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.

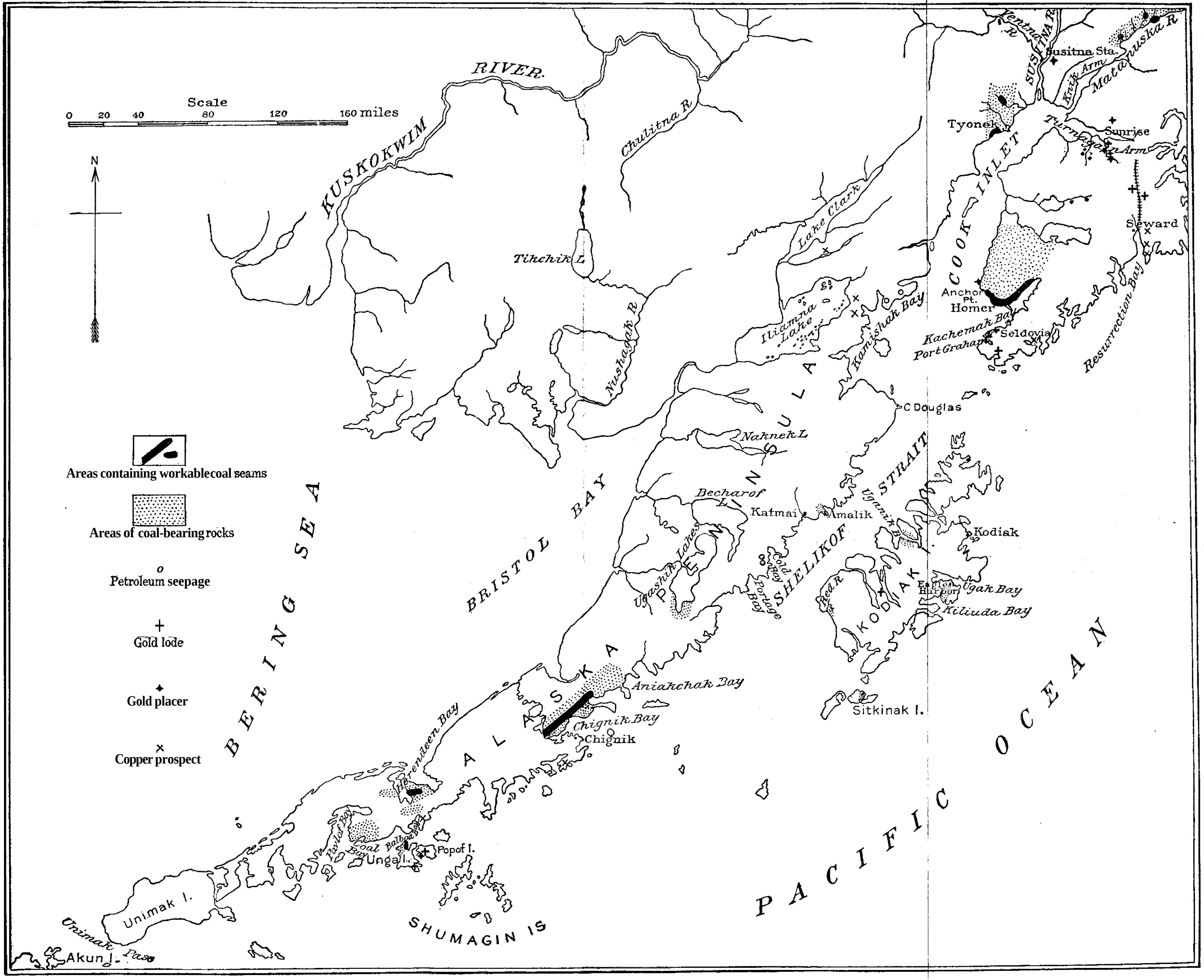
Most of the data to be presented were collected during the months of June to September, 1908, much of this time, however, being spent in examining the Unga, Herendeen Bay, and Chignik Bay coal fields. A part of the results of a study made in 1906 of the Cook Inlet coals is also incorporated. Free use 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

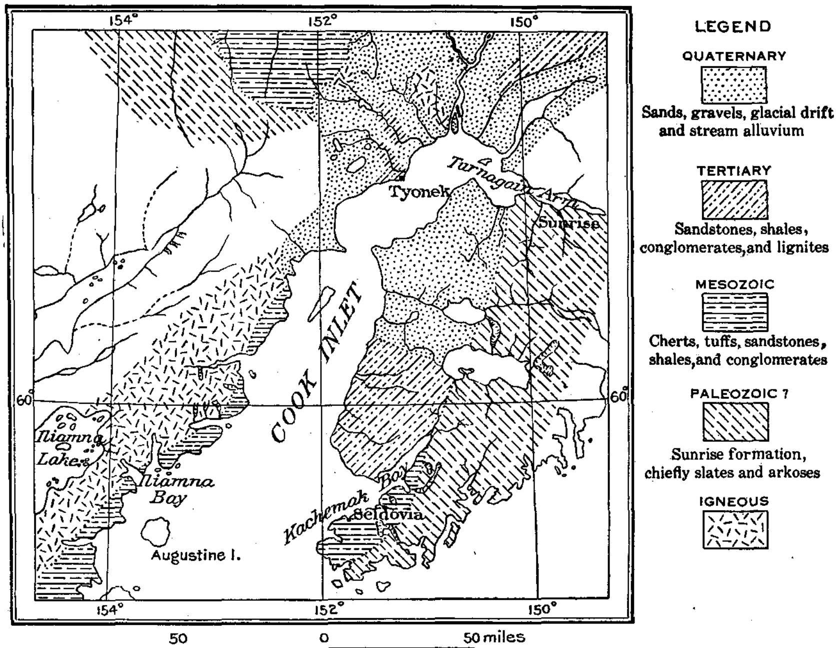


FIGURE 2.—Geologic sketch map of Cook Inlet region.

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 ana 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 Oetaceous (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 calcarwus sandstone.	1,800+	
Upper Jurassic	Chignik and Herendeen hays.	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 above-mentioned 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 Bag district but from a lithologic unit that occupies a very small area, seems to indicate post-Miocene age. The most extensive post-Miocene lormations 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, horth 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.

QEOLOOY.

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.

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

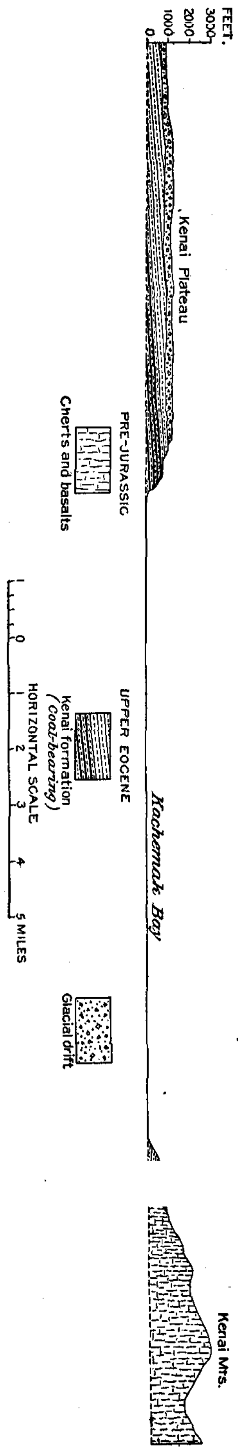


FIGURE 3.—Diagrammatic structure section across Homer coal field.

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 to-day 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.

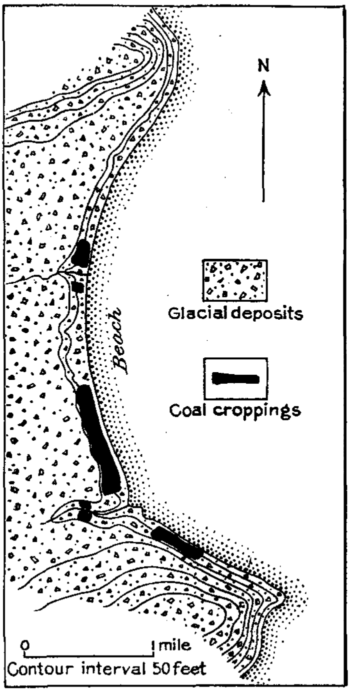


FIGURE 4.—Map showing distribution of coal croppings along the Tyonek beech, Cook Inlet.

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.

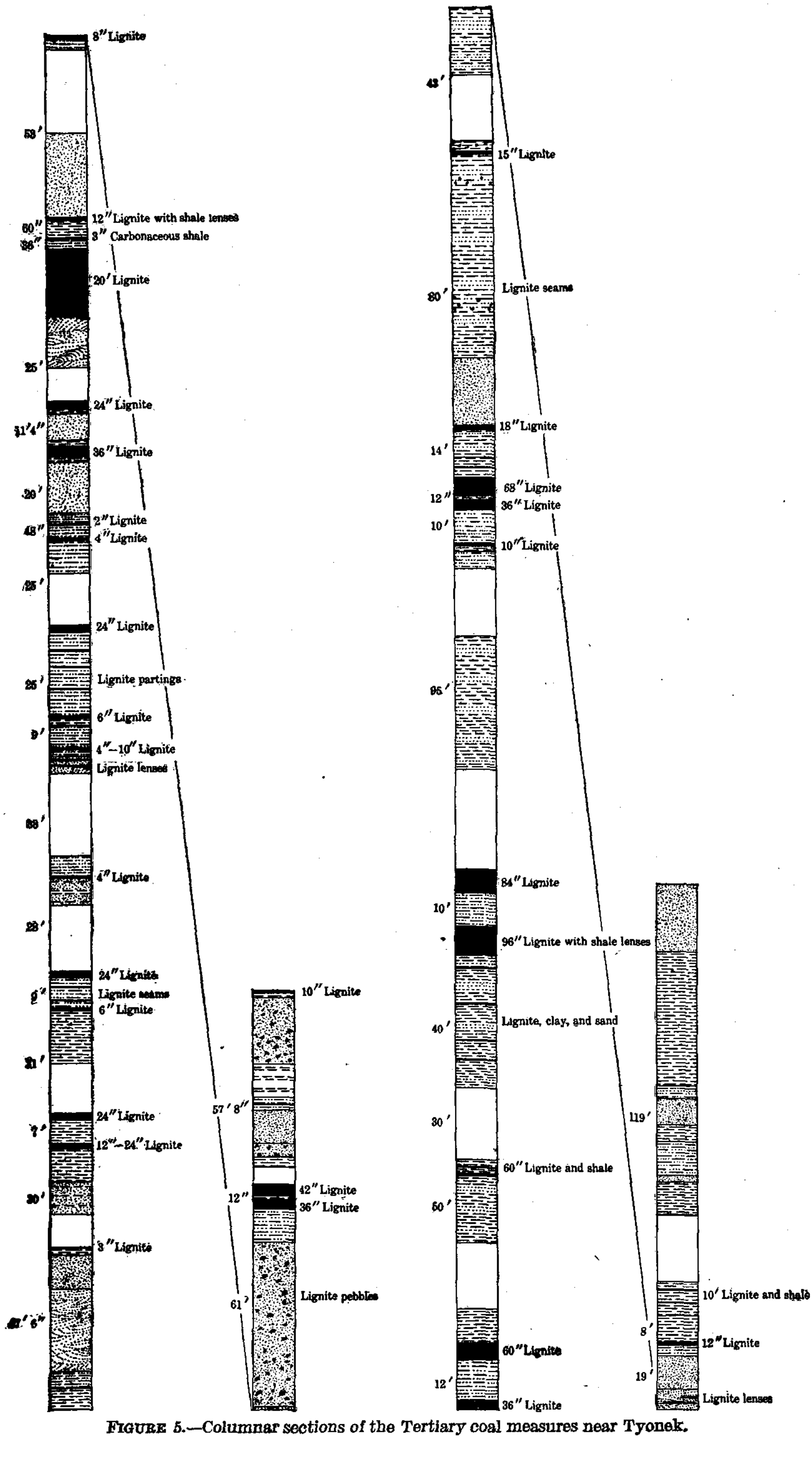


FIGURE 5.—*Columnar sections of the Tertiary coal measures near Tyonek.*

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 $3\frac{1}{2}$ 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.

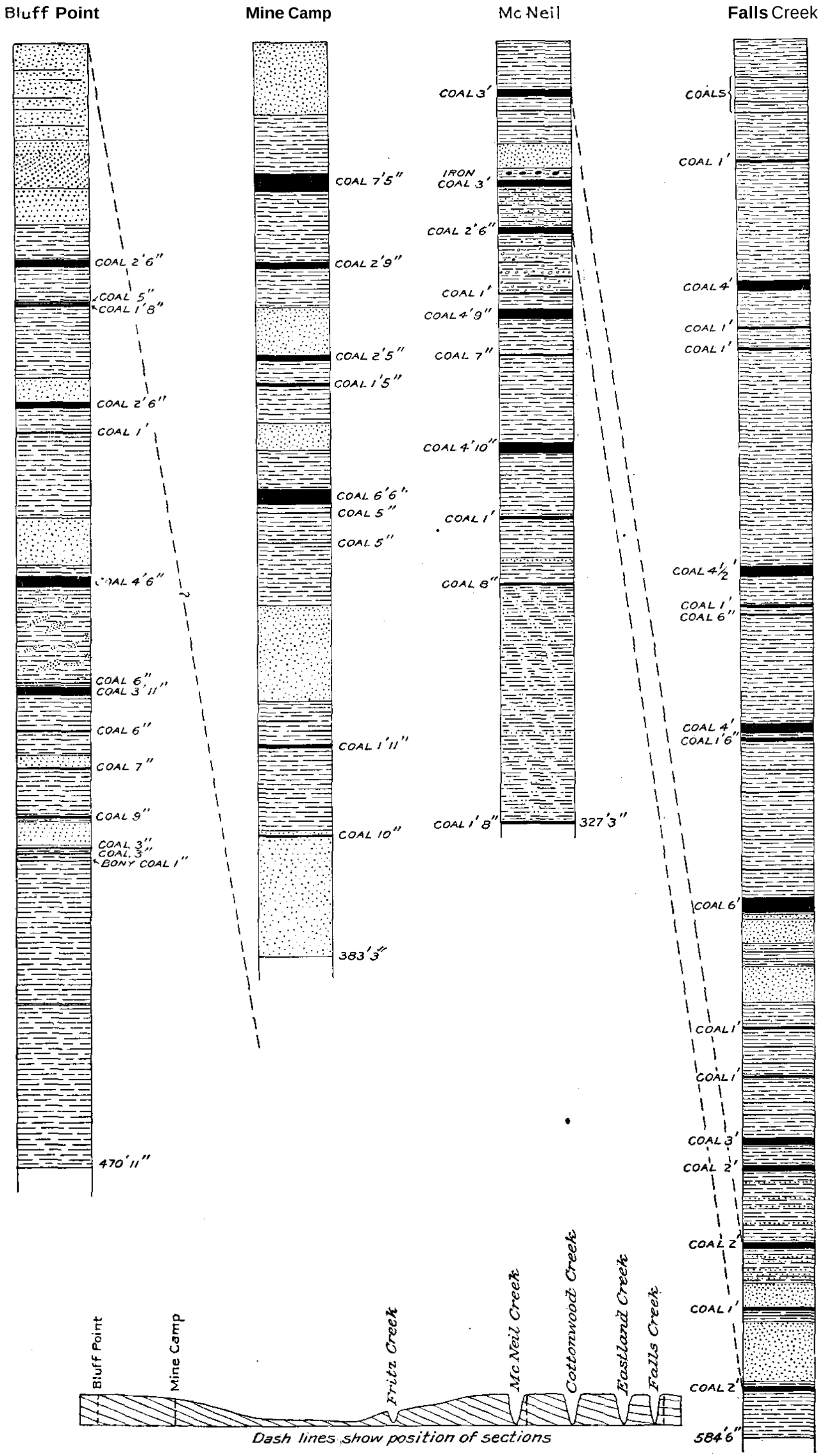
	Ft.	in.
Drift, probably glacial material and recent alluvium	85	
Sandstone	45	
Soapstone	5	
Coal	6	6

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.

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.

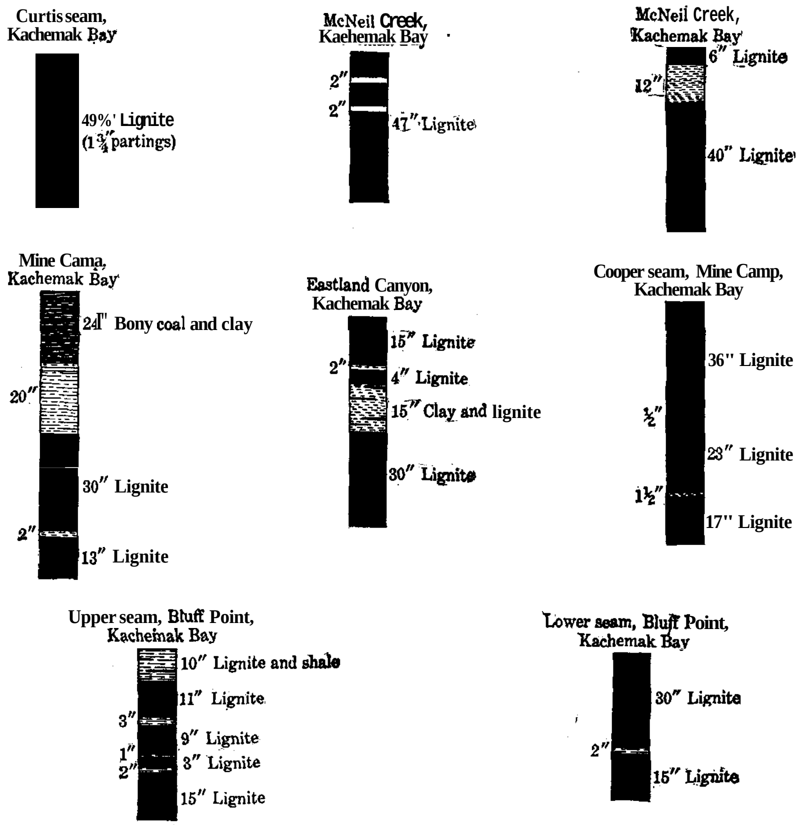


FIGURE 7.—Sections of coal seams at Kachemak Bay.

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, 10½ 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

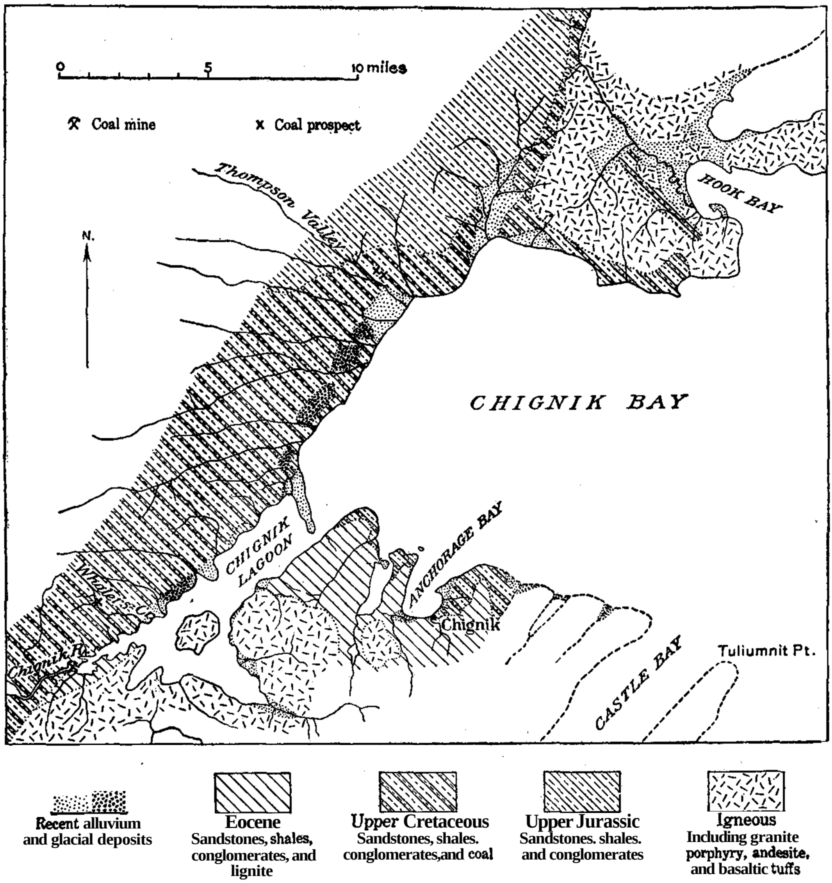


FIGURE 8.--Geologic map of Chignik Bay coal field.

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.

QEOLOQY.

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 Aows. 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

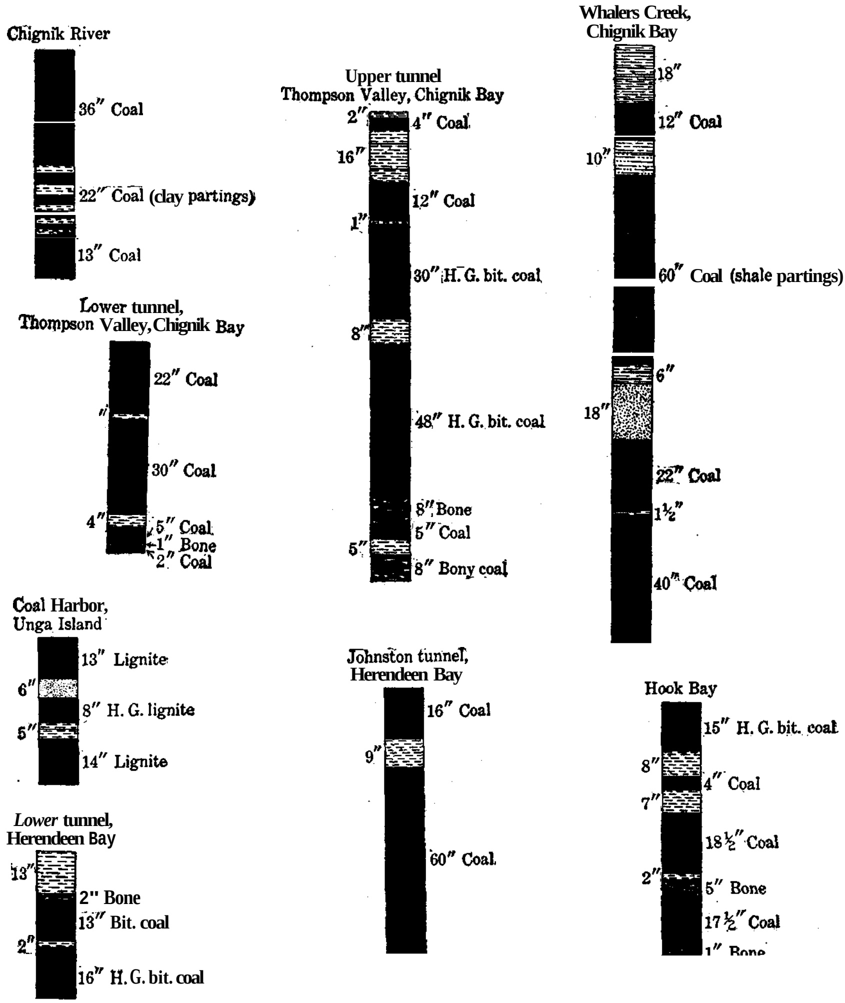


FIGURE 9.—Sections of coal seams in the Chignik Bay and Herendeen Bay fields and at Coal Harbor.

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, 1898, 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. Coalyshale		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

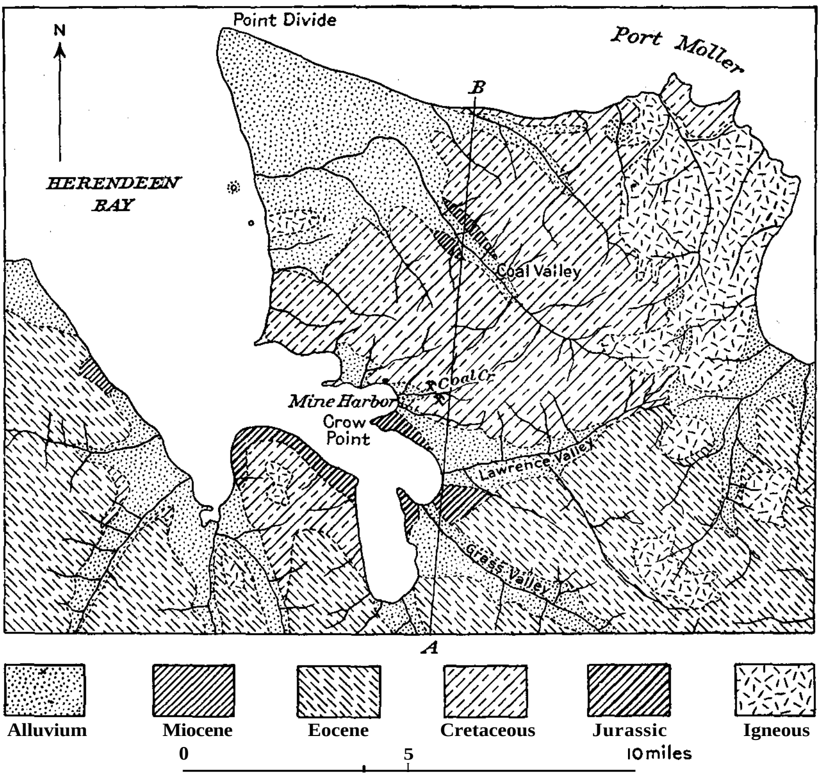


FIGURE 10.—Geologic map of Herendeen Bay coal field. A-B, line of section, figure 11.

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.

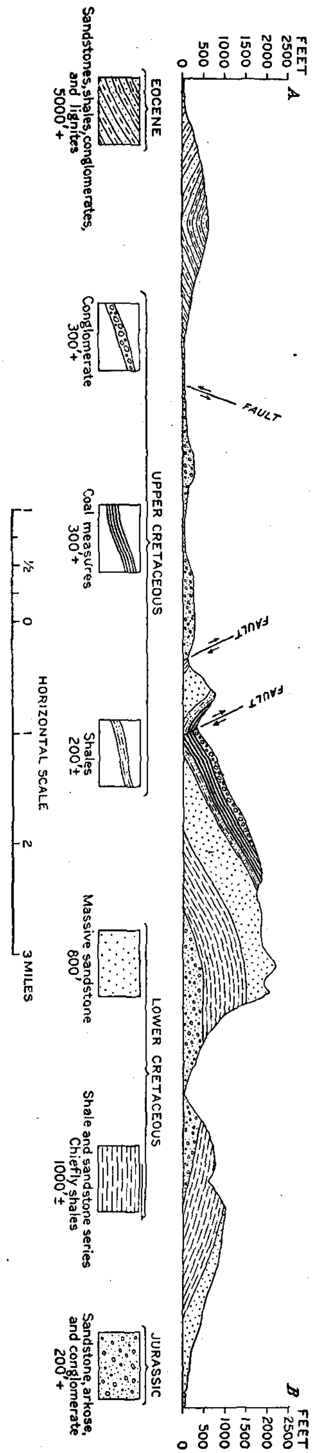


FIGURE 11.—Structure section across Herendeen Bay coal field along line *A–B*, figure 10.

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. Rone		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 ana 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 difficultyin 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 difficultto 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 coalexposed 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 airect route, or double the haul to the Pacific. At Balboa Bay there is an excellent harbor and good bunker sites are available.

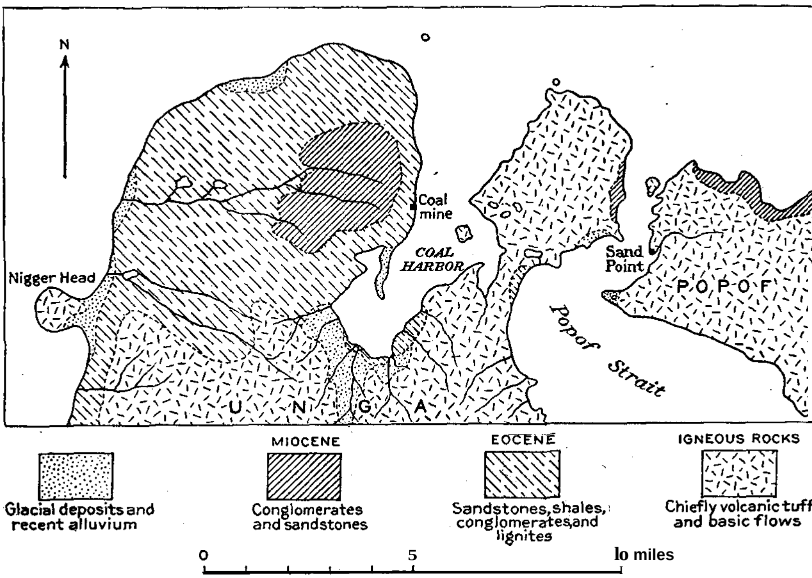


FIGURE 12.—Geologic map of Coal Harbor coal field, Unga Island.

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

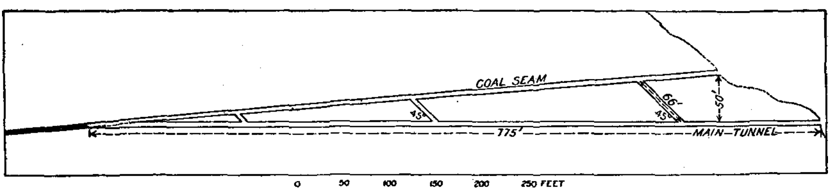


FIGURE 13.—Vertical section at Coal Harbor mine, Unga Island.

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.

Firm, coarse grit and conglomerate roof.	Ft.	in.
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 Ray, 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	4.82	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	[illegible]	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,

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. 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. 37-69. 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,

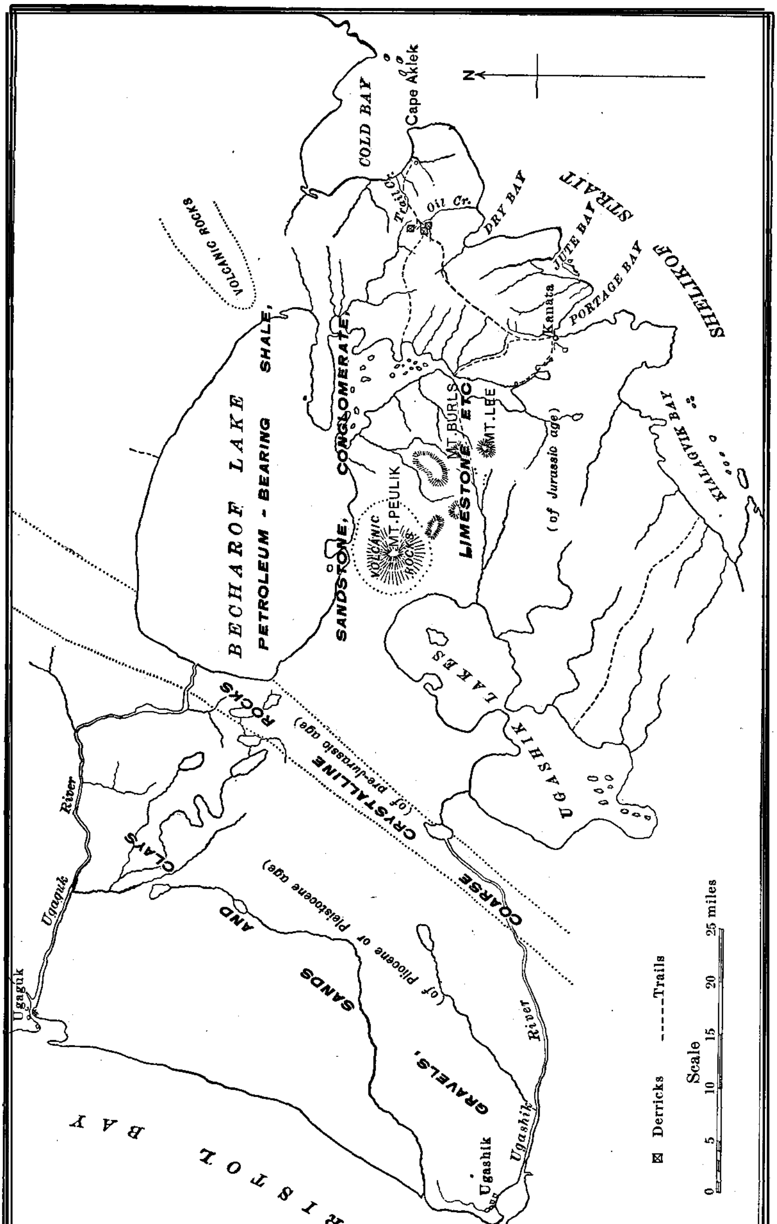


FIGURE 14.—Sketch map of Cold Bay petroleum field.

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.

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[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

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[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.

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