THE COAL RESOURCES OF ALASKA

BY

ALFRED HULSE BROOKS

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THE COAL RESOURCES OF ALASKA.

By ALFRED H. BROOKS.

INTRODUCTION.

Alaska embraces nearly 600,000 square miles and stretches through almost 20° of latitude and 50° of longitude. Practically no detailed investigations of any part of this vast Territory have been made, and of at least a third of its area not even preliminary topographic and geologic surveys have been made. Our knowledge of its mineral resources is therefore very incomplete, and this is especially true regarding the coal, which naturally has received relatively much less attention at the hands of prospectors than the precious metals. A few coal mines have been opened, and concerning these some detailed facts are obtainable. Elsewhere in the Territory occurrences of coal are only very briefly described or are only incidentally mentioned in the various reports dealing with the mineral resources.

In 1895 Dr. William H. Dall, of the United States Geological Survey, studied the coal resources of the Pacific coastal belt. His route extended from the neighborhood of Sitka to Unalaska on the Aleutian Islands, and he visited a number of localities in Cook Inlet. Dr. Dall's opportunities for observations were necessarily limited, as the entire journey occupied but a part of the summer months. In his report[a] he gave not only the results of his field observations, but also a summary of all existing knowledge of the coal resources of Alaska. Dr. Dall's previous explorations in other parts of the Territory enabled him to include also a summary of the geology and paleontology of Alaska. In the last few years the discovery of the various gold placer fields has led to great activity in exploratory work in Alaska, and has added considerably to our knowledge of the geology of the Territory, especially of the interior.

It will be the purpose of the writer to briefly summarize such parts of Dr. Dall's and other reports as refer more directly to practical problems of coal supply and development in the Territory. The question of the distribution of the coal-bearing rocks involves a discussion of

[a] Report on the coal and lignite of Alaska, by William H. Dall: Seventeenth Ann. Rept. U. S. Geol. Survey, Part I, pp. 769–908.

the distribution of the Cretaceous and Tertiary formations of the region. These geologic relations of the coal-bearing strata will be treated as briefly as is consistent with the intricacy of the subject. As this report is for the most part purely a compilation, and has been rather hastily prepared, the writer wishes to disclaim any purpose of making an original contribution to a scientific discussion of the geologic problems.

GEOGRAPHIC SUBDIVISIONS.

GENERAL STATEMENT.

Alaska includes a number of natural provinces which are defined not only by their geographic positions, but also by striking differences of relief, of climatic conditions, and consequent variations in vegetation. These natural subdivisions of the Territory may be conveniently used in a discussion of the mineral resources.

For the purpose of this report the Territory will be divided into six provinces, as follows: Southeastern Alaska, southwestern Alaska, the Kuskokwim region, the Yukon Basin, northwestern Alaska, and northeastern Alaska.

SOUTHEASTERN ALASKA.

In southeastern Alaska is included the coastal belt bordering on the Pacific Ocean, extending northward from Dixons Entrance to Prince William Sound and including the Alexander Archipelago. It is bounded on the north and east, as far as Mount St. Elias, by the international boundary, and for convenience of discussion will be made to include the Copper River Basin. It is characterized by an irregular coast line and by rugged topography. Two mountain ranges separate this coastal belt from the interior. The St. Elias Range is the most extensive and rugged of these, and with its continuation, the Chugach Mountains, stretches from Cross Sound westward, nearly to the head of Cook Inlet. To the southeast, the submerged portion of this range is represented by the islands of the Alexander Archipelago. The second mountain system is the so-called "Coast Range," which extends parallel to the coast line from near the head of Lynn Canal, southeast into British Columbia. These mountains give rise to the many glaciers which are such characteristic features of the landscape of this region. Five rivers of considerable size find their sources in the interior beyond these coast mountains. Of these, the Copper River traverses the Chugach Mountains, and the Alsek River cuts across the St. Elias Range. The Chilkat River rises in the interior, flows parallel to the St. Elias Range, and empties into Lynn Canal. The Taku and Stikine rivers both have their sources beyond the Coast Range.

SOUTHWESTERN ALASKA.

Southwestern Alaska embraces the Aleutian Islands, Alaska Peninsula and adjacent islands, Kenai Peninsula, and the Cook Inlet region with drainage basins of its tributary rivers. The coast line is very irregular and is generally abrupt, the mountains rising almost directly from the sea. Besides the deep embayment of Cook Inlet, there are many minor indentations and embayments. The Aleutian Islands have similar types of shore line and are mountainous, often containing peaks of considerable height which are of volcanic origin. The islands mark a series of volcanic vents which are extended inland along the Alaskan Peninsula nearly to the head of Cook Inlet. This line of volcanic activity marks the Aleutian Range, which lies close to Cook Inlet and its connecting body of water, Shelikof Strait. To the west of this range is a rugged mountain mass which extends in a northeasterly direction from the neighborhood of Bristol Bay and seems to be coextensive with the great Alaskan Range. Kenai Peninsula, which separates Cook Inlet from Prince William Sound, is a rough mountain mass with very irregular coast line. Kadiak Island and its associated islands form a southwestern extension of the same type of topography, but the relief is not so great.

The only rivers of considerable size in this part of Alaska are those entering the head of Cook Inlet. The Sushitna River rises on the southern slope of the Alaskan Range and flows southward through a broad valley into Cook Inlet. The Matanuska, a somewhat smaller river, is also tributary to the upper part of Cook Inlet.

KUSKOKWIM REGION.

Under this heading is included an area lying west of Cook Inlet and east and south of the Yukon, and draining into southeastern Bering Sea, chiefly through the Kuskokwim River. The eastern part of this region is broken by a more or less irregular mass, which in its northern extension is a well-defined mountain system called the "Alaskan Range." To the west of these mountains is the broad basin of Kuskokwim River. A small area in the southern part of this region drains directly into Bering Sea by a number of short rivers.

YUKON BASIN.

Yukon River drains a large, irregularly shaped area lying in part in Alaska and in part in the British Northwest Territory and British Columbia. Its chief tributaries are the Koyukuk, Tanana, Porcupine, White, Pelly, and Lewes. The two last unite to form the Yukon proper, and their drainage basins lie entirely within Canadian territory. The headwaters of the Lewes lie 25 miles from Lynn Canal, while the head of the Pelly has its source near the head of the Stikine River.

The larger part of the basin is occupied by the dissected Yukon Plateau, which near the headwaters has an elevation of about 5,000 feet and falls off to the north near the Great Bend of the Yukon to about 2,500 feet. To the east of the plateau lies the mountain range which is the northern extension of the Rocky Mountains. This range continues nearly to the Arctic coast, then makes an abrupt turn to the west parallel to the coast, forming the Romanzof, Davidson, and De Long mountains, in which lies the Arctic Yukon watershed. On the southwest side of the Yukon Basin the Coast Range in its northwestern extension merges into the Yukon Plateau, while the great mountain mass of the St. Elias Range forms the barrier between the coast and the interior and in part also the watershed. This range continues northward to the head of White River, beyond which divide it is more sharply defined by the Nutzotin Mountains and the Alaskan Range, which separate the Yukon waters from those of the Copper and Sushitna rivers. In about longitude 150° the Alaskan Range makes a decided bend to the southwest, and from this point the Yukon Basin is bounded by a low range of mountains lying between the Tanana and Kuskokwim watersheds.

NORTHWESTERN ALASKA.

Under this heading is included a rather ill-defined area lying northwest of the Yukon Basin, which for the most part is drained by rivers flowing into the Arctic Ocean. Seward Peninsula, which is cut off from the mainland mass by Norton Sound on the south and Kotzebue Sound on the north, is an important topographic feature of this province. North of this is a minor peninsula, which has Point Hope as its western extremity. Several rivers drain from Seward Peninsula into Norton Bay, and a number of others into Bering Sea and the Arctic Ocean. Two rivers of considerable size flow into Kotzebue Sound—the Kowak on the south and the Noatak on the north.

Seward Peninsula is for the most part a dissected upland with a number of minor ranges. In the areas drained by the Noatak and the Kowak[a] rivers are a number of mountain masses extending in an east-west direction. From Point Hope and Cape Lisburne a low range of mountains stretches to the eastward, and is probably a westward extension of the Romanzof Mountains, which lie near the Arctic Ocean close to the international boundary.

NORTHEASTERN ALASKA.

This province has been but little explored. As used here it includes the drainage basins of the rivers which enter the Arctic Ocean between Point Barrow[b] and the international boundary. The largest of these

[a] This river is more generally known among prospectors as the "Kobuk" River.

[b] The accompanying map, being limited by the size of the pages of this report, does not extend quite far enough to the north to include Point Barrow.

rivers is the Colville, which has its source near the head of the Noatak. A range of considerable height separates this northerly drainage from the waters of the Yukon Basin. The geology and mineral resources of this region are entirely unknown, so it will receive no further description in this report.[a]

GEOLOGIC RELATIONS.

DESCRIPTION OF MAP.

The map (Pl. XXXV) summarizes the existing knowledge of the distribution of coal and of the coal-bearing rocks in the Territory. It will be noted that the occurrences of coal represented on the map are chiefly along the waterways, where the most detailed investigations have been made. This fact makes it probable that further exploration will show considerable extension of the coal-bearing horizons.

The coals of Alaska that are of commercial importance as far as known belong in two larger subdivisions of the geologic column, namely, the Mesozoic and the Cenozoic.[b] Those of the former are probably all of Cretaceous age, and those of the latter fall in the various divisions of the Tertiary.

In the Yukon Basin, where both Cretaceous and Tertiary beds carry workable coal seams, the incompleteness of the geologic studies makes it impossible to differentiate the beds of the two periods. On the accompanying map, therefore, the coal-bearing beds have been mapped as a unit, irrespective of their position in the geologic column. In the descriptions of the different localities, however, all the available facts in regard to the age of the beds will be presented.

Localities from which coal has been reported, but where no very definite information exists in regard to its exact location or its commercial value, have been indicated by descriptions printed on the face of the map. Areas of Cretaceous and Tertiary rocks which are not known to carry workable coal beds are also approximately indicated by brief lithologic descriptions on the map. This is done because it is believed that future investigations may show that coal exists in some of the beds that are now considered barren.

A study of the literature bearing on the geology of Alaska has led to some tentative conclusions regarding the geologic horizons of the workable coal seams found in different parts of the Territory. The commercial coals of southeastern and southwestern Alaska occur in the Tertiary, and chiefly in its lowest division. The coals of the

[a] Since the above was written Messrs. W. J. Peters and F. C. Schrader have made an exploratory survey from the Koyukuk to the Colville and the Arctic Ocean.

[b] The writer has described some impure coals associated with rocks of Carboniferous age in the Upper White and Tanana River basins, but these are believed to be of no commercial importance. The position of these is indicated on the accompanying map. Compare A reconnaissance from Pyramid Harbor to Eagle City, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, Part II, p. 382.

Yukon Basin are less well known, but seem to be of both Cretaceous and Tertiary age. The Cape Lisburne coal of northwestern Alaska is probably Cretaceous, or at least Mesozoic.

DESCRIPTION OF TABLE OF SECTIONS.

All the available data regarding the succession of the Cretaceous and Tertiary beds in this region have been gathered together in the accompanying table. As the writers on Alaskan geology have only in rare instances given their results in the form of vertical sections, the matter presented in this table can be regarded as only approximately accurate. In most cases these vertical sections are only generalizations of sections having considerable horizontal extent. Where the succession of beds in formation has been described by the geologist, it has been so represented in the table, but in most cases the writers have confined their descriptions to generalizations of the lithologic characters, often without indicating the stratigraphic position of the various beds in the formation. In only a few instances were any estimates of thickness made, and these are included in the table. The arrangement of the sections in the table is geographic, the first being the Porcupine River section in northern Alaska, and the last being in the Queen Charlotte Islands, near the southeastern limit of Alaska.

MESOZOIC ROCKS.

Cretaceous Rocks.[a]

SUBDIVISIONS AND STRATIGRAPHIC POSITIONS.

Rocks which have been referred to the Cretaceous have a wide distribution in Alaska and adjacent portions of Canada. These have been described in different localities under various formation names[b] and have usually been assigned to the Lower Cretaceous. The paleontologic evidence obtained, as yet, is but fragmental, and, according to Dr. Stanton,[c] consists mainly of the identification of a single species *Aucella crassicollis* Keyserling, which has been found rather widely distributed in Alaska. This species marks a definite horizon in the Knoxville beds of the Lower Cretaceous of California, and also occurs in the Lower Cretaceous of Russia, but the genus *Aucella* occurs abundantly in the Upper Jurassic as well as the Lower Cretaceous, and the identification of a single species of that genus represented by a few imperfect and fragmentary specimens can not safely be depended on for separating Jurassic from Cretaceous rocks. It is probable that all

[a] The writer is indebted to Dr. T. W. Stanton for many important notes and suggestions bearing on this part of the report.

[b] See table of sections opposite this page.

[c] Twentieth Ann. Rept. U. S. Geol. Survey, Pt. VII, pp. 161, 168, and 309; also Geology of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, p. 184.

the Alaska beds from which *Aucella crassicollis* has been reported are Lower Cretaceous, though part of them may be Jurassic. For convenience of description, the Aucella beds will be here provisionally assigned to the Lower Cretaceous until their stratigraphic position has been determined.

Upper Cretaceous beds have been found at a few localities. McConnell[a] regards the highest members of the Cretaceous section on the Porcupine as probably Upper Cretaceous. Schrader[b] found Upper Cretaceous beds on the lower Koyukuk, and the higher part of the Queen Charlotte Island Cretaceous[c] is also Upper Cretaceous.

DISTRIBUTION.

The Cretaceous section has been studied in the Queen Charlotte Islands in greater detail than in any other part of this province. There the work of Richardson[d] and later of Dawson[e] has resulted in a division of the Cretaceous into various formations, shown in the table opposite page 526. The beds consist of conglomerate sandstones, shales, and agglomerates. Whiteaves,[f] who studied the paleontologic collections made by Richardson and Dawson, arrived at the conclusion that the formations are in part Upper and in part Lower Cretaceous. The Cretaceous rocks of Queen Charlotte Islands, as well as those of Vancouver Island lying to the south, include some valuable coal deposits.[g]

In the Atlin Lake region of British Columbia, which is drained by the Lewes River, Cretaceous rocks have been recently reported by J. C. Gwilliam.[h] He states that these beds include greenish sandstone and conglomerate, and that as far as known they carry no coals. Of this occurrence Dr. Stanton, in a personal letter, says:

> I have recently seen a few fragmentary fossils collected by Mr. Gwilliam in the Atlin Lake region, and they seem to be of early Jurassic age. They are probably from the beds referred to in the report cited.

Dawson many years ago mapped a number of areas of Cretaceous rocks along the Pelly and Lewes rivers,[i] and at several localities these

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[a] An exploration in the Yukon and Mackenzie basins: Geol. Nat. Hist. Survey Canada, new series, Vol. IV, 1888-89, p. 21 D; Cretaceous System in Canada, by J. F. Whiteaves: Trans. Royal Society of Canada, Vol. XI, Section IV, 1893, pp. 16 and 17.

[b] A reconnaissance along Chandlar and Koyukuk rivers: Twenty-first Ann. Rept. U. S. Geol. Survey, Pt. II, p. 474.

[c] Op. cit., pp. 12, 13; Geol. Nat. Hist. Survey Canada: Mesozoic fossils, Vol. I, Pt. III; On the fossils of the coal-bearing deposits of Queen Charlotte Islands, by J. F. Whiteaves, 1884; ibid., Pt. IV, 1900.

[d] Geol. Nat. Hist. Survey Canada, 1872-73, pp. 1-100.

[e] Geol. Nat. Hist Survey Canada, 1878-79, pp. 1 B-101 B.

[f] Geol. Nat. Hist. Survey Canada: Mesozoic fossils, Vol. I, Pt. III; On the fossils of the coal-bearing deposits of Queen Charlotte Islands, 1884. See also Mesozoic fossils, Vol. I, Pt. I, 1876, and Pt. IV, 1900, and Cretaceous System of Canada: Trans. Roval Soc. Canada, Vol. XI, Section IV, 1893.

[g] Mineral wealth of British Columbia, by G. M. Dawson: Geol. Nat. Hist. Survey Canada, Vol. III, Pt. II, p. 85 R.

[h] Rept. Geol. Nat. Hist. Survey Canada, 1901, p. 5[illegible].

[i] Yukon District and British Columbia: Geol. Survey of Canada, new series, Vol. III, Part I.

beds are known to carry coals. Dr. Stanton states that parts of these beds are doubtfully correlated with the Laramie and part with the Queen Charlotte Cretaceous.

In the Alexander Archipelago no Cretaceous rocks have thus far been found. In the Copper River Basin Schrader and Spencer[a] have recently given the name Kennicott to a series of green sandstones, black shales, and conglomerates. Fossils have been found in this formation which show that at least part of it is of Lower Cretaceous age. No coal has been found in the Kennicott.

Schrader's[b] Orca series consists of brown and gray sandstone, black limestone, arkoses interbanded with dark shale, and some conglomerate. This series was provisionally placed in the Lower Tertiary, but it now seems more likely that it is of Jurassic[c] age or older. The Orca series occupies considerable areas around Prince William Sound and the mouth of Copper River. As far as determined it carries no coal.

Near the headwaters of the Matanuska and in adjacent portions of the Copper River Basin, Mendenhall[d] has described the Matanuska series, consisting of fine conglomerates, limestones, green shales, and a basal bed of heavy conglomerate. In some localities these rocks carry lignite seams. The whole series is cut by igneous rocks. Fossils collected by Mendenhall from the Matanuska were determined by Stanton to belong with the beds here classed as Lower Cretaceous.

Spurr[e] has given the name Tordrillo series to a succession of black shales, often carbonaceous, arkoses, and impure limestones, with intrusives, which he found on the Skwentna River, a tributary of the Sushitna. These were not found to be coal bearing. The assignments of the Tordrillo to the Cretaceous is based on structural grounds, there being no paleontologic evidence.

In southwestern Alaska there are Mesozoic beds, some of which are probably Cretaceous, but so far as known they do not carry coals. Dr. Stanton has made the following report on some fossils from Herendeen Bay, collected by Ernest L. Locke:

> The fossils from Herendeen Bay, Alaska, have been examined and found to consist of a number of specimens of *Aucella* and a fossil plant. The *Aucella* appear to be identical with *A. crasicollis* Keyserling, a Lower Cretaceous species common in Russia and in the Knoxville beds of California and Oregon. The plant has been sent to Professor Ward, who says it is a cycad, and compares it with Jurassic and Lower Cretaceous species.
>
> The beds which have yielded these fossils are therefore almost certainly of Lower

[a] Geology and Mineral Resources of a Portion of the Copper River District; a pamphlet published in 1901 by the U. S. Geological Survey under authority of a resolution of Congress.

[b] A reconnaissance of a part of the Prince William Sound and Copper River region: Twentieth Ann. Rept. U. S. Geol. Survey, Pt. VII, pp. 404–408.

[c] Geology and mineral resources of a portion of the Copper River district.

[d] Reconnaissance from Resurrection Bay to the Tanana: Twentieth Ann. Rept. U. S. Geol. Survey, Pt. VII, pp. 317, 325.

[e] A reconnaissance in southwestern Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, Pt. VII, p. 153.

Cretaceous age, the only other possibility being Upper Jurassic. I would question, however, whether the coal of that neighborhood is of the same age. Some years ago Mr. C. H. Townsend, then naturalist on the United States Fish Commission steamer *Albatross*, brought back some of these Aucellæ and other Mesozoic fossils from Herendeen Bay, but he also brought some Tertiary invertebrates from the same neighborhood, and a collection of fossil plants in close proximity to the coal, which Professor Knowlton described as Eocene. These plants are described and figured in Proc. U. S. Nat. Mus., Vol. XVII, pp. 207–240, and they are also referred to by Dr. Dall in Seventeenth Ann. Rept. U. S. Geol. Survey, Pt. I, pp. 805–807.

Near the north shore of Bristol Bay, as described by Spurr, is a series of impure limestones, shale, conglomerates, and arkoses, with igneous rocks, to which he has given the name Oklune.[a] These he assigns to the Lower Cretaceous on stratigraphic evidence. One hundred miles to the north, in the Kuskokwim Valley, Spurr found a basal conglomerate succeeded by sandstones, arkoses, and carbonaceous shales, with some lignitic seams, which he grouped together as the Holiknuk series.[b] It contains plant remains and invertebrate fossils. The few fossils collected by Spurr indicate that these rocks are Lower Cretaceous.

In the Koyukuk River Basin, near the sixty-sixth parallel, some Lower Cretaceous rocks have been found by Schrader.[c] These consist of impure limestones, often pink or reddish in color, and often closely folded. So far as known these Cretaceous rocks carry no coals. Schrader also makes mention in the same report of Upper Cretaceous rocks, consisting of impure limestones, occurring near the mouth of the Koyukuk River and on the Yukon River. On his map, however, he has not attempted to differentiate these from the Tertiary rocks.

Dr. Stanton has furnished the writer with the following notes on the fossils collected by Schrader. The fossils from the Upper Koyukuk, near the sixty-sixth parallel, include *Aucella crasicollis* Keyserling from two localities, indicating the Lower Cretaceous age of these beds. The following species were obtained from a locality on the Yukon near the mouth of the Koyukuk:

Fossils found on Yukon River near mouth of the Koyukuk.

Ostrea sp.
Anomia sp.
Mytilus sp.
Pectunculus cf. P. veatchi Gabb.
Opis ? sp.
Lucina ? sp.
Trigonia cf. T. leana Gabb.
Corbula sp.
Actæonella cf. A. oviformis Gabb.

Trigonia and *Actæonella* are very characteristic Cretaceous forms, and indicate a horizon much higher than that of the Aucella-bearing beds from the localities on the Upper Koyukuk.

[a] Reconnaissance in southwestern Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, Pt. VII, p. 163.
[b] Op. cit., p. 159.
[c] A reconnaissance along Chandlar and Koyukuk rivers: Twenty-first Ann. Rept. U. S. Geol. Survey, Pt. II, p. 474.

The writer has given the name Nilkoka beds[a] to a succession of fine conglomerates, red and green slates, and sandstones that occur on the Lower Tanana. These were provisionally placed in the Paleozoic, but it now seems more likely that they are Cretaceous.

Spurr[b] and McConnell[c] report the presence of Cretaceous rocks on the Yukon near the international boundary. Spurr describes the succession of beds as being about as follows: Coarse basal conglomerate with carbonaceous shale, succeeded by fine sandstone, and these overlain by black carbonaceous slate and coal seams; above these are slates and limestones. He has given the name Mission Creek to this series, after the type locality, and gives 1,000 feet as a minimum thickness. These rocks are known to carry coals in some localities on the Yukon above the mouth of the Porcupine. It seems probable to the writer that detailed study will show that the same series is represented on the Lower Yukon below the mouth of the Porcupine.

On the Porcupine, McConnell[d] found a conglomerate sandstone and shale series, in part of Lower Cretaceous age, regarded by him as equivalent to those of Queen Charlotte Island. The upper members of the series are probably Upper Cretaceous.

In northwestern Alaska, Cretaceous rocks are known to occur only near Cape Lisburne. The plants from the coal seams of that vicinity have been assigned by Professor Ward[e] to the Mesozoic and probably to the Lower Cretaceous. We have but a few scattered notes on the geology of this locality. The coal veins are said to occur in sandstones and conglomerates.[f] Schuchert has reported the presence of (Upper) Silurian beds at Cape Lisburne.[g] Schuchert's determinations[h] are

[a] A reconnaissance in the Tanana and White River basins: Twentieth Ann. Rept. U. S. Geol. Survey, Pt. VII, p. 472.

[b] Geology of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, Pt. III, pp. 175-184.

[c] An exploration in the Yukon and Mackenzie basins: Geol. Nat. Hist. Survey Canada, new series, Vol. IV, 1888-89, p. 21 D.

[d] An exploration in the Yukon and Mackenzie basins: Geol. Nat. Hist. Survey Canada, new series, Vol. IV, 1888-89.

[e] Distribution of fossil plants, by Lester F. Ward: Eighth Ann. Rept. U. S. Geol. Survey, Pt. II, p. 926.

[f] Coal deposits of Alaska, by Winthrop Packard: Colliery Guardian, Nov. 30, 1900, Vol. LXXX, No. 2083.

[g] Report on Paleozoic fossils from Alaska, by Charles Schuchert: Seventeenth Ann. Rept. U. S. Geol. Survey, Pt. I, pp. 899-900.

[h] Since the above was written, Mr. Schuchert has received some interesting fossils from the Cape Lisburne region, collected by Mr. H. D. Dumars and presented by Mr. A. C. Maddren, of Seattle, Wash. In a letter Mr. Schuchert says:

"There is an interesting coral fauna of Middle Devonian age from 'limestone of cliffs 4 miles south of Cape Lisburne, just south of the mouth of a considerable stream. The rocks strike east and west, and dip south at 45°' (Dumars). This limestone has *Endophyllum*, two species; *Syringopora* near *S. tabulata; Syringopora* near *S. perelegans; Diphyphyllum* near *D. simcoense; Diphyphyllum* near *D. stramineum; Zaphrentis*, probably two species.

"'Underneath' the coral limestone cliff, 'about 500 yards north of the limestone, coal occurs in shale.' In the shale 'and associated with a 4 feet seam of coal' was found a small species of *Lepidodendron*, which Mr. David White tells me is related to *L. chemungense*. It indicates either Upper Devonian or Lower Carboniferous age for the shale. Since the coral limestone is of Middle Devonian age, this shale with coal must lie above the limestone and not 'underneath,' as stated by Mr. Dumars.

"At the Corwin mine locality, 30 miles east of Cape Lisburne, Mr. Dumars 'picked up on the beach'

from fossils collected by Fisher and Kupreanof, and reported by Grewingk. The Mesozoic and Paleozoic beds are apparently found very near together, but what their relation is must be left for future determinations.[a]

THICKNESS.

Dawson has placed the thickness of the Lower Cretaceous beds on Queen Charlotte Island at 9,500 feet and the Upper Cretaceous at 3,500 feet. This is the only definite measure of thickness which has been made. Spurr places the minimum thickness of the Mission Creek series at 1,000 feet and McConnell states that the upper member of the Cretaceous on the Porcupine is several thousand feet in thickness. What little evidence there is available seems to point toward the conclusion that there is a thinning out of the Cretaceous toward the northwest.

STRATIGRAPHIC RELATION.

Wherever the Cretaceous formations have been found in contact with the underlying rocks, an unconformity has usually been found between the beds of the two ages. In many instances there is unmistakable evidence of the existence of an erosional interval below the lowest member of the Cretaceous. The underlying rocks are often closely folded and highly metamorphosed, while the Cretaceous beds are but little altered. They are also found overlying beds of various ages. These facts, which are brought out in the table of sections, go to show that in Mesozoic but pre-Cretaceous times there was a period of dynamic activity which folded and metamorphosed the rocks and that some erosion took place previous to the deposition of the lowest Cretaceous beds.

Dawson has noted a slight unconformity[b] between the two upper divisions of the Lower Cretaceous. This seems to be of a local character and has not been noted elsewhere in the province.

LITHOLOGIC VARIATIONS.

Though the data are very incomplete, a few broad generalizations concerning the horizontal variations in the Cretaceous beds may perhaps be ventured. Almost everywhere where the base of the Cretaceous has been studied, it is found to consist of heavy conglomerate

a small form of *Stigmaria ficoides* indicative of Carboniferous age. There is therefore in this region a formation of Carboniferous age.

"At the Corwin mine Mr. Dumars gathered a very interesting lot of fern plants from shale and sandstone. He writes that 'the rocks are made up of shales, sandstones, and conglomerates,' and that 'several of the coral beds are 10 or more feet in thickness.' These plants are probably of early Mesozoic age."

[a] Since the above was written, Mr. F. C. Schrader has studied a geologic section extending from the Koyukuk northward to the Arctic Ocean. In this section he found both Mesozoic and Tertiary rocks. A description will be found in his forthcoming report.

[b] Geol. Nat. Hist. Survey Canada, 1878-79, p. 67 B.

whose pebbles can usually be traced to a local source in the older formations. The character of this basal conglomerate and its distribution suggest that in early Cretaceous time, at least, the sediments were of a littoral character, and that in the sea in which they were deposited there were many land masses above water which afforded sediments.

A study of the Cretaceous sections shows them to be made up predominantly of coarse material. Conglomerates and sandstones are abundant, while shales and limestones are relatively rare. On the Koyukuk alone the Cretaceous is represented by limestone beds. In the Queen Charlotte Islands considerable volcanic sedimentary material is found in the rocks of this age, but is relatively rare in other localities. Igneous intrusive rocks are not uncommon. The unconformity which separates the Cretaceous from the Tertiary rocks will be referred to below.

DEFORMATION AND METAMORPHISM.

Since the Cretaceous sediments were laid down they have become consolidated and more or less folded. The amount of alteration to which they have been subjected varies greatly in different localities. As an example, the rocks of the Tordrillo and Matanuska series are often much altered and closely folded, while the Cretaceous rocks of Queen Charlotte Island, upper Lewes River, and the Koyukuk are less folded and comparatively little altered. In the regions of greater metamorphism igneous intrusives are not uncommon. So far as determined, the presence of the intrusives seems to be rather a resultant of the fracturing of the sediments during their deformation than the source of their metamorphism. The evidence points toward the conclusion that the deformation of the Cretaceous rocks differed very much in intensity in different parts of the province.

STRUCTURE.

The structure of but few Cretaceous areas has been determined. In some localites, as on the Lewes River, the strata are known to occur as a series of broad, open folds, and in others, as on the Yukon, they are closely folded, faulted, and jointed.

POSITION OF COAL.

In the Queen Charlotte section the coal occurs at about the middle of the Lower Cretaceous beds (compare table of sections). At no other locality has the horizon of the coal been determined, but such evidence as is available suggests an equivalent position of the coal.

Dr. Stanton has furnished the writer with the following note in regard to the position of known coal-bearing horizons in the Pacific coast and in Canada:

> These are, in the Lower Cretaceous, the Queen Charlotte, on the islands of British Columbia, which is correlated with the Kootanie in the Rocky Mountain region; in

the Upper Cretaceous, the Naniamo formation on Vancouver Island, which is correlated with the Chico formation of California, the Pelly River beds near the middle of the Upper Cretaceous in Manitoba and the Northwest Territory, and the Laramie at the top of the Cretaceous in the Rocky Mountains. This horizon is doubtfully recognized in the north on the Yukon, Pelly, and Porcupine rivers.

SUMMARY.

Cretaceous beds are extensively developed in the region under discussion. Some limestones occur in them, but arenaceous sediments, such as sandstones and conglomerates, are more characteristic rock types. The greater part of the sediments which have been referred to the Cretaceous are shallow-water and littoral deposits. It seems probable that the Cretaceous rocks have not mantled the entire region in which they were so widely distributed and that there were a number of land masses in the Cretaceous sea.[a] Such conditions would be favorable for the accumulation of coal deposits. The coal of the Cretaceous rocks seems to have been laid down in basins of rather limited extent.

Igneous intrusives are not uncommon in the beds of this age. The degree of deformation and metamorphism to which the Cretaceous rocks have been subjected varies greatly.

TERTIARY ROCKS.

SUBDIVISIONS AND STRATIGRAPHIC POSITIONS.

The Tertiary rocks have a wide distribution in Alaska and have been described by a number of writers. Dr. Dall was the first to make a systematic attempt to subdivide and correlate the strata of this age. He differentiates three groups, of which the lowest is the Kenai[b] group, consisting of bluish sandstones, shales, and conglomerates with lignitic seams. To the upper member of the Kenai group, consisting of conglomerate and sand layers, he has given the name "Unga beds." The Kenai rocks were at first supposed to be Miocene, but later determinations by Knowlton place them in the Upper Eocene.[c] The plant remains in the Kenai are terrestial and fresh-water forms.[d] Above the Kenai occur brown sandstones containing marine shells of Miocene age, which Dr. Dali has correlated with his Astoria group of Oregon.[e] To these Miocene sandstones of the Yukon Basin he has given the name "Nulato," from the type locality. Dall's subdivisions have been adhered to by other geologists except in minor details. Spurr has added as another subdivision of the Tertiary some beds which he believes to be younger than the Nulato sandstone and of probably Upper Miocene or Pliocene age. These will be referred to below.

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[a] On late physiographical geology of the Rocky Mountain region in Canada, by George M. Dawson: Trans. Royal Soc. Canada, Sec. IV, May, 1890.

[b] Correlation papers; Neocene, by W. H. Dall: Bull. U. S. Geol. Survey No. 84.

[c] Geology of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, Pt. III. Also Fossil flora of Alaska: Proc. U. S. Nat. Mus., Vol. XVII, pp. 207-240.

[d] Dall, op. cit., p. 237.

[e] Op. cit., p. 233.

DISTRIBUTION.

Tertiary rocks have a wide distribution in southeastern Alaska and in adjacent portions of British Columbia. Dawson reports Tertiary beds on Graham Island[a] and on all the islands of the Queen Charlotte group. They consist of coarse, sandy beds with some conglomerate, considerable volcanic material, and some lignitic beds. These rocks are provisionally correlated with the Kenai beds. At one locality on Graham Island,[b] sandstones containing fossils of Miocene or Pliocene age were found. These also contained some lignitic seams.

Conglomerates, sandstones, and shales belonging to the Kenai group have been found in the northern half of the Alexander Archipelago,[c] and at Kasaan Bay, Prince of Wales Island. These occurrences are shown on the map (Pl. XXXV), the rocks being mapped as coal-bearing formations. To the west of the Alexander Archipelago lignitic rocks are found at Lituya Bay,[d] overlain by Miocene sandstone belonging to the Astoria group. Lignite-bearing rocks are found at Yakutat Bay which are probably Tertiary,[e] but their age has not been determined.

Between Icy Bay and Controller Bay coal-bearing rocks which have been provisionally assigned to the Kenai have been reported by F. H. Shepherd.[f] These beds are said to be considerably metamorphosed and to carry abundant plant remains. Near Cape Yaktag a sandstone has been found containing Miocene fossils.[g]

In the Copper River Basin the Tertiary[h] age is represented by a vast thickness of volcanic rocks, including both lavas and tuffs, and containing no true sediments. The same conditions probably held true during Tertiary times[i] along the northern front of the St. Elias Range, though there the effusives are associated with sediments which have been provisionally assigned to the Tertiary.

The type locality for the Kenai group is on the western side of the peninsula from which it takes its name. Here the Kenai, consisting of conglomerate sandstone with numerous beds of lignite, according to Dall,[j] overlies in some places Cretaceous rocks, in others meta-

[a] Geol. Nat. Hist. Survey Canada, 1878 and 1879, p. 85 B.

[b] Op. cit., p. 86 B.

[c] Coal and lignites of Alaska, by Wm. H. Dall: Seventeenth Ann. Rept. U. S. Geol. Survey, Pt. I, pp. 772–782.

[d] Op. cit., pp. 763–784.

[e] Dall, op. cit., p. 784.

[f] Reconnaissance in southwestern Alaska, by J. E. Spurr: Twentieth Ann. Rept. U. S. Geol. Survey, Pt. VII, p. 263.

[g] Op. cit., p. 264.

[h] Geology and Mineral Resources of a Portion of the Copper River District, by F. C. Schrader and Arthur C. Spencer; a pamphlet published in 1901 by the U. S. Geological Survey, under authority of a resolution of Congress.

[i] A reconnaissance from Pyramid Harbor to Eagle City, by Alfred H. Brooks: Twenty-first Ann. Rept. U. S. Geol. Survey, Pt. II, pp. 362–363.

[j] Op. cit., p. 788.

morphic rocks, which are probably Jurassic or Triassic. Under the name Yentna beds[a] Spurr has described some coarse sandstones and conglomerates with shales and lignites, which occur near the mouth of the river of the same name. These he regards as being probably of the same age as the Kenai. Spurr also found beds of clay, sand, and brown lignite in the same region, which he regarded as being younger than the Yentna beds. To these he has given the name Tyonek beds and Hayes River beds, after the different localities in which they have been found. Eldridge[b] mapped the Tyonek beds as part of the Kenai.

Eldridge[c] also reports Kenai rocks on the Sushitna, 100 miles from Cook Inlet. This same formation is known to occur at various points along the eastern margin of the Alaskan Peninsula[d] and the adjacent islands, as is also the Astoria group. In the Aleutian Islands the Tertiary seems to be represented chiefly by volcanic rocks, though Dall[e] reports some sediments.

Miocene fossils have been found in some partially consolidated coarse sandstones, arkoses, and clays on the north shore of Bristol Bay, to which Spurr[f] has given the name Nushagak beds. On Nunivak Island and adjacent portions of the mainland coal-bearing beds, which are probably Kenai,[g] have been reported. On the island they are largely covered by basalts. The following is quoted from Dall:[h]

> In the Yukon Valley (lower) and thence to the shores of Norton Sound a large area is occupied by lignite and leaf-bearing sandstones of the Kenai group, a smaller portion of which are overlaid by the Nulato marine sandstones, analogous to the Crepidula bed of Unga in age, but containing a different series of fossil shells.

Near the mouth of the Koyukuk[i] Schrader found the Nulato sandstone closely associated with Upper Cretaceous beds. On the Upper Koyukuk,[j] there are considerable areas of conglomerates and sandstones containing lignites which are believed to be of Kenai age. It is probable that the same series[j] occurs in the Chandlar Valley.

In the lower ramparts of the Yukon, Spurr[k] found Kenai beds, consisting of greenish sandstones, clay, and shales, with coarse conglomerate and seams of lignite. Below the mouth of the Tanana are beds of cross-bedded gravel and sands which have yielded some plant

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[a] Reconnaissance in southwestern Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, Pt. VII, p. 172.

[b] A reconnaissance in the Sushitna Basin and adjacent territory, by George H. Eldridge: Twentieth Ann. Rept. U. S. Geol. Survey, Pt. III, p. 17.

[c] Op. cit., p. 17.

[d] Dall, op. cit., pp. 797–811.

[e] Op. cit., pp. 811–814.

[f] Reconnaissance in southwestern Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, Pt. VII, pp. 173–174.

[g] Coal and lignite of Alaska: Seventeenth Ann. Rept. U. S. Geol. Survey, pp. 814–815.

[h] Correlation papers; Neocene: Bull. U. S. Geol. Survey No. 84, p. 245.

[i] A reconnaissance along Chandler and Koyukuk Rivers: Twenty-first Ann. Rept. U. S. Geol. Survey, Pt. II, p. 478.

[j] Op. cit., p. 477.

[k] Geology of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, pp. 188–189.

remains of Miocene or Pliocene age. To these beds Spurr[a] gave the name Palisade conglomerate. Near the international boundary, on the Yukon, the Kenai[b] is again found considerably developed. The basal member near the mouth of Mission Creek is a massive conglomerate, above which are greenish sandstones, impure limestones, carbonaceous shales, and lignites. In the vicinity are some cross-bedded gravels and sands with lignites, which Spurr[c] has called the Twelvemile beds, and has provisionally correlated with his Palisade conglomerate and with some Tertiary sediments found by McConnell[d] on the Porcupine River near the international boundary. Above these localities on the Yukon, Tertiary beds have been recently reported by McConnell[e] on the Klondike and Indian rivers.

In northwestern Alaska we have only very limited knowledge of the development of Tertiary rocks. Mendenhall[f] reports lignitic rocks on the Tubutulik River and some soft sandstones on the Koyuk River in the eastern part of the Seward Peninsula, which he considers to be Tertiary. On the Kowak River[g] lignites are known to be associated with conglomerates and sandstones, which are probably of Tertiary age. The writer is indebted to Mr. L. M. Prindle for two fossil leaves from the Kowak River. These occur in a siliceous shale, associated with grit and conglomerate, with scattered carbonaceous material. The locality is about 25 miles up Shunguak Creek, which is tributary to the Kowak from the north about 250 miles from Kotzebue Sound. These fossils are fragmentary, but Dr. Knowlton is inclined to assign them to the Tertiary.

The results of Mr. Schrader's work in the Colville River Valley and along the north Arctic coast are not yet available. He has informed the writer, however, that he found both Mesozoic and Tertiary rocks in this northern region. The Mesozoic beds are confined to the mountains, and the Tertiary beds go to make up the Arctic coastal plain east of Point Barrow.

THICKNESS.

No measurement of the thickness of any complete section of Tertiary has been made. On the Yukon, near Mission Creek, Spurr[h] estimated that the Kenai rocks might have a thickness of 10,000 feet. Near the Unalaklik on Norton Bay Dall[i] measured 2,000 feet of Tertiary strata. On Cook Inlet their thickness may be several thousand feet.

[a] Op. cit., pp. 199–200.
[b] Op. cit., pp. 185–188.
[c] Op. cit., pp. 196–197.
[d] Geol. Nat. Hist. Survey Canada, new series, Vol. IV, 1888–89, p. 127 D.
[e] Summary Report: Geol. Nat. Hist. Survey Canada, 1901, pp. 44, 48.
[f] Reconnaissance of Norton Bay region: U. S. Geol. Survey, 1901.
[g] Cruise of the Corwin, 1885, p. 48.
[h] Geology of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, p. 194.
[i] Correlation papers; Neocene: Bull. U. S. Geol. Survey No. 84, p. 246.

The younger Tertiary beds have a thickness of several hundred, or, at most, a thousand feet. In the Copper River Basin[a] the accumulation of Tertiary volcanics probably has a thickness of many thousand feet.

DEFORMATION AND METAMORPHISM.

The Kenai is usually gently folded and locally considerably faulted. The faulted regions are those which lie in proximity to recent volcanic activity. The Kenai beds are indurated, but rarely metamorphosed. Exceptions to this rule are assignable to the metamorphic action of intrusive rocks. The Nulato sandstone is somewhat indurated and usually gently folded. The Miocene-Pliocene rocks show evidence of having suffered slight disturbances. Their beds are often entirely unconsolidated.

STRATIGRAPHIC RELATIONS.

The Tertiary beds are always found to overlie the older rocks unconformably. They are found resting not only on the Cretaceous but also on many of the older series. Spurr has pointed out that the youngest Tertiary formations, which have been provisionally placed in a Miocene-Pliocene group, bear an unconformable relation to the beds which they overlie. It has not been determined whether this second unconformity is local or widespread. The facts suggest that they may represent deposits formed during the erosion of the peneplain which is now partially preserved in the dissected Yukon Plateau.

LITHOLOGIC VARIATIONS.

The oldest Tertiary formation is the Kenai, which is nearly everywhere represented by coarse conglomerates with sandstones and some shales. The character of the sediments suggests littoral deposits, and the almost universal presence of lignite suggests shallow-water conditions. Like the Cretaceous, which they resemble in physical character, the Kenai rocks probably have not mantled the entire region in which they are now found, but were deposited in more or less isolated basins along a continental margin. The Nulato sandstone is of different character, and probably originally formed a continuous covering in the region where it is now found, and was subsequently partly removed by erosion. The Miocene-Pliocene beds are most probably purely local deposits which were laid down in lakes or along rivers.

POSITION OF COALS.

Lignitic seams are widely distributed in the rocks of this age. Those occurring in the Kenai are the only ones having commercial importance

[a] Geology and Mineral Resources of a portion of the Copper River District, by F. C. Schrader and Arthur C. Spencer; a pamphlet published in 1901 by the U. S. Geological Survey, under authority of a resolution of Congress.

at present. The best coal seams probably occur in the lower part of the Kenai formation. In the Puget Sound region[a] the coal-bearing Tertiary beds are believed to be also of Eocene age.

SUMMARY.

In southeastern Alaska Tertiary sediments are found in the northern part of the Alexander Archipelago, at Prince of Wales Island, and along the western margin of St. Elias Range. In the Copper River region the Tertiary is represented by volcanic rocks. Sediments of this age are found near the head of the Sushitna and probably in the adjacent portions of the Tanana Valley. They are extensively developed in southwestern Alaska, and with associated volcanics form the Aleutian Islands. The highest point on the Yukon where they have been found is on Indian River. Future explorations will probably show extensive Tertiary deposits in northern and northwestern Alaska. The earliest deposits of this period are the Kenai beds, containing fresh-water plant remains; later the Nulato marine sandstone was deposited. The youngest beds of Miocene-Pliocene age are probable local accumulations in lakes.

Igneous rocks are associated with the Tertiary sediments, sometimes almost to the exclusion of the former. The deformation of the Tertiary beds is, as a rule, very slight. Coal is widely distributed in all the Tertiary formations, though the workable seams are probably confined to the Kenai.

THE COAL.[b]

SOUTHEASTERN ALASKA.

GENERAL STATEMENT.

The coal-bearing formations of southeastern Alaska nearly all belong to the Kenai division of the Tertiary. The only exceptions are some lignitic veins occurring in Cretaceous rocks on western tributaries of Copper River. It has already been shown that the Kenai rocks have a wide distribution in this part of the Territory, and nearly everywhere carry some coal. They are found in the belt running between the coast and the St. Elias Range in a southwesterly direction from the vicinity of Controller Bay, and have been found at intervals as far as Lituya Bay near Cross Sound. They have also been found on the eastern margin of Barinof Island, on Admiralty Island, on Kuiu Island, on Kupreanof Island, and on the adjacent mainland. In general character they vary considerably, but are usually made up of sandstones and conglomerates. They have received relatively but

[a] Some coal fields of Puget Sound, by Bailey Willis: Eighteenth Ann. Rept. U. S. Geol. Survey, Pt. III, pp. 393-436.

[b] For analyses of coals, see tables pp. 549-550 and 565.

little deformation; are usually gently folded and sometimes faulted. In the Alexander Archipelago they overlie an older series made up of metamorphic rocks, which are occasionally carbonaceous, but do not carry coals, so far as known. Prospecting for coal should be confined to the younger series, made up of conglomerates, sandstones, and shales. Areas should be sought where the rocks are little disturbed, as the faulting which often accompanies the deformation breaks the continuity of the seams and makes mining unprofitable.

The Comax and Nanaimo coal fields of Queen Charlotte and Vancouver islands, as have been shown, occur in rocks of Lower Cretaceous age. These include anthracitic, bituminous, and lignitic coals. No beds belonging to this period have been found in the panhandle of southeastern Alaska.

ALEXANDER ARCHIPELAGO.

The most extensive explorations for coal in the archipelago have been made on Kootznahoo Bay, a deep indentation on the western side of Admiralty Island. Dall[a] describes the bay as affording good facilities for navigation, with the exception of the narrow entrance, which has strong tidal currents. The land in the neighborhood is rather low and wooded. The bed rock is shale and sandstone of the Kenai formation. Near the entrance the rocks are crumpled and faulted. The deformation decreases toward the northeast, and near McCluskey's mine the beds are found to be only gently folded, being nearly horizontal.

At the Sepphagen mine, on Favorite Bay, the southern arm of Kootznahoo Inlet, the coal seam is said to be about 1 foot thick and to occur in friable sandstones and soft shales. A small shaft was sunk on this vein of lignite,[b] but in 1895 the work had been abandoned. Dall[c] is of the opinion that the coal was in a small pocket and soon exhausted. On the west side of the bay a coal seam a few inches thick occurs in a reef which is covered at high water. Dall notes a seam of coal, 6 to 8 inches thick, on a small island. Between the two arms of Favorite Bay the associated sandstones are gently folded and faulted. At Point Sullivan, near the entrance to the bay, a shaft has been sunk 120 feet. The lignite, which is of low grade, is said to occur in two seams separated by 6 or 8 inches of shale. The associated gray shales are much slickensided. Analysis shows this coal to be of poor quality. On the southern shore of Mitchell Bay, the northern arm of the inlet, some small coal seams have been found. One, about 5 inches in thickness, occurs in hard sandstone on a small embayment just west of Passage Island. "A similar seam, 4 inches thick, and another, 4 to 6 inches

[a] Coal and lignite of Alaska: Seventeenth Ann. Rept. U. S. Geol. S rvey, Pt. I, p. 776.
[b] For composition see table, page 549.
[c] Op. cit., p. 778.

thick, are reported to exist on the southeast shore of the bay, but these, of course, have no commercial value."[a]

The Meade and Mitchell seam, which is a lignite containing much amber, occurs on "Davis Creek," a southeast arm of Mitchell Bay. Dall[a] describes this locality as follows:

> There are at present two tunnels, 100 yards or more apart. The western tunnel (Mitchell) has been timbered, but is now full of water and the roof crushed in, probably on account of the decay of the timbering. The visible seam near high-water mark averages 1 foot in thickness, but is much contorted. One hundred feet west of the tunnel the seam turns vertical, bifurcates, and then runs out to a feather-edge. Dip, SE. flat, variable; strike, 25° NE. Above the coal the rock is almost wholly sandstone, without fossils; below, shale, with leaf impressions and vegetable remains. The eastern tunnel (Meade) is in similar rock and is similarly situated, but the strata are somewhat less contorted. The coal is about 1 foot thick. * * *
>
> As noted by Bryant and others, in the small fissures of the coal a good many grains of fossil resin or amber were perceptible, and occasionally a small pocket holding a teaspoonful of this yellowish, coarse, powdery material occurred. No large masses of it were noticed, though it is doubtless true, as reported, that they are occasionally found.

The Brightman and De Groff seam is on Lighter Creek, about 1½ miles to the southeast. There at the time of Dall's visit the developments consisted of an abandoned tunnel 100 feet in length. A seam of shaly lignite, about 14 inches thick, is included between two layers of hard sandstone beds. Dall considers the seam worthless.

The most promising locality is the Firestone mine, or McCluskey's seam, as it is called. This is a good lignite, which has had considerable local use. The mine is situated on a southeasterly arm of Kanalku Bay, a southeasterly arm of Mitchell Bay. The following is quoted from Dall's description: [b]

> In a small cove at the head of the left arm of this inlet, farther east than any of the other locations, is an outcrop of coal which has been stripped and prospected by Mr. James McCluskey. There are two principal outcrops of coal. One, at the foot of a small vertical bluff, dips at about the angle of the beach, 25° SE., with a strike 40° NE. The rock above it is a coarse sandstone without fossils. The seam is 18 inches thick, and is visible from low-water to about high-water mark or a little farther. It has been excavated along its face for a depth of 2 feet and a distance of 100 feet. In the beach, and normally covered by the sand and gravel, are several other parallel seams of coal, separated by variably thick beds of shale and slaty sandstone. The upper layer is the best and clearest, and does not exceed a foot in thickness. Below this seam is 6 or 8 feet of shale, and then a parallel seam of brown lignite mixed with bright coal and thin leaves of shale. This contains many particles of fossil resin and impressions resembling woody fiber. Owing to the wash over it, the full extent and uniformity of the seam could not be distinctly seen, but it appeared to include about 3 feet, with the central portion somewhat more shaly than the rest. Whether this mass is a local thickening of a seam elsewhere thinner, or part of a uniform bed, can be determined only by more extensive exploration. The rocks about this mine are less disturbed than in the more western portions of the

[a] Op. cit., p. 780. [b] Op. cit., p. 782.

area about the inlet, and the prospect of continuity in the veins is therefore somewhat better.

This outcrop is the only one in the inlet in which work has been recently done, and nearly 100 tons of coal have been taken out. The coal has met with a ready sale locally.

The more recent developments at the Firestone mine show a 16-foot seam, containing about 9 feet of coal and 6 feet of impurities.

Some coal developments have been made near Point Gardiner, at the southern end of Admiralty Island. At this point the carbonaceous beds, including lignite and impurities, are about 7 feet in thickness. Some mining was done near Point Gardiner[a] a number of years ago, but the opening was abandoned, as the rocks proved to be much broken and faulted and the coal not of good quality. Since 1898 prospecting in the vicinity has been renewed, and in 1900 considerable development was done, though the enterprise had not reached a producing stage.

At Coal Bay, an arm of Kasaan Bay, on the east side of Prince of Wales Island, lignite has long been known to occur. The writer has made a brief examination of this locality. A soft feldspathic sandstone overlies the older metamorphic rocks unconformably. The sandstone is gently folded and contains some small seams of lignite. The lignite is of good quality, but the largest seam observed, which was about one-half mile from the head of the bay, is only 8 inches thick. No fossils were found in these beds, but the rocks are believed to be of Kenai age.

On Kuiu Island near Port Camden there are said to be several veins of coal about 6 inches thick. On the western coast of the same island Dr. Dall mentions rocks of the coal-bearing formation. As yet no seams have been reported from this locality. At Whale Bay, Barinof Island, coal-bearing rocks of the Kenai formation are said to occur.

LITUYA BAY.

Near this bay rocks of the Kenai formation have been found. Coal seams have been reported, but nothing has been developed which is of commercial importance. The coal is said to be a bright lignite.

YAKUTAT BAY.

On the northwest shore of Yakutat Bay coals have been reported and an attempt was made at development. In the adjacent region, on the shores of Disenchantment Bay,[b] a bright lignite vein of good quality was found about ten years ago, and some prospecting was done by Jack Dalton, but it was abandoned because of its distance from deep water.

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[a] Op. cit., p. 773.

[b] Population and Resources of Alaska, Eleventh Census, p. 230.

CONTROLLER BAY AND ICY BAY.

Coal from this region was reported to Mr. Spurr by Mr. F. H. Shepherd, of Nanaimo, British Columbia.[a] Here there is said to be one field which lies adjacent to the shores of Controller Bay and reaches from Cape Martin to Chilkat village, and another reaching 40 miles westward from Icy Bay. The rocks are believed to be altered Tertiaries, probably Kenai. They are said to be more altered as they leave the coast and approach the mountain front. Some of the coal seams are said to reach a thickness of 27 feet, while many are from 10 to 12 feet in thickness. The coal possesses a bright, black luster and conchoidal fracture, and has all the characteristics of semianthracite with the exception of hardness and specific gravity. In the second field, near Icy Bay, Neocene rocks have been found which are said to contain petroleum. Petroleum is also reported from the vicinity of Catalla[b] and from Kayak Island. Schrader and Spencer[c] report a good quality of coal, a semianthracite, from the head of Chilkat River, which reaches the coast near Kayak Island.

On Kayak Island,[c] near Controller Bay, coal has been found which is said to be a lignite of good character, and is probably a part of the same field as that to the north. Considerable prospecting has been done on the island, but no developments have been made.

REGION TO THE WEST OF CONTROLLER BAY.

In the region adjacent to the Copper River and Prince William Sound no workable coal deposits have been found and Tertiary sediments are not present. Some rocks described by Mendenhall in the Copper River Basin, and presumably of Cretaceous age, are known to carry coal, but have not thus far developed any seams of commercial importance. Of this region Mendenhall says:[d]

> Along the upper course of Bubb Creek [lying in the Copper River Basin], as within the valley of the Matanuska, thin coal seams may occasionally be seen interbedded with the shales and sandstones forming the stream bluffs.

Coal is also reported from the Chistochina and Gakena rivers,[e] both tributary to the Copper.

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[a] Reconnaissance in southwestern Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, p. 263.

[b] Geology and Mineral Resources of a Portion of the Copper River District, by F. C. Schrader and Arthur C. Spencer; cited on previous pages.

[c] Op. cit.

[d] Reconnaissance from Resurrection Bay to Tanana: Twentieth Ann. Rept. U. S. Geol. Survey, Pt. VII, p. 324.

[e] Geology and Mineral Resources of a Portion of the Copper River District, by Schrader and Spencer; cited on previous pages.

SOUTHWESTERN ALASKA.

GENERAL STATEMENT.

As in southeastern Alaska, the workable coal beds are believed to be confined entirely to the Kenai formation, which has extensive development in this region. The rocks of this formation have been found near the head of Cook Inlet and at various localities to the southwest, nearly to the southern extremity of the Alaska Peninsula. They almost everywhere include lignitic seams, which at a number of localities are known to be workable. Rocks of this formation overlie the older metamorphic series unconformably. They are most often found as broad folds which are locally much faulted. As might be expected in a region of volcanic activity, the deformation of the rocks is of a local character. Volcanic rocks, both extrusive and intrusive, are often associated with coal-bearing beds. Spurr[a] has called attention to the fact that the higher Tertiary beds occurring about the Kenai also contain lignites of inferior quality. These younger beds can usually be distinguished from the Kenai by the fact that they consist of only slightly cemented or uncemented material. The coal in these beds is a brown lignite, which retains its woody fiber.

SUSHITNA RIVER.

The Kenai rocks on the Sushitna, which have been referred to, carry some coal, according to Eldridge. The outcrops of the Upper Sushitna coal-bearing rocks[b] occur along the main river above the Chulitna for 6 or 7 miles. The strata form bluffs 100 to 300 feet high and consist of clays and sandstone. The beds are undulating, dipping from 5° to 10°. There are 10 or 15 coal seams along this exposure, which are from 6 inches to 6 feet thick. Eldridge obtained no fossils, and according to his description these beds more nearly resemble the Upper Tertiary beds of the region, which carry the inferior coals, than those of the older Kenai formation. Eldridge also makes mention of some coal seams on the Upper Cantwell River, observed by him from a distance. Near the mouth of the Yentna he noted clays, sandstones, and conglomerates which carry small seams of lignite. Spurr[a] found the same rocks at the mouth of Hayes River, a tributary of the Skwentna, where they include seams of good lignite several feet thick.

On the western side of Cook Inlet near Tyonek, Eldridge[c] also found Kenai rocks, and reports concerning them as follows:

> The extent of the Tyonek field was not investigated, but from independent reports by prospectors and Indians it is inferred that it extends for several miles inland, and

[a] Reconnaissance in southwestern Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, Pt. VII, p. 262.

[b] A reconnaissance in the Sushitna Basin and adjacent territory, Alaska, by George H. Eldridge: Twentieth Ann. Rept. U. S. Geol. Survey, Pt. VII.

[c] Op. cit., p. 21.

from a point 7 or 8 miles west of Tyonek along the coast as far northward at least as Theodore River. From a point 2 miles west of Tyonek to one about 6 miles west there is a continuous outcrop of the Kenai formation—sandstones, shales, and coal seams—along the beach bluffs. The strata dip from 35° to 60° SE., the amount varying locally. The general strike of the series, NNE., would carry the strata to a point about 10 miles up the Chulitna, where, indeed, coal is reported in veins equaling in size and number those at the beach. Coal is also reported about 30 miles up the Beluga River, nearly in line with the Chulitna and Tyonek exposures. This would make an outcrop on the strike, beneath the superficial deposits of silt and gravel, of approximately 30 miles, with a width, as shown at the beach, of about 4 miles. The number of seams, large and small, exposed along the beach west of Tyonek is 36, but it is possible that some of them are repetitions by faulting, though no actual evidence to this effect was found. The beds vary in thickness from a foot to 15 feet, there being many from 4 to 6 feet thick. As a rule, not only is the coal[a] of low grade, but the seams are many times split by slate, clay, or sand partings. There are, however, three or four seams in which probably one or two 3-foot benches of moderately clean coal might be found.

Spurr regards these rocks as belonging to the younger Tertiary series, and not to the Kenai. He reports the coal to be a brown lignite of inferior quality.[b]

KENAI PENINSULA.

General description.—The western part of this peninsula is largely occupied by the coal-bearing rocks of the Kenai series, while in the eastern part the older metamorphic series prevail. The following description of this field is quoted from Dall:[c]

This region includes the area west of the Kenai Mountains and extending along the eastern side of Cook Inlet, between Kachemak Bay on the southwest and Turnagain Arm at the northeast. This area is more than 25 miles wide and over 80 miles long, thus covering at least 2,000 square miles. The land comes to the sea in steep bluffs, generally with only a narrow beach at their base. The height of the bluffs is greatest at Bluff Point, near the entrance to Kachemak Bay, where it reaches 1,800 feet within half a mile of the water. Thence northeastward the strata describe a series of gentle, enormously extended waves, plainly visible from vessels sailing by the coast. The height of the plateau grows gradually less; at Cape Kasilof the coal seams finally sink below the sea level, and on the south shore of Turnagain Arm the land rises less than 50 feet above the sea level. The upper surface is more or less undulating, cut by numerous streams which form narrow, deep valleys in the soft Tertiary rocks, and, according to native reports, sometimes rise in large, shallow lakes which receive the drainage from the glaciers of the Kenai range. Nearly all this area is heavily wooded with spruce and larch, mixed with poplar, alder, and willow along the water courses. Entrance to some of the larger streams may be had at high water, but the only harbor is at Kachemak Bay. The Kenai formation containing the coal probably underlies the entire area of the plateau, but again it is only at Kachemak Bay that the strata are elevated to their greatest height, and the lower and more densely consolidated coal seams are brought near the surface. * * *

If the indications of Wossnessenski are correct there would seem to be a succession of about four gentle folds from Port Graham to Cape Kasilof, a distance in a north-

[a] Compare table of analyses, this report, p. 549.

[b] A reconnaissance in southwestern Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, Pt. VII, p. 262.

[c] Coal and lignite of Alaska: Seventeenth Ann. Rept. U. S. Geol. Survey, Pt. I, pp. 787–788.

erly direction of some 70 miles. The lignite beds crop out at many places along the western shore of this area. At Anchor Cape (Kasnatchin), the northern head of Kachemak (or, as it is sometimes called, Chugachik) Bay, the coal is under water, but rises northward with the flexure of the strata. * * *

At Cape Starichkof two parallel beds of coal are visible for a long distance. The lower one is about 112 feet above the beach and is separated by 9 to 12 feet of sand and clay from the upper coal bed, above which the bluff rises 40 to 70 feet higher. At Cape Nenilchik the upper bed covers about 18 feet of fine, yellow sand and is separated from the lower bed by about 20 feet of sand and clay.

Kachemak Bay.—This is a deep indentation on the western side of the peninsula. It is about 30 miles in length and affords a good harbor. On its shores are the most extensive developments of coal mining in Alaska. The town of Homer, which is the chief settlement on the bay, is situated on the north side near the sandspit. Dall[a] says that bold cliffs of Kenai conglomerates, sandstones, and shales rise directly from the water or from a narrow beach. These beds carry many seams of lignite; the largest was observed near Coal Point, and is about 7 feet thick, with some thin shale partings. The beds dip at a low angle to the north. The coal, which is lignite,[b] is bright and clear, and has a tendency to break into cubical fragments when dried, and resembles anthracite in appearance. On the south side of the bay the coal-bearing rocks occur in isolated patches.

According to Dall, the most westerly developments are near Homer, on what he calls the Bradley seams, which consist of an aggregation of coal and shale, having a thickness of 7 feet. The thickest vein of clear coal measures 18 inches. It is the lowest seam in the section, and appears to be more compact and glossier than those occurring at a higher horizon.

About five miles to the east of Homer some developments have been made on the Curtis seam, which Dall describes as follows:

> The clear coal is here 4 feet 7 inches thick, with about 6 inches of iron-stained sandstone above it and a thick, adhesive, gray clay below. This seam would require timbering to avoid caving in, if worked to any extent. Above this are three other seams, separated by thick beds of clay or soft sandstone. One of these, the lower seam, is nearly 4 feet thick; the others are somewhat thinner. The strata are here nearly horizontal. The coal, though lighter than the Bradley, is fairly compact, with a dull fracture, no visible pyrite, occasional thin lenses of sand or shale, and a tendency to break up cubically.

To the east some prospecting has been done on coal veins exposed in McNeil and Cottonwood canyons. The most extensive developments up to the time of Dall's visit were made in Eastland Canyon, on the north side of the bay, about 10 miles northeast of Homer. He describes the locality as follows:[c]

> A small tramway leads back several hundred yards into the canyon, and at a height of 270 feet above the tide we found a vein 2 feet 4 inches thick of clear coal, and associated with it alternate seams of coal and clay, or "bone," the total thickness of

[a] Op. cit., p. 789. [b] See table of analyses, this report, p. 549. [c] Op. cit., p. 793.

the series being 6 feet. The rocks here are nearly horizontal, and comprise sandstone, whitish clay containing large waterworn bowlders, shales, and lignite, the upper part covered with from 5 to 10 feet of reddish gravel. The bluffs attain a height of from 600 to 800 feet, the land behind them reaching 1,800 feet. These explorations were begun in December, 1894, by the North Pacific Mining and Transportation Company, under the supervision of Mr. Curtis. About 300 tons had been taken out and sent to San Francisco for trial, and another cargo was to be shipped shortly after our visit. Mr. Curtis had only a few men employed, and the work he was doing was of the nature of exploration. The development of the property, he stated, would depend upon the result of experiments with the coal.

In the last two years there has been considerable development of coal in the vicinity of Homer by the Cook Inlet Coal Fields Company. Buildings have been erected and 6 miles of railway constructed. In the report of the governor of Alaska for 1900,[a] the company is said to be developing coal veins which are from 2 to 7 feet thick, aggregating 150 feet in all.

KADIAK ISLANDS.

Evidence of the presence of coal has been found at a number of points on the islands, but no developments have been made. These coals occur in the coarse sandstones and conglomerates of the Kenai, which are evidently an extension of the same formation occurring on the peninsula of the same name to the north. Lignites[b] are reported from Sitkinak Island, from Red River, and from Ugak Bay on the eastern side of Kadiak Island.

AMALIK HARBOR.

This bay connects with Shelokof Strait, which separates Kadiak Island from the mainland. The coal veins[c] occur in coarse sandstones on the south side of the entrance to the harbor behind Takhli Island. The beds dip about 30° NE. In the lower beds of the sandstone, which is 250 feet thick, there are three seams of coal, each of which is about 18 inches thick. The coal is bituminous and of good quality. Its bituminous character may be due to the presence of a granite dike which cuts the sandstones in close proximity.

ALASKA PENINSULA.

The Kenai rocks are well distributed over the peninsula and are known to carry coal at several localities. Spurr[d] makes note of coal veins on the southeastern shore of the southeast one of the Ugashik lakes in the northern part of the peninsula. So far as determined this coal is of rather poor quality, but resembles cannel coal in appearance.

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[a] Page 58. [b] Dall, p. 800. [c] Dall, p. 799.

[d] A reconnaissance in southwestern Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, Pt. VII, p. 262.

Coal has been mined for local use on the left bank of the Chignik River, about 15 miles from Chignik Bay. The country rock is Tertiary sandstone, which forms low bluffs along the river. Dall describes the occurrence as follows:[a]

> The mine is directly on the bluff, on the left bank of the stream. The beds dip N. 25° E., and the strike is N. 15° to 20° W. The bedding is very regular on the whole, with a few small slips. The coal occurs in one small seam, about 16 inches in average thickness, of which 1 inch is a more or less regular streak of sandstone. Above this seam are about 11 inches of hard sandstone and 6 inches of coal. About 6 feet higher is a 6 or 8 inch seam, very adhesive to the roof, which is of a very firm sandstone. The coal is solid, clean, bright, with no visible pyrite or lime. The rocks are of a brownish sandstone, gray where not weathered. * * *
>
> There are two 6-foot tunnels, about 40 feet apart and 240 feet long. * * *
>
> The seam comes to the surface of the ground in a ravine about 30 feet above the upper tunnel, and has been traced inland more than half a mile.

At Coal Cape,[b] southwest of Chignik Bay, lignite beds outcrop, and lignites are reported from Coal Bay, from the neighborhood of Portage Bay, and from Pavloff Bay.

On the west side of the peninsula coal has been reported from only one locality, namely, at Herendeen Bay, where it has been mined, but so far without any great measure of success. The coal-bearing beds occupy an area lying between Port Möller and its southern arm, Herendeen Bay. The beds are of Kenai age,[c] but are intimately associated with Cretaceous rocks. According to Mr. Ernest G. Locke, who examined the region, the rocks associated with the coal consist of clays, shales, and heavy conglomerates. The largest vein is 4½ feet thick, and there are many smaller ones. The beds are said to be much folded and faulted, giving an irregularity to the coal veins which calls for careful mining methods. Mr. Locke informed the writer that the coal, which he describes as bituminous, is of excellent quality, is hard, clean, and breaks into large chunks, which will stand handling and weathering.

SHUMAGIN ISLANDS.

These islands lie adjacent to the southern coast of the Alaska Peninsula, in latitude 55°. Popoff and Unga islands, the westernmost of the group, contain considerable areas of Kenai rocks.[d] The same beds are represented along the western margin of Nagai Island and probably on Sannakh Island. The Kenai beds overlie an older metamorphic series.

Coal has been mined on Coal Bay, an indentation of the northern

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[a] Coal and lignite of Alaska: Seventeenth Ann. Rept. U. S. Geol. Survey, Pt. I, pp. 802–803.

[b] Dall, op. cit., p. 804.

[c] Dall, op. cit., pp. 806–807. Also Stanton's statement regarding fossils from this locality, this report, p. 528.

[d] Dall, op. cit., pp. 809–810.

shore of Unga Island, for many years. In this locality Dall notes the following section:

Section at Coal Bay, Unga Island.

	Feet.
Conglomerates and sandstones with a little sandy shale	200
Thin leaves of lignite aggregated into three series of 3 feet each, interstratified with beds of sand and gravel of variable thickness, with some pyrite. Total about	40
Soft sandstone and gravel, little indurated	150
Lignitic bands, not exceeding 8 inches, very pyritiferous, interstratified with sands and gravel	200
Clay ironstone with leaf impressions to beach	4

The best veins of coal are a foot thick. The coal is hard, clean, and black, and slacks on weathering into small cubical fragments. Dr. Dall's conclusion in regard to this coal is unfavorable. It is, however, convenient of access for steamers running to Dutch Harbor from Cook Inlet or Kadiak, and continues to be mined in a small way.

ALEUTIAN ISLANDS.

Dall[a] has described a number of localities in the Aleutian Islands from which coal has been reported, and also some in which fossil amber has been found. There seems to be no doubt that there are lignite-bearing Tertiary beds in the archipelago. It will remain for future investigations to determine whether or not these Tertiary beds belong to the older series, which carry commercial coals.

CHARACTER OF COALS OF SOUTHEASTERN AND SOUTHWESTERN ALASKA.

The coals of the southern part of the Territory vary in character from the brown lignites of the Tyonek fields to the bituminous and semianthracite of the Controller Bay region. The larger percentage of these coals, and practically all of those which have received any development, may be classed as lignites.

A number of proximate analyses[b] of these coals are grouped together in the table, page 549. For the sake of comparison the volatile matter and fixed carbon have been recalculated as percentages of the total fuel constituents.[c] The ratio between these two constituents, which gives an index of the fuel values of the coals, is given at the right of the table, and is called the fuel ratio.

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[a] Op. cit., pp. 811-814.

[b] In all the analyses made by the Geological Survey, except two, the old methods were employed. By this method the volatile matter is determined by heating three and one-half minutes over Bunsen burner and three and one-half minutes over blast. Moisture was determined by heating one hour at 100° C., and the Eschka method of determining sulphur was employed. Two analyses, by Mr. Steiger, one from the Upper Koyukuk and one from a point 12 miles above Nulato, on the Yukon, were by methods recommended by "Committee on Coal Analysis." (Jour. Am. Chem. Ass., Vol. XXI, No. 12.)

[c] These calculations were made by Mr. George B. Richardson.

Analyses of coal from southeastern and southwestern Alaska.

Locality.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Character of coal.	Recalculated.		
							Fuel elements.		Fuel ratio.
							Volatile matter.	Fixed carbon.	
McCluskey seam, Kootznahoo, Admiralty Island[a]	2.44	44.75	47.93	4.88	0.67	Lignite (coking)	48.28	51.72	1.07
Sepphagen seam, Kootznahoo, Admiralty Island[b]	1.66	35.40	31.80	31.14	.32	do	52.68	47.32	.90
Sullivan seam, Kootznahoo, Admiraly Island[c]	.82	21.86	35.52	41.80	.51	do	38.10	61.90	1.62
Mitchell seam, Kootznahoo, Admiralty Island[d]	2.37	31.73	30.89	35.01	.47	Lignite	50.67	49.33	.97
De Groff seam, Kootznahoo, Admiralty Island[e]	2.57	55.44	29.75	12.24	.89	Lignite (coking)	65.08	34.92	.53
Chilkat River, near Controller Bay[f]	.77	13.79	82.36	3.08	.....	Semianthracite (coking)	14.34	85.66	5.97
Controller Bay[g]	.75	13.25	82.40	3.60	.....	do	13.85	86.14	6.22
Icy Bay[h]	.78	13.22	80.30	5.70	.....	Semianthracite	14.13	85.86	6.07
Tyonek, Cook Inlet[i]	9.07	49.41	30.84	10.68	.....	Brown lignite (coking)	61.57	38.48	.62
Bradley seam, Cook Inlet[j]	12.64	43.36	37.14	6.86	.49	Lignite (coking)	53.94	46.06	.85
Eastland seam, Cook Inlet[j]	11.72	46.50	34.64	7.14	.40	do	57.31	42.69	.74
Eastland[k]	10.35	52.22	34.58	2.85	.17	do	60.16	39.84	.66
Eastland[k]	11.59	50.70	30.84	6.87	.22	do	62.18	37.82	.61
Curtis seam, Cook Inlet[k]	11.67	52.37	21.01	14.95	.46	do	71.37	28.63	.40
Fort Graham, Cook Inlet[l]	1.25	39.87	49.89	7.82	1.20	Lignite	44.42	55.58	1.25
Red River, Kadiak[m]	12.31	51.48	33.80	2.41	.17	Lignite (coking)	60.37	39.63	.65
Amalik Harbor, Alaska Peninsula[n]	1.62	36.56	52.92	8.90	.75	Semibituminous coal (coking).	40.86	59.14	1.44

[a] Coal and lignite of Alaska, by W. H. Dall: Seventeenth Ann. Rept. U. S. Geol. Survey, Pt. I, p. 782. Analysis by U. S. Geol. Survey.

[b] Dall, op. cit., p. 779. Analysis by U. S. Geol. Survey.

[c] Dall, op. cit., p. 780. Analysis by U. S. Geol. Survey.

[d] Dall, op. cit., p. 783. Analysis by U. S. Geol. Survey.

[e] Dall, op. cit., p. 781. Analysis by U. S. Geol. Survey.

[f] Geology and mineral resources of part of the Copper River Basin, by F. C. Schrader and Arthur C. Spencer, U. S. Geol. Survey, 1901. Analysis by U. S. Geol. Survey.

[g] Reconnaissance in southwestern Alaska, by J. E. Spurr: Twentieth Ann. Rept. U. S. Geol. Survey, Pt. VII, p. 263. Analysis furnished by Mr. F. H. Shepherd.

[h] Spurr, op. cit., p. 263. Analysis furnished by Mr. F. H. Shepherd.

[i] Reconnaissance in Sushitna Basin and adjacent territory, by G. H. Eldridge: Twentieth Ann. Rept. U. S. Geol. Survey, Pt. VII, p. 23. Analysis by U. S. Geol. Survey.

[j] Dall, op. cit., p. 795. Analysis by U. S. Geol. Survey.

[k] Dall, op. cit., p. 796. Analysis by U. S. Geol. Survey.

[l] Dall, op. cit., p. 797. Analysis by U. S. Geol. Survey.

[m] Dall, op. cit., p. 800. Analysis by U. S. Geol. Survey.

[n] Dall. op. cit., p. 799. Analysis by U. S. Geol. Survey.

Analyses of coal from southeastern and southwestern Alaska—Continued.

Locality.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Character of coal.	Recalculated.		
							Fuel elements.		Fuel ratio.
							Volatile matter.	Fixed carbon.	
Chignik River, Alaska Peninsula[a]	1.89	41.47	48.46	8.18	1.71	Semibituminous coal (coking).	46.11	53.89	1.17
Unga, upper seam, Shumagin Islands[b]	11.26	40.51	41.24	6.99	2.17	Bright lignite (coking)	49.55	50.45	1.02
Unga, lower seam, Shumagin Islands[b]	10.58	66.21	15.26	7.95	.56	Dull lignite	81.27	18.73	.23
Herendeen Bay, Alaska Peninsula[c]	3.43	39.00	47.40	10.17	.44	Bituminous coal (noncoking).	45.14	54.86	1.21

[a] Dall, op. cit., p. 803. Analysis by U. S. Geol. Survey. [b] Dall, op. cit., p. 810. Analysis by U. S. Geol. Survey. [c] Dall, op. cit., p. 807. Analysis by U. S. Geol. Survey.

The comparisons of the moisture contents of the analyses given in this report are liable to be misleading, as there was in most cases no uniformity of methods employed in the collection and preservation of the samples. An exception to this are those collected by Dr. Dall, who says:[a]

> These analyses are of coal taken from the seam and tied up in bags of stout duck, and analyzed immediately on arrival at headquarters. The moisture is probably about normal for coal treated in the ordinary way of commerce.

In the table on page 552 some average analyses of Pacific coast coals are compared with those of southern Alaska. This shows that the Cook Inlet lignites have a normal percentage of water; that the volatile matter is above and the fixed carbon below the average of the Pacific coast lignites. The same comparison showed 7.73 per cent of ash for Cook Inlet and 9.79 per cent for Pacific coast lignites. The average of five varieties of Cook Inlet coals gave 0.392 per cent of sulphur, and the average of fourteen Pacific coast lignites gave 1.71 per cent of sulphur. In their fuel ratios the average of the Pacific coast is decidedly better than of the Cook Inlet. The coals of Alaska Peninsula average somewhat better. The mean of five analyses gave a fuel ratio of 1.27 per cent compared with 1.17 of Pacific coast lignites and 1.20 for Vancouver Island coals. Unfortunately these better classes of coals have not yet been found in sufficient quantities to warrant mining operations on a large scale.

The best coals of the Territory are the seams of semianthracite found between Icy Bay and Controller Bay. The analyses of three of these coals (see table) show them to be far superior to any of the others, including the best of the British Columbia coals. Unfortunately it is not known whether the samples analyzed represent averages of the seams or were picked. The extent of these coal seams, and whether broken or undisturbed, have also not been determined.

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[a] Coal and lignite of Alaska: Seventeenth Ann. Rept. U. S. Geol. Survey, Pt. I, p. 827.

Comparison of average analyses of Southern Alaska and British Columbia and Pacific coast coals.

	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Recalculated fuel element.		
					Volatile matter.	Fixed carbon.	Fuel ratio.
Average composition of 5 Cook Inlet lignites[a]	11.59	49.03	31.64	7.73	60.77	39.33	0.64
Average composition of 4 Alaska Peninsula coals[b]	2.05	39.23	49.92	8.77	44.132	55.84	1.27
Average composition of 34 Pacific coast lignites[c]	11.55	36.13	42.10	9.79	47.45	52.55	1.17
Average composition of 15 Vancouver Island coals chiefly from Nanaimo and Comax[d]	.....	30.33	60.23	9.44	33.50	60.23	1.20
Average composition of 3 coals from the vicinity of Controller Bay[e]	.76	13.42	81.68	4.12	14.21	85.68	6.06

[a] Dall, op. cit., p. 828. [b] This report, see table pp. 549–550. [c] Dall, op. cit., p. 829.
[d] Mineral wealth of British Columbia, by G. M. Dawson: Geol. Nat. Hist. Survey Canada, new series, Vol. III, Pt. II, 1887–88, p. 92 R.
[e] This report, see table, pp. 549–550.

While chemical analysis helps to determine the fuel value of a coal, it is at best an incomplete test, and a final decision can be reached only by putting the coal to the actual use for which it is intended. Though the Alaskan coals have been used on local steamers and coasting vessels, very little accurate information is available regarding their fuel value. The Cook Inlet lignites and the Alaska Peninsula semibituminous coals have been considerably used, but the Controller Bay semianthracites, so far as known, have never been tested.

Dr. Dall collected some data in regard to tests made of southern Alaska coals, and the following is quoted from his report:[a]

Coal from the best of the Kootznahoo Inlet beds, which have been designated the McCluskey outcrop, was tried in steam launch No. 18 of the United States Coast and Geodetic Survey steamer *Patterson*, under coiled tubular boiler. According to the informal report of the engineer, it burned well and developed about three-fourths of the steaming value of the Wellington (B. C.) coal usually used. It was decidedly better than the Comax coal.

During part of the expedition of twenty-eight days' cruising on the steam tug *Kodat*, in July and August, 1895, we were obliged to burn coal from the Bradley seam, Kachemak Bay, Cook Inlet, which was dug out of the beach at low water with crowbars and burned as it was, covered more or less with barnacles and seaweed. This coal, being under water most of the time, must have had a larger percentage of moisture than the normal amount belonging to it. The opinion of the engineer of the *Kodat* was to the effect that this lignite did from 60 to 75 per cent of the duty of Wellington (B. C.) coal.

Several hundred tons of coal from Eastland Canyon, Kachemak Bay, were imported

[a] Op. cit., pp. 830, 831, and 832.

into San Francisco by the Alaska Mining and Transportation Company, in 1895, and distributed to various manufacturing establishments for trial. Among these was the foundry of Messrs. W. T. Garrat & Co., well known as the principal brass founders of the Pacific coast. I was informed by their manager that this coal, to the amount of 50 tons, had been in use for making steam in their establishment, and was regarded by them as a very fair article of steaming coal. When a good fire was kept up they used 2,600 pounds in a given time, during which they would have used 2,200 pounds of Comax (B. C.) coal. With a low fire and small pressure of steam the amount used was 2,240 pounds to 1,350 of Comax. They stated that if the Cook Inlet coal could be furnished at a price corresponding to its relative efficiency compared with the British Columbian coal they should be glad to make regular use of it.

By permission of the Secretary of the Navy, and at the request of some New York parties, Lieut. R. P. Schwerin, in April, 1891, proceeded to the Cook Inlet region to examine the coal fields. The party was provided with a diamond drill and examined numerous seams. From four localities in particular, one of which was the McNeil canyon, Kachemak Bay, 50 tons of coal each were mined and brought to San Francisco. Lieutenant Schwerin informed me that during the entire summer this coal was used under the boiler and for cooking in camp and aboard ship. It gave very satisfactory results for stationary purposes, though the coal slacks into chip-like fragments rather rapidly after exposure to a dry atmosphere. He induced the Southern Pacific Company of California to make a test of the coal on their locomotives, a purpose for which it proved unfit, owing to its sparking tendency, which under forced draft was very pronounced in spite of the use of fine netting over the stacks. There was no trouble of this kind when used under a stationary engine or in a cooking stove.

The following summary of the data of the test, prepared September 29, 1891, was kindly furnished to Dr. Becker by Lieutenant Schwerin, who is now one of the staff of the Southern Pacific Railway organization. The kinds of coal with which the Cook Inlet lignite was compared were the ordinary Nanaimo coal from Vancouver Island and bituminous Cardiff coal imported as ballast by wheat ships.

Comparative test of Cook Inlet, Nanaimo, and Cardiff coals.

	Cook Inlet.	Nanaimo.	Cardiff.
Number of trips	2	2	4
Average number of miles per trip	86	168	86
Average gallons water used per trip	3,734	13,836	2,989
Average pounds fuel per trip	6,982	18,551	3,601
Average number loaded cars per trip	6.2	11.98	6
Average number empty cars per trip	.....	1.401	75
Average tons weight loaded cars per trip	155.35	.....	139
Average tons weight empty cars per trip	.....	.....	21.25
Average tons weight train without the engine and tender	155.35	301.47	160.25
Gallons water used per ton of train	24.04	45.895	18.653
Pounds fuel used per ton of train	44.94	61.535	22.473
Water evaporated per pound of fuel	4.46	6.215	6.917
Fuel burned per gallon of water evaporated	1.87	.....	1.205
Average steam pressure	130.5	143	150.3
Average temperature of air	.....	.....	52°

Comparative test of Cook Inlet, Nanaimo, and Cardiff coals—Continued.

	Cook Inlet.	Nanaimo.	Cardiff.
Average temperature of feed water	68°	.....	57°
Average temperature of steam	355.6°	.....	365.7°
Area of grate, in square feet	16.87	25.6	16.87
Average fuel per hour per square foot of grate, pounds	.....	.....	54.215
Total heating surface	1,325	1,288	1,325
Pounds fuel burned per hour per square foot of heating surface	.....	.....	.69
Pounds fuel burned per ton per mile	.5226	.3663	.2613
Equivalent evaporation from temperature of feed water	5.33	7.507	8.369
Average number of miles run per ton fuel burned	24.635	18.112	47.762
Per cent value of fuel from evaporation	63.678	89.7	100

It thus appears that the Cook Inlet coal, under these conditions, has 71 per cent of the heating effect of Nanaimo coal and 63.7 per cent of Cardiff bituminous, a result which agrees fairly well with that derived from the other tests above mentioned.

The Herendeen Bay coal has been tested in United States Fish Commission steamer *Albatross*, and the following report was submitted by C. R. Roelker, passed assistant engineer, United States Navy, in regard to it:[a]

The following statement regarding the coal received from the mine recently opened in Herendeen Bay is based on the results obtained with some 80 tons of this coal consumed while this vessel was engaged in her usual work at sea under average conditions.

The quantities of coal consumed and of refuse matter were carefully measured; the behavior of the coal in the furnaces was closely observed, and the results obtained have been deduced from the entries in the steam log.

The average consumption of the coal was at the rate of 25 pounds per square foot of grate per hour. The boilers furnished the same amount of steam as when we have been using a fair quality of Wellington coal, but to obtain this result we had to burn from 20 to 25 per cent more of the Herendeen Bay coal.

The coal ignites readily and burns with considerable flame, forming a loosely cohering coke, which easily breaks up into small pieces; thus a considerable amount of small particles of coal is lost through the grates. There was a large proportion of fine stuff in the coal, which burned well, but contained an excessive quantity of refuse matter.

The refuse amounted to 26 per cent of the total weight of fuel consumed; it consists of ash and cinders, no glassy clinker being formed. The smoke produced is lighter in color than that of Wellington coal and less soot is formed.

To form a correct estimate of the value of this coal for steaming purposes from the foregoing statement the following facts should be taken into consideration, viz, the coal received by us was the first lot taken from this newly opened mine; it came from one of the smaller veins through which a tunnel had been driven then 200 feet

[a] Bull. U. S. Fish Commission, Vol. IX, 1891, pp. 282-283.

in order to get access to the main veins; no proper facilities for screening the coal existed and in order to supply the quantity required by us a large amount of fine coal, containing much dirt, was delivered. It may be reasonably expected that as the mine becomes further developed and proper screening facilities are provided the amount of refuse matter in the coal will be greatly diminished and its steam-generating power correspondingly increased.

It will be, however, absolutely necessary to store this coal under shelter, as it appears to absorb moisture readily and the constant rains which have prevailed in this region during the present season would soon saturate it to such an extent as to greatly diminish its value as a fuel.

KUSKOKWIM REGION.

This region, embracing the basin of the Kuskokwim River and streams tributary to Bristol Bay, is not known to carry any workable seams, but small veins have been found at several localities. Spurr[a] states that the Cretaceous rocks on the Kuskokwim, below Kolmakof, are locally carbonaceous, and that Mr. Kilbuck, missionary at Bethel, found some small lignite seams there. In the same report reference is made to the occurrence of coal on Nunivak Island and Kaluyak Point. At the former place the seams are of brown coal, and one tested by Kilbuck was found to be very good for common use. The coal from Kaluyak Point, according to Kilbuck, occurs in a seam from 1½ to 2½ feet thick. This coal, which is lignite, has also been tested at Bethel and found to be good.

YUKON BASIN.

GENERAL STATEMENT.

The workable coals of the Yukon Basin, so far as determined, all occur in beds of Tertiary and Cretaceous age. In some parts of the basin carbonaceous beds have been found in strata of Paleozoic age, but these seem to have little or no fuel value. The writer[b] has described some impure coal seams occurring at the head of White River, which are probably of Carboniferous age.

Regarding the distribution of the coal-bearing strata in the Yukon district, our information is very incomplete. Coals are known to occur at a great many localities, but the horizons in which they are found have often not been determined and have seldom been traced away from the main waterways. A study of the various reports referring to the Yukon Basin has convinced the writer that it is at present impossible to differentiate the coal-bearing horizons, and on the accompanying map they are all grouped together. Spurr, in his study of the gold districts, incidentally mapped a number of different formations

[a] A reconnaissance in southwestern Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, Pt. VII, p. 262.

[b] A reconnaissance from Pyramid Harbor to Eagle City, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, Pt. II, p. 382.

which carried coal, but these subdivisions, because of lack of data, can not be carried to adjacent areas.

The oldest beds which carry coal, as has been shown, are probably of Cretaceous age, and occur in what Spurr named the "Mission Creek series." This series overlies the older metamorphic rocks unconformably. Spurr[a] describes this rock as black, calcareous, or feldspathic shale which alternates with thin beds of impure limestone and with beds of gray sandstone. These beds are generally considerably and sometimes intensely folded; are sometimes slightly sheared and altered, but are ordinarily fresh and recent in appearance. Cretaceous rocks are widely distributed in the basin.

The workable coals of Tertiary age occur in the Kenai series, which has the same character as in southwestern Alaska. These coals are all lignites (compare table of analyses, p. 565). In the discussion of the geologic relations mention has been made of some younger Tertiary beds of Miocene of Pliocene age which carry lignites. These latter probably have no commercial importance. The Kenai has been identified at various points along the Yukon between Dawson and the mouth of the river.

LOWER YUKON.

Coal has been reported from the vicinity of Anvik. The locality is said to be away from the main river. No details are available regarding this locality. A coal opening, developed by W. E. Williams,[b] has been described as being located on the north bank of the Yukon, about 60 miles above Anvik, but no further data are available.

Governor John G. Brady informed the writer that in the summer of 1900 some coal was being taken out of the Clemens Thein[b] mine, which is situated on the right bank about 90 miles below Nulato. Governor Brady stated that the vein was about 2 feet thick, and that a test of the coal seemed to show that it possessed good steaming qualities.

NULATO.

Near Nulato several coal openings have been made. Schrader[c] has made mention of the Pickett mine, about 10 miles above Nulato. The coal is a lignite, but is compact and is said to be a good steaming coal. The vein is about 30 inches thick. The coal is very fine after slaking in the air. The Blatchford mine, about 9 miles below Nulato, has produced some coal. The occurrence is probably similar to that at the Pickett mine, but no descriptions were obtained. The horizon of the coals in the vicinity of Nulato and below has not been definitely determined.

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[a] Geology of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, Pt. III, p. 175.

[b] The positions of the mines are only approximately located on the accompanying map.

[c] A reconnaissance along Chandlar and Koyukuk rivers: Twenty-first Ann. Rept. U. S. Geol. Survey, Pt. II, p. 486.

KOYUKUK RIVER.

Schrader also found coal, probably of Tertiary age, on the Upper Koyukuk. He makes mention[a] of one coal vein near Tramway Bar where the lignite is about 12 feet in thickness, of which 9 feet is comparatively pure coal but is of inferior quality (compare table of analyses, p. 565). He also makes mention of lignitic fragments in the gravels of Chandlar River.

PALISADES.

Mr. H. N. Wood, assistant engineer, Revenue-Cutter Service, in a personal letter to the writer, makes the following statement:

> About 60 miles below the Tanana, just above the bluff known as the Palisades, is a vein claimed to be 20 feet thick. A prospecting tunnel has been dug, but no coal has been taken out for the use of steamers that I am aware of.

Spurr,[b] in his description of the geology of the vicinity, considers the beds to be of Miocene or Pliocene age. This fact would suggest that these coal seams belong to the Upper Tertiary, which usually carry inferior coals.

RAMPART REGION.

A number of coal veins have been found in the Lower Rampart region of the Yukon, chiefly in the neighborhood of Minook and Hess Creek. These are lignites occurring in the sandstones and conglomerates of the Kenai formation. The following is quoted from Spurr:[c]

> On the right-hand side of the Yukon, just below the mouth of Whymper River (or Hess Creek) there are exposed frequent seams of rather impure, lignitic coal which occurs in the shales of the Kenai series. These shales alternate with conglomerates, grits, and impure limestones. On this bluff three distinct seams have been opened by Oliver Miller, a noted Alaskan prospector. One of these seams is 2 feet thick, with two or three clay partings; another, in which a tunnel 40 feet in length has been driven, shows 3 or 4 feet of mixed coal and coaly shale, and then a seam of clear coal 18 inches thick. This coal is generally brittle, and contains amber like that of Coal Creek and vicinity. Next it is a bed of yellow and red clay, and then comes again carbonaceous shale, passing into green sandstone and conglomerates. All these beds are nearly vertical, and are even slightly overturned, the folding being well shown in the steep bluff.

The Drew mine, as nearly as can be determined, is at this locality described by Spurr. This is the most important of the Alaskan-Yukon mines and has produced considerable coal. A shaft 75 feet deep has been sunk, which is cribbed and housed and equipped with steam hoisting gear. Bunkers of 80 tons capacity are conveniently situated, with chutes to reach the decks of steamers moored at the bank. Another location in this vicinity is the Pioneer mine, situated

[a] Op. cit., p. 485.

[b] Geology of the Yukon Basin: Eighteenth Ann. Rept. U. S. Geol. Survey, Pt. III, pp. 199-200.

[c] Geology of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, Pt. III, p. 381.

about 30 miles above Rampart. This mine is said to have produced considerable coal in 1900. A 4-foot vein of coal, which has been prospected, is located on Minook Creek, about 4 miles from Rampart City.

DALL RIVER.

Mr. Walter C. Mendenhall has kindly furnished the following notes on the occurrence of coal on the Dall River, a westerly tributary of the Yukon:

One mile above the mouth of a small stream entering Dall River about 70 miles above its mouth a seam of lignitic coal, measuring approximately 11 feet in thickness, outcrops. The lignite and the associated gray and black shales have been extensively folded and now dip at an angle of 45° to the southeast. The lower half of the outcrop is a firm, clean, bright lignite, light in weight and resisting weathering fairly well, but the upper portion contains streaks of clay and bone, making it worthless as a fuel. The 4 or 5 feet at the base of the exposure compares well in appearance with other Alaskan lignites, and doubtless is a fuel of good quality.

BIG BLACK RIVER.

This is an easterly tributary of the Porcupine, which it joins about 20 miles above Fort Yukon. Coal has been reported from this stream,[a] but no details are known regarding its occurrence. It seems probable that it is a northerly extension of the same series that carries coal on the Yukon near the international boundary.

ALASKA EXPLORATION COMPANY MINE.[b]

This is said to be located 60 miles above Circle City. Up to 1900 only development work had been done. The vein is said to be 7 feet thick, and analysis shows it to be a lignite of good quality. It probably occurs in Kenai sandstone, though the horizon may be Cretaceous.

MISSION CREEK.

On the lower reaches of this stream and of its tributary, American Creek, there is a considerable development of Cretaceous rocks, which often carry lignites. As far as known, no attempts have been made to mine these coals.

FORTYMILE RIVER.

Toward the headwaters of the west fork of Fortymile fragments of lignite are common in the stream gravels. This lignite is probably associated with beds of Cretaceous age. Its distance from water transportation precludes its having any immediate value.[c]

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[a] Reconnaissance of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, Pt. III, p. 381.

[b] The position of this mine is only approximately indicated on the accompanying map.

[c] Reconnaissance from Pyramid Harbor to Eagle City, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, Pt. II, p. 383.

BRITISH NORTHWEST TERRITORY.

The most extensive developments of the Yukon coals are on the Canadian side of the international boundary. The Alaska Exploration Company has done considerable systematic mining on Coal Creek, a tributary of Rock Creek, which flows into the Klondike. This mine is about 25 miles distant from Dawson. According to McConnell,[a] the coal is a lignite and the seams are locally disturbed. The lignite is hard and compact and shows no trace of woody fiber. There are two seams separated by a clay layer with clay roof and floor. The upper seam has a thickness of 3 feet; the lower, from 2 to 3 feet.

A coal mine has been opened by the North American Trading and Transportation Company on Cliff Creek,[b] 55 miles below Dawson, near the Yukon River. McConnell describes two lignite zones, consisting of alternating beds of clay and carbonaceous shales. The upper contains about 11 feet of coal in a section of about 16 feet, consisting of coal and clay partings. The lower contains two lignitic seams, 2 and 9 feet thick, and separated by 24 feet of clay. McConnell also makes mention of the discovery[c] of anthracite coal near the White Horse Rapids. Coal has long been known to occur in the Cretaceous rocks on the Lewes River,[d] 5½ miles above Rink Rapid, where there are several veins, the lowest of which is about 3 feet thick. A good many years ago a short drift was put into this vein. More recently a mine has been opened up which now furnishes coal for the river steamers.

In a letter dated Dawson, March 24, 1901, F. C. Schrader has given the writer the following description of an occurrence of coal on the Nordenskiold River, which joins the Lewes River a few miles above Five Finger Rapids:

> About 18 miles above its mouth occur coal beds, some 6 or 7 feet in thickness, and of fair grade. The associated rocks are bluish grits and sandstones, which are probably Cretaceous. The dip, which is to the northwest, averages 50°. The coal outcrops on both sides of the valley at points several miles apart. The locality where some development has been done is known as Porter's coal mine. Fossil plants are said to occur in this locality.

NORTHWESTERN ALASKA.

GENERAL STATEMENT.

Very little is known of the geology and mineral resources of this region except of the southern half of the Seward Peninsula, which has been studied in some detail. The coals of this region are, so far as known, of Tertiary and Cretaceous age. Tertiary rocks have been

[a] A summary report of the geological survey department for the year 1900, Ottawa, No. 26, p. 45.
[b] McConnell, op. cit., p. 46.
[c] Op. cit., p. 48.
[d] Exploration in the Yukon district and British Columbia, by G. M. Dawson: Rept. Geol. Survey Canada, new series, Vol. III, Pt. I, 1887–88, p. 148 B.

found near the eastern shore of Norton Bay,[a] and probably have extensive development to the east, while at Cape Lisburne[b] Cretaceous beds are known to occur, and what are probably Tertiary beds on the Kowak River. Outside of these three areas we have no absolute knowledge of the presence of rocks of Tertiary or Cretaceous age.

ULULUK CREEK.

Dall[c] makes mention of lignitic beds on Ulukuk Creek, a branch of the Unalaklik River. The beds, consisting of sandstones and argillites, dip 25° to 55° to the northwest. Capt. D. H. Jarvis informed the writer that some very good looking coal had been found near Unalaklik Cape, near the eastern shore of Norton Sound. These probably belong in the same series described by Dall.

SEWARD PENINSULA.

The country rock of the southern half of this peninsula is mostly of a metamorphic and igneous character and does not carry coal. In the eastern part of this area, however, Mendenhall[d] found some beds which he assigned to the Tertiary, and he saw some indications of the presence of coal, which he describes as follows:

> The only rocks encountered in the reconnaissance likely to carry coal are the sediments supposed to be of Tertiary age outcropping on the Tubutulik and Koyuk rivers in narrow belts. No direct evidence of the presence of this mineral was secured on the Koyuk, but along the river bank, associated with the sandstone outcrops on the Tubutulik, are numbers of small pieces of bright compact coal, seemingly of good quality. Some time would have to be spent in careful prospecting to determine the extent and value of the deposit.

KOWAK RIVER.

Lignites have been reported from the Kowak River which are said to be associated with sandstones and conglomerates. Lieut. John C. Cantwell[e] was the first to note this coal, and it has since been visited by prospectors. The following is quoted from his report:

> The coal is intimately mixed with a fine white clay, which renders its use for a small furnace almost impossible. However, it is my opinion, based on the experience of others, that the seams if worked would produce a good quality of coal.
>
> I saw numerous specimens of extra good bituminous coal which the Indians claim could be easily obtained on some of the small tributaries of the Kowak, but I never succeeded, although I tried several times, to definitely locate the place where such coal could be obtained.

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[a] Correlation Papers, Neocene, by W. H. Dall: Bull. U. S. Geol. Survey No. 84, p. 246.
[b] Report on coal and lignite of Alaska: Seventeenth Ann. Rept. U. S. Geol. Survey, Pt. III, p. 820.
[c] Bull. U. S. Geol. Survey No. 84, p. 248.
[d] Report on the Norton Bay region; U. S. Geol. Survey, 1901.
[e] Report of the cruise of the revenue-marine steamer *Corwin* in the Arctic Ocean in the year 1884, p. 56. Report of the cruise of the revenue-cutter *Corwin* in the Arctic Ocean, 1885, p. 48.

Lieutenant Stoney makes the following reference to coal on the Kowak, which he calls the Putnam River:[a]

> On my second trip to the Putnam [Kowak] I discovered a vein of bituminous coal outcropping on the north side of the river about 90 miles from the mouth. I tried a lot of it in the furnace of the steam launch with very satisfactory results, though it had long been exposed to the weather. The vein was between 2 and 3 feet thick and dipped at an angle of 30° from the river. I think that a good quality of coal will be found farther in the bank.

Since the above was written, Mr. Walter C. Mendenhall has made a geologic reconnaissance of the Kowak River, and he has kindly furnished the writer with the following notes on the coal:

> A short distance below the mouth of Reed River, on the north bank of the Kowak, a succession of beds of conglomerate, composed of pebbles of quartz, mica-schist, limestone, and serpentine, in a matrix containing much mica-schist, is exposed. The single conglomerate beds vary in thickness from 10 to 200 feet, but are uniform in character. Softer beds are associated with them, but are poorly exposed. These are sandstones, shales, fireclays, and lignites. A half dozen beds of the latter are indicated, but those sufficiently well exposed to measure are thin, not over 6 or 8 inches. One or two others may be 2 to 3 feet thick, to judge from the rather extensive bloom. The lignite examined is dirty with many shale partings, and the weathered fragments gathered burned rather slowly, but without heavy smoke. Rather offensive gases were given off, as is usually the case with low-grade lignites. The deposit is not economically important.

CAPE LISBURNE.

This cape is the northern promontory of a land mass projecting into the Arctic Ocean in about latitude 69°, and is about halfway between Cape Prince of Wales and Point Barrow. Coal was reported to occur in the vicinity of Cape Lisburne by Kellett[b] and other English explorers in the middle of the century. In 1879 Captain Hooper mined some coal for his vessel from a vein in this vicinity which was discovered the preceding year by Capt. E. E. Smith.[c] Since that time veins have been spasmodically worked for use of the revenue vessels and whalers. No systematic development was carried on, but when a vessel ran short of fuel a landing was made and the seamen were put to work digging out the coal at the most convenient place. One locality where mining was thus carried on has been called the Corwin mine; another the Thetis mine.

The geology of the Lisburne region has not been studied, though there are some random notes regarding it by various observers. The cape itself, which is about 800 feet high, is said to be made up of limestone,[d] which extends southward for some 40 or 50 miles. The

[a] Naval Explorations in Alaska, by Lieut. George M. Stoney, United States Navy; United States Naval Institute, Annapolis, Md., 1900, p. 80.

[b] Alaska: Its Population, Industries, and Resources, by Ivan Petroff, Eleventh Census, p. 2.

[c] Report of the cruise of the United States revenue steamer *Corwin* in the Arctic Ocean. Capt. C. L. Hooper, U. S. R. M. S., Washington, 1880, pp. 30 and 32.

[d] Coal deposits of Alaska, by Winthrop Packard: The Colliery Guardian, Nov. 30, 1900, Quoted from New York Evening Post. Date not given.

strike of the rocks is probably in a general northeasterly and southwesterly direction, though no direct statement regarding it has been found in the literature. The coal seams, which are very numerous, are reported to be 6 inches to 40 feet in thickness. They are exposed in cliffs [a] facing the sea.

The rocks associated with the coal seams are sandstones [b] and conglomerates which are assigned to the Cretaceous.[c] The coal-bearing series is said to extend from near Cape Lisburne [d] to Cape Beaufort, the most promising veins lying in about the center of this segment of the coast. The coal from the Corwin coal mine is semibituminous,[b] burning with little smoke, kindling readily, and leaving a fine white ash. It has been found to be a good steaming coal.

During the summer of 1900 the Corwin Trading Company inaugurated a systematic development of this coal field. Some of the coal was shipped to Nome, where it found a ready sale. The district unfortunately lacks a good harbor, and the vessels in taking on coal have protection only from southerly and easterly storms, unless an offshore ice pack furnishes a lee.

In connection with these deposits it is interesting to note that Lieut. L. O. Howard [e] reports the finding of coal on the Colville River, near latitude 69°. As the strike seems to run in an easterly and westerly direction, this discovery suggests that the coal-bearing rocks of Cape Lisburne may extend inland.

Since the above was written Mr. F. C. Schrader, of the United States Geological Survey, has visited this locality. Mr. Schrader has kindly furnished the writer with the following notes in advance of the publication of his report:

> This coal occurs approximately 30 miles east of Cape Lisburne, where it seems to have been long known to the whaling vessels, which have occasionally made use of it when in need of fuel in the Arctic regions. It seems to be a bituminous coal, occurring in slate and sandstone of probably Mesozoic age, or older. The occurrence of the coal, so far as observed in the locality, is in eight or ten veins, varying from 1 to 16 feet in thickness, and all apparently persistent. They are all exposed within a distance of about three-eighths of a mile along the coast, which here cuts them diagonally, forming a generally steep-faced bluff, which rises from 30 feet high on the west to more than 100 feet above tide on the east. The veins dip southwestward at an angle of approximately 35°.
>
> The coal is of fair grade, and nearly all the veins are comparatively pure. Though some folding, slight faulting, and jointing has taken place in the region, the coal has not suffered much from crustal disturbance.
>
> The property, so far as known, has all been staked, mostly by the Arctic Development Company of San Francisco, which has been operating on the ground during the last season—1901—and has been disposing of the coal in the Nome market, where it

[a] See drawing by Captain Hooper in report cited, p. 30.
[b] Packard, op. cit.
[c] See page 530 of this report.
[d] Population and Resources of Alaska, by Henry D. Woolf, Eleventh Census, pp. 132–133.
[e] Naval Explorations in Alaska, p. 69; United States Naval Institute, Annapolis, Md., 1901.

is said to readily command $18 to $20 per ton in competition with Comox or United States coal at $25 per ton. The coal is said to be a good article for house use, but is not so satisfactory for steaming purposes on the ocean, owing to its too light specific gravity for the high-draft steamer furnaces.

There are no harbor facilities in the region of the mines, but the beach is open, exposed, and shallow, and susceptible to heavy surfs, much the same as at Nome, so that ocean vessels do not approach nearer than three-eighths of a mile to the shore. Loading at the present date is accomplished by lighterage, as at Nome.

KOK RIVER.

This stream flows into Wainwright Inlet,[a] which is a minor indentation of the Arctic coast, in about latitude 71°. In 1889 Henry D. Woolfe[b] found extensive deposits of lignite on the banks of the Kok River, not far from the sea. He claims that it is a hard lignite which burns well and leaves but little ash. It could be brought to the coast by light-draft barges.

Mr. F. C. Schrader has kindly furnished the writer with the following notes on the coals of the Arctic and Koyukuk regions from his unpublished manuscript:

On the upper John River, a northerly tributary of the Koyukuk River, in approximately latitude 67° 7′ N. and longitude 152° W, considerable coal detritus was observed. This was of such quantity and character as to suggest the occurrence of bituminous coals of economic value somewhere in the region north of this locality and in the drainage basin of the John River. The remoteness of its location would make it valuable only for local consumption.

Lignitic coal was also found in the region of the mouth of the Anaktoobuk River, a tributary of the Goobie or Colville River. This locality is about 70 miles from the coast, the latitude and longitude being approximately 69° 32′ N. and 150° 55′ W.

The coal, which is a good grade of lignite, occurs in several seams 1 to 3 feet or more in thickness. The beds are nearly horizontal or dip very gently to the north and are well exposed for several miles along the river. They are probably Tertiary and form part of a series which goes to make up the Arctic coastal plain in this region. They are exposed in bluffs rising to a height of 200 feet above the river. The associated beds are mud rock, soft sandstone, impure limestone, and intermediate rock types. The coal occurs for the most part between the base and the middle of the section. It is a good grade of lignite and was used satisfactorily in camp fire, yielding a strong and lasting heat. Should there be a demand for coal on this part of the Arctic coast it might prove of economic value, the gradient and volume of the river being such that at high water it could be brought to the coast by river steamers.

CHARACTER OF COALS OF YUKON BASIN AND NORTHWESTERN ALASKA.

The table of analyses on page 565 shows the coals of this part of the Territory to be chiefly lignites, except those of Cape Lisburne, which are semi-bituminous. In their fuel values, as far as can be determined by analyses, they average much better than the Cook Inlet coals and not

[a] This inlet is just north of the limits of the accompanying map, Pl. XXXV.

[b] Population and Resources of Alaska, Eleventh Census, 1893, p. 133.

much below those of British Columbia. The use of the Yukon coals has been confined entirely to river steamers and to domestic purposes along the river. Not much information is obtainable in regard to their use on the river steamers, but they are usually said to be inferior to the Comox and Nanaimo coals. So far as known, they are never used alone, but are always mixed with the imported coals or with wood.

The writer is fortunate in being able to present the opinion of Mr. H. N. Wood, assistant engineer, United States Revenue-Cutter Service, on this subject. Mr. Wood was attached for two years to the United States steamer *Nunivak* while she was patrolling the Yukon River. The following is quoted from a personal letter, dated February 24, 1901:

> My experience with Yukon coal was limited to a trial of the coal of but one of the Yukon River mines. This was that from the one known as Drew's mine, which is located on the bank of the Yukon directly opposite the mouth of Hess Creek. An attempt was made to steam the boilers of the United States steamer *Nunivak* using this coal alone, but without success. Used mixed with Comox coal in the proportion of two parts of Yukon to one part Comox, moderate steaming could be done. Used with wood it served fairly well, about 400 pounds being used with one cord of wood. Used to maintain low-banked fires when the engine was stopped, it seemed to be fully as good as Comox coal. If, however, a fire was wanted to furnish steam for running a 10-kilowatt dynamo, the Yukon coal was inferior, due chiefly to the waste caused by the shifting of the coal through the grates when the fires were disturbed with fresh coal or fire tools. Although the attempt to steam with this coal was a failure, I am of the opinion that with some experimenting to determine the best kind of grates, amount of grate surface and draft most suitable, and the proper way to handle the coal in the furnace, good results could be obtained. Judging by my limited experience, the Yukon coal will compare with Comox coal and with wood about as follows, using the average hourly consumption of the *Nunivak* as a basis: 1,200 to 1,500 pounds Comox coal=2,000 to 2,500 pounds of Yukon coal=1¼ to 1½ cords of spruce wood. Comox coal was on the market in St. Michael in 1899 at $15 per long ton. The same price was charged per short ton for the Yukon coal at the mine. The cost of wood is from $6 to $10 per cord.
>
> As far as I was able to learn, through inquiries of captains and engineers on river steamers, there are no vessels that have ever successfully used the native coal alone. It is used chiefly mixed with wood, sometimes with outside coal. The quality of the coal from the various mines of the Lower Yukon is said to vary but little. That from the mine of the upper river, in British territory, is claimed to be somewhat better. The general opinion of river engineers of the Yukon coals is decidedly unfavorable.
>
> I was told by a man who served on the *Nunivak* in the capacity of chief oiler that the quality of Yukon coals was very much like that of the coal obtained at Coal Bay, in Cook Inlet. This man had served on a vessel on the coast that made a trial of the Cook Inlet coal.

The Cape Lisburne coals are, from all reports, decidedly the best coals which are known to occur in any considerable quantity in Alaska. They have been successfully used on whaling vessels and on revenue cutters, and during the summer of 1900 were used at Nome for domestic and steaming purposes. Coal is known to occur in this northern region in considerable quantities, but it will remain for future investigations to determine whether it is all of as high grade as the samples which have been analyzed and tested. The writer is indebted to

Analyses of coals of Yukon Basin and northwestern Alaska.

	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Character of coal.	Recalculated.		
							Fuel elements.		Fuel ratio.
							Volatile matter.	Fixed carbon.	
Lewes River, 5½ miles above Rink Rapid[a]	6.03	36.92	49.03	8.02	.....	Lignitic coal	42.95	57.05	1.33
Cliff Creek, upper working, Yukon River[b]	8.57	42.04	45.77	3.62	.....	Lignite (coking)	47.87	52.13	1.08
Cliff Creek, lower working, Yukon River[b]	10.58	40.10	46.74	2.58	.....	do	46.17	53.83	1.16
West of Dugdale on White Pass Railway[b]	2.31	5.59	67.20	24.90	.....	Anthracite (coking)	7.67	92.33	12.03
Coal Creek, upper seam, Yukon River[c]	18.31	34.96	40.88	5.85	.....	Lignite (coking)	46.09	53.91	1.17
Coal Creek, lower seam, Yukon River[c]	19.37	33.85	37.45	9.33	.....	do	47.47	52.53	1.11
Cliff Creek, Yukon River[d]	18.0	44.3	33.6	3.1	0.82	Lignite	56.87	43.13	0.75
Do.[d]	16.0	35.5	38.5	10.0	Trace.	do	47.97	52.03	1.08
Do.[d]	16.6	42.9	25.5	15.0	.....	do	62.71	37.29	0.59
Do.[d]	12.5	37.5	34.6	15.4	.....	do	52.01	47.99	0.92
Do.[d]	9.98	44.08	40.99	4.95	2.37	do	51.82	48.18	0.93
American Creek, Yukon River[e]	6.75	39.13	37.59	16.53	3.40	Lignite (noncoking)	51.01	48.99	0.96
Left bank of Yukon, 60 miles above Circle City[f]	7.7	29.8	51.8	9.4	1.0	do	36.52	63.48	1.73
Small creek emptying into Yukon below Coal Creek[g]	6.24	43.94	47.74	2.08	.....	Hard lignite	47.93	52.07	1.08
Miller's mine nearly opposite mouth of Hess Creek, Yukon River[g]	7.29	37.38	36.91	18.42	.....	do	50.32	49.68	0.98
Upper Koyukuk[h]	4.47	34.32	48.26	12.95	.....	Brown lignite (noncoking)	41.55	58.45	1.40
Twelve miles above Nulato on the Yukon[h]	0.86	25.75	66.51	6.88	.....	Semibituminous (coking)	27.92	72.08	2.22
Cape Lisburne[i]	3.75	43.75	47.39	5.11	.360	Semibituminous (noncoking)	48.00	52.00	1.08

[a] Exploration in the Yukon district and British Columbia by George M. Dawson: Geol. Survey Canada, 1887–88, new series, Vol. III, Pt. I, p. 149 B. Analysis by G. C. Hoffman, Geol. Survey Canada.

[b] R. G. McConnell, Summary report for 1901, Geol. Survey Canada, p. 48. Analysis by Geol. Survey Canada.

[c] McConnell; op. cit., p. 46. Analysis by Geol. Survey Canada.

[d] North American Trading and Transportation Company.

[e] Maps and descriptions of Alaska, by E. C. Barnard, U. S. Geol. Survey, 1898, p. 81. Analysis by U. S. Geol. Survey.

[f] Alaska Exploration Company. Analysis by G. Beraud.

[g] Geology of the Yukon gold district, by J. E. Spurr: Eighteenth Ann. Rept. U. S. Geol. Survey, Pt. III, p. 382. Analysis by H. N. Stokes, U. S. Geol. Survey.

[h] Reconnaissance along Chandlar and Koyukuk rivers, Alaska, by F. C. Schrader: Twenty-first Ann. Rept. U. S. Geol. Survey, Pt. II, pp. 485–486. Analysis (not published) by George Steiger, U. S. Geol. Survey.

[i] Corwin Trading Company. Analysis by Albert H. Welles.

Mr. George O. Fogg, secretary of Corwin Trading Company, for the following reports on the quality of this Cape Lisburne coal:

Analysis of sample of Alaskan coal.

[Analyst, Albert H. Welles.]

	Per cent.
Moisture	3.75
Volatile matter	43.75
Fixed carbon	47.39
Ash	5.11
Total	100.00
Sulphur	0.36

Color of ash, light brown.

The coal is of very good quality in every way.

Mr. Charles L. Norton, of the Massachusetts Institute of Technology, made the following report to the Corwin Trading Company on Cape Lisburne coal:

I find that the specimens of Alaska coal which you recently sent me have a calorific power of 7,560 calories per gram, or 13,600 B. T. U. per pound. This is quite as good as the average western coal, and is not more than 10 per cent inferior to the best eastern coals. I can not guarantee the sampling of the coal, as I have had only a few small sample lots to work from. To guarantee the same I should have to select samples from several tons. I have made 28 combustions of the samples you sent me, and the figure given below is the average value.

Comparative values:

New River	14,200 B. T. U.
Alaska Corwin	13,600 B. T. U.

DEVELOPMENT OF COALS.

Some of the early explorers report the presence of coal in what is now the territory of Alaska, but during the first century of Russian occupation no attempt seems to have been made to exploit it. In 1852 operations were inaugurated by the Russian American Company to open coal mines at Port Graham[a] on the western side of Kenai Peninsula. This was probably the first mining done in Alaska, and the Russians soon abandoned it, but induced an American company to develop coal mines at Port Chatham. These mining operations were continued for about ten years,[b] and supplied the Russian company's steamers. With the development of the British Columbia, Puget Sound, and other Pacific coal fields the enterprise became unprofitable, and was abandoned when the Territory was transferred to the United States.

In 1868[c] Commander Mitchell, United States Navy, visited Kootznahoo Inlet, Admiralty Island, in the United States steamship *Saginaw*,

[a] Alaska: Its Population, Industry and Resources, by Ivan Petroff, Tenth Census, p. 115.

[b] Coal and lignite of Alaska: Seventeenth Ann. Rept. U. S. Geol. Survey, p. 786.

[c] Dall, op. cit., p. 777.

to find the coal which had been reported by a native at Sitka. He mined a few tons, and the following year Capt. J. R. Meade, who had succeeded to the command of the *Saginaw*, secured some 30 to 50 tons at this locality which had been mined by contract with natives.

In 1868 Capt. J. W. White, of the United States Revenue steamer *Wayanda*, reported coal near Point Gardiner, at the southern extremity of Admiralty Island, and some years later[a] an unsuccessful attempt was made to mine these coals. The southern Alaskan coals have been worked spasmodically for local use ever since the Territory was transferred. Thus Dall, in 1872, mined coal at Coal Bay, Unga Island,[b] for the United States steamship *Humboldt*, which he commanded, and mining at this locality has gone on intermittently and in a small way for many years.

In 1888[c] the Alaska Coal Company started some mining at Kachemak Bay. The same company and the North Pacific Mining and Transportation Company continued mining in this locality for a number of years. Since 1899 the Cook Inlet Coal Fields Company seems to have controlled this field and is now carrying on rather extensive operations. In 1893 mining in a crude manner was inaugurated at Chignik River and has since been intermittently carried on by the Alaska Packers' Association.

In southeastern Alaska considerable prospecting has been done at Killisnoo, and the Firestone mine, owned by James McCluskey, which was established in 1880, has been occasionally worked for local use. Though the output is small, it must be classed as a working mine. In 1898 the Admiralty Coal and Fuel Company was established, and during the season of 1900 did considerable development work.

In 1889 the Alaska Mining and Development Company was organized to develop the coals at Herendeen Bay, on the western side of the Alaska Peninsula. The Alaska Commercial Company subsequently gained control of this enterprise, but it does not seem to have been a financial success.

The coals of the Yukon River attracted very little attention, though a few crude attempts at mining were made, until the excitement which attended the discovery of gold in the Klondike region in 1897. Within a year there were probably upwards of a hundred steamers on the Yukon River, and while the banks will furnish ample wood for some years, yet that easiest of access was rapidly being cut. Wood commanded anywhere from $8 to $20 a cord. Moreover, on the lower Yukon, below the Holy Cross Mission, there is no timber of any kind, and the steamers were forced to carry a supply of fuel wood from higher up the river sufficient to last them for the voyage to St. Michael and return.

[a] Dall, op. cit., p. 773. [b] Op. cit. [c] Dall, op. cit., pp. 791 and 793.

Some of the larger companies soon saw the advantage in the use of coal, and a supply of it was kept in store at St. Michael for use of the river steamers. The disadvantage of this coaling station is that when a steamer is taking her heaviest cargo of freight on her up trip she must carry her largest quantity of coal. If coal could be found on the upper river the steamers running to St. Michael would bring it down very cheaply and distribute it along the river at points where it is needed. These conditions have led to considerable investigations of the coal supply of the Yukon River, and at several localities organized attempts have been made to open up the coals.

Since steamers were introduced on the Lewes River, in 1898, the coal deposit near Rink Rapids has been opened up. On the Nordenskiold River the Porter Bros. have made some developments on a coal vein. These are both in Yukon Territory. The North American Trading and Transportation Company has opened up a considerable mine on Cliff Creek, which is on the Canadian side of the boundary. This plant includes a small railway and locomotive. On Coal Creek, also in Yukon Territory, the Alaska Exploration Company has a producing mine. This same company during 1900 started some developments on the Alaskan side of the line, about 60 miles above Circle City.

The oldest mine on the Yukon is opposite the mouth of Hess Creek. This location was formerly known as Miller's mine, now as Drew's mine. The workings are quite extensive and the equipment includes a steam hoisting apparatus, coal bunkers, etc. The Pioneer mine, some distance below Hess Creek and 30 miles above Rampart, has a similar equipment. Both of these mines produced considerable coal in 1900, which was sold chiefly to steamers.

Near Nulato, the Blatchford and Pickart mines produced some coal, but were worked in a smaller way. Similarly, the Clemens Thein mine and the Williams mine, both between Anvik and Nulato, were coal producers in a small way.

Mention has already been made of the discovery of coal at Cape Lisburne, in the early part of the century, and the subsequent development of the seams for use of whalers and revenue cutters. As a result of the rapid development of the Nome gold fields, these, the nearest coal deposits, have received some attention. The Corwin Trading Company is now engaged in a systematic attempt to develop these deposits to supply Nome and the whaling ships. The latter have in the past always brought their coal from Puget Sound.

CONCLUSION.

In the foregoing an attempt has been made to summarize the existing knowledge of the coal resources of Alaska. It has been shown that coal-bearing rocks have a wide distribution in the Territory; that the coals are chiefly lignites, with some bituminous coals, and in a few localities semianthracites.

Developments have been entirely along waterways, where the coal could be handled cheaply and receive the benefit of water transportation. The southeastern and southwestern Alaska coal fields, as far as developed, are on tide water along a coast line affording good harbors which are open to navigation the entire year. They can be mined comparatively cheaply, and while many of them are not equal in quality to the other Pacific coast coals, yet they have found a ready market for local steamboat and domestic use. No developments have been made of the higher grade coals which are known to occur in southern Alaska, except in a few localities, where the faulted conditions of the seams and associated beds prevented economic mining. These higher grade coals are worthy of the attention of the prospector and capitalist. If found to occur in sufficient quantities they could compete with all other coals in the Pacific coast market.

The development of the Yukon coals is dependent entirely on their finding a local market. Because of their low grade, of the expense of mining them, and the cost of transportation, they could never be exported. As long as the placer mines of the Yukon Basin continue to make a large annual output of gold, these Yukon coal mines will find ready sale for their products. As in southern Alaska, so also in the Yukon Basin, the coals seem to vary greatly in character. It should be the aim of prospectors and mining companies to do careful preliminary work before developing a mine, and thus avoid opening up low-grade lignite seams. The Yukon coals are said to bring about $15 a ton at the mines.

Nome has offered a splendid market for coal during the last two years. Probably very little has sold as low as $25, and it has gone up as high as $75, or even $100, per ton, with an average during the summer of 1900 of about $40 to $50. It was this that led to the development of the Cape Lisburne field, which is only 200 miles away. These mines would also supply fuel to whalers, who use large quantities of coal on their cruises in the Arctic Ocean.

In 1900 about 13,000 tons of coal were shipped as cargo to Alaska from Washington ports, and the amount imported from British Columbia into Alaska was probably considerably more. No accurate data as to the coal produced by Alaskan mines are obtainable, but the total is probably between 4,000 and 5,000 tons, of which about a third is from mines on the Yukon River.

Besides the coal there are three other possible sources of fuel supply in Alaska—timber, petroleum, and peat. Of these the first is the only one which has been used.

Southeastern Alaska is heavily forested and affords timber which is ample for fuel. Certain species of trees are found as far west as Kodiak Island. Beyond Kodiak to the west and north the coast region of Alaska is practically treeless. The sheltered regions afford some willows and occasionally a little spruce, but for the most part the coastal belt is covered simply with moss, grass, and low shrubs. This type of vegetation extends northward to Point Barrow, and from there eastward. These moss and grass covered plains and rolling plains are termed "tundras," and are found encircling the globe as the northern continental margins.

The interior of Alaska has usually a sufficient supply of wood for the ordinary purposes of building and mining and for fuel. The larger river valleys, such as that of the Yukon, are often heavily forested with spruce and other trees. On the Yukon, near the international boundary, the timber line stands at about 3,000 feet; northward it decreases in elevation, and on the Koyukuk is about 2,500 feet. Still farther to the north and west it further decreases in altitude, and on the Upper Kowak the timber is said to be limited to the floor of the larger river valleys. In the northern Arctic drainage, according to all reports, there is no timber except the willows, which, however, grow to considerable size. The Kuskokwim, Sushitna, and Copper rivers all have timbered basins. During the great influx of population of the last three years much timber has been destroyed by fire in the dry summer months.

In the north and northwest part of the Territory, from Norton Bay around to the mouth of the Mackenzie, the shore was once abundantly supplied with driftwood. The Eskimos, who have been using this wood for generations, are very economical in the matter of fuel, and until the coming of the white man the probabilities are that the wood was accumulated faster than it was used. This driftwood is brought down from the interior by the larger rivers, whose banks are wooded. The cutting of the wood along the banks of the Yukon has already decreased the annual contribution of driftwood to the northern Bering Sea. This, together with rapid exhaustion by the white man of the supply which had accumulated in the past, will soon cause the Eskimo as well as the white man to be dependent on other sources for fuel. The north Arctic coast eastward from Point Barrow, which is but thinly populated by natives and seldom visited by whites, has some driftwood. The possibilities of using for fuel the thick growth of vegetable matter which covers most of the treeless regions of Alaska has been suggested, but has never been put to practical test. During the months of June and July, 1900, extensive fires swept through much of the treeless region of Nome and other portions of the Seward Peninsula. The moss and

grass when dry were found to burn rapidly with considerable flame, and fires ran nearly over the entire region visited by prospectors during the dry months. This fact makes it evident that the surface growth of the tundra could be used for fuel, provided it were properly dried. This material has in many places been accumulated to considerable thickness as peat bogs.

Of the third source of fuel supply, petroleum, we have no definite knowledge of the existence in commercial quantities. It is reported to have been found in southern Alaska, between Yakutat and Controller bays, and also on the west side of Cook Inlet near Kachemak Bay.