis Bay. From this plant electric drills have been worked in two tunnels 1½ miles south of the south end of this bay. One of these tunnels is 85 feet in length and cuts five schistose zones, 2 to 18 inches in width, in greenstone. These zones carry pyrite, chalcopyrite, and pyrrhotite. The main or lower tunnel was started to intersect these and several other ore-bearing schistose zones, and is 160 feet in length. This company is constructing a small sawmill to be run by water power.

HERRING BAY.

Herring Bay is the large bay at the northwest corner of Knight Island. At the head of its southeastern arm the Crown Copper Company has built two bunk and mess houses and a small floating dock. A quarter of a mile to the south is a tunnel 25 feet in length; and about a mile from the camp and on the east side of a lake is another tunnel 100 feet in length, in greenstone, which was run to intersect some veins that outcrop on the ridge to the northeast. Other prospects are situated on the same arm of Herring Bay, and also on the northeast arm. At the latter locality there is a tunnel 50 feet long in greenstone with cracks filled by quartz, pyrite, sphalerite, and chalcopyrite, which is also disseminated to a small extent in the country rock.

GALENA BAY.

Near the head of Galena Bay the Galena Bay Mining Company has built a small town, constructed a dam that gives a 52-foot head of water, and installed an electric power plant. The electric power is transmitted about 3 miles southward and used to run an air compressor at the mouth of a long tunnel. This tunnel, which is about 750 feet above sea level, is being driven to intersect a large shear zone that outcrops to the east 800 feet or so above the tunnel. In 1905 this tunnel was about 300 feet in length, and in August, 1908, it had reached a length of over 1,500 feet. It is expected that when the tunnel strikes the ore zone an aerial wire-rope tramway will be installed from the tunnel to tidewater, a distance of about 18,000 feet. The material for this tramway is now on the ground.

BOULDER BAY.

Reynolds-Alaska Development Company.—This company has twenty claims located on the east side of the head of Boulder Bay. The property is developed by a wharf, an electric plant, an air compressor, office, and bunk houses, a supply house, a superintendent's house, and about 2,100 feet of drift in the main tunnel and 200 feet of drift in a smaller opening. The main tunnel is at tide water, and is composed of a rather complicated system of crosscuts, winzes, and raises, driven through interbedded greenstones, slates, and graywackes. It is electrically lighted on the main drifts. A few veins of chalcopyrite were encountered. About 150 feet above this system is the smaller tunnel mentioned above. It is in greenstone having locally small quantities of disseminated chalcopyrite. Veins 2 to 3 inches wide also occur, and on the face a foot of ore was present. Just to the right of the main adit is a small excavation from which it was reported several tons of shipping ore were procured. Several hundred tons of ore are said to have been shipped from this property. Some of this ore came from two large bowlders, composed mainly of iron and copper sulphides, which were found on the beach at the mouth of the main tunnel.

Fielder & Hemple prospect.—The claims of this prospect lie at the head of Boulder Bay, and are practically surrounded by the property of the Reynolds-Alaska Development Company, described above. A tunnel and several small crosscuts, aggregating about 200 feet in length, have been run at an elevation of 400 feet and a quarter of a mile from the bay. Some ore is ready for shipment, most of it having been obtained within 20 feet of the surface. Two small excavations, 120 feet above the tunnel, uncover surface showings of chalcopyrite stringers in sheared greenstone.

ELLAMAR.

The Ellamar mine, formerly known as the Gladhaugh, continued shipping in 1908, but the amounts were materially decreased from the customary output. The earlier shipments were derived from a rather poorly defined ore shoot in which the chalcopyrite was more abundant than the pyrite and pyrrhotite, and the later shipments evidently came, in part at least, from outside this ore shoot. It is reported that there is still a large tonnage of this lower-grade ore in the mine. The ore body is a lens-shaped mass of these copper and iron sulphides and has been opened in the 100, 200, 300, 400, and 500 foot levels of the mine. On the 500-foot level the ore body has decreased in size to about 40 by 70 feet, and it pinches out before reaching the 600-foot level. Prospecting for other ore bodies in the

strike of this ore lens is now being carried on by diamond drilling southeast of the mine.

LANDLOCKED BAY.

Standard Copper Mines Company.—This company has constructed a wharf, ore bunkers, an office, etc., on the north side of Landlocked Bay. From the wharf a wire-rope aerial tramway, 2,526 feet in length, leads up the south side of Copper Mountain. Above this tramway is another, 923 feet long, leading to the mouth of a tunnel about 2,000 feet above sea level. This tunnel is run to intercept three ore-bearing zones that outcrop on the mountain above. In August, 1908, it had reached a length of 420 feet. The lowest ore zone is intersected near the mouth of the tunnel, and from this considerable ore has been mined and most of it has been shipped. The second zone is not clearly cut by the tunnel, which at the time of visit was thought to be entering the third zone. These zones are schistose areas in the greenstone of Copper Mountain and they carry lens-shaped bodies of ore. The property has also been developed by several smaller tunnels and strippings.

Three Man Mining Company.—This company has a considerable number of claims, locally known as the Dickey claims, about the head of Landlocked Bay. Most of the development work has been done on the north side of the bay, where numerous tunnels have been run, strippings made, and several veins revealed. Much of the work has consisted of drifting along the veins or of short crosscuts that intersect the veins. The veins are in greenstone, graywacke, and slate, and consist of schistose shear zones carrying chalcopyrite and pyrrhotite. These sulphides occur to some extent in solid, more or less lens-shaped bodies within the schistose rock. The sulphide bodies, which are in places composed very largely of chalcopyrite, vary from a few inches to a few feet in thickness. Small shipments of ore have been made from these claims, and more is now ready for shipment. Most of the work, however, has been devoted to uncovering the veins, and not to getting out ore.

Hemple prospect.—This prospect is located west-northwest of the head of Landlocked Bay. A good trail has been opened to the mess house, 1,500 feet from the shore. At 400 feet above sea level is a tunnel 125 feet in length, the first 40 feet of which is in broken greenstone with numerous small veins of chalcopyrite. A second tunnel, 600 feet in elevation, is about 400 feet long and crosscuts three ore-bearing zones. Some sorted ore is on the dump. Extending 1,200 feet west from this upper tunnel is a series of fifteen to twenty small strippings and pits on a schistose zone in greenstone. Several of these openings show veinlets of ore.

FIDALGO BAY.

Whalen & Nelson prospect.—On the south side of Fidalgo Bay, 7 miles east of Fish Bay, is a smaller bay called Whalen Bay. Two miles east from its head and about 700 feet above sea level are some strippings and a small tunnel. The country rock is a hard black to greenish slate, and the ore is a hard band of nonslaty rock containing irregular stringers and disseminated grains of chalcopyrite and pyrrhotite. This band of ore is 2 to 4 feet in thickness where examined, and it is reported to have been uncovered at intervals for a considerable distance, in some places being 12 feet thick.

Fidalgo Mining Company.—The prospect owned by this company is located on the south side of Fidalgo Bay, a mile southwest of Whalen Bay. Twenty-four claims, known locally as Blakney's prospect, have been staked. A supply house at the beach, a bunk house, and a tunnel are the main developments on this property. The tunnel is 2,800 feet from the shore and 450 feet in length. It follows a well-defined shear zone. Two rather definite lens-shaped ore shoots, each about 5 by 50 feet in cross section, have been struck at 200 and 300 feet from the entrance, and many small stringers of ore, which is chiefly chalcopyrite, occur throughout the tunnel. A small crosscut beyond the second ore shoot shows a 20-inch vein of nearly solid chalcopyrite. Several small strippings have been made on the shear zone, which has been traced for about 3,000 feet. Some ore is ready for shipment.

Fidalgo Alaska Copper Company.—This company's property is on the south side of Fidalgo Bay, south of Fish Bay and half a mile east of Irish Cove. The main development work has been done near the top of a hill which rises about 1,000 feet above the sea. A large amount of stripping has been done, and several short tunnels and two longer ones have been run. The main tunnel has over 400 feet of workings. The country rock is a hard black to gray slate, with a little graywacke. The ore, which is chalcopyrite with a little pyrite, occurs in hard, fractured zones in the country rock as a cement to the fractures, as irregular stringers, as disseminated grains, and as larger replacements of the country rock. These fractured zones are irregular in size and extent; some of them have been proved not to continue far, but the extent of others is not yet shown by the developments. Altogether there is a considerable amount of ore exposed in the strippings and in the tunnels, and some ore is ready for shipment.

GOLD ON PRINCE WILLIAM SOUND.

By U. S. GRANT.

Placer gold in small amounts has been found in a few of the streams flowing into Prince William Sound. Some of these localities are as follows: Solomon Gulch, on the south side of Port Valdez; Mineral Creek and Gold Creek, on the north side of Port Valdez; streams near the front of Shoup Glacier; King River, at the extreme southwest corner of Port Nellie Juan. Only a small amount of work has been done on these placers, and on none of them has the work proved really profitable.

For several years there have been reports of the finding of "float" ore, carrying considerable values in gold, on the shores of Jackpot Bay, west of Chenega Island. Recently (1908) one vein carrying ore of this character has been located on the east side of this bay near its head (the south end). The country rock at this locality is graywacke and graywacke slate, with a general north-northeasterly strike, parallel with the axis of the bay, and a dip of 40° to 60° WNW. A quarter of a mile from the shore of the bay and approximately 770 feet above sea level an opening has penetrated 8 feet into a quartz vein and runs up the cliff side for 12 feet. The vein strikes N. 52° W. and dips 67° W. It is, as here exposed, 20 to 28 inches in width and has a fairly well defined central zone which is rich in metallic sulphides—arsenopyrite, galena, and sphalerite. This central zone is 6 to 11 inches in thickness. Three samples for assay were taken across the outer parts of the vein, and three across the central sulphide zone. The first samples showed 0.5 ounce per ton of gold and 0.3 ounce of silver, or a total value of $11.89 per ton. The second set gave 2.5 ounces per ton of gold and 5.9 ounces of silver, or a total value of $54.73 per ton.[a] Though this vein is small and its extent is not known, still its gold content should encourage further search for gold-bearing veins in this vicinity.

[a] Assays by W. H. Coghill and D. F. Higgins, jr., of Northwestern University.

NOTES ON THE GEOLOGY AND MINERAL PROSPECTS IN THE VICINITY OF SEWARD, KENAI PENINSULA.

By U. S. GRANT and D. F. HIGGINS, Jr.

INTRODUCTION.

Seward is situated on Kenai Peninsula at the north end of Resurrection Bay, in west longitude 149° 27′ and north latitude 60° 6′. This bay (fig. 1) lies between Prince William Sound on the east and Cook Inlet on the west, and extends farther north than any of the other bays facing the Gulf of Alaska between these two large inlets. Seward is of importance as the tide-water terminus of the Alaska Central Railway and the outfitting point for gold fields to the north.

The rocks in the vicinity of Seward have been examined by two geologists of the United States Geological Survey—W. C. Mendenhall,[a] who visited this district in 1898, and F. H. Moffit,[b] who was there in 1904. In August, 1908, the writers spent three days at Seward and in the vicinity examining copper prospects and incidentally obtaining information on the general geology.

GEOLOGY.

Previous descriptions.—Mendenhall[c] has described the Sunrise "series" as consisting of interbedded fine blue-black slates and dark-gray arkoses, which form the country rocks from Seward northward to Sunrise, on Turnagain Arm of Cook Inlet, and from Sunrise eastward to Passage Canal (or Portage Bay) and Port Wells, in the northwestern part of Prince William Sound.

Moffit[d] has described the same "series" of rocks as extending from Seward northward to Turnagain Arm, and stated that it holds a few conglomerate beds containing well-rounded pebbles chiefly of argillaceous rock and granite, with less numerous pebbles of quartzite or quartz; that the cleavage of the Sunrise "series" near Resurrec-

[a] A reconnaissance from Resurrection Bay to the Tanana River, Alaska, in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 265-340.

[b] Gold fields of the Turnagain Arm region: Bull. U. S. Geol. Survey No. 277, 1906, pp. 7-52.

[c] Op. cit., pp. 305-307

[d] Op. cit., pp. 17-18.

tion Bay is in general parallel with the bedding, which is about N. 10° E.; that several massive quartzite beds, from 4 to 6 feet thick, are conspicuous in the vicinity of the glacier east of Seward, about 2 miles from Resurrection Bay; and that the beds at this last locality lie in immense folds slightly overturned to the east.

Below are given some further descriptions of the geology (1) at Seward, (2) from Thumb Cove southward along the east shore of Resurrection Bay to a point opposite the south end of Renard Island, and (3) on Renard Island. These localities are shown on the accompanying map of Resurrection Bay (fig. 1).

Seward.—The town of Seward is beautifully situated on an alluvial fan formed by a stream that comes from the mountains to the west. The eastern mountain just north of this stream is apparently composed of easily disintegrated slates, and the pebbles in the stream bed are mainly of slate and graywacke. On the shore, and also a few rods back from the shore of Resurrection Bay for about a quarter of a mile southwest of the railway dock at Seward, are exposures of graywacke, which varies from coarse to fine in grain and has interbedded with it a small quantity of dark-gray slate. The bedding is not distinct, but apparently the strike is north and south and the dip about 65° W.

Thumb Cove and the shore to the south.—On the north side of Thumb Cove, just west of the main stream near the head of the cove, there are exposures of graywacke somewhat similar to that at Seward. The rock here is much fractured and broken and the fractures are healed by quartz veins of very fine grain, almost chalcedonic in appearance. The strike is N. 18° E. and the dip 40° W. Along the north shore of this cove, west of the above-mentioned locality, graywacke with a little slate exists in several exposures which were not closely examined. The general direction of the dip here is west-northwest, at an angle of 20° to 50°.

The country rock for a mile northeast of Thumb Cove is greenstone, chiefly in flows, which are commonly ellipsoidal[a] and in some places amygdaloidal. The ellipsoidal greenstones consist largely of more or less spherical masses which vary from a few inches to 10 feet in diameter. Here there are a few glaciers, the moraines of two of which were examined and found to contain, in addition to the common greenstone, a number of varieties of coarser-grained igneous rocks, mostly basic. At the mouth of the valley that runs north-northeastward from the northeast corner of Thumb Cove lie many bowlders of rocks similar to those in the moraines, such as medium-grained diabase with red jasper-like veinlets; medium-grained diabase with porphyritic feldspar crystals; light-colored greenstone with

[a] Clements, J. M., The Vermilion iron-bearing district of Minnesota: Mon. U. S. Geol. Survey, vol. 45, 1903, p. 144.

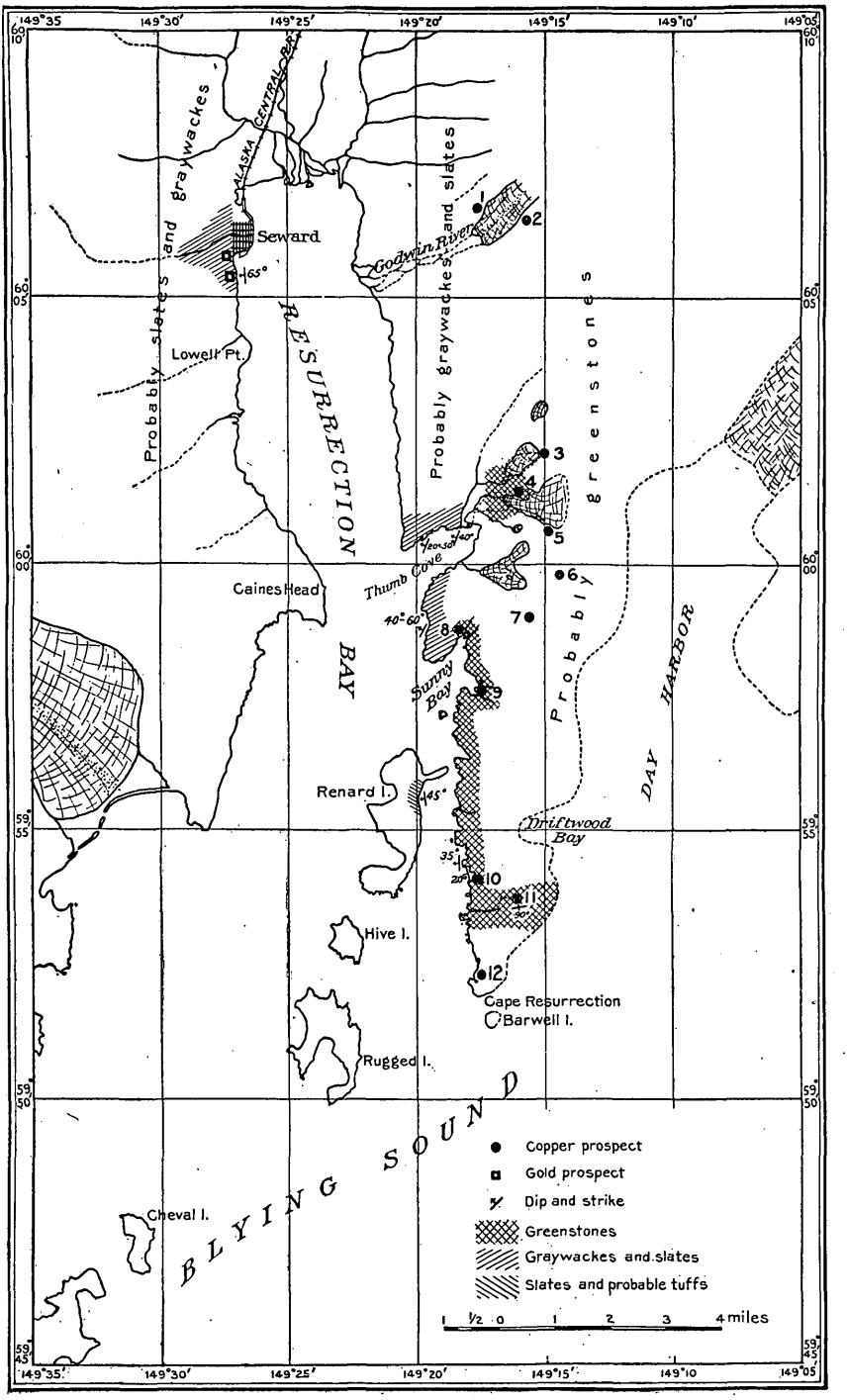


FIGURE 1.—Map of Resurrection Bay.

quartz amygdules; coarse-grained diabase with red stains; fine-grained gray granite, or aplite, in dikes in greenstone; coarse-grained diabase with large plates of augite; medium-grained diorite with veins of diorite-pegmatite. It is thus probable that the high mountains east and northeast of Thumb Cove are composed of basic igneous rocks, both extrusive and intrusive, and that the lower mountains north of the bay and west of the valley above mentioned probably consist of slate and graywacke.

Graywacke with a little slate is seen along the shore between Thumb Cove and Sunny Bay. The general dip is from 40° to 60° NNW. On the northwest side of Sunny Bay black slate, in many places highly fractured, alternates with greenstone in flows undoubtedly interbedded with the slate. Some of these flows are ellipsoidal in structure. At the extreme north end of Sunny Bay greenstone becomes the country rock, and it extends southward along the east side of Resurrection Bay as far as the present examination went—that is, to a locality opposite the south end of Renard Island; thence this rock was traced eastward across the point on the east side of this bay. This greenstone varies in character, but is in general a fine-grained, altered diabase or basalt, which as a rule occurs in flows that are commonly ellipsoidal in structure. The dip ranges from 20° W. to vertical. Cutting the greenstone are a few diabase dikes, usually less altered than the main country rock. In one locality, about an eighth of a mile north of the Iron Mask claim (prospect No. 10), is a layer of black slate about 15 feet thick interbedded with greenstone and dipping about 35° W.

Renard Island.—On the east side of Renard Island, just south of the long sand spit which projects northeastward, is an eastward-facing cliff consisting of black slate overlain by rather soft green and gray schistose rocks of at least two varieties. The rocks have a marked cleavage, which runs about parallel with the bedding; the strike is N. 7° W. and the dip is 45° W. The gray rock is fine grained, except for small crystals of feldspar, rarely of quartz, around which the matrix of the rock seems to have flowed or been sheared. This rock is possibly a water-laid tuff or perhaps a sheared trachyte or andesite. Higher up in the cliff are fine-grained green schistose rocks, which are probably sheared greenstones or tuffs. At the base of the cliff and probably coming from it are fragments of coarse-grained diabasic greenstones and coarse-grained graywackes.

Summary and conclusions.—Most of the east side of Resurrection Bay from Thumb Cove southward is occupied by basic igneous rocks, which occur chiefly in the form of flows of ellipsoidal greenstone. The same rocks, with their intrusive coarser-grained equivalents, undoubtedly make up the mountainous highland between Resurrection Bay and Day Harbor and extend northward for an unknown dis-

tance. The flows in general dip to the west and are overlain by a series of graywackes and slates, which on Renard Island contain probably water-laid tuffs or sheared extrusives. The graywackes and slates have been compressed into folds whose axes strike a little east of north, and these rocks undoubtedly make up the east shore of Resurrection Bay northward from Sunny Bay. They also probably form the western mountainous ridge which runs from Thumb Cove northward to and beyond Godwin River.

The rocks on the east side of Resurrection Bay appear to belong to one general period, which began with numerous basic lava flows, in part, at least, submarine. These were followed by clastic sediments, which were deposited on and locally interbedded with the later lava flows. With the sediments some tuffaceous material was probably deposited.

The mountains immediately west of the northern half of Resurrection Bay are probably composed of graywackes and slates, and in some of these mountains the slates are soft and easily disintegrated. The relation of the rocks on the west side of the bay to those on the east side is not clear.

The Sunrise "series," as heretofore described, does not include igneous rocks, except near the mouth of Knik River, at the head of Knik Arm of Cook Inlet, where greenstone tuffs, rhyolites, and rhyolite tuffs have been described as included in this "series."[a] The presence of conglomerates in the Sunrise "series" and the finding of a considerable terrane of surface igneous rocks in connection with the slates and graywackes on the east side of Resurrection Bay seem to indicate the possibility of the separation of the rocks in the vicinity of Resurrection Bay and northward into two unconformable groups. One of these would contain, at least locally, much contemporaneous igneous material and is extremely similar in lithology and general characteristics to the Orca "series," which is extensively developed to the east on Prince William Sound. The relation, if the separation above suggested can be made, of the igneous rocks and associated sediments to the rest of the Sunrise "series" is not clear. From analogy with the district to the east (Prince William Sound), where a "series" (Orca) containing contemporaneous igneous rocks is younger than a "series" (Valdez) of more metamorphosed sediments, it might be concluded that the same relation held in the Resurrection Bay region, but convincing evidence for such a conclusion is not at hand. At the present time the relation of the Sunrise "series" to the Valdez "series" and to the Orca "series" has not been determined.

[a] Paige, Sidney, and Knopf, Adolph, Geological reconnaissance in the Matanuska and Talkeetna basins, Alaska: Bull. U. S. Geol. Survey No. 327, 1907, pp. 13-15.

The age of these rocks is likewise uncertain. The Sunrise has been assigned to the Paleozoic and to the Mesozoic, as has the Orca, which is possibly Mesozoic; the Valdez is probably Paleozoic.

COPPER PROSPECTS.

Comparatively little work has been done on the copper prospects in the vicinity of Seward, most of them having been staked recently. They are all, so far as known, located east of Resurrection Bay. In the following paragraphs they are described in order from north to south, the numbers in the descriptions referring to localities on the accompanying map (fig. 1).

Prospect No. 1.—This is just north of the glacier at the head of Godwin River and about 2,400 feet above sea level. It was staked by L. F. Shaw, John Deubruel, and G. Bouchaert, of Seward. Little work has been done here. Specimens from the prospect are nearly solid pyrrhotite with a little chalcopyrite, and there is said to be one large bowlder here, about 700 pounds in weight, of similar ore. An 8-foot vein carrying both copper and gold is also reported as occurring near this same locality.

Prospect No. 2.—This prospect, staked by W. L. Redman and Samuel Guyot, of Seward, is just south of the glacier at the head of Godwin River and about 2,700 feet above sea level. The vein here is reported to be 9 feet in width, and the specimens shown the writers are composed of porous, heavily iron-stained gossan carrying malachite, azurite, and chalcopyrite. No work has been done at this locality.

Prospects Nos. 3, 4, and 5.—At these localities are the Real Thing, Copper Chief, and Iron Cap groups of claims, staked by S. E. Likes and A. H. Frazer, of Seward. There are twenty-three claims in these groups. At the time of visit (August, 1908) the Real Thing and the Iron Cap groups were covered with snow. Each is located at the foot of a high cliff forming the edge of the gathering ground of a small glacier. It is reported that the magnetite in connection with the chalcopyrite at the Real Thing group extends along and up the cliff in a northwest-southeast direction for a horizontal distance of 500 to 600 feet. The lead has been traced three-quarters of a mile. The vein is reported to be as wide as 9 feet, having chalcopyrite on one side and magnetite on the other. Specimens presented by Mr. Likes show the magnetite to be fine, uniformly grained, massive, and blue black in color. Much of it is pure, but more commonly minute grains of chalcopyrite are scattered through it. The contact of the main part of the chalcopyrite and the magnetite is very abrupt. The specimens show veinlets of chalcopyrite 0.03 inch wide, extending for 0.3 to 0.4 inch into the magnetite. With the chalcopyrite is pyrite in irregular patches—possibly im-

perfect crystals—and in elongated patches that may be veinlets. The Iron Cap lead was reported to have been traced for 4,500 feet along the glacier. Magnetite is reported to occur below, giving away to chalcopyrite and pyrite farther up the cliff.

A part of the showings of the Copper Chief group of claims was seen. The lead consists of a brecciated and sheared zone, about 6 feet wide, in partly ellipsoidal greenstone. This zone strikes N. 37° W. and dips 35° S. Pyrite, chalcopyrite, hematite, and a little epidote occur distributed through the numerous quartz veinlets and through the part of the greenstone nearest the shear zone. The hematite occurs only in the quartz. The greenstone is fine grained, dense, and of a leek-green color when fresh.

Prospect No. 6.—This lies to the south-southeast of those last described, and is reached from Day Harbor. There are several claims here, staked by the Reynolds-Alaska Development Company. They are reported to carry chalcopyrite in shear zones in the greenstone.

Prospects Nos. 7 and 8.—E. F. Pitman and A. C. Gould, of Seward, have staked a group of six claims, called the Feather Bed group, running eastward from the northeast corner of Sunny Bay. At the shore a small amount of digging has been done and some pieces of float containing pyrite and a little chalcopyrite have been encountered. The chief claims of this group are about 1½ miles east of the shore and were not visited because they were reported to be covered with snow. These claims are said to contain a shear zone which holds four stringers of nearly pure chalcopyrite; the stringers vary up to 7 inches in thickness and are reported to carry 14 to 19 per cent of copper. The zone strikes a little east of north and is about vertical; it has been traced from an elevation of about 2,500 feet up to 3,500 feet.

Prospect No. 9.—This prospect, called the Peterson claim, is located at the water's edge on the east side of the north part of the south arm of Sunny Bay. The country rock is a rather fine grained, fairly fresh diabase. A tunnel, 35 feet in length, has been run along a brecciated and vertically sheeted zone, which is 5 feet in width, strikes N. 32° W., and dips 68° W. The cement of the breccia is composed of quartz, calcite, sphalerite, pyrite, epidote, and chalcopyrite. About 200 feet to the southwest of this tunnel is another, 35 feet in length, extending along a similar brecciated zone which carries less vein material. This zone is 6 feet wide, strikes N. 12° W., and is vertical.

Prospect No. 10.—This prospect, called the Iron Mask claim, is on the east shore of Resurrection Bay, opposite the south end of Renard Island, and was staked by H. E. Ellsworth, of Seward, and the Reynolds-Alaska Development Company. A small opening has been

made here at high-tide level in a brecciated mass of greenstone. The breccia, as exposed, is 12 feet in thickness and has been traced for 100 feet or more along the shore. It is overlain by nonbrecciated greenstone, the junction between the two striking N. 27° W. and dipping 20° W. This appears to be the strike and dip of the flows at this locality. The rock of the breccia is a very fine-grained diabase in fragments varying from a few inches to less than a fourth of an inch in size. The material between the larger fragments is composed of the small fragments and a greenish cement. The original breccia, which is probably a flow breccia mixed with tuffaceous material, has been slightly broken and the fractures have been healed by quartz and pyrite, with a little calcite and chalcopyrite. These minerals have also penetrated and locally replaced the original cement and some of the fragments. A very little sphalerite occurs here. Assays across this 12-foot brecciated zone are reported to show 1.1 per cent of copper, and some small streaks carrying more chalcopyrite gave 7 to 8 per cent of copper.

Prospect No. 11.—This is about a mile east-southeast of No. 10, and was staked by E. F. Pitman and A. C. Gould, of Seward. There are three claims here, called the Fairview group, running eastward from the shore. A cliff a short distance from the water shows considerable iron stain, which is not accessible. The main showings are about three-quarters of a mile east from the shore, along a cliff on the south side of a mountain which rises to an elevation of about 2,500 feet. At the base of this cliff is a brecciated zone in the greenstone somewhat similar to that described above. This zone is 8 to 10 feet in thickness, strikes N. 78° E., and is vertical. Higher up and about 300 feet to the east is another similar zone (possibly the same one faulted a little to the north), from 8 to 10 feet in thickness. Fragments in the breccia are from 1 inch to 12 inches in diameter and consist of a medium to fine-grained diabase. This breccia seems to have been again fractured, the fractures filled, and the original cementing substance replaced, in part or wholly, by quartz, pyrite, marcasite, and chalcopyrite. Many pieces of the breccia are rounded and split in concentric layers when weathered. The cement is soft and much weathered and is now usually in the form of gossan, and the whole zone is much iron stained, although it has not been impregnated with these sulphides through its entire thickness. In one place there is a band 6 feet thick where the cement is fairly rich in sulphides; an assay of this material is said to have given 9.8 per cent of copper. This brecciated zone has been penetrated by a tunnel 10 feet in length, but the tunnel could not be reached at the time of the writer's examination on account of snow.

About a quarter of a mile to the northeast of this point, on the east side of the ridge, there are poor exposures of an irregular quartz vein

perhaps 10 feet in width, standing vertical and running approximately east and west. No work has been done here. The rock contains much quartz and is commonly free from sulphides, but locally holds pyrite and a little chalcopyrite.

Prospect No. 12.—This is on the east shore of Resurrection Bay, about half a mile from Cape Resurrection. It was staked by W. R. Lietzke, of Seward. Specimens reported to come from this place consist of quartz containing some fragments of diabase, pyrite, and a little chalcopyrite. It is probable that this prospect is in a brecciated zone similar to those at Nos. 10 and 11 described above. Mr. Lietzke also has a prospect about a mile northeast of Cape Resurrection, near the shore.

Summary and conclusions.—The copper prospects examined are on veins in basic igneous rocks, chiefly in flows of ellipsoidal greenstone. These veins occur (1) as shear zones, (2) as brecciated zones where there has been little shearing, and (3) as brecciated zones parallel with the flows of greenstone. The first and second varieties of veins cut across the flows indiscriminately, and the third are apparently flow breccias which have been further fractured by movements due to folding. The first variety includes prospect No. 4, and probably also Nos. 3, 5, 6, and 7; the second, prospect No. 9; and the third, prospects Nos. 10 and 11, and probably also No. 12.

The copper-bearing mineral of these prospects is chiefly chalcopyrite, a sulphide of iron and copper, carrying when pure 34.5 per cent of the latter metal. The pyrite and pyrrhotite may carry very small amounts of copper. Locally, at or very near the surface, the chalcopyrite has altered to the carbonates, malachite and azurite. The copper in the veins has undoubtedly been derived from the surrounding greenstones probably at no great depth from the surface.

At the time of visit (August, 1908) little development work had been done on these copper prospects, and little ore had been revealed. At none of the prospects examined (Nos. 4, 8, 9, 10, and 11) had the existence of a good thickness and a considerable extent of merchantable ore been demonstrated. Some of the prospects could not be examined, for lack of time, and some because they were high up in the mountains and covered with snow, which lay on the ground much later than usual in the summer of 1908. The most encouraging statement concerning the copper veins on the east side of Resurrection Bay that can be made with the present information is that they occur in essentially the same manner and in the same kinds of rocks as the copper deposits to the east, on Prince William Sound, where there are two producing copper mines and some promising prospects.

From analogy with other copper veins of similar character elsewhere, there is no good reason to expect that ore bodies which may be found in the area under discussion will necessarily increase in size or

in richness with depth. In fact, the opposite is more likely to be the case. Thus in developing a prospect it is good practice to follow the ore and not to run long crosscuts to intersect veins in depth. Under present conditions a copper prospect in this district, to afford encouragement for further work, should show a reasonable probability of the presence of several thousand tons of ore carrying at least 4 per cent of copper, or, if this metal is less in amount, sufficient values in gold or silver to offset the deficiency.

GOLD PROSPECTS.

Two tunnels have been run westward into the ridge along the shore, one at Seward and one a quarter of a mile south. The south tunnel is about 50 feet above the water, 60 feet long, and runs S. 73° W. along a zone of brecciated graywacke. This zone is 3 feet wide, strikes with the tunnel, dips 70° N., and is due to breaking along parallel joint planes. The rock has been cemented by quartz, containing a little pyrite, chalcopyrite, sphalerite, and pyrrhotite. The northern tunnel is 100 feet above the water and about 40 feet long, on a similar brecciated zone in graywacke. This zone strikes N. 47° W. and dips 80° N.; it shows from 6 inches to 2 feet of nearly pure quartz. Assays from each of these veins are reported to have shown small amounts of gold.

A few gold prospects are reported to occur in the valley of Falls Creek, about 25 miles north of Seward and 5 miles east of the Alaska Central Railway. Some of these claims were staked by C. E. and J. W. Stevenson, and others by F. P. Skee and John Lechner, all of Seward. Messrs. Skee and Lechner report that they have one vein on which a tunnel 100 feet in length has been run. A winze 40 feet deep has been sunk in this tunnel, and at the bottom of the winze the vein is 3 feet 10 inches wide. In the tunnel itself the vein is 2 feet wide. The vein consists of quartz, carrying free gold near the surface and probably a telluride of gold lower down. Twenty tons of ore are said to have been shipped from this vein in 1906 and 11 tons in 1907, the ore averaging $35 per ton in gold. Specimens from the vein contain considerable native gold.

Other gold-bearing quartz veins have been discovered near Moose Pass, which is about 12 miles northwest from milepost 33 on the Alaska Central Railway. Several claims have been staked at this locality and some prospecting was done on them in the summer of 1908.[a]

[a] Personal communication from W. W. Atwood.

MINERAL RESOURCES OF SOUTHWESTERN ALASKA.

By W. W. Atwood.

INTRODUCTION.

It is proposed to summarize briefly[a] in this paper the mineral resources of Alaska Peninsula and the adjacent islands—the region usually termed southwestern Alaska. (See Pl. V.) As the lignitic coal fields which border Cook Inlet form a part of the same general province, they also will be briefly considered.

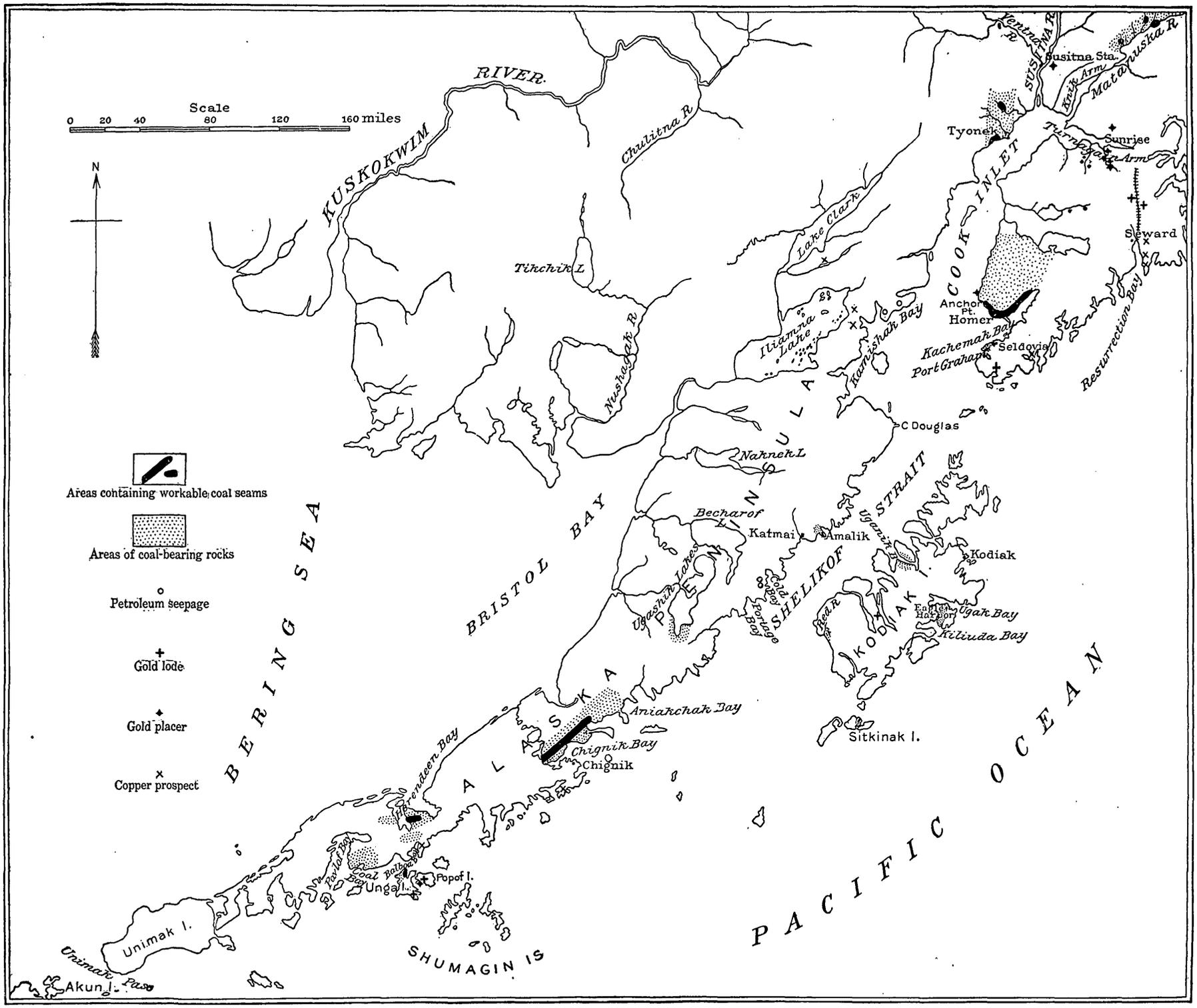
Most of the data to be presented were collected during the months of June to September, 1908, much of this time, however, being spent in examining the Unga, Herendeen Bay, and Chignik Bay coal fields. A part of the results of a study made in 1906 of the Cook Inlet coals is also incorporated. Free use has been made of the work of previous investigators in this field, to whose reports reference will be made. In this study H. M. Eakin rendered efficient aid, both in the field and in the office.

TOPOGRAPHY.

Cook Inlet occupies a broad synclinal depression bordered on the east by a low escarpment from which a gravel-floored plateau slopes up to the western margin of the Kenai Mountains. These mountains stand 5,000 to 6,000 feet above the sea and give rise to several small glaciers. The southwestern extension of the Kenai Mountains is found in the highlands of Kodiak and Afognak islands, which rise to elevations of about 3,000 feet.

West of Cook Inlet there is another escarpment marking the seaward face of an inland gravel-floored plateau, which slopes up toward rugged unexplored mountains that form a southern extension of the Alaska Range. From the West Foreland of Cook Inlet to the latitude of Cape Douglas the Chigmit Mountains, 3,000 to 3,500 feet in altitude, parallel the coast and are broken by several broad gaps. The Aleutian Range begins at Cape Douglas and stretches to the southwest, forming the axis of Alaska Peninsula and, in its submerged portions, the Aleutian Islands. These mountains vary greatly in alti-

[a] A more complete report is in preparation.



MAP OF SOUTHWESTERN ALASKA, SHOWING DISTRIBUTION OF KNOWN MINERAL DEPOSITS.

tude, in some places being only 2,000 to 3,000 feet high and in others rising to 5,000 to 6,000 feet above the sea. They include several active volcanoes exceeding 10,000 feet in altitude. Northwest of the Aleutian Range there is a belt of lowlands which extends from the base of the mountains to Bering Sea.

The coast line of southwestern Alaska exhibits extreme irregularity along the Pacific and great simplicity along the western shore of Cook Inlet and the shores of Bering Sea. The Pacific seaboard is marked by numerous indentations and wave-cut cliffs and affords many harbors. The northwest margin of Alaska Peninsula, on the other hand, has an even coast line bordered by numerous sand bars and sand reefs, with many tidal lagoons.

CLIMATE.

This province lies in about the same latitude as the British Isles, and except in the northern part does not suffer from severe climatic conditions. The rainfall varies from about 100 inches annually in the western portion of Alaska Peninsula to about 16 inches along the shores of Cook Inlet. At Coal Harbor (Unga Island) the average annual rainfall is 48 inches. During the summer rain falls at frequent intervals, but does not usually interfere with out-of-door work.

The mean winter temperature on Alaska Peninsula and Kodiak Island is about 30°, but in the northern portion of Cook Inlet it is about 12°. Ice forms in the upper portion of the inlet, preventing navigation from early in November until May. During the summer most of the snow disappears from the Kodiak group of islands and from the lowlands of Cook Inlet and Alaska Peninsula. The mean temperature from May to October, inclusive, varies from 49.3° in the Cook Inlet region to 49.1° at Kodiak and 45.5° at points farther west.

VEGETATION.

The lowlands bordering Cook Inlet and the lower slopes of the adjacent mountains are clothed with forests of spruce and hemlock. These trees range up to 16 inches in diameter. The alluvial lands are overgrown with grasses and forms of marsh vegetation. Southwestward from Cook Inlet, on the islands of Afognak and Kodiak, the trees become smaller and less numerous, and west of Kodiak and on Alaska Peninsula there are no trees. The largest forms of plant life on Alaska Peninsula, except near the head of Bristol Bay, are stunted alders that in places reach 15 feet in height, but more commonly are but 6 to 8 feet. Willow bushes border the rivers and the more marshy places in the lowlands. The vegetation in this western portion of the peninsula consists chiefly of mosses and grasses. The grasses are exceedingly luxuriant and by the end of the season are 5 feet or more in height.

TRANSPORTATION.

Seward, Kodiak, and Seldovia may be reached by steamer from Seattle. At Seldovia connections may be made for other Cook Inlet ports, and at Seward for all points to the west, including Iliamna and Cold bays, Afognak, Kodiak, Chignik, Unga, Sand Point, Balboa Bay, Coal Harbor, Unalaska, and, from June to September inclusive, Nushagak. Small schooners or launches may be engaged at several of the above ports, and the local boatmen may be trusted to take parties to intermediate and less-frequented parts.

Inland travel is not more difficult in this region than in most mountainous districts. After the zone of alder bushes and tall grasses has

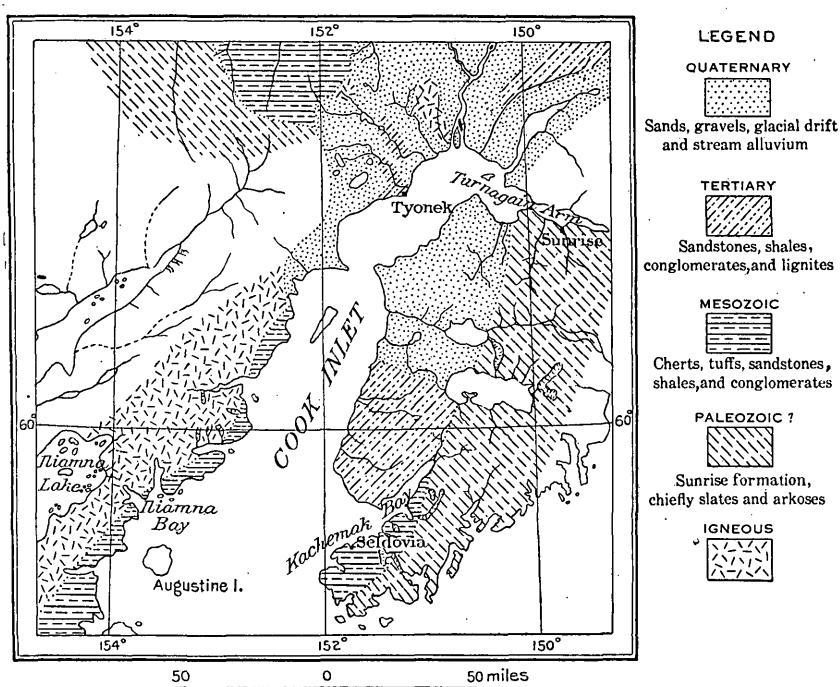


FIGURE 2.—Geologic sketch map of Cook Inlet region.

been passed the climbing is comparatively easy. In portions of the area pack horses could be used to advantage during the summer.

GEOLOGY.

KENAI PENINSULA.

The general geologic features of Kenai Peninsula (see fig. 2), as determined by Moffit,[a] are as follows:

A monotonous succession of slates and arkoses, together with scattered beds of conglomerate or quartzite, are believed to be the oldest

[a] Moffit, F. H., Mineral resources of Kenai Peninsula, Alaska: Bull. U. S. Geol. Survey No. 277, 1906,, pp. 16–28.

rocks. Some granitic intrusives are found cutting these rocks, which are probably of Paleozoic age and were termed the Sunrise "series" by Mendenhall.[a] This series probably dominates throughout the Kenai Mountains. A succession of closely folded cherts and green diabases cut by acidic porphyries occur south of Kachemak Bay and are provisionally referred to the Triassic. Their relation to the Sunrise formation is not known. In the same general region are some gently folded tuffs and agglomerates which are of Lower Jurassic age. Resting unconformably upon these rocks are the lignite-bearing sandstones and shales of the Kenai formation, only slightly disturbed. These Kenai beds are present at Port Graham, Kachemak Bay, and thence stretch northward along the eastern shore of Cook Inlet. In addition to the consolidated rocks there are extensive deposits of Quaternary silts, sands, and gravels, as well as glacial bowlders and till.

The geologic conditions in the islands southwest of Kenai Peninsula are probably similar to those in the peninsula. Kodiak, the largest of these islands, is known to contain considerable thicknesses of slate that are probably either of Triassic or of Paleozoic age, and coal-bearing rocks, probably of late Eocene age, are known to outcrop at several places on the islands. (See Pl. V.)

ALASKA PENINSULA.

The geologic conditions on the west shores of Cook Inlet and Shelikof Strait have been studied by Stanton and Martin.[b]

The Alaska Peninsula contains a coarse crystalline core of granite or of similar rocks, flanked on the eastern side by Mesozoic sediments and on the western side by late Tertiary or post-Tertiary beds. The Mesozoic beds are overlain in places by early Tertiary formations. Both the Mesozoic and the Tertiary beds are cut by andesite and basalt. The intrusion and volcanic overflow have continued from late Jurassic time until the present, the region containing several active volcanoes.

* * * * * * *

The general relations of the formations may be epitomized in the following section:

Tertiary.—Kenai formation. Shales, sandstones, and conglomerates, with several beds of coal. The entire formation nonmarine and characterized by a large flora. Thickness, 2,000± feet.

Unconformity.

Upper Cretaceous.—Lithologically similar to the Kenai, but including some marine shales and sandstones, with an Upper Cretaceous fauna. Thickness, 1,000± feet.

Unconformity.

Lower Cretaceous (not seen within the area studied). Shales and sandstones, with *Aucella crassicollis*.

Unconformity (?).

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[a] Mendenhall, W. C., Reconnaissance from Resurrection Bay to the Tanana River, Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, p. 305.

[b] Stanton, T. W., and Martin, G. C., The Mesozoic section on Cook Inlet and Alaska Peninsula: Bull. Geol. Soc. America, vol. 16, 1905, pp. 393, 410.

Upper Jurassic.—Naknek formation. Conglomerate, arkose, sandstone, and shale, with interstratified andesite flows. Thickness, about 5,000 feet.

Middle Jurassic.—Enochkin formation. Shales and sandstones, with some conglomerate beds. Thickness, 1,500 to 2,000 feet.

Unconformity. (Possibly conformable on Lower Jurassic when that is present.)

Lower Jurassic.—Tuffs and sandstones. Thickness, 1,000± feet.

Unconformity.

Upper Triassic.—Thin-bedded cherts, limestones, and shales, usually much folded and contorted and with many intrusive masses. Thickness, 2,000± feet.

Base not seen.

From Chignik Bay westward to Pavlof Bay, in the district examined by the present writer during the summer of 1908, the general structure of the peninsula is anticlinal. For nearly 200 miles the central mountain belt is made up of a great series of sedimentary beds. In the Chignik area the main fold is composed of Upper Jurassic and Upper Cretaceous rocks. No Lower Cretaceous has as yet been identified in this region. Bordering the main anticlinal fold there are gently folded strata including sediments of Upper Cretaceous and Eocene age. Post-Eocene intrusions of granite and Recent basaltic flows are associated with the sedimentary formations south of the main fold at Chignik Bay.

At Balboa Bay and northward across the peninsula to Herendeen Bay the structure is well exposed. There the central fold includes some Upper Cretaceous beds and a great thickness of Eocene sediments, with possibly some sediments of Oligocene age. Laccolithic intrusions and faulting have modified the main anticlinal fold so that there are domical structures in the midst of the fold and crystalline rocks are exposed at several places. Intrusive sheets appearing as sills and dikes are also common in this portion of the range.

To the north and south of the central fold in the Herendeen and Balboa Bay district there are minor anticlines and synclines. On the north or Herendeen Bay side these minor folds are composed of sediments that range in age from Upper Jurassic to Miocene. On the south side the sediments are of Eocene and Miocene age.

The middle and western portions of Alaska Peninsula have been and continue to be a region of active volcanism. Vast quantities of lava have been poured out at various places, and fragmental materials from the volcanoes blanket large parts of the area.

The islands near Alaska Peninsula, so far as they were examined, are composed chiefly of igneous rocks. Small areas of sedimentary formations appear on certain of these islands, but the wide range of stratified deposits exposed in the peninsula have not yet been recognized on the islands. Recent volcanic material mantles a large portion of Unga and the neighboring islands of the Shumagin group. The following table gives the geologic column as exposed in the western portion of Alaska Peninsula:

Geologic sequence in western part of Alaska Peninsula.

Age.	Geographic distribution.	Lithologic character.	Thickness (feet).	Remarks.
Recent	Stream valleys	Sands, muds, and gravels.		
Pleistocene	Lowlands and along valleys.	Unconsolidated clays, sands, gravels, and glacial drift.		
Post-Miocene	Unga Island, Popof Island, Balboa Bay, Port Moller, and Chignik Bay.	Tuffs, agglomerates, breccias, and flows.		Many volcanic deposits still show cone structure.
Miocene	Unga and Popof islands, Balboa and Herendeen bays, and Port Moller.	Loosely cemented clays, sands, gravels, and conglomerates. Some beds furnish abundant marine fossils.		These deposits usually occur in very small areas.
Eocene	Chignik Bay, Unga Island, center of Alaska Peninsula, and Herendeen Bay region.	Shales, sandstones, grits, and conglomerates. Locally carries lignite.	Up to 5,000	Carries workable lignite bed at Coal Harbor. Occupies a very large part of Alaska Peninsula in Herendeen Bay region.
Upper Cretaceous	Chignik and Herendeen bays.	Conglomerate, sandstone, and shales, with coal seams.	600+	Contains valuable coal beds at Chignik and Herendeen bays.
Lower Cretaceous	Herendeen Bay	Shale, sandstone, and calcareous sandstone.	1,800+	
Upper Jurassic	Chignik and Herendeen bays.	Sandstones, conglomerates, and arkose.	1,000+	

The Upper Jurassic sediments are exposed along the shores of Chignik Bay, Chignik Lagoon, and Chignik Lakes. They also outcrop in the central portion of the mountain area northwest of Chignik Bay and west of Hook Bay. In the Herendeen Bay region Upper Jurassic strata are exposed south of Mine Harbor at Crow Point, in the base of Pinnacle Mountain, and on the west shore of Herendeen Bay. These sediments consist of dense, fine-grained sandstones of bluish color, conglomerates, shales, and arkose. They are the oldest sedimentary rocks exposed in either the Chignik or the Herendeen Bay districts. In the Chignik area they are associated with the central part of the main anticlinal fold of the peninsula. In the Herendeen Bay district these rocks outcrop north of the main axis in minor folds exposed along the shores of Herendeen Bay. The Chignik localities have yielded several collections of invertebrate fossils whose age has been determined by T. W. Stanton.

The Upper Jurassic beds in Pinnacle Mountain, Herendeen Bay, are overlain by Cretaceous rocks and both have been folded, truncated, and in part covered by volcanic material, which issued from the summit of Pinnacle Mountain. The exposures on the west shore of Herendeen Bay are near the beach and consist chiefly of fine-grained blue sandstones. The fossil material procured from these localities has been examined by Mr. Stanton, who reports that within the Upper Jurassic of Herendeen Bay two horizons are represented. At the upper horizon are forms related to *Aucella pallasi*. The beds

at this horizon are best exposed in Crow Point. At the lower horizon are forms related to *Aucella bronni*. The beds at this horizon are typically exposed near the base of Pinnacle Mountain.

Among the collections procured from the Chignik Bay region there are no fossils of Lower Cretaceous age. In parts of this region, at least, the Upper Cretaceous beds unconformably overlie the Upper Jurassic, and it may be that there is no Lower Cretaceous in the region. In the Herendeen Bay district the Lower Cretaceous appears in three belts extending through the Herendeen Bay coal field, coming to the surface on the flanks of the folds. The fossil material procured from these formations indicates that there are two horizons within the Lower Cretaceous. At the upper horizon are forms related to *Aucella crassicollis*, and at the lower are forms related to *Aucella piochii*. One of the collections contains some forms related to those of the upper horizon and others related to those of the lower horizon. The sediments of this period consist of sandstones, shales, and conglomerates.

Upper Cretaceous sediments are exposed in the mountains northwest of Chignik Bay and west of Chignik Lake. They are also present in the Herendeen Bay district. They are exposed in the central portion of the main anticline below a great laccolithic intrusion and in the syncline at the south margin of the Herendeen Bay coal field. They also appear on the flanks of the adjoining anticline to the north, on the south side of Pinnacle Mountain, and in the hills west of Herendeen Bay. The Upper Cretaceous sediments consist of sandstones, shales, conglomerates, a little limestone, seams of bituminous coal, and some lignite. Upper Cretaceous fossils were procured by Paige[a] from the coal measures in the Herendeen Bay field and by the present writer from the several other localities abovementioned in this district and in the region of Chignik Bay.

Eocene, Miocene, and post-Miocene formations are exposed in this portion of the peninsula. The Eocene strata include at least 5,000 feet of sandstones, shales, conglomerates, and seams of lignite, and form the central portion of the Aleutian Range in the Balboa-Herendeen Bay district. They extend westward at least as far as Pavlof Bay and eastward to the Chignik Bay region. Several collections of fossil shells and plants have been procured from these beds. The shells are those of marine invertebrates and have been determined by W. H. Dall to be of upper Eocene age. Mr. Dall reports that some of the material from these strata may be upper Eocene or Oligocene. The plants, as determined by F. H. Knowlton, are all of Kenai age. They were procured from beds that are interstratified with those from which the shells were obtained. Kenai plants from Alaska have been determined by Mr. Knowlton to be of upper Eocene age and the harmony

[a] Paige, Sidney, The Herendeen Bay coal field: Bull. U. S. Geol. Survey No. 284, 1906, p. 103.

between the age determinations of the plants and animals is exceedingly satisfactory. The nature of the Eocene deposits indicates that the area of sedimentation was several times just below sea level, probably near to shore, and at other times above sea level, receiving wash from higher lands, or overgrown by dense growths of vegetation.

Miocene sediments appear in Unga and Popof islands and at several places on the north and south sides of Alaska Peninsula. They consist of sandstones, shales, and conglomerates that represent offshore, shallow-water deposition. An abundance of fossil material was procured and has been identified by Mr. Dall. At Coal Harbor, Unga Island, the Miocene strata conformably overlie the Kenai formation (upper Eocene), but at other localities the Miocene sediments appear to rest unconformably upon different formations and to have been restricted to local basins. They are but little disturbed.

One collection of fossil plants, from the Herendeen Bay district but from a lithologic unit that occupies a very small area, seems to indicate post-Miocene age. The most extensive post-Miocene formations consist of volcanic tuffs and basic lava flows. They are widespread on the mainland in the vicinity of the Balboa-Herendeen Bay district, and cover many square miles in the islands to the south and in the region about Chignik Bay.

Much of the volcanic material just described may be of Pleistocene or even post-Pleistocene age, and there is little doubt that some of it is. Glacial drift mantles the lowlands on the north side of the Alaska Peninsula and is irregularly distributed in the mountain valleys.

Since Pleistocene time the land has risen, relative to sea level, and the terraces bordering the coast are covered with Recent alluvium. In the valley bottoms and at the heads of bays there are other alluvial deposits of post-Pleistocene age.

DISTRIBUTION OF KNOWN MINERAL DEPOSITS.

GENERAL OUTLINE.

The known mineral wealth of southwestern Alaska consists of coal, petroleum, gold, and copper. The distribution of these deposits is shown on the accompanying map (Pl. V). The important coal fields are located in Matanuska Valley, on the shores of Cook Inlet, near Chignik Bay, and near Herendeen Bay. Less important deposits of coal and lignite have been found at various places in Alaska Peninsula and neighboring islands.

The oil seepages occur in the vicinity of Cold Bay and on the west shore of Cook Inlet.

Placer gold has been found in paying quantities in the creek placers of the Sunrise district of Cook Inlet and in the beach placers

on Popof and other islands. Some placer gold occurs also on the north shore of Kachemak Bay near Anchor Point, and in the lower part of the valley of Cooper Creek near Lake Kenai. Some development work has been done on gold-bearing ledges about 25 miles north of Seward, near the line of the Alaska Central Railway; at Moose Pass, south of the head of Turnagain Arm; and at several points in Kodiak Island. A gold-bearing quartz ledge has been located on Dry Island, north of Kodiak. Several locations for gold have been made on Popof Island, and on Unga Island lode mining has been conducted successfully for a number of years.

Copper claims have been located on the east shore of Resurrection Bay opposite Seward and southward to Cape Resurrection. In the vicinity of Lake Clark and Lake Iliamna some copper has been found, but as yet little work has been done in this district. On the west shore of Prospect Bay, a small reentrant a few miles west of Chignik Bay, there are evidences of copper, and on the east shore of Balboa Bay there is an abandoned copper prospect. In this report only the coals of Cook Inlet and the coals and other mineral deposits of Alaska Peninsula and Unga and Popof islands will be described.

COAL.

COOK INLET.

INTRODUCTION.

Coal is exposed on the shores of Cook Inlet at Port Graham, in the vicinity of Homer, and near Tyonek. Port Graham is an indentation in the east shore of Cook Inlet about 8 miles southwest of Seldovia. The extent of coal-bearing rocks at this place is somewhat less than 1 square mile. The Homer field includes the land bordering Kachemak Bay and northward to Cape Kasilof. (See fig. 2.) There are at least 1,000 square miles in this field. The coal near Tyonek is exposed along the beach, beginning at a point about 3 miles south of the town and extending southward for nearly 4 miles, and in several of the valleys north of Tyonek at least as far as Beluga River. This field contains about 150 square miles.

Each of these coal fields is in a lowland area. A sea cliff forms the shore line, and the upland surface has a rolling topography, with low hills and shallow depressions characteristic of areas mantled by glacial drift. At Port Graham the coal is on the north side of the bay, just within the entrance. It is limited at the east and west by masses of igneous rocks that form bold headlands at the margin of a small bay. From Cape Kasilof southward to Anchor Point and thence eastward for several miles beyond the Homer Split the shores of Cook Inlet and Kachemak Bay are bordered by a cliff that ranges in height from 50 to 400 feet, in which the coal beds occur. (See

fig. 2.) Near Tyonek a sea cliff forms the shore line where the coal measures outcrop, but along the shore to the north there is low alluvial land, which extends inland to the margin of the coal belt.

GEOLOGY.

The geology of the Cook Inlet coal fields is relatively simple. The coal measures rest unconformably upon the pre-Jurassic diabase and cherts and Lower Jurassic tuffs, sandstones, and calcareous beds. The coal-bearing formations are slightly deformed and are overlain unconformably by Pleistocene deposits and later alluvium. Fossil plants have been procured from various localities in this field, and they have all been grouped with the Kenai. The type areas of the Kenai formation are at Port Graham and on the shores of Kachemak Bay. The age of the Kenai plants was at first thought to be Miocene, but later they were assigned to the upper Eocene. Marine invertebrate shells of upper Eocene age have been found in close association with Kenai plants in Alaska Peninsula, and there can be little doubt that the coal-bearing beds bordering Cook Inlet are upper Eocene also.

The Kenai formation consists of sand, sandstone, clay, shales, conglomerate, and seams of lignite. Much of the material is but loosely cemented. Several sections of the coal measures are given in Plate VI and figure 5.

The north-south section through the Homer field (fig. 3) shows the structural relations of the coal measures in that portion of the region. The distribution of outcrops along the beach at Tyonek is shown in figure 4.

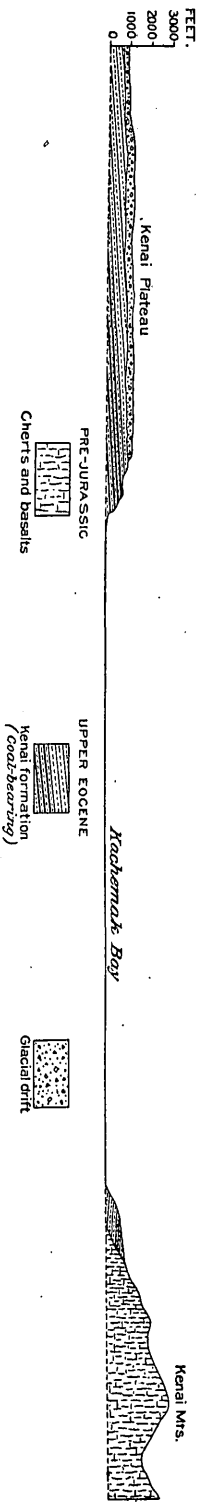


FIGURE 3.—Diagrammatic structure section across Homer coal field.

COAL NEAR TYONEK.

The coal exposed near Tyonek is a tough woody lignite. Huge trunks of trees, now partly changed to lignite, are exposed at several places and suggest by their arrangement

the drifting of logs into a big swamp or pond, or a group of fallen trees in a forest. A measured section in the coal-bearing series is given in figure 5. The entire series appears to be conformable and represents conditions of sedimentation similar to those existing today in the large deltas. The sediments indicate frequent changes in the conditions of deposition. They are such as are handled by streams of low grade and consist of sands, clays, gravels, and fragments of wood, showing a marked absence of coarse material. Most of this material is unconsolidated, or but partly cemented. Fossil leaves procured from this series have been determined by F. H. Knowlton to be of Kenai age.

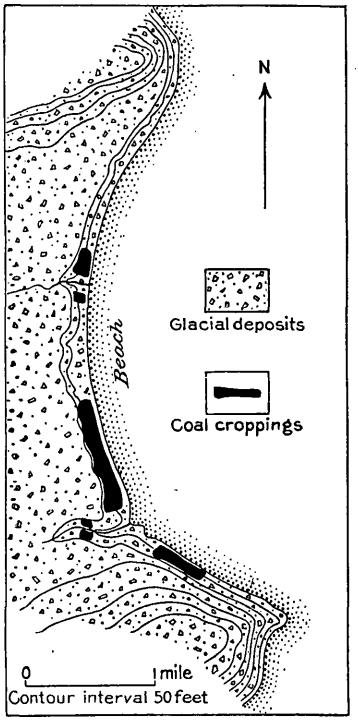


FIGURE 4.—Map showing distribution of coal croppings along the Tyonek beach, Cook Inlet.

Many of the seams of lignite have been on fire, and the clays associated with them have been burnt to a brilliant red color. Certain seams are known to have been burning for at least ten years. Near the base of the measured section (fig. 5) there is a bed of conglomerate in which the matrix is sand and the pebbles lignite. The lignite pebbles are very well rounded, and when broken the fresh fracture faces are exceedingly brilliant. They break with a conchoidal fracture. The streak from these pebbles is dark brown or black, and the material appears to be of much better grade than that outcropping as seams in this vicinity. It is difficult to believe that this great number of lignite pebbles may be accounted for as drift wood along a beach, and an alternative hypothesis is that they were derived from a lower coal-bearing series, or possibly from some seam in the lower portion of this series. This hypothesis would imply that there was a distinct unconformity in the series, and that the lower portion of it became exposed, in portions of the field at least, while sedimentation was continuing in adjoining areas. A similar conglomerate horizon was found near Beluga River and also in the section along the north shore of Kachemak Bay.

Figure 4 shows in detail the distribution of the outcrops, together with some data on the position of the beds. At the northernmost outcrop the section on page 120 is exposed.

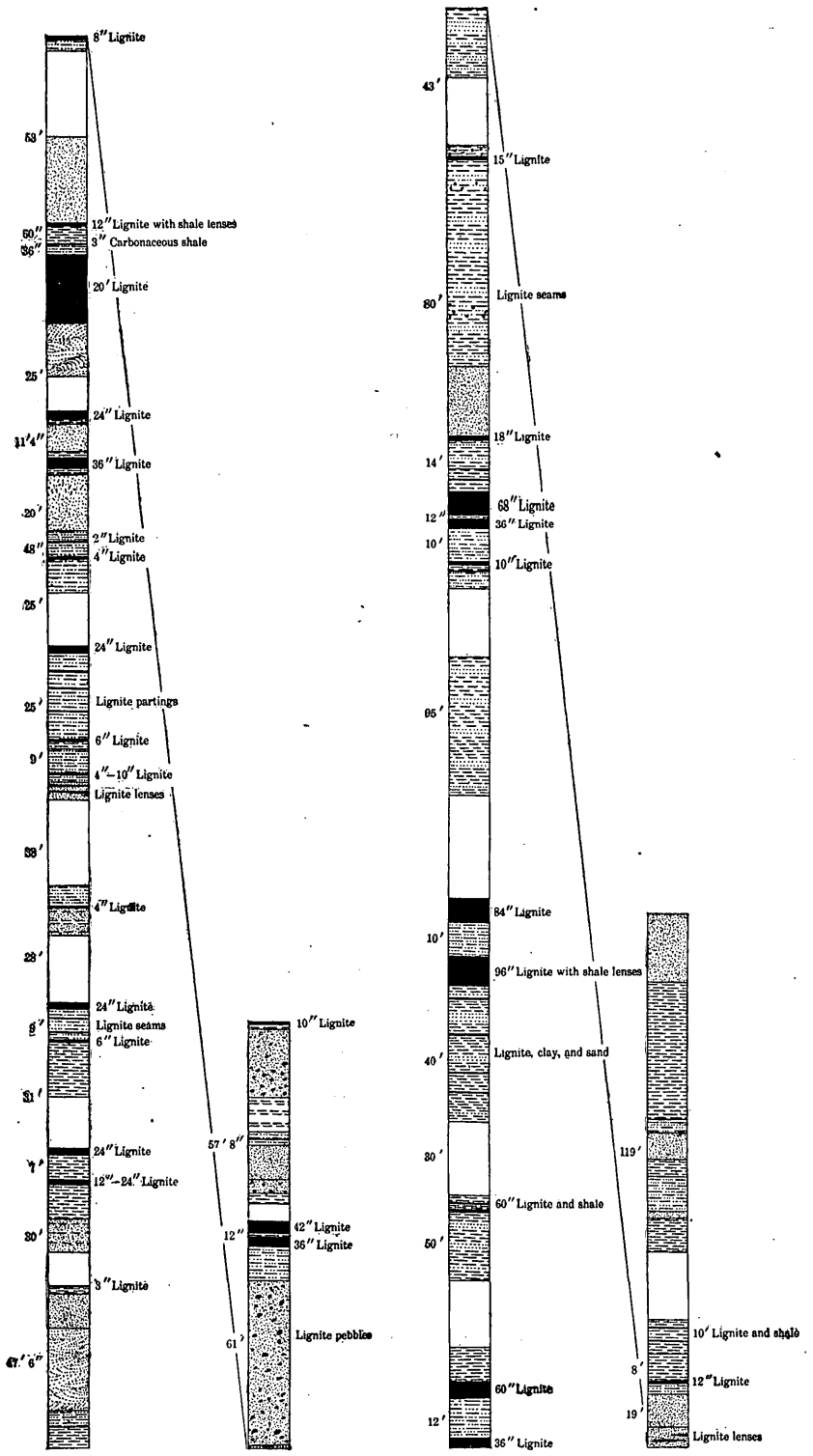


FIGURE 5.—Columnar sections of the Tertiary coal measures near Tyonek.

Section at northernmost coal outcrop near Tyonek.

	Ft.	in.
Glacial drift	10–15	
Blue clay	5	
Lignite	10	4
Blue clay	1	6
Lignite	16	6

The lower or larger seam was sampled and the analysis is given in the table on page 126. There are at least 36 seams of lignite, large and small, exposed along the beach. Several of them are from 8 to 10 feet thick, but most of them vary from 3 to 4 feet.

Each year 400 to 500 tons of low-grade lignite are taken from the Tyonek beach. This material is used for domestic purposes and as fuel on local steamboats.

Northwest of Tyonek, in the area where Beluga River crosses the coal field, the beds in general continue to dip to the northeast, and in following the valley upstream the entire section may be examined. (See Pl. V.) From these exposures it is evident that the lignite seams in the upper portion of the section are of much poorer grade than those near the base. The strike varies from N. 17° E. to N. 22° W., and the average dip is about 55°. The sediments are of the same character as those exposed along the beach south of Tyonek, consisting of loose sands, sandstones, clays, shales, conglomerates, and seams of lignite. Near the base of the section there are two seams of lignite 10 and 12 feet thick, which are more brittle and harder and appear to be of much better grade than any exposed elsewhere in the field. They outcrop 10 miles above the mouth of the Beluga, measured along the stream, and about 2 miles above a belt of dangerous rapids. The analysis of a sample taken from the larger of these seams is given on page 126.

Near the base of the section and not far from the western margin of the coal field there has been some minor folding and faulting, and heavy beds of conglomerate are exposed. These conglomerates are separable into three beds. The lowest is at least 200 feet thick and consists of fine gravel and cobblestones, grading up to 6 inches in diameter. All of this material is well worn by water. The pebbles consist of quartz, granites, basalt, schist, lignite, and various fine-grained igneous rocks. The general color of the conglomerate is dark brown. The intermediate conglomerate consists of similar material and is separated from the heavy conglomerates above and below by thin beds of sandy shale. The uppermost bed of conglomerate consists of sands and gravels, the larger pebbles of which grade up to 2 inches in diameter. White quartz pebbles are exceedingly abundant, and as the sand is of a grayish color the outcrops of this conglomerate, on account of their general light-gray color, are very conspicuous. Associated with the quartz are pebbles of schists, granites, basalts,

greenstones, and various other igneous rocks. The thickness of this conglomerate is about 300 feet.

Below the conglomerate series there is a great thickness of shales and sands, in which lignite seams occur. A few fragments of dicotyledonous leaves were procured from this locality, but the material was not such as could be identified.

The heavy conglomerates outcropping along Beluga River, together with the contrast between the poor lignite above and the better lignites below, suggest a subdivision in the coal-bearing series. The fact that these conglomerates, as well as that exposed along the Tyonek beach and on the north shore of Kachemak Bay, contain lignite pebbles seems to indicate that there was at least a somewhat widespread change in the general conditions of deposition in the midst of the period. The examination along Beluga River was made without the help of an accurate map, and no unconformity was determined, but the exposures suggest that structural unconformity may exist there.

Some coal has been taken from the seams outcropping on the banks of the Beluga and carried downstream in small boats, but the difficulty of handling the boats in the narrow portions of the river and at the rapids makes this work dangerous.

COAL ON KACHEMAK BAY.

The coal measures outcrop at intervals along the north shore of Kachemak Bay, from the vicinity of Anchor Point to the head of the bay. The remaining space is filled in with glacial drift, which occupies the valleys of the preglacial surface and mantles the entire area of the coal fields. (See fig. 2.)

About 1½ miles southeast of Anchor Point seams of lignite appear in the beach at extreme low tide. These seams vary from 12 to 20 inches in thickness, strike about N. 50° E., and dip from 10° to 15° SE. The lignite is bright and clean and breaks with a cubical fracture, but lignite in such thin seams is not of much economic value. Southeastward to Troublesome Gulch several more thin seams of high-grade lignite outcrop. The strike remains about the same as that farther west, but the dip is toward the north, or into the bluff. This change in the direction of the dip indicates a gentle fold in the strata. Between Troublesome Gulch and the mouth of Diamond Creek a low anticlinal fold appears along the beach. About 1½ miles east of Troublesome Gulch a lignite seam with the following section outcrops:

Section of lignite near Troublesome Gulch.

	Ft.	In.
Coarse sand.		
Lignite	2	
Carbonaceous shale		3
Lignite	1	9
Clay.		

The analysis of a sample from this seam is given in the table on page 126. Three-fourths of a mile west of Diamond Creek a seam of lignite 3½ feet thick was sampled and the analysis of this sample also is given in the table. The section here is as follows:

Section of lignite near Diamond Creek.

	Ft.	in.
Carbonaceous shale	1	3
Lignite		3
Carbonaceous shale		5
Lignite	1	
Shale		2
Lignite	2	7
Clay.		

The next important outcrops are at Bluff Point, near the old coal mines of the Cook Inlet Coal Fields Company. This part of the field and the area extending eastward to the head of the bay have been examined by Stone,[a] to whose report the reader is referred for details. In this part of the field 2,000 to 3,000 feet of coal-bearing rocks are exposed; these include an aggregate of over 60 feet of workable coal beds, the thickest bed of which is about 7 feet. Detailed sections of the coal-bearing strata are presented in Plate VI and figures 6 and 7.

Though some mining has been done at Kachemak Bay for many years, the entire production probably does not exceed a few thousand tons. During the summer of 1906 the coal lands northwest of Homer were surveyed for patents in 160-acre claims. This work included all the land bordering the shore from the mine camp, near tunnel No. 1, westward to a locality within 2 or 3 miles of Anchor Point, and inland throughout this coastal belt for about 3 miles. In 1907 patent surveys were continued in this field and one shaft was sunk on the McDougal property, a recently staked claim, to a depth of 141 feet 6 inches. The following record from the surface downward is reported at this shaft:

Record of shaft on McDougal property, Kachemak Bay.

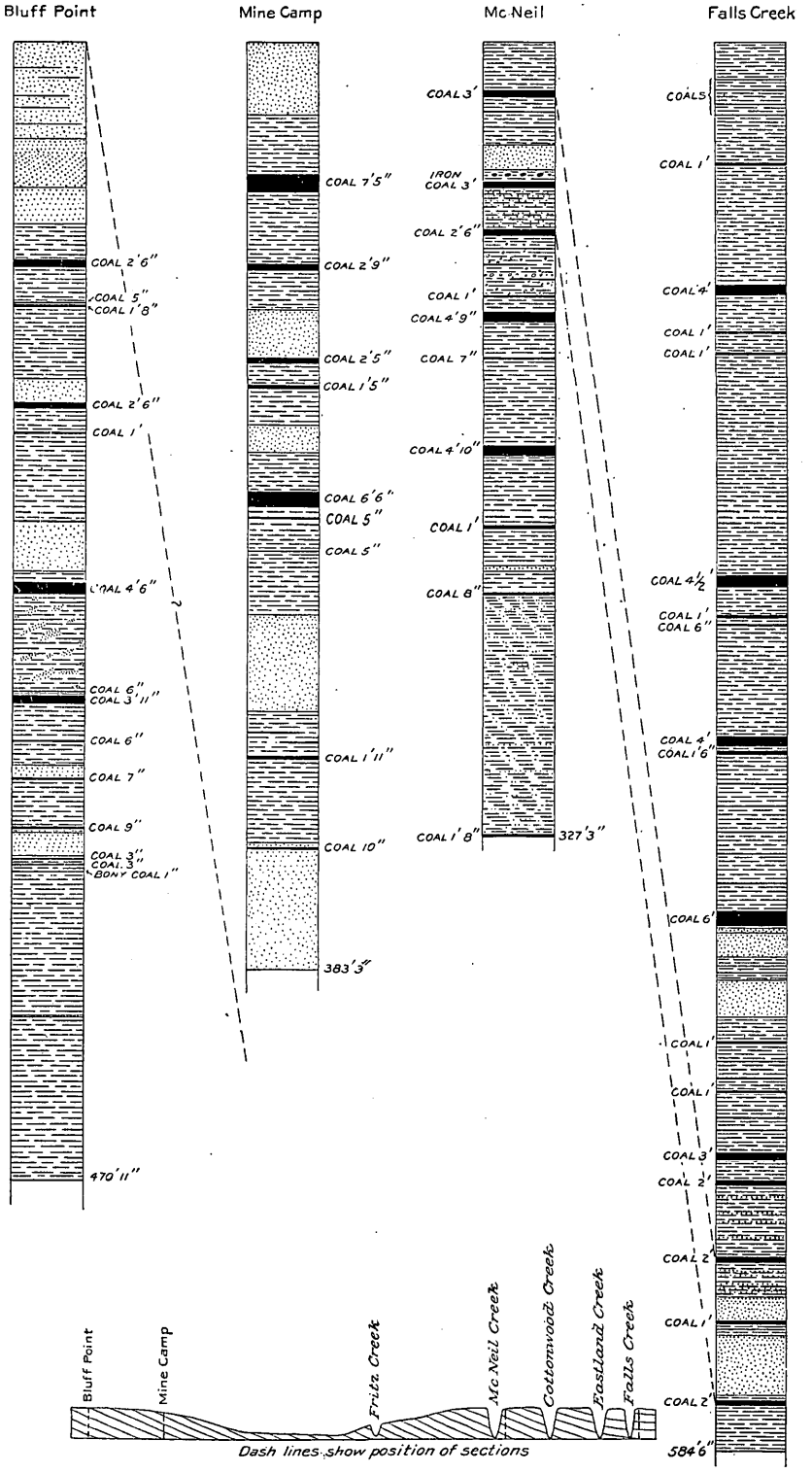
	Ft.	in.
Drift, probably glacial material and recent alluvium	85	
Sandstone	45	
Soapstone	5	
Coal	6	6

No very definite report of progress in this field has been received for the season of 1908, but there does not seem to have been much activity.

COAL AT PORT GRAHAM.

At Port Graham, a few miles south of Kachemak Bay, there is a small area of sandstones, clay shales, and lignitic coal beds, which are

[a] Stone, R. W., Coal fields of the Kachemak Bay region: Bull. U. S. Geol. Survey No. 277, 1906, pp. 60–66.



COLUMNAR SECTIONS OF THE TERTIARY COAL MEASURES, KACHEMAK BAY.

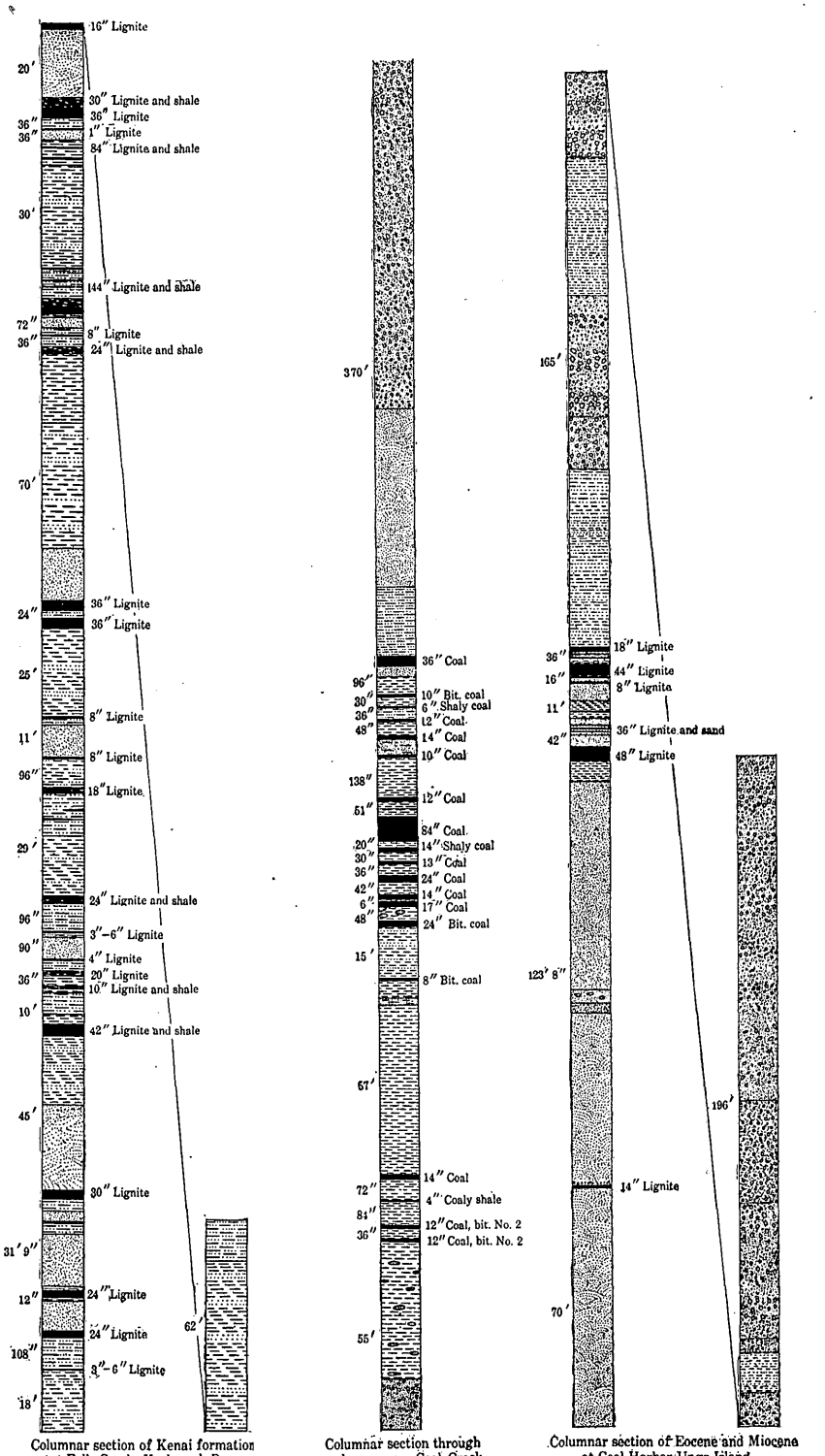


FIGURE 6.—Columnar sections of the coal measures at Kachemak Bay, Coal Harbor, and Herendeen Bay.

of Kenai age.[a] There are probably several coal beds, but only two were accessible at the time of Stone's visit in 1904. One showed a thickness of 8 to 9 feet of coal, including some bone. This coal is black, brilliant, and clear.

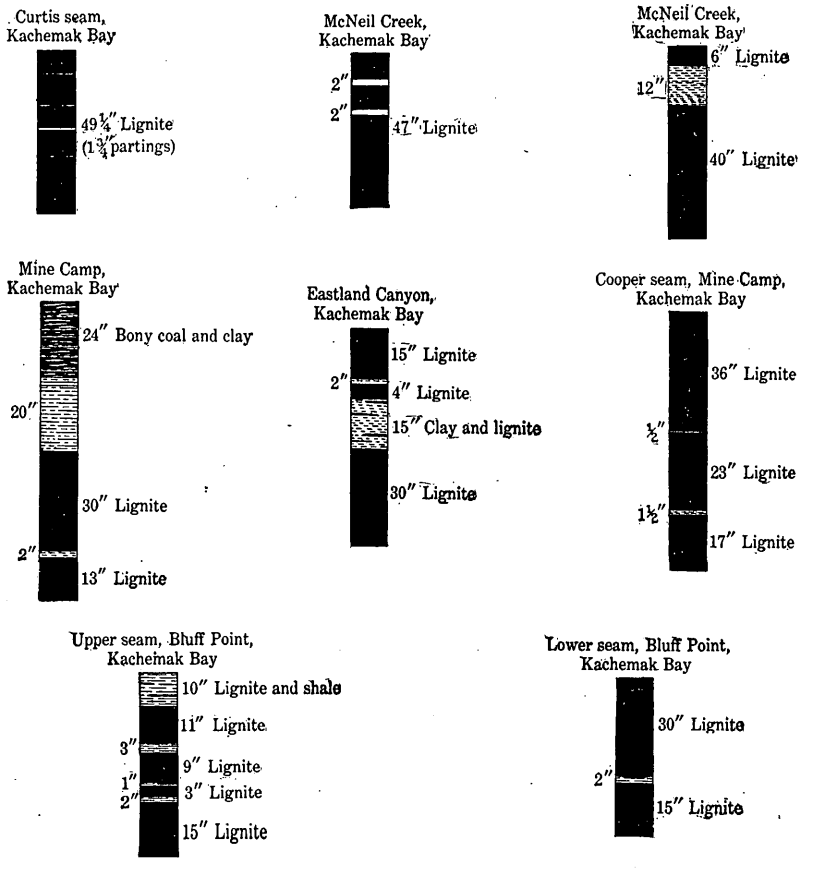


FIGURE 7.—Sections of coal seams at Kachemak Bay.

Mining was carried on by the Russians at Port Graham from 1855 to 1867, and since that time there has been some production, amounting lately to 1,000 to 2,000 tons annually. This lignite is used for domestic purposes and on local steamboats.

COMPOSITION OF COOK INLET COALS.

The following analyses will give a fair idea of the character and fuel value of the coals of the Cook Inlet region, which must all be classed as lignites. The samples taken in the field were sealed in air-tight

[a] Stone, R. W., op. cit., pp. 66–68.

cans and sent to the laboratory. The results of the proximate analyses of the coals as collected have been recalculated to give the analyses on the air-dried basis. The samples were obtained at the following localities:

4458. North shore of Port Graham.

4457. North shore of Kachemak Bay, 3 miles east of Homer Spit.

4429. North shore of Kachemak Bay, 1 mile west of Homer Spit; 6-foot bed.

4426. North shore of Kachemak Bay, three-fourths of a mile west of Diamond Creek, several miles southeast of Anchor Point.

4432. North shore of Kachemak Bay, 1½ miles east of Troublesome Gulch, several miles southeast of Anchor Point.

4425. Loose lignite pebbles from a conglomerate on west shore of Cook Inlet, about 4 miles south of village of Tyonek.

4465. Near south end of Tyonek beach, west shore of Cook Inlet, about 4 miles southwest of village of Tyonek.

4464. West shore of Cook Inlet, first outcrop south of Tyonek, about 3 miles from village.

4434. Northwest of Tyonek, 10 miles up Beluga River, above canyon and rapids.

4456. Northwest of Tyonek, 10¼ miles up Beluga River, above canyon and rapids.

Analyses of Cook Inlet coals.

[Analyses by F. M. Stanton, U. S. Geological Survey.]

SAMPLES AS RECEIVED.

Laboratory No.	Proximate analysis.				Ultimate anlaysis.						Calorific value.	
	Loss on air drying.	Moisture.	Volatile combustible.	Fixed carbon.	Ash.	Sulphur.	Hydrogen	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
4458	8.20	19.96	38.73	32.46	8.85	0.52	5.81	49.53	0.92	34.37	4,885	8,793
4457	7.00	18.12	42.77	23.61	15.50	.43	5.51	44.77	.88	32.91	4,386	7,895
4429	9.40	18.59	36.13	34.92	10.36	.34	5.81	49.08	1.14	33.27	4,749	8,548
4426	19.40	28.06	33.51	32.81	5.62	.19	6.45	45.61	.85	41.28	4,340	7,812
4432	7.50	19.95	35.88	29.18	14.99	.41	5.82	44.55	.97	33.26	4,474	8,053
4425	20.80	27.60	31.47	37.18	3.75	.40	6.54	47.98	.86	40.47	4,638	8,348
4465	13.00	22.31	40.50	27.97	9.22	.30	6.20	44.23	.83	39.22	4,325	7,785
4464	9.60	20.68	41.80	29.12	8.40	.32	6.12	45.70	.77	38.69	4,440	7,992
4434	8.60	19.45	34.36	29.81	16.38	.22	5.49	44.72	.79	32.40	4,428	7,990
4456	6.40	17.44	38.25	28.89	15.42	1.63	5.61	45.25	1.15	30.94	4,581	8,246

AIR-DRIED SAMPLES (CALCULATED FROM TABLE ABOVE).

Laboratory No.	Proximate analysis.			Ultimate analysis.						Calorific value.		Classification ratios.		
	Moisture.	Volatile combustible.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.	Fuel ratio.	Carbon-hydrogen ratio.	Carbon-oxygen ratio.
4458	12.81	42.19	35.36	9.64	0.57	5.34	53.95	1.00	29.50	5,321	9,578	0.84	10.10	1.82
4457	11.95	45.99	25.39	16.67	.46	5.09	48.14	.95	28.69	4,716	8,489	.55	9.45	1.67
4429	10.14	39.88	38.54	11.43	.38	5.26	54.17	1.26	27.49	5,241	9,434	.97	10.29	1.97
4426	10.74	41.57	40.71	6.97	.24	5.33	56.59	1.05	29.81	5,384	9,692	.98	10.61	1.83
4432	13.46	38.79	31.55	16.21	.44	5.39	48.16	1.05	28.75	4,836	8,706	.81	8.93	1.67
4425	8.60	39.73	46.94	4.73	.50	5.34	60.59	1.08	27.75	5,856	10,540	1.18	11.34	2.18
4465	10.70	46.78	32.15	10.62	.34	5.47	50.84	.95	31.79	4,971	8,948	.69	9.29	1.59
4464	12.26	46.24	32.20	9.29	.35	5.60	50.55	.85	33.52	4,911	8,840	.69	9.02	1.50
4434	11.87	37.59	32.61	17.92	.24	4.96	48.92	.86	27.08	4,843	8,752	.87	9.86	1.80
4456	11.79	40.86	30.86	16.47	1.74	5.23	48.34	1.22	26.97	4,894	8,809	.75	9.24	1.05

REPORTED OCCURRENCES OF COAL ON KODIAK ISLAND AND ALASKA PENINSULA.

There are a number of localities on Kodiak Island and Alaska Peninsula where lignitic coal beds have been found, some of which may have future commercial importance for local use. (See Pl. V.) Dall[a] reports three occurrences of Kenai strata carrying coal beds—on the east side of Kodiak Island, at Uyak Bay, Eagle Harbor, and at Kiliuda Bay. He also states that coal occurs at the mouth of Red River, near the westernmost point of Kodiak Island, and at two localities on Uganik Island, and a 10-foot bed of lignite is reported on Sitkinak Island. On Alaska Peninsula, besides the Chignik Bay and Herendeen Bay fields, which will be described below, the reported occurrences of coal are as follows: Near Amalik Harbor Dall[b] noted an 18-inch bed occurring in a sandstone and conglomerate series 250 feet thick. Stone[c] described a section in this same region made up of sandstones and fine conglomerates, with some shales, in which occurs a 5-foot bed of coal. There are also less well authenticated accounts[d] of the occurrence of coal at Ugashik Lake and Aniakchak Bay.

CHIGNIK BAY.

INTRODUCTION.

Chignik Bay lies on the Pacific side of Alaska Peninsula, in longitude 158° west and latitude 56° 20′ north. (See Pl. V.) The coal belt, which includes at least two workable beds, stretches from Chignik River on the southwest to the northeast beyond the head of Hook Bay, paralleling the western shore of Chignik Bay for a distance of at least 30 miles. (See fig. 8.)

On the south shore of Chignik Bay there is a small reentrant known as Anchorage Bay, an excellent harbor, where the town of Chignik is located. A small steamer from Seward calls at this port once each month. To the west are Chignik Lagoon and Mallard Duck Bay, nearly cut off from the larger body of water by a sand and gravel spit. At the entrance is a sand bar which makes the inner harbor unavailable for boats drawing more than 12 feet of water. An irregular channel leads through the lagoon to the mouth of Chignik River, but the larger portion of the lagoon is dry at low tide. There is a water route up Chignik River to a chain of lakes in the central part of the peninsula, and thence after a short portage small boats may descend to Bering Sea. Boats drawing more than

[a] Dall, W. H., Coal and lignite of Alaska: Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, p. 800.
[b] Op. cit., p. 798.
[c] Stone, R. W., Coal in southwestern Alaska: Bull. U. S. Geol. Survey No. 259, 1905, p. 161.
[d] Stone, R. W., op. cit., pp. 162-163.

2 feet of water can not safely navigate the Chignik. At high tide small launches drawing barges can ascend the river as far as the coal mine.

Hook Bay lies near the north entrance to Chignik Bay. It is bordered in part by alluvial lands and in part by rugged cliffs. On the south side of Hook Bay there are sheltered waters and an excellent harbor.

The area underlain by coal west of Chignik Bay is on the southeast slope of the main mountain belt of the peninsula. The summits

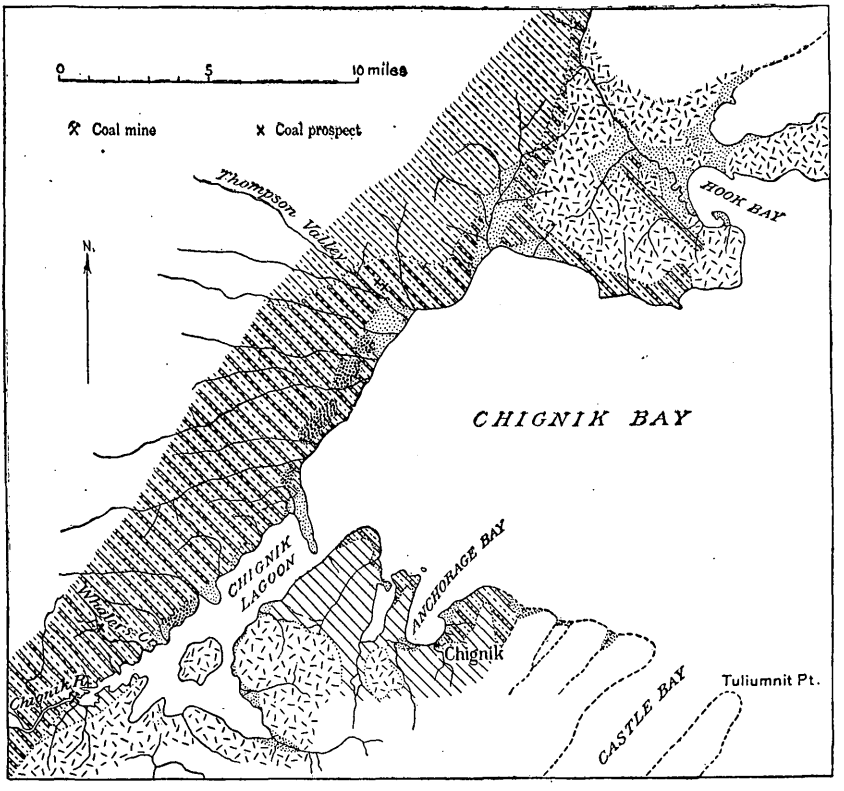


FIGURE 8.—Geologic map of Chignik Bay coal field.

reach elevations of about 2,500 feet and the broad anticlinal structure gives long, gentle slopes to the mountains. A series of nearly parallel valleys, of open U-shaped forms, cross from the summit region to the margin of Chignik Lagoon and Chignik Bay. In these valleys and on the intervalley areas, above the heavy covering of grasses and mosses, the formations are well exposed.

The winter snows do not leave the lower lands until April or May. During the summer there is considerable rain and much cloudy weather, and by the latter part of September fresh snows begin to appear on the mountains. The climatic conditions from April to October are not, however, such as to interfere with out-of-door work.

The Alaska Packers Association has a cannery in this region, on the south shore of Chignik Lagoon, and the Northwestern Fisheries Company one at Anchorage Bay.

GEOLOGY.

The central mountain area consists of a great series of sedimentary rocks (fig. 8). These beds apparently continue far to the northeast and southwest and they border the southern shore of Chignik Bay to Castle Cape. South of a line passing through Chignik Lagoon and west of Anchorage Bay there is a great mass of igneous rocks, chiefly andesites and basalts. Basaltic dikes are common in the area bordering these igneous rocks. South of Anchorage Bay there is a huge granite boss and apparently associated with it are great granite sills. Several such sills are well exposed on the north shore of Anchorage Bay. In the vicinity of Hook Bay there are other masses of granite and large areas that are mantled with volcanic tuffs and basic lava flows. Only in the extreme northeastern and southwestern parts of the coal belt do igneous rocks come into close contact with the coal, and there the coal does not appear to have been affected by the igneous activities.

The sedimentary series is known to include both Upper Jurassic and Upper Cretaceous formations, together with others that are probably of Eocene age. The absence of Lower Cretaceous fossils in the collections procured in this region is surprising, inasmuch as that horizon is well represented at Herendeen Bay, about 100 miles to the west. A description of the sedimentary formations of this portion of the peninsula is given on pages 112–115.

The structure of the central part of the peninsula is that of a broad anticline, the axis of which extends at least as far southwest as Pavlof Bay, thence stretches northeast through the Balboa-Herendeen bays region, northwest of Chignik Bay and through Chignik Lake, thus following the crest line of the Aleutian Range. Eastward from Chignik Lagoon and along the south shore of Chignik Bay the sedimentary strata are gently folded and somewhat faulted. Toward the upper limit of the sedimentary rocks more and more intruded sheets of lava appear, and the last of the sediments is succeeded by vast flows of lava. In the vicinity of Hook Bay there have been two or three centers of volcanic eruption. Great quantities of fragmental material were erupted, lavas were outpoured, and large blocks of sedimentary formations were disturbed.

THE COAL.

Coal beds have been opened at four localities in the Chignik Bay field, all in sedimentary rocks of Upper Cretaceous age. (See fig. 8.) Outcrops of coal are also known in other localities in the region, and some of these are included in the Eocene beds. The developed coals are at Chignik River, Whalers Creek, Thompson River, and northwest of Hook Bay. Some detailed sections of these coals are given

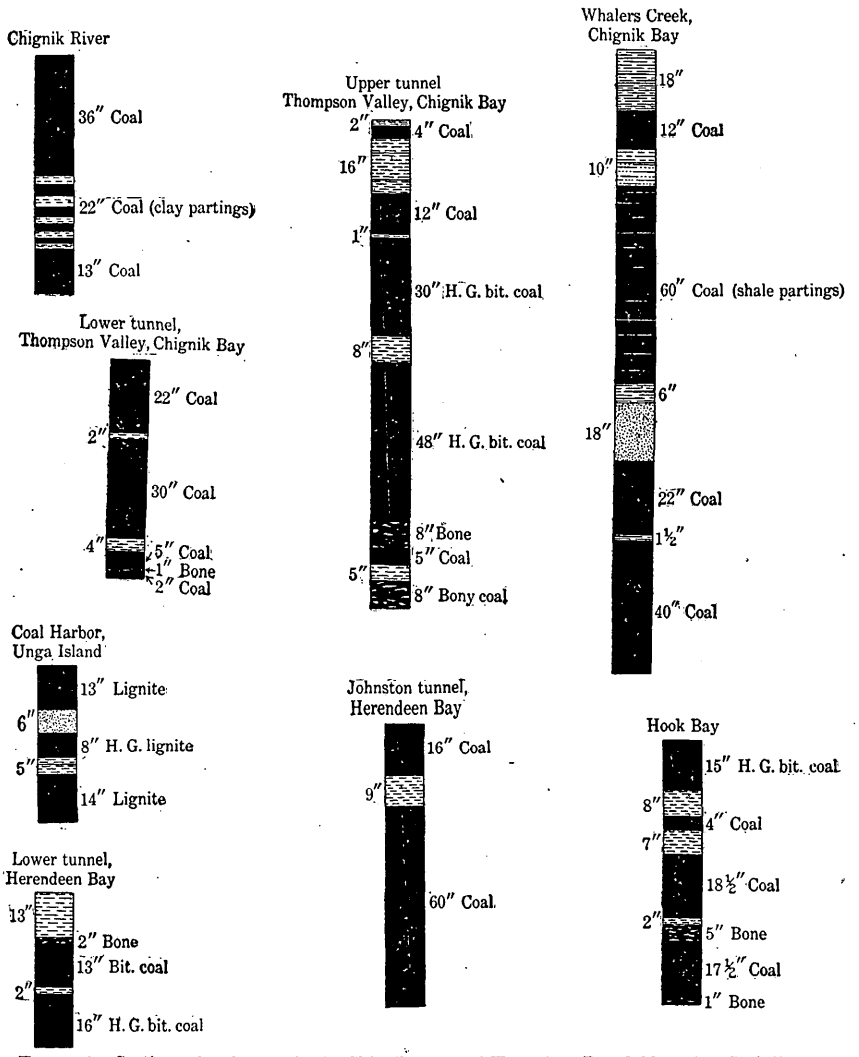


FIGURE 9.—Sections of coal seams in the Chignik Bay and Herendeen Bay fields and at Coal Harbor.

in figure 9, and an account of each locality will be given in the following paragraphs.

Chignik River.—Coal was discovered in the bluff of Chignik River in 1885,[a] but active mining was not undertaken until 1893. Since

[a] Dall, W. H., Coal and lignite of Alaska: Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, p. 802.

that time the Alaska Packers Association has operated its mines to procure fuel for the cannery on Chignik Lagoon and for the steamers engaged in the fisheries. The coal bed that has been worked outcrops on the river bluff 3 miles above the head of Chignik Lagoon, and has been traced inland for a little more than half a mile. At this locality it strikes N. 2° E. and dips 24° E.

Two 6-foot drifts about 40 feet apart have been carried in on the coal bed. The upper drift is about 250 feet long and has been widened to 40 feet in the clear at places; it has a single crosscut to the lower drift. The upper drift is now abandoned, and work is being done only in the lower drift, which runs in nearly straight for 500 feet. At the face of the drift there is a roll in the floor which cuts out the greater part of the coal. Rooms have been opened on the upper side of the drift as far as the roll, which runs diagonally to the tunnel. In the first room, which is about 150 feet from the entrance, the roll is 75 yards from the drift, in the second room about 50 yards, and in the third room but 20 yards. The coal is carried from the rooms to the drift in chutes and taken out in tram cars, from which it is dumped directly on the barge. A section of the bed measured in the drift is as follows:

Section of Chignik River coal bed.

	Ft.	in.
Dry bone, with thin coal streaks		3–9
Coal		6
Coal and dirt		8
Coal	1	
Bony coal (gob)	1	5
Coal	1	4
	5	2

The roof of the bed, which is shale with thin layers of coal, is very even and is overlain by sandstone. The floor, however, is not so regular, and the roll or swelling in it reduces the thickness of the bed at the end of the drift from 5 feet to 9 inches. It is possible that the roll, which is known to be rather long, may be narrow, and that a short tunnel driven through it would discover the full thickness of the coal bed on the other side.

The coal is solid and bright and comes out in good-sized pieces. When used under a boiler it has to be stoked very frequently to keep it burning freely. Properly handled it is a fairly satisfactory steaming coal, although it makes a large amount of ash and the fires have to be cleaned often. An analysis of this coal is given on page 146.

The Chignik River mine is worked throughout the year by two men without machinery, the coal being undercut by hand and shot down. Coal outcrops at several other places on the north bank of Chignik River east of the coal mine, but these beds have not yet been worked, and at the surface do not appear to be of as good grade as that at the mine.

Whalers Creek.—Whalers Creek is a small stream entering Chignik Lagoon from the north a short distance below the mouth of Chignik River. Coal is exposed for 600 feet along the northernmost of the three main branches of the creek. This exposure is along the strike of the coal measures, which outcrop at the coal mine on Chignik River. The strike of the coal is N. 5° E., and the dip is 22° E. The section of the coal is as follows:

Section of Whalers Creek coal bed.

	Ft.	in.
Shaly sandstone roof.		
1. Coaly shale		10
2. Shale		8
3. Coal	1	
4. Coaly shale		4
5. Sandy shale		7
6. Coal with slate partings	5	
7. Coaly shale		6
8. Sandstone	1	6
9. Coal	1	10
10. Shaly coal		1½
11. Coal	3	4
Sandy shale floor.		

A slope has been driven for 130 feet and the coal is reported to hold its thickness uniformly except at two places, where there are slight rolls. The slope follows the lower part of the bed, including Nos. 8 to 11 in the above section. The coal bed including Nos. 9 to 11 was sampled in the usual way and analyzed with the result given on page 146.

The coal is bright, black, and blocky, being much the same as that mined at Chignik River, but at this locality the section of the coal is better in that the partings are thin. About 500 feet downstream from the mine opening there is a nearly vertical fault, which probably cuts off the coal bed. On the upstream side, about 40 feet from the opening, there is a vertical fault, which throws the coal down 6 feet. At 115 feet upstream from the mine another fault which cuts off the coal has been reported. This upper portion of the valley was filled with snow when the region was visited by the writer.

Although faults have disturbed the coal somewhat, there appears nevertheless to be a very considerable body of good coal available. The location of this coal is favorable for shipment on small boats down Chignik Lagoon, or by a railway that might be built across Chignik River a short distance above the mouth, and thence across a lowland area to the head of Dorenoi Bay, where excellent harbor facilities are reported. The distance from Whalers Creek to the head of Dorenoi Bay by the proposed railway route is about 10 miles.

Coal has been reported to outcrop at several places high on the mountain slopes northeast of the outcrops of coal in Whalers Creek.

The localities pointed out in the field by prospectors are along the general strike of the coal measures, and presumably contain the same beds that are exposed elsewhere in the field.

Thompson Valley.—Thompson Valley lies northwest of the northern portion of Chignik Bay, and is a broad, open, flat-bottomed valley, heading among the high mountains at least 10 miles from the beach. Coal is exposed on the northeastern slope 1¾ miles from the beach and 300 feet above the valley floor. The strike of the beds is N. 61° E., and the dip is 21° NW. Two workable coal beds are exposed for at least a mile and their extent is probably much greater. Where the tributary streams to Thompson Valley cross these coals there are falls or cascades in their courses. The detailed measurements of these beds are given below:

Sections of coal beds in Thompson Valley.

LOWER BED.

	Ft.	in.
Sandy shale roof.		
1. Coal	1	8
2. Shale parting		2
3. Coal	2	6
4. Coaly shale		4
5. Coal		5
6. Bone		1
7. Coal		2
Sandstone floor.		

UPPER BED.

	Ft.	in.
Cross-bedded sandstone roof.		
1. Clay		2
2. Coal		4
3. Coaly shale		4
4. Shale		8
5. Coaly shale		4
6. Coal		12
7. Clay parting		1
8. Coal	2	6
9. Coaly shale		8
10. Coal	4	
11. Bone		8
12. Coal		5
13. Shale		5
14. Bony coal		8

A short tunnel has been driven into the upper bed. A sample was taken from beds numbered 6, 8, and 10 in the foregoing section of the upper coal, and the analysis is given on page 146.

There is a large body of good coal available at this locality. The conditions for mining are favorable, and the space at the base of the bluff is ample for mine buildings and mine bunkers. The chief difficulty in the way of exploiting this coal is in making arrangements for shipping. The beach at the mouth of Thompson Valley is

exposed to the severe storms from the Pacific Ocean. A railway from the valley to Chignik Lagoon could be easily built, for the route would be over a lowland area and not more than 9 miles in length. The conditions in Chignik Lagoon, however, are not favorable for loading large ocean-going vessels; hence it would probably be necessary to continue the railway along the northwest shore of the lagoon and then by the same route as that from Whalers Creek to the head of Dorenoi Bay, already described.

Hook Bay.—Hook Bay is in the northern part of the field examined. The coal in this vicinity occurs near the headwaters of the right-hand branch of the stream entering Hook Bay from the west and in the foothills of the main mountain range. Here the general strike of the beds is N. 11° E., and the dip is 34° E. The section of the coal is as follows:

Section of the Hook Bay coal bed.

	Ft.	in.
Firm sandstone roof.		
1. High-grade bituminous coal	1	3
2. Clay		8
3. Coal		4
4. Clay		7
5. Coal	1	6½
6. Clay parting		2
7. Bony coal		5
8. Coal	1	5½
9. Bone		1
Shale floor.		

Above this bed is an 8-foot bed of sandstone overlain by a thin layer of coal. Below the main bed of coal lies 4 feet of shaly sandstone, underlain by a 3-foot bed of coal, in the middle of which there is a 6-inch parting of shale. The claims have been prospected at a number of places, and one tunnel has been driven in on the main seam for a distance of 40 feet. The exposures in this tunnel show the coal to be uniform in thickness and quality.

In sampling this bed a cut was made across Nos. 5 to 8 inclusive in the above section. The analysis is given on page 146.

The strike, so far as the beds could be examined, is uniform and appears to continue without notable break for at least half a mile to the northeast. The tunnel opening is 50 feet above the stream bottom, where there is space for mine buildings. At present there is a wagon road from Hook Bay to the coal croppings, along a stream bottom where the general gradient and space would be favorable to railway construction. Hook Bay is an excellent small harbor, and is bordered by favorable sites for wharves and bunkers. The distance from the harbor to the coal is about 8 miles. At present four claims are staked out in this field, and development work is

being done under the auspices of the Alaska Peninsula Mining and Trading Company.

HERENDEEN BAY.

INTRODUCTION.

Herendeen Bay, the western arm of Port Moller, is on the northwest side of the Alaska Peninsula at about 160° west longitude and 55° 30′ north latitude. (See Pl. V.) The head of the bay is near the central portion of the peninsula, and is only 8 miles from the head of Balboa Bay, a reentrant on the Pacific side. The portage

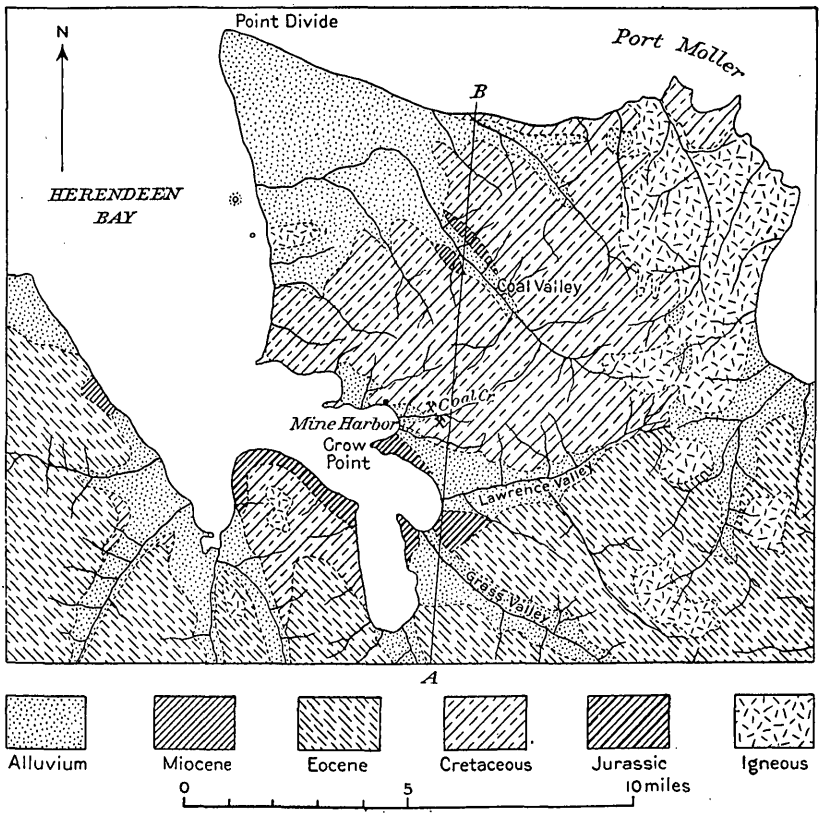


FIGURE 10.—Geologic map of Herendeen Bay coal field. *A-B*, line of section, figure 11.

from one of these bays to the other is made by an excellent trail over a pass not more than 500 feet above sea level, which connects two broad, flat-bottomed valleys.

The coal which has been opened and is now being developed is found in a small peninsula between Herendeen Bay and the main or eastern arm of Port Moller. (See fig. 10.) Within that area the coal-bearing formations occupy at least 40 square miles, and coal is exposed at various localities. Some beds of lignite outcrop on

the western shore of Herendeen Bay and are reported to extend several miles to the west. In the central portion of the Alaska Peninsula, in the mountain slopes east of the trail to Balboa Bay, other beds of lignite outcrop.

Within the coal field the topography is that of gently rounded hills and low mountains. The highest points are a little over 2,400 feet in altitude, but the portions above 2,000 feet constitute but a small part of the area. The largest valley is that of Coal Creek, which is located in the central portion of the field. This valley is a broad, open, flat-bottomed trough leading northward through the coal field and westward to Herendeen Bay. The smaller valleys drain westward into Herendeen Bay and eastward into Port Moller. They are somewhat rugged, and travel is easier on the intervalley ridges than through the gorges.

Throughout the summer season, from June to October, the mean temperature is about 46° F. During the winter months, from October to May, the mean monthly temperature ranges from 13° F. to 39° F. The annual precipitation during 1903, when records were kept at the Herendeen Bay mine camp, was 46.22 inches. In the summer the number of clear days ranges from five to ten a month. During the three years from 1902 to 1904, inclusive, there were twenty-seven days when the minimum temperature was below zero and four days when the maximum temperature was below zero. Mine Harbor was frozen in the years from 1902 to 1906, inclusive, during the following periods: December 18, 1902, to May 6, 1903; December 29, 1903, to May 26, 1904; January 3, 1905, to May 25, 1905; January 15, 1906, to March 17, 1906.

In 1908 Herendeen Bay could be reached by way of Bering Sea by private means of transportation from Unalaska or Nushagak. The more common route is by regular steamer to Balboa Bay and thence by trail across the peninsula to the head of Herendeen Bay.

GEOLOGY.

This coal field is located in the minor folds northwest of the main anticlinal arch of Alaska Peninsula. The sedimentary formations exposed range in age from Upper Jurassic through Lower and Upper Cretaceous to Eocene. (See fig. 10.) Pleistocene deposits mantle a small part of the area, and in the valley bottoms and along the shores there are alluvial deposits of post-Pleistocene age. The description of the geology of the western portion of Alaska Peninsula, given on pages 114 to 115, is based chiefly on work done in the vicinity of Herendeen Bay. A few details may be added here.

In the western part of the field, where the coal locations have been made, the formations have not been modified by volcanic intrusions or extrusions, but at the eastern margin of the field there are numerous

dikes, vast quantities of volcanic tuffs, and extensive lava flows. Four volcanic centers, from which lava flows and fragmental material issued, are situated near the eastern margin of the field. At the northern margin and along Herendeen Bay there are volcanic tuffs, but they are not so associated with the coal as to be significant. The northwestern portion of the small peninsula in which the coal is located is mantled in part by glacial material and in part by recent alluvium.

The central part of the field has a synclinal structure, with the axis plunging westward. To the north of this fold there is a broad anticline. Several small faults were noted within the coal field, and at the southern margin there is a fault contact indicating a throw of no less than 1,000 feet. These faults may be detected by the shifted outcrops (see fig. 10) exposed in the higher portions of the field, where there is little or no vegetation. In the mine tunnels may be recognized numerous minor faults of the same general nature as the major faults detected on the surface. Figure 11 shows the general structural conditions along a nearly north-south line through the coal field.

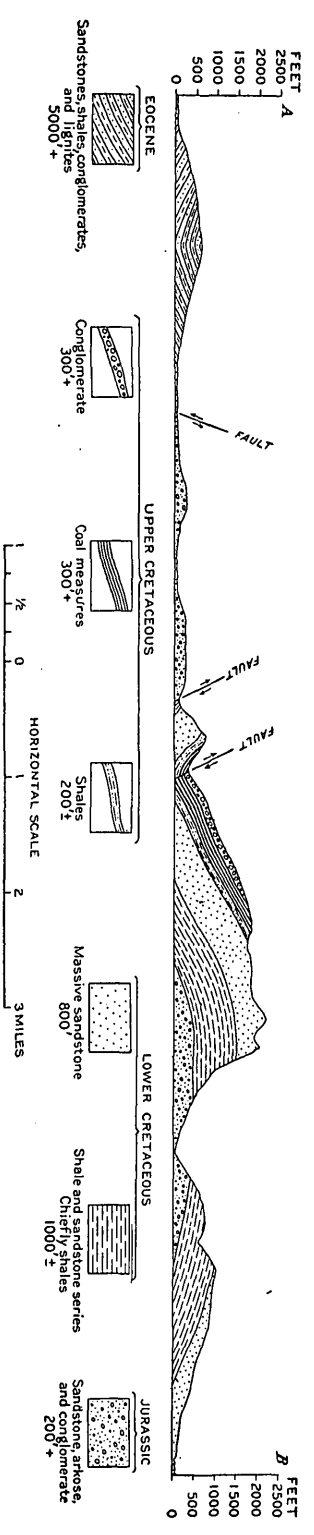


FIGURE 11.—Structure section across Herendeen Bay coal field along line *A-B*, figure 10.

THE COAL.

The presence of coal in the Herendeen Bay region has been known for a number of years. Several attempts have been made toward its development, but little has yet been mined. The first exploitation of the field was undertaken in 1880 by a corporation under the name of the Alaska Mining and Development Company. Two drifts were run, one about 200 feet, the other about 300 feet in length, on a coal bed of 4 feet average thickness. The coal was brought to the

water front by a steam motor on a small tramway, and several hundred tons were taken out in 1890, of which the U. S. S. *Albatross* used between 200 and 300 tons.[a] At that time there was no immediate market for the coal, as the Western States and Territories were fully supplied from the Washington and Vancouver mines. The field was therefore abandoned and no further work was done until 1898, when C. A. Johnson relocated the coal land and started what is known as the Johnson tunnel. In 1902 the property passed into the hands of a company that did very little work, and in 1904 this company forfeited all its rights. The present claimants made surveys of the field and did some careful prospecting, which included a small amount of core-drill work. This work has been done under the supervision of Philbrick & Foster, as agents for the present claimants.

Within the coal field the best-known outcrops are near the head of Coal Valley and in the valley of Mine Creek. Coal is exposed also near the head of the next valley east of Coal Valley and at several places about the margin of the volcanic tuffs a little farther east. Outcrops of coal have been reported in tributaries to Lawrence Creek. The main coal measures outcrop about 5 miles north of Mine Harbor, on the east shore of Herendeen Bay. This locality is known as Coal Bluff. On the north coast of the coal-bearing peninsula and 9 miles east of Point Divide there are two beds of lignite, and on the west shore of Herendeen Bay nearly opposite Coal Bluff several others are exposed. Columnar sections of these coals are given in figure 9.

The following section in the coal measures was obtained on the south slope of the Mine Creek valley:

Section in the coal measures, Mine Creek valley, Herendeen Bay.

	Ft.	in.
Conglomerate	300	
Coarse sandstone, cross-bedded, with huge sandstone concretions weathering brown from abundance of limonite	50	
Sandy shale	20	
Coal seam, medium grade	3	
Firm cross-bedded sandstone, fossil leaves	3	
Shale	5	
Coal, bituminous		10
Shale	2	6
Shaly coal		6
Shale, with sandstone cones	3	
Coal, bituminous	1	
Shales	4	

[a] Dall, W. H., Report on coal and lignite of Alaska: Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, p. 805.

	Ft.	in.
Coal, bituminous	1	2
Shaly sandstone, with sandstone cones	4	
Coal, bituminous		10
Shales	4	
Coaly shales	1	6
Shales	3	
Carbonaceous shales	1	
Shales	2	
Coal, bituminous	1	
Shales	2	
Coaly shales, with shale partings	2	3
Coal, with bony partings and shaly bed	7	
Shales	1	8
Shaly coal	1	2
Shale	2	6
Coal, bituminous	1	1
Shales	3	
Coal, bituminous	2	
Shales	3	6
Coal, bituminous	1	2
Shales		6
Coal, bituminous	1	5
Shales, with sandstone cones	4	
Coal, bituminous	1	8
Shales and sandstone interbedded	15	
Coal, bituminous		8
Shales	5	
Shaly sandstone	2	
Shales	50	
Coal	1	2
Shales	6	
Coaly shale		4
Shales	7	
Coal, bituminous	1	
Shales	3	
Coal, bituminous	1	
Shales, with sandstone cones	40	
Coarse cross-bedded sandstone and conglomerate	15	
Shales and sandstones.		

Dip, 30° N.; strike, N. 91° E.

On the left fork of Mine Creek Paige [a] measured the following section:

Section of coal beds on left fork of Mine Creek.

	Ft.	in.
Coal, crushed	7	
Shale	9	
Coal, bony	1	
Shale and sandstone	6	6
Coal, crushed		8
Coal, fairly solid (partly obscured by slide)	10	

[a] Paige, Sidney, Bull. U. S. Geol. Survey No. 284, 1906, p. 107.

	Ft.	in.
Shale, carbonaceous	3	4
Covered by slide	20	
Coal with bone (details not observed)	12	
Shale and coal	4	
Coal	2	8
Shale	6	
Coal	3	
Remainder hidden by slide.		

The detailed section of the coal exposed in the lower tunnel on Mine Creek is as follows:

Section of lower tunnel coal bed, Mine Creek, Herendeen Bay.

	Ft.	in.
Shale roof.		
1. Shaly coal	1	1
2. Bone		2
3. Coal, bituminous	1	1
4. Shaly coal		2
5. Coal, high-grade bituminous	1	4
Firm sandstone floor.		

Strike, N. 91° E.; dip, 30° N.

A section of the coal at the Johnson tunnel, which is on the south slope of the Mine Creek valley about 870 feet above sea level, is as follows:

Section of the Johnson tunnel coal bed, Mine Creek, Herendeen Bay.

	Ft.	in.
Shale roof.		
1. Coal	1	4
2. Clay		9
3. Coal, high-grade bituminous	5	
Clay floor.		

Strike, N. 101° E.; dip, 34° NE.

Samples of coal were taken from each of the above beds, and the analyses appear on page 146. No work had been done in the lower tunnel during the ten months preceding the examination, but the sample was procured by crosscutting near the farther end of the tunnel, where work had been done most recently. Material from beds 1 to 5 in the above section was included in this sample. The Johnson tunnel also had been closed for fully ten months, but a sample was procured from bed No. 3 in the above section by first cleaning the face of the seam and then making a crosscut.

The Johnson tunnel is about 100 feet long. The coal continues for about 75 feet, becomes much broken, and finally disappears. Some prospecting has been done to find the continuation of this bed, but it has not yet been located. In drifting it has been necessary to use timber to support the roof. The coal which has recently been mined here has been entirely for local consumption and has amounted to but a few tons each year.

The lower tunnel, near the stream bed and at an elevation of 275 feet above sea level, has been driven for 150 feet along the strike of the coal. At this place the roof is firm, and no timbering was necessary beyond the entrance. During 1907 about 20 tons was taken from this drift for use in drilling and for domestic purposes. The walls of the drift indicate that there has been some minor faulting at various places, the movement ranging from a few inches up to a foot. This is typical of the distributive faulting associated with the larger movements in the field and is of the same general character.

Three drill holes have been put down in the lowlands near the mouth of Mine Creek. The deepest reached a depth of 350 feet and some coal was found. The other holes were sunk 150 feet and 28 feet. The work was unfortunately delayed by the loss of tools. As yet no coal of minable thickness has been found by drilling.

In the portion of the field where work has thus far been done the mining conditions are not especially difficult. The coal beds dip at angles varying from 25° to 35° and they are well exposed in the valley bluffs. The faulting that has disturbed the formations has not been on a large scale, and when the structure is worked out in detail there should not be much difficulty in locating the coals in the different fault blocks. From the lower drift coal may be easily taken to tide water. At present a good horse trail reaches the mouth of this tunnel, and it would not be difficult to construct a wagon road or a railroad to that point. The Johnson tunnel, at an elevation of 870 feet, is less favorably located for transporting the coal. The horse trail, which reaches the lower tunnel, continues to this higher opening, but the ascent is in part difficult. Coal has, however, been packed out on horses over this trail. The construction of a road to this opening would be expensive, but the coal might easily be handled by tramways to more accessible places in the valley.

The coal exposed at Coal Bluff has the appearance at the surface of being of as high a grade as that outcropping at several other places. The coal exposed near the headwaters of Coal Creek, in certain of the tributaries from the west and in the continuation of the coal belt in which the Johnson tunnel is located, but in the opposite side of the syncline, appears to be of good grade, and in this part of the field faulting has not so greatly disturbed the formations. During the writer's visit this part of the field contained so much snow that the coals could not be satisfactorily examined.

The absence of forests will make it necessary, in the development of the field, to ship in timber. If these coals are mined on a large scale, they should be carried by railway to Balboa Bay for shipment. The route from Mine Harbor to Balboa Bay is about 16 miles long and an easy one for railway construction. Mine Harbor is well protected and is sufficiently deep for commercial purposes, but

during several months of each year the upper part of Herendeen Bay is locked in ice. During the summer months coal could be shipped by way of Herendeen Bay to Bering Sea, and thus to the Alaskan ports farther north. If coal is mined from the head of Coal Valley, the problem of taking it to tide water on the Pacific side of the peninsula is a little more difficult. A railroad could be constructed along Coal Valley and connected with Mine Harbor by a route which would add about 15 miles to the direct route, or double the haul to the Pacific. At Balboa Bay there is an excellent harbor and good bunker sites are available.

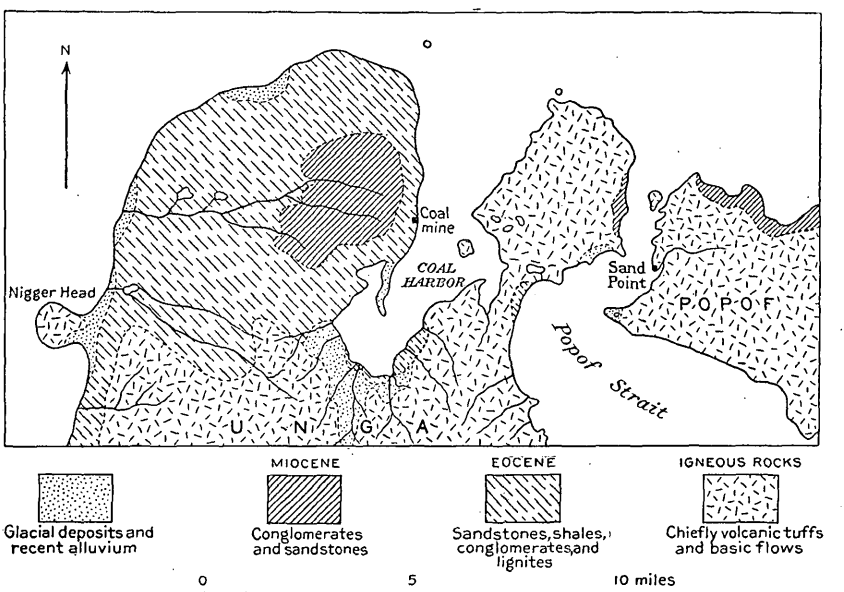


FIGURE 12.—Geologic map of Coal Harbor coal field, Unga Island.

COAL HARBOR.

INTRODUCTION.

Unga is the largest and westernmost island of the Shumagin group, which lies southeast of Balboa Bay (Pl. V). Coal-bearing strata outcrop on the west shore of Coal Harbor, at the north end of the island. These coal measures appear to underlie the northwestern portion of the island and to include about 40 square miles. (See fig. 12.)

At the eastern margin of this coal field the upland surface is a little more than 600 feet above the sea; it declines gradually to the west, reaching sea level at the western shore of the island. The entire field is therefore in a lowland area. The streams flow to the west over the gentle slopes of the upland surface and through shallow valleys. Bordering the field at the east is a steep bluff, 600

feet high, which becomes lower to the north and south and inconspicuous at the northwestern and western margins of the field. The topography of the upland surface is varied somewhat by a mantle of glacial drift, in which there are numerous small depressions containing lakes or swamps.

Unga Island enjoys a milder and more equable climate than the mainland to the north. Practically all of the winter snow disappears during the summer, and the number of clear days exceeds that for the mainland.

The northern portion of the island is overgrown by grasses and shrubs. A few patches of alder bushes are scattered on the valley slopes, but there are no trees on the island.

GEOLOGY.

The distribution of the formations in and near the coal field is given in figure 12. The coal-bearing rocks are of upper Eocene age and are overlain conformably by Miocene conglomerates. The Eocene sediments consist of sands, sandstones, clays, shales, conglomerates, and seams of lignite, and much of the material is but poorly cemented. A section was measured a short distance north of the coal mine on the west shore of Coal Harbor. The base of the section is 50 feet above mean tide level. This section is given graphically in columnar form in figure 13. The upper 200 feet represent Dall's Unga

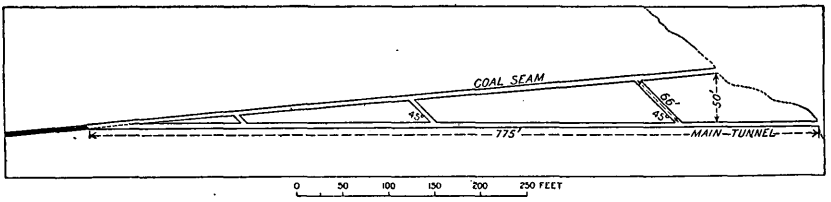


FIGURE 13.—Vertical section at Coal Harbor mine, Unga Island.

conglomerates, determined by him to be of Miocene age. These beds rest conformably upon the lower coal-bearing series, which are of upper Eocene age and have been correlated with the Kenai formation. The base of the Eocene is not exposed. The coal-bearing beds are nearly horizontal, the dip being to the west at about 9°.

Miocene beds outcrop on the northeast coast of Unga Island and on the north shore of Popof Island. Fossils procured from these localities have been reported by Dall to represent an upper Miocene horizon.

The igneous rocks in the north end of Unga Island (fig. 12) consist of granites, basalts, and volcanic tuffs. In the northeastern portion of the island basalts and tuffs overlie the Miocene beds unconformably. Coarsely crystalline rocks occur also south of the coal field, in the central portion of the island.

Glacial deposits are present in the mountain valleys south of Coal Harbor and on lowlands at the northwestern shore of the island. Along the coast line and in valley bottoms there are recent alluvial deposits, and near the north and northeast shores lie small areas of sand dunes.

THE COAL.

Previous to 1882 there had been no mining in this field except that by Russians, who are reported to have taken some coal from outcrops near the beach. From 1882 to 1884 a company was engaged in mining at this locality and is reported to have kept twenty men at work throughout that period and to have supplied with fuel small steamers engaged in seal hunting. Some of the coal was used for domestic purposes, and two cargoes, amounting to about 700 tons, are reported to have been sent to San Francisco in 1883. The property is now under the control of the Tide Water Consolidated Company. Several drifts have been opened and one mine put into operation on a shipping basis. (See fig. 13.) Bunkers have been built about 100 feet from the shore, and a steel conveyor connects them with the mine. The developed coal bed outcrops about 200 feet above tide water. The detailed measurements of the upper part of the coal bed as now exposed in the mine are as follows:

Section of coal bed in Coal Harbor mine.

	Ft.	in.
Firm, coarse grit and conglomerate roof.		
Lignite	1	1
Loose sand		6
Lignite		8
Coaly shale		2
Clay		3
Lignite		10
Lignite		4
	3	10

Strike, N. 12° W.; dip, 8° W.

The bed was sampled in the usual way, the sand and shale, which could be readily separated in mining, being excluded. The analysis of this sample is given on page 146.

There are no special difficulties associated with the mining or shipment of this lignite, and if mined with sufficient care to keep it clean it may be able to compete with the somewhat better coals that are being shipped to this part of Alaska. It will at least continue to be of value to the natives and to the few white people living on Unga and the neighboring islands.

COMPOSITION OF CHIGNIK BAY, HERENDEEN BAY, AND UNGA ISLAND COALS.

The following table gives the results of the proximate analyses of some of the coals from the Chignik Bay, Herendeen Bay, and Unga Island fields. The samples were sealed in air-tight cans as soon as collected and then sent to the laboratory. The analyses of the coal as received have been recalculated to obtain the analyses on the air-dried basis. The samples were obtained at the following localities:

6952. Coal bed on west side of main stream, 7 miles northwest of Hook Bay, east side of Chignik Bay, Alaska Peninsula.

6956. Chignik Bay, Thompson Valley, three-fourths mile above mouth of stream.

6955. Chignik Lagoon, Whalers Creek, three-fourths mile above mouth.

6953. Chignik River, north side, 2 miles below Chignik Lake.

6957. Herendeen Bay, Mine Creek, three-fourths mile above mouth.

6951. Herendeen Bay, Mine Creek, 1¼ miles above mouth.

6954. Unga Island, Coal Harbor, 1¼ miles west-northwest of Gull Island.

Analyses of Chignik Bay, Herendeen Bay, and Unga Island coals.

[Analyses by F. M. Stanton, U. S. Geological Survey.]

SAMPLES AS RECEIVED.

Laboratory No.	Proximate analyses.				Ultimate analyses.						Calorific value.	
	Loss on air drying.	Total moisture.	Volatile combustible.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
6952	4.00	5.07	27.24	42.42	25.27	2.26	4.53	55.76	0.59	8.38	5,618	10,112
6956	6.50	10.77	30.37	43.99	14.87	.70	4.98	55.27	.61	23.57	5,356	9,641
6955	2.50	5.02	34.28	45.45	15.25	1.75	4.87	62.04	.56	15.53	6,245	11,241
6953	5.20	7.06	31.48	39.68	21.78	1.30	4.83	55.14	.61	16.34	5,470	9,846
6957	4.60	7.48	32.13	48.77	11.62	.31	5.11	63.49	.91	18.56	6,256	11,261
6951	5.30	8.01	33.53	51.35	7.11	.41	5.41	66.44	.80	19.83	6,547	11,785
6954	12.50	23.27	25.42	25.13	26.18	.53	5.27	34.76	.52	32.74	3,227	5,809

AIR-DRIED SAMPLES (CALCULATED FROM TABLE ABOVE).

Laboratory No.	Proximate analyses.			Ultimate analyses.						Calorific value.	
	Moisture.	Volatile combustible.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
6952	1.11	28.38	44.19	26.32	2.35	4.26	58.08	0.61	8.38	5,852	10,533
6956	4.57	32.48	47.05	15.90	.75	4.56	59.11	.65	19.03	5,728	10,310
6955	2.58	35.16	46.62	15.64	1.79	4.71	63.63	.57	13.66	6,405	11,529
6953	1.96	33.21	41.86	22.97	1.37	4.48	58.17	.64	12.37	5,770	10,386
6957	3.02	33.68	51.12	12.18	.32	4.82	66.55	.95	15.18	6,558	11,804
6951	2.86	35.41	54.22	7.51	.43	5.09	70.16	.84	15.97	6,913	12,343
6954	12.31	29.05	28.72	29.92	.60	4.44	39.73	.59	24.72	3,688	6,638

COAL AND PAVLOF BAYS.

Coal and Pavlof bays are indentations on the south coast of Alaska Peninsula, about 50 miles west of Unga Island. The main anticlinal axis of the peninsula continues southwestward from the Balboa-Herendeen Bay region to the eastern shore of Pavlof Bay. The fold is here composed chiefly of the upper Eocene beds, which have yielded fossils of invertebrates and some plant remains. On the north shore of Coal Bay and on the east shore of Pavlof Bay there are thin beds of coal which have been worked for the local markets. The bed at Coal Bay is from 15 to 18 inches thick. On the shores of Pavlof Bay there are two beds of lignite, each of which is less than 12 inches thick.

PETROLEUM.

Petroleum is known to occur at two localities in southwestern Alaska—in the Enochkin Bay district and in the vicinity of Cold Bay.[a] These fields were not visited by the writer, but both have been examined by Martin,[a] and the following account is abstracted from his reports. The map (fig. 14) published by Martin, chiefly from data furnished by A. G. Maddren, is here reproduced.

The Enochkin Bay oil seepages and so-called "gas springs" are in an area of shales and sandstones of Jurassic age, which are thrown up into a long anticline. This dominant structure parallels the coast, bending from an east-west strike at the south end of the fold to a northeast-southwest strike at the north end. Several wells were driven at this locality between 1898 and 1904, the deepest being about 1,000 feet deep, but no flow of oil was obtained.

At Cold Bay there are many large seepages and several wells were drilled in 1903 and 1905, but yielded no flow of oil. Here the rocks are chiefly Jurassic shales and sandstones and the structure is similar to that at Enochkin Bay.

GOLD.

INTRODUCTION.

The gold placers of the Sunrise district have been described by Moffit,[b] and the recent mining developments are summarized elsewhere in this volume (p. 52). The gold deposits of Kodiak Island were not studied by the writer, but a brief account of this district is given on page 30. U. S. Grant describes the gold prospects in the vicinity of Seward on page 107.

During the summer of 1906 a few miners were at work on the Anchor Point beach placers, using rockers or small sluice boxes, and

[a] Martin, G. C., Petroleum of Pacific coast of Alaska: Bull. U. S. Geol. Survey No. 250, 1905, pp. 37–59 Notes on the petroleum fields of Alaska: Bull. U. S. Geol. Survey No. 259, 1905, pp. 133–138.

[b] Moffit, F. H., Gold fields of Turnagain Arm region: Bull. U. S. Geol. Survey No. 277, 1906, pp. 1–52.

they reported that they were making "fair wages." The gold which they obtained was very fine and the deposit exceedingly shallow,

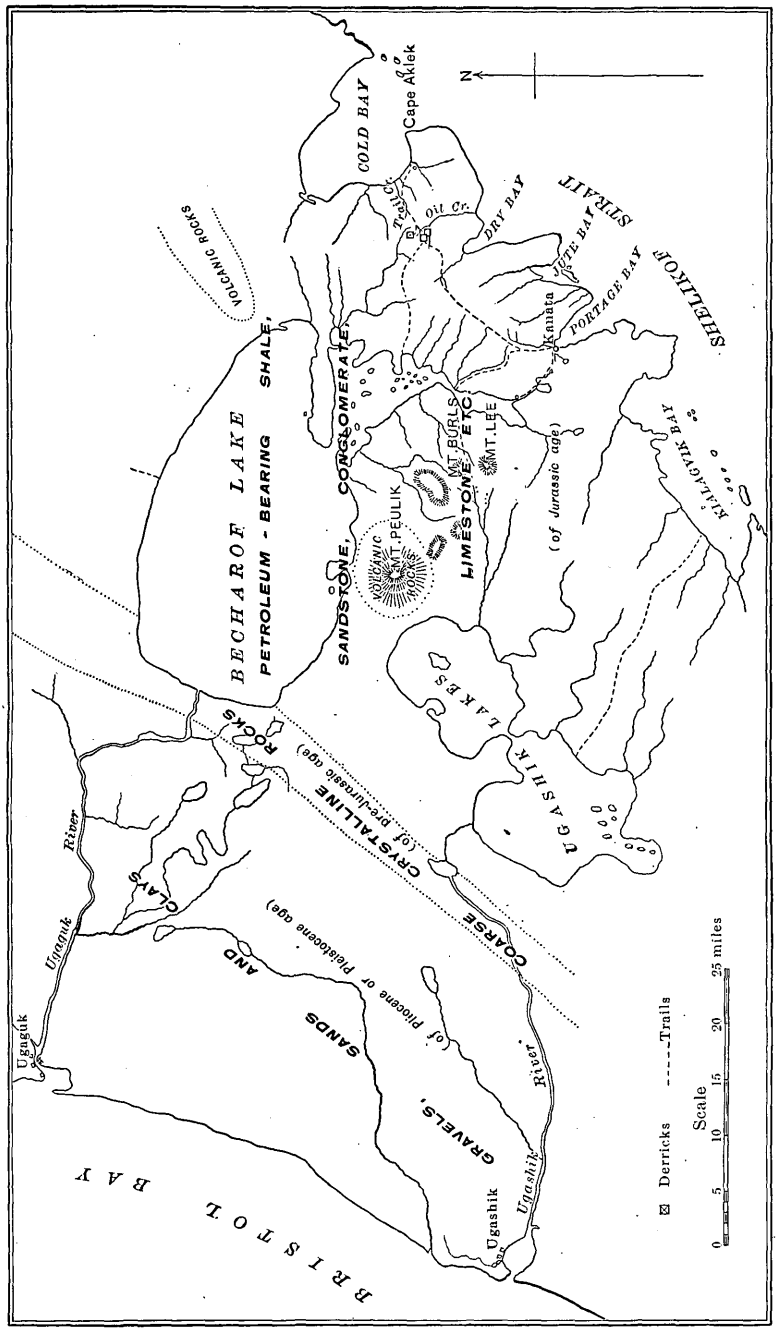


FIGURE 14.—Sketch map of Cold Bay petroleum field.

making it necessary to move frequently to different parts of the beach.

POPOF ISLAND.

Placer gold was discovered by Louis Herman in the beach about 1½ miles south of Sand Point post-office on Popof Island in the summer of 1904. (See Pl. V.) During 1904 and 1905 active work was in progress, and it is reported that gold amounting in value to about $12,000 was taken from these beach placers. The productive belt is about three-fourths of a mile long. From twenty to forty men were at work during the summer of 1904 with rockers, washing the coarse sand and gravel. All the gold that was found was below mid-tide, and most of it around large bowlders at about the level of low tide. Little work has been done on this beach since 1905. In 1908 but one man was engaged in rewashing the sand and gravel from time to time, and he is reported to have found it unsuccessful and finally to have abandoned operations.

During 1908 most of the interest on this island was centered on four lode claims that were staked on the hills immediately adjoining the beach placers. No distinct quartz ledges have been located on the claims of Louis Herman and G. C. Duchen, but the rock there exposed contains some free gold. Specimens in which free gold is plainly visible may be found in the surface zone of oxidation and weathering. This zone varies from 5 to 10 feet in thickness. Several samples were taken from the weathered material and when crushed and panned they yielded some free gold. The owners of this property have had several samples assayed and reported values up to $20 a ton. On the Louis Herman property a short tunnel has been driven and four shafts sunk below the zone of surface weathering. Ore samples were taken from three openings on this property, and though they vary greatly in their content of gold one sample was exceedingly rich. The rock in which this gold occurs is an andesite similar to that in Unga Island where the Apollo mine is located. The unweathered rock appears as a light-gray lava, containing an abundance of small pyrite crystals. In an adjoining claim one small quartz ledge has been discovered and some development work has been done.

UNGA ISLAND.

Gold-bearing ledges have been found at a number of places in Unga Island. (See Pl. V.) In the southeastern portion of the island, about 1 mile from the head of Delarof Harbor and 4 miles from the town of Unga, are located the Apollo and Sitka mines. A third mine has been opened on the Shumagin group of claims near the head of Baranof or Squaw Harbor. Several locations for gold lodes have been made on the ridge south of the Apollo mine, in the valley west of the Shumagin mine, and at points about 2 miles south of Coal Harbor.

Apollo Consolidated mine.—This mine was on a productive basis from 1891 to 1904, and was reopened during the summer of 1908, when 40 of the 60 stamps in the mill were put into operation and ore that had already been mined was run through the mill. The occurrence at this locality has been described by Becker[a] and by Martin, who visited it in 1904, gathering some additional data.[b]

The deposit as described by Becker is a reticulated vein or zone of fracture, in a country rock of andesite and dacite. The ores include free gold, pyrite, galena, zinc blende, copper pyrite, and native copper. The ore is free milling, a large part of the gold being carried in the native state. The gangue minerals are quartz and subordinate amounts of calcite and orthoclase. The ore body strikes N. 20° E. It is from 5 to 40 feet wide and forms a shoot that pitches northward. At the south end of the workings the shoot comes to the surface at an elevation of 600 feet, and at the north end it narrows and becomes of low grade at a depth of about 800 feet. Several attempts have been made to reach the ore body at lower levels by shaft and tunnel, and long crosscut tunnels have been driven in prospecting the adjoining areas. The ore body was exceedingly rich in places, carrying up to $50 a ton. The average for the main ore body was perhaps about $8. The main shoot has now been worked out. Some ore has been taken from minor zones of fracture in the crosscut tunnels, but this material has not been found in sufficient quantities to justify a continuation of the work. The country rock has been mineralized to a certain extent on either side of the main ore body.

Becker concluded that the country rock is Miocene or post-Miocene from its lithologic similarity to andesite, which is supposed to overlie the Miocene at the north end of the island. He would accordingly make the mineral veins of very recent Tertiary or post-Tertiary age. The present writer believes the post-Miocene andesites at the north end of Unga Island to be distinct in age from the country rock in which the gold ledges occur. The younger andesites cover a portion of the south end of the island and irregularly overlie the gold-bearing formation. The age of the rock in which the gold-bearing ledges occur is not definitely known, but it is believed by the writer to be Mesozoic, or older.

Sitka mine.—This mine is located across the valley from and north of the Apollo mine. The ore body is associated with a shear zone which strikes at right angles to the Apollo ore body. The rock in which this ore occurs is of the same general type as that at the Apollo mine. The ores consist of free gold, galena, zinc blende, and pyrite. The gangue minerals are quartz and subordinate amounts of calcite.

[a] Becker, G. F., Reconnaissance of the gold fields of southern Alaska: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 12, 83–85.

[b] Martin, G. C., Gold deposits of the Shumagin Islands: Bull. U. S. Geol. Survey No. 259, 1905, pp. 100–101.

The ore is of low grade and has never yet paid for the working. During the past summer some of the material in the dump was run through the mill and the superintendent believes that the ore could now be mined and milled at a profit. This mine is connected by a tramway with the Apollo plant, so that the ore may be handled at the Apollo mill.

Shumagin mine.—Three claims have been staked out along two ledges which strike N. 60° E. and outcrop in a low ridge one-half mile southwest of the head of Baranof Harbor. The southern ledge is about 50 feet thick, but the ore has not proved sufficiently rich to encourage mining. The other ledge varies in width from 2 to 3 feet and is reported to carry values between $4 and $5 to the ton and nowhere to run below $2. These quartz ledges are in shear zones and are interrupted by many horses of country rock. The present workings consist of a lower tunnel, which has been driven 363 feet, passing through the wider quartz ledge and within a short distance of the second ledge. At the end of this tunnel a crosscut 75 feet long has been made. The upper tunnel is 79 feet long and at the end there is a crosscut running 116 feet to the east and 53 feet to the west along the ore body. The two tunnels are separated in elevation by 150 feet.

UNALASKA ISLAND.

The island of Unalaska is off the western extremity of Alaska Peninsula, near one of the most frequented routes from the Pacific Ocean to Bering Sea. It is important chiefly on account of its splendid natural harbor, on which are located two coaling and trade stations, Dutch Harbor and Unalaska. Several years ago an unsuccessful attempt was made to develop and mine some gold-bearing quartz veins near the village of Unalaska. A 3-stamp mill and a couple of tramways to connect the mill with the mine were erected, but these are now in a state of ruin. Quartz veins of economic value are reported by prospectors on several of the islands farther west.

The following notes are quoted from a report on this district made in 1905 by Collier.[a]

> The hard rocks of the islands are volcanic and consist of interbedded tuffs and flow that are cut by numerous dikes. The most common rocks are dark-gray andesites.[b] * * *
>
> South of Dutch Harbor for several miles the rocks are cut by a system of nearly vertical joint planes which extend approximately east and west. Mineralization has occurred along these joints, and in some instances quartz veins have been formed. Several such quartz veins are exposed in the bluff west of Unalaska, where they have been prospected by short tunnels. The best example, however, is found at the gold mine located 1½ miles south of Unalaska and about a quarter of a mile from the shore of Captains Bay, where a number of small veins of this kind are contained in compact

[a] Collier, A. J., Auriferous quartz veins on Unalaska Island: Bull. U. S. Geol. Survey No. 259, 1905, pp. 102-103.

[b] Emerson, B. K., Harriman Alaska Expedition, vol. 6, Geology, 1904, p. 29.

gray andesite. The largest of these forms the main ore body of the mine and has been opened for about 200 feet. It has a maximum width of 6 or 7 feet, but thins out in both directions from the widest part and at the ends of the tunnels is not over 1 or 2 feet wide. The samples obtained here consist of kaolin and cellular quartz, heavily stained with iron in the form of limonite. Samples obtained on the dump and around the mill indicate that a considerable portion of the ore originally contained unweathered pyrite and sulphide minerals. A sample taken by the writer from the face of the drift at the principal ore body was assayed by E. E. Burlingame & Co., of Denver, who reported 0.02 ounce of gold to the ton and a trace of silver. It is reported that before the mill was built assays promised very high values, which were not realized from the ore when milled.

COPPER.

INTRODUCTION.

There are no copper mines in southwestern Alaska, but several locations have been made for copper in the Turnagain Arm district, in the vicinity of Seward, in the region of Lake Clark and Lake Iliamna west of Cook Inlet, at Prospect Bay, and on the east shore of Balboa Bay. Reference to the copper in the Turnagain Arm district may be found in Moffit's report on the mineral resources of the Kenai Peninsula.[a] The Lake Clark and Lake Iliamna region was not visited by the writer, but the occurrence of copper ores is reported by mining men who examined this district during the summer of 1908.

PROSPECT BAY.

Prospect Bay is a few miles west of Chignik Bay, on the south shore of Alaska Peninsula. (See Pl. V.) The copper property here has attracted some attention, and various reports regarding it have appeared in Alaskan and Pacific coast papers. The ore body is located at the west shore near the head of Prospect Bay, and fortunately near an excellent little harbor behind a sand and gravel hook. The zone that is staked is about 50 feet wide and consists of crushed rocks in which there are numerous small cavities containing minerals in the crystalline form. The minerals include pyrite, galena, sphalerite, chalcopyrite, and quartz. The crystalline development is in places of the geode type. The country rock to the southwest is coarsely crystalline and of a granitic type. The contact to the northeast is not well exposed. When visited during the early part of the past season, no large body of high-grade ore had been developed, as currently reported. Hand specimens which are fairly rich in copper minerals may be procured from the fracture cavities.

BALBOA BAY.

On the east shore of Balboa Bay, in the midst of the andesitic lava, there is a shear zone in which some copper occurs. There are several prospects in this vicinity and one short tunnel was driven some years ago, but has now been entirely abandoned.

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[a] Moffit, F. H., Bull. U. S. Geol. Survey No. 277, 1906, p. 48.