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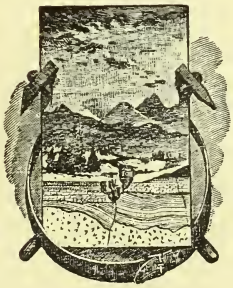
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

THE COAL RESOURCES OF THE YUKON, ALASKA

BY

ARTHUR J. COLLIER



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LETTER OF TRANSMITTAL.

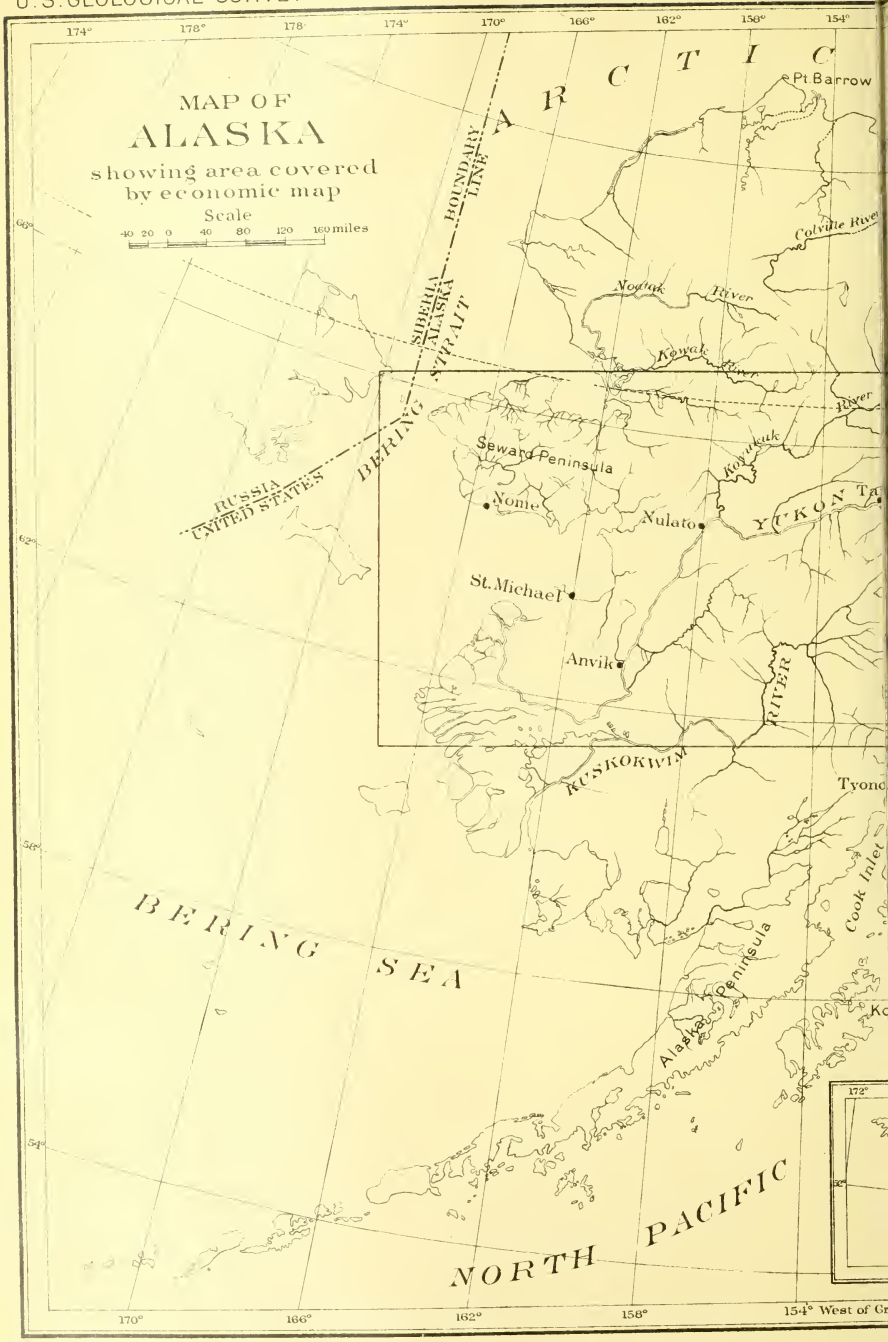
DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., June 13, 1903.

SIR: I have the honor to submit herewith a report entitled "The Coal Resources of the Yukon," by Mr. Arthur J. Collier, and to recommend its publication as a bulletin. This report deals entirely with the economic results of Mr. Collier's investigations during the last field season. His studies of the Yukon section developed some very important stratigraphic results regarding the Mesozoic and Tertiary succession, but the limited time made it impossible for him to solve the many interesting problems that arose in the course of the work. It has therefore seemed best to include in this report only the barest outline sketch of the geology, the more complete discussion of the stratigraphy being deferred until the results of further studies, already begun, shall be available.

Very respectfully,

ALFRED H. BROOKS,
Geologist in Charge of Geologic Work in Alaska.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.


MAP OF
ALASKA
showing area covered
by economic map
Scale
40 20 0 40 80 120 160 miles
174°
178°
178
174°
170°
166°
162°
158°
154°
ARCTIC
Pt Barrow
BOUNDARY LINE
SIBERIA ALASKA STRAIT
Colville River
Noatak River
Kowak River
Kowak River
Kobuk River
BERING
RUSSIA
UNITED STATES
Seward Peninsula
Nome
Kulato
YUKON TA
St. Michael
Anvik
RIVER
KUSKOKWIM
Tyonc
Cook Inlet
BERING SEA
Alaska Peninsula
Ko
172°
NORTH PACIFIC
170°
166°
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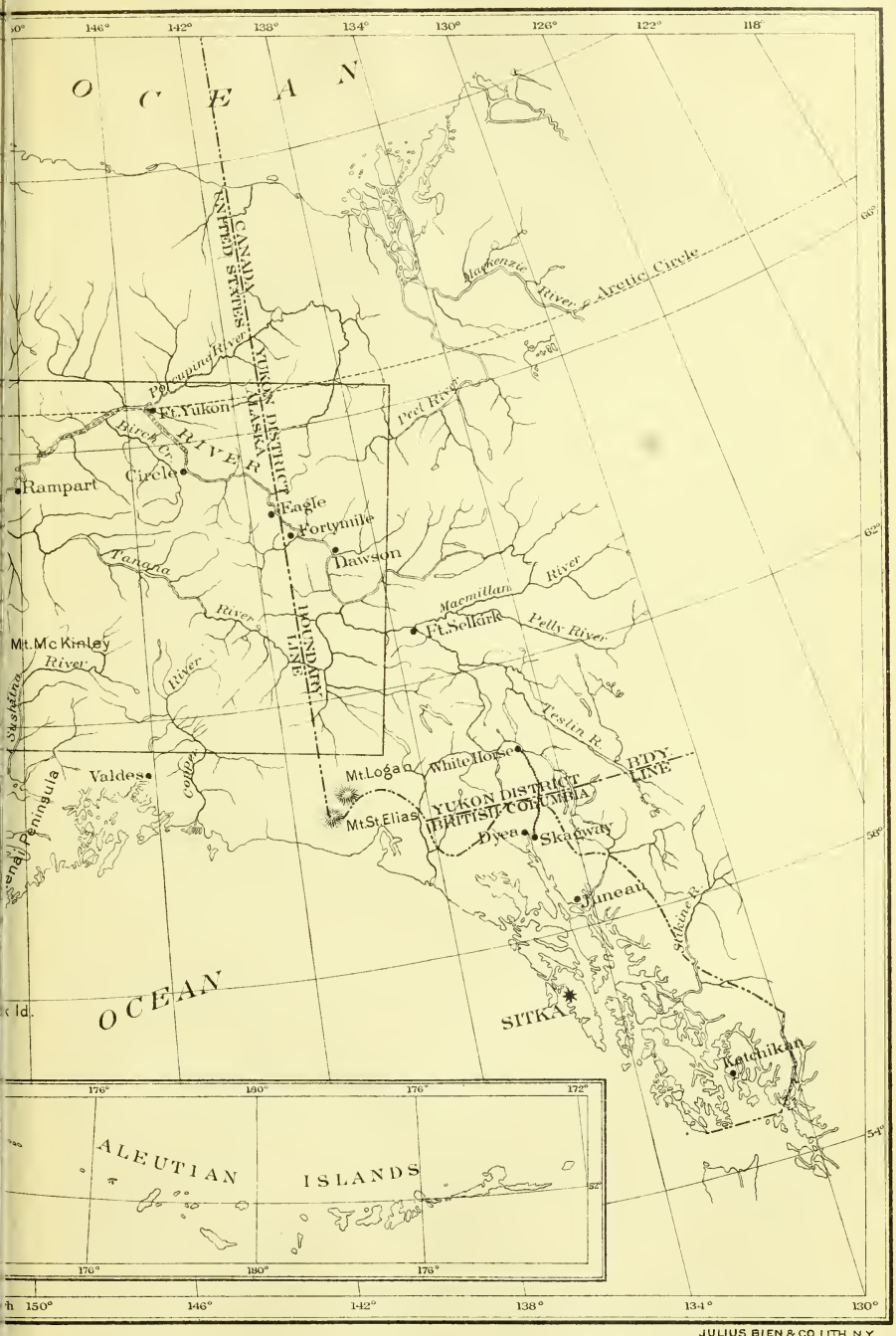


JULIUS BIEN & CO. LITH. N.Y.

THE COAL RESOURCES OF THE YUKON, ALASKA.

By Arthur J. Collier.

INTRODUCTION.

During the summer of 1902 the writer was detailed to make an examination of the coal deposits along Yukon River, in Alaska. His instructions were, in part, as follows:

> You are hereby assigned to the work of making a geologic reconnaissance of the Yukon River from the international boundary to the delta.
>
> The most important economic problem is the investigation of the coal deposits. You are expected to make a careful study of all the coal seams which have been exploited adjacent to your route of travel. It is important to obtain paleontologic data in regard to the age of the coal. You are also expected to visit such placer deposits as may be easily accessible from the river. You will devote special attention to the problems of stratigraphy of Yukon River section, and are expected to visit the various localities at which fossils have been found and make extensive collections.

In compliance with these instructions, a small party, consisting of Sidney Paige and Charles Kronholm, camp hands, and the writer, geologist in charge, left Seattle early in June and went by steamer and railway to Dawson, Yukon Territory. There a canoe and a rowboat were purchased.

The party left Dawson June 15, and the following three months were spent in a study of the geology and coal resources along the Yukon for 1,200 miles. The greater part of the investigation was confined to the actual river bank, yet the work was extended away from the stream when time and circumstances would permit. The work was continued until the close of the season, about the middle of September, which found the party at Pimute, a small native settlement near the head of the delta. At this point the party embarked, September 17, on the river steamer *John J. Healy* for St. Michael, and thence returned to Seattle.

In the prosecution of the work the writer received much assistance from residents of Alaska along the route. The investigation was greatly expedited by many favors received from agents and officials of the Northern Commercial Company. Much valuable information

was also obtained from E. J. Chamberlain, United States deputy mineral surveyor at Eagle, and from W. E. Williams, a mining engineer, who has had the management of a number of Yukon coal mines.

Nearly all the known coal beds accessible from the Yukon were examined, though the limited time in some cases made it necessary to do the work very hastily. Collections of fossils were made from 53 localities, many of which were entirely new. In numerous instances these collections were sufficient to determine the age of the coal beds, yet some remain in doubt. These studies and collections have thrown much light on some of the vexed problems of Yukon stratigraphy, but important questions still remain to be settled by further investigations. The paleontologic and paleobotanic collections have been studied by Drs. T. W. Stanton and F. H. Knowlton, of the Survey, and by Mr. Charles Schuchert, of the United States National Museum. Though the results of these studies are of far-reaching importance, their publication is deferred until further paleontologic and stratigraphic field studies have been made and more definite evidence for correlations has been secured.

The study of the structural and stratigraphic geology of the terranes exposed along the river was rendered more difficult by the lack of an accurate base map, for up to the present time no complete instrumental survey of the Yukon has been made. Sketches of a portion of the stream were made by Dall and other members of the Western Union Telegraph survey in 1864-65 and in 1866. Captain Raymond[a] made latitude determinations at and below Fort Yukon in 1869. Lieut. Frederick Schwatka[b] made a military reconnaissance of the Yukon in 1883, and a topographic sketch of the river from its source to its mouth was made at this time by Charles Homan, topographer of the party. The position of the river at the international boundary, at Fort Yukon, and at Nulato has been determined by astronomic observations made by parties of the Coast Survey, and the positions of Fort Hamlin, Rampart, Tanana, and the mouth of the Koyukuk have been determined by parties of the United States Geological Survey, who have also surveyed some short stretches of the river. For the details of the stream between these points all map makers have ultimately depended on Lieutenant Schwatka's map as modified by supplementary sketches made by various travelers and explorers. During the last season Mr. Sidney Paige, under the writer's direction, carried a canoe traverse from Eagle, near the international boundary, to Pimute. This sketch survey was carried on by estimated distances and compass azimuths. The map of the Yukon submitted with this report (Pl. II) is taken from a map of Alaska

[a] Raymond, Charles P., Reconnaissance of the Yukon River: Narratives of Explorations in Alaska. Washington, D. C., 1900, p. 19 et seq.

[b] Schwatka, Frederick, Military reconnaissance in Alaska in 1883: Senate Ex. Doc. No. 2, 48th Congress, 2d session.

U.S GEOLOGICAL SURVEY

ECONOMIC MAP OF THE YU

SHOWING DISTRIBUTION OF THE

BY ARTHUR J. CO

Scale

20 10 0 20 40

LEGEND

SEDIMENTS

PLEISTOCENE

Alluvium

Yukon silts

TERTIARY OR OLDER

Known areas of coal-bearing rocks, chiefly Upper Eocene and Upper Cretaceous

MESOZOIC-PRE-CAMBRIAN

Non coal-bearing sediments including some igneous rocks

IGNEOUS

TERTIARY

Lavas and tuffs

Coal mines

Coal prospects

JULIUS BIEN & CO. LITH. N.Y.

KON RIVER, ALASKA

COAL-BEARING ROCKS

LLIER

0 50 100 miles

compiled in 1902 and 1903 by E. C. Barnard,[a] of the United States Geological Survey, but has some minor corrections and additions from data obtained by Mr. Paige and the writer.

References to coal outcrops are not uncommon in some of the earlier writings on travel and exploration in Alaska, but up to 1895 no systematic attempt had been made to gather this information together. In that year Dall visited many of the localities where coal occurs in the Pacific coast province of Alaska, and in the report[b] based on this investigation included a summary of all the available data in regard to the coal in the interior. In the following year Spurr visited a number of the coal prospects on the Yukon and embodied descriptions of them in his report.[c] During the years from 1898 to 1902 information in regard to coal in Alaska was gathered by the various parties of the United States Geological Survey working in the district, and also by members of the Canadian survey in the adjacent parts of the Yukon Territory. Brooks summarized all this information in a report[d] which also contained a provisional table of correlation of the coal-bearing horizons.

It will be the purpose of the following report to summarize the economic results of the present investigation of the coals of the Yukon and to consider briefly their commercial bearing, while the discussion of the more purely scientific problems will be left for another report. It is hoped that this report, in spite of its incompleteness, may aid the development of coal mining on the Yukon, which must be of importance in connection with the exploitation of the other resources of this northern region.

GEOGRAPHY.

The Yukon is the largest river of Alaska and one of the largest on the continent. It has a length, from its mouth to the source of its longest tributary, of about 2,400 miles, of which 1,300[e] miles are in Alaska (see map, Pl. I). It empties into Bering Sea, and its headwaters lie far to the southeast, in British Columbia. Its drainage basin includes a large, irregularly shaped area, roughly blocked out by the Rocky Mountain system on the north and east and by ranges of the Pacific[f] mountain system on the south and west. To the south-

[a] Brooks, Alfred H., The geography of Alaska: Prof. Paper U. S. Geol. Survey No. — (not yet published).

[b] Dall, William H., Report on coal and lignite of Alaska: Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, pp. 769–908.

[c] Spurr, J. E., Geology of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 101–391.

[d] Brooks, Alfred H., Coal resources of Alaska: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, pp. 515–571.

[e] The U. S. Coast Survey (*see* Route Map of Yukon River, Chart No. 3098) estimates the distance by river from St. Michael to Dawson at 1,313 miles. River pilots and steamboat men estimate the same distance at above 1,900 miles. The actual distance probably falls between these estimates.

[f] Brooks, Alfred H., Geography of Alaska: Prof. Paper U. S. Geol. Survey No. —.

east the basin is not outlined by any mountain chain, and the tributaries of the Yukon interlock irregularly with those of the Liard, which is confluent to the Mackenzie, and with the Stikine, flowing into the Pacific. The chief of the Yukon tributaries are the Koyukuk, the Tanana, the Porcupine, the White, the Pelly, and the Lewes. The last two rivers named unite to form the Yukon proper. The general trend of the upper drainage channels of the basin is to the north and northwest to the point where the Yukon touches the Arctic Circle; at this point the river makes a right-angled bend to the southwest and continues to hold this general course to the head of the delta.

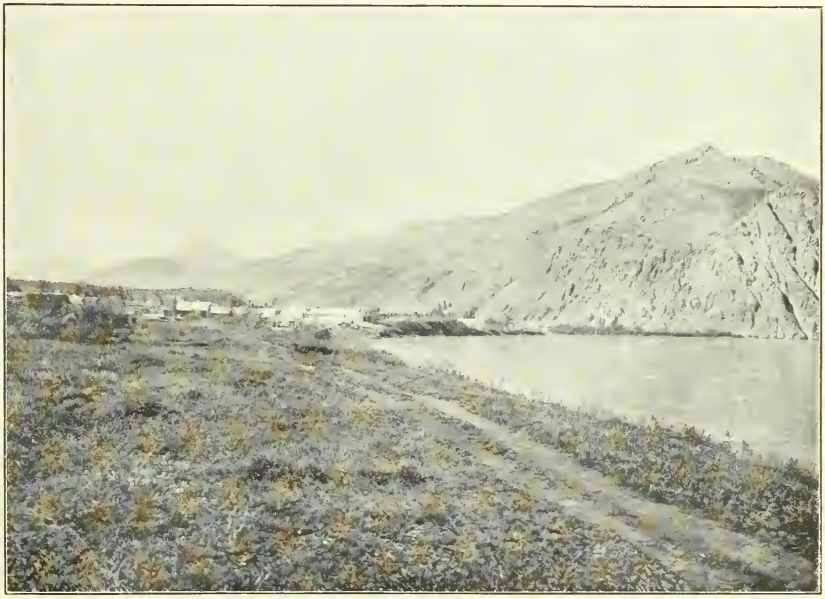
The catchment basin of the Yukon, which includes about one-quarter of the area of Alaska, lies for the most part in what has been called the Central[a] Plateau region—that great dissected upland area lying between the Rocky Mountain system on one hand and the Pacific mountain system on the other. In its upper course the Yukon Valley is incised to a depth varying from 2,000 to 3,000 feet, and has a width of from 2 to 3 miles. Near the international boundary the valley contracts to a width ranging from one-half mile to a mile, and 150 miles below it broadens out again and merges into that extensive lowland known as the Yukon Flats. Through this lowland the Yukon finds its way by many intricate channels, which in places spread out to a width of 10 or even 15 miles. Below the flats the river flows through a constricted part of its valley, known as the Ramparts, from which it emerges near the mouth of the Tanana. For about 600 miles below the Ramparts the valley is broad, and the river meanders over a wide flood plain. At the head of the delta the Yukon separates into a number of widely diverging distributaries.

Since the Yukon is one of the great rivers of the world and is navigable by steamer for over 2,000 miles, and in both winter and summer is the great natural highway of travel through the interior of Alaska, development has been more rapid and exploration has been made more complete along it than in most other parts of Alaska.

By the middle of the nineteenth century the Russian and Hudson Bay fur traders had already established themselves on the Yukon, and up to the time of discovery of gold, in the early eighties, this trade was the only thing that brought white men into the country. After the discovery of gold many prospectors made their way into the region, and at the time of the finding of the Klondike placers, in 1896, mining was carried on at several points on and near the Yukon, and camps were established at Rampart and Circle in Alaska and at Forty-mile on the Canadian side. At that time one or two small steamers brought all the supplies from St. Michael for the mining camps and trading posts. The influx of population brought about by the Klondike discoveries led to a phenomenal development of the transporta-

[a] Brooks, Alfred H., Geography of Alaska: Prof. Paper U. S. Geol. Survey No. —.

A. CHARACTERISTIC VIEW OF THE BANKS OF THE YUKON, SHOWING FUEL RESOURCES.



B. EAGLE, ON YUKON RIVER. SEAT OF U. S. DISTRICT COURT, U. S. CUSTOM-HOUSE, AND FORT EGBERT U. S. MILITARY POST.

tion facilities, so that in 1898 and 1899 there were nearly 100 steamers on the Yukon and its tributaries. At present probably 25 steamers furnish all the transportation required. At this time the principal Alaskan settlements on the river are Koserefski, Anvik, and Nulato, Indian villages, and Tanana, Rampart, Circle, and Eagle, mining towns. United States military posts are maintained at Tanana and Eagle, known as Fort Gibbon and Fort Egbert, respectively. Pls. III, *B* and VI, *B* show views of two characteristic towns—Eagle, a settlement of white men, and Nulato, an Indian village.

The city of Dawson, in Canadian territory, is the most important settlement on the Yukon, and the traffic of the river consists largely of freight to this point. The White Pass and Yukon Railroad competes with the river steamers for the Dawson freight. All perishable goods for Dawson and points below go by this route. The greater part of the freight, however, still comes by the longer and slower river route. The steamers plying on the Yukon up to the present time have, in the majority of cases, depended for fuel on wood cut and piled on the river banks. Pl. IV shows the character of the steamers and the nature of the fuel used. In the earlier days of steamboat navigation it was customary for steamboats to tie up to the river bank while their crews cut wood and carried it on board. A few of the river steamers now burn coal altogether; others burn both coal and wood. Up to the present time wood has been easily obtained near the river banks, but since the timber of the Yukon is small and of slow growth, the supply is limited, and woodcutters are obliged to bring it a greater distance every year. Pl. III, *A* shows the general character of the timber which has afforded fuel for river steamers.

Coal mines have been operated at a number of points, the oldest being the Drew mine, first known as the Miller mine, 25 miles above Rampart. Mines in operation during 1902 are located at Five Finger Rapids and Cliff Creek, both in Canadian territory, and at several points near Nulato, in American territory.

This coal has been burned with varying success by Yukon River steamers. The results obtained depend on a number of factors, among them being the character of the coal, the appliances for burning coal on the steamers, and the experience of the firemen. It is planned to use petroleum from the California fields as fuel on some of the steamers of the Northern Commercial Company during the season of 1903.

SKETCH OF GEOLOGY.[a]

The first notes on the geology of the basin of the Yukon were those made by Dall,[b] who ascended the river to Fort Yukon in 1866. Subsequent travelers occasionally referred to the geology and

[a] This sketch of the geology was prepared with the collaboration of Mr. Alfred H. Brooks.

[b] Dall, W. H., Am. Jour. Sci., 2d ser., vol. 45, 1868, pp. 97-98; also Bull. U. S. Geol. Survey No. 84, p. 247.

mineral resources of the region, but no investigations were made by a geologist until 1888, when Dawson[a] visited the upper basin. In the following year McConnell[b] extended the observations of Dawson as far as Fort Yukon by his trip down the Porcupine. Further information was obtained by Russell[c] in 1890, who ascended the full length of Yukon and Lewes rivers, and by Hayes,[d] who entered the basin by way of the Hootalinqua and left it by the White River Valley, in 1891. Somewhat more systematic work was begun by a trip made by Spurr, Goodrich, and Schrader,[e] who in 1896 made a rapid reconnaissance of the river from Chilkoot Pass to Nulato. The result of their work led to the publication of the first geologic map of a section of the Yukon, together with suggestions for the correlation of the work of all the previous investigators of the region. Spurr's report contains the first attempt at a determination of the stratigraphic succession in the basin of the Yukon, and in the accompanying table his nomenclature has been accepted as far as possible. In 1898 Spurr[f] made a reconnaissance in southwestern Alaska, and in the map accompanying his report embodied the results of his previous investigations on the lower Yukon. In the same year Brooks[g] made a reconnaissance of White and Tanana rivers. In 1899 Schrader[h] studied the geology of Chandlar and Koyukuk rivers, and thus extended the knowledge of the stratigraphy from the Yukon northward, while Brooks[i] made a reconnaissance which extended to the Yukon at Eagle. In 1901 Mendenhall[j] made a trip from Fort Hamlin to Kotzebue Sound, and the result of his work throws further light on the geology north of the Yukon. In 1902 Brooks[k] briefly summarized all of the available information regarding the stratigraphy of the Mesozoic and Tertiary terranes of the Yukon. During the last few years the Canadian geologists have been actively at work

[a] Dawson, George M., Report on an exploration in the Yukon district, N. W. T., and adjacent northern portion of British Columbia: Geol. and Nat. Hist. Surv. Canada, Ann. Rept., new series, vol. 3, pp. 1B–277B.

[b] McConnell, R. G., Report on an exploration in the Yukon and Mackenzie river basins, N. W. T.; Geol. and Nat. Hist. Surv. Canada, new series, vol. 4, 1888–89, pp. 134D–145D.

[c] Russell, I. C., Notes on the surface geology of Alaska: Bull. Geol. Soc. America, vol. 1, 1889, pp. 99–162.

[d] Hayes, C. Willard, An expedition through the Yukon district: Nat. Geog. Mag., vol. 4, 1892, pp. 117–159.

[e] Geology of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 87–392.

[f] Spurr, J. E., A reconnaissance in southwestern Alaska in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1899, pp. 31–264 and maps 4–14.

[g] Brooks, Alfred H., A reconnaissance in the Tanana and White river basins, Alaska, in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1899, pp. 425–494.

[h] Schrader, F. C., Preliminary report on a reconnaissance along the Chandlar and Koyukuk rivers, Alaska, in 1899: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 441–486.

[i] Brooks, Alfred H., A reconnaissance from Pyramid Harbor to Eagle City, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 331–391.

[j] Mendenhall, W. C., Reconnaissance from Fort Hamlin to Kotzebue Sound, Alaska: Prof. Paper U. S. Geol. Survey No. 10, 1902.

[k] Brooks, Alfred H., Coal resources of Alaska: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, pp. 515–571.

A. STEAMER LOADING WOOD ON UPPER YUKON.

B. WOOD-BURNING STEAMER ON YUKON, BELOW EAGLE.

studying the stratigraphy and mineral resources of the Yukon Territory. Notable among these is R. G. McConnell.[a]

The following table is intended to present in a concise form the present state of knowledge of the stratigraphic column of the Yukon below the international boundary. The table is based on the results of all previous investigations of the region, modified by the field studies of the writer and the studies by various paleontologists of the collections made. Though a number of horizons were found which up to the time of the present investigation were unknown in the region, it has been thought best not to introduce any new formation names in this publication nor to attempt any far-reaching correlations. The formation names already current in geologic literature have been retained as far as they were borne out by the studies of the last season.

Provisional tabular statement of Yukon stratigraphy.

Age.	Formation name.	Contact relations.	Lithologic character.
Recent	Alluvium		Flood-plain deposits.
Pleistocene?	Yukon silts	Unconformity	Fresh-water silts, sands, and gravels.
Post-Eocene Tertiary.	Twelvemile beds. Palisade conglomerate.	(?)	Sands, clays, and gravels.
Upper Eocene	Kenai series	(?)	Fresh-water sandstones, shales, and conglomerates.
Upper Cretaceous.		Conformity?	Fresh-water and marine sandstones, shales, arkoses, and conglomerates.
Lower Cretaceous.		(?)	Fresh-water calcareous sandstones.
Do		(?)	Marine black, slaty shales, and thin-bedded limestones.
Permian		Unconformity	Marine, massive, white limestones, heavy conglomerates, and gray shales.
Lower Carboniferous.		do	Marine black slates and thin-bedded limestones.
Devonian?	Rampart series	(?)	Volcanic material, interbedded with limestone, slate, etc.
Older than Devonian.	Fortymile series	Unconformity	Schists and interbedded limestones.
Do	Birch Creek series.	Conformity	Quartzites and schists.
Undetermined	Pelly gneisses	Unconformity	Gneissoid and schistose granites.

The section along the Yukon between the international boundary and the delta includes terranes widely separated in the geologic column,

[a] McConnell, R. G., Yukon district; Summary report of the Geological Survey Dept. for the year 1900, Ottawa, 1901, pp. 37–52.

and in some instances having very intricate stratigraphic relations. This succession contains some horizons which have been fairly well established by stratigraphic and paleontologic studies, but also others whose position in the geologic column is very much in doubt.

An examination of the table will show that the oldest rocks in the region are of a gneissoid character, and for these the name Pelly gneisses has been suggested by Brooks and accepted by McConnell. These Pelly gneisses are an intricate series of crystalline rocks whose genesis is doubtful. A part of the rocks grouped with these gneisses are altered intrusives, and closer investigation will undoubtedly show that some of them are younger than the sediments they are supposed to underlie. One belt of the Pelly gneisses occurs in the Fortymile, along the axis of an anticlinal uplift, as described by Spurr, and another was seen by the writer between the Melozi[a] and the Yukon. The gneissic series everywhere shows evidence of having been subjected to profound metamorphism. The Pelly gneisses are succeeded unconformably by a great thickness of quartz-schists and quartzites, called by Spurr the Birch Creek series. These pass above into a white crystalline limestone formation named the Fortymile series by Spurr. Both of these series find extensive development in the upper part of the region under discussion. The Rampart series, characterized by rocks of greenish color and preponderance of volcanic matarial, overlies these unconformably, and is probably of Devonian age. The two older formations are more altered than the younger, but all have undergone considerable deformation and igneous intrusions are abundant.

Near Seventymile River the writer found a series of black slates and shales interbedded with thin bands of semicrystalline limestones, in which Lower Carboniferous fossils were found. These beds are intensely crumpled.

The next succeeding horizon is the so-called Tahkandit series of Spurr, which is made up of conglomerates, sandstones, and shales overlain by a heavy bed of semicrystalline limestones, which has yielded abundant fossils near Nation River. These fossils are regarded as Permian. Spurr's Tahkandit group is not included in the accompanying table, because he gave to this name a broader significance than can be accepted in the present investigation. This sandstone, conglomerate, and limestone series is closely folded and much metamorphosed.

Below Nation River the Permian beds are overlain by a great thickness of black, slaty shale containing some intercalated beds of limestones and calcareous sandstones. In these beds the writer found fossils which were determined by Dr. Stanton to be *Aucellæ* of Lower

[a] This river is known in Alaska as the Melozikakat. Melozi is here used in conformity with the decision of U. S. Board on Geographic Names, "kakat" being merely a native term for river

Cretaceous age. These beds would belong with Spurr's Mission Creek group. This name has, however, not been retained in the present stratigraphic classification, because it was found that under it Spurr had included beds as widely separated in the geologic column as the Eocene and Carboniferous. The Lower Cretaceous beds outcrop for about 80 miles along the Yukon. The beds are rather closely folded and somewhat faulted.

On the lower portion of the river, near Nulato, some fresh-water cycad-bearing beds have been found which are also probably assignable to the Lower Cretaceous. These beds are chiefly calcareous sandstones, with some shales. They differ from the Lower Cretaceous of the upper river in that they are apparently of fresh-water origin. Their relation to the Upper Cretaceous which outcrops in the vicinity has not been determined.

The Upper Cretaceous is represented near Nulato by sandstones, conglomerates, and dark-colored shales, which outcrop along the river at intervals for about 100 miles. These have in part yielded a marine invertebrate fauna of Upper Cretaceous age, as determined by Stanton. Fossil plants were found in the same general horizon and were assigned by Dr. Knowlton to the Upper Cretaceous. It is evident, therefore, that these beds include both marine and fresh-water deposits. The fresh-water beds carry coals of commercial importance. The Cretaceous beds have undergone considerable deformation, but are not metamorphosed, and, in fact, are only slightly indurated.

The succeeding horizon is made up chiefly of sandstone and conglomerate, with some shale. It is called the Kenai series, and is of Upper Eocene age. These beds usually carry abundant plant remains, which show them to be of fresh-water origin. The Kenai series has been named from its typical occurrence on Kenai Peninsula and has been identified in various other parts of Alaska. It occurs in isolated areas on the Yukon near the boundary and near Rampart, and is more extensively developed near Nulato. On the upper river it unconformably overlies various horizons below the Upper Cretaceous, but near Nulato its relation to the Upper Cretaceous seems to be one of conformity. The Kenai beds are, as a rule, little disturbed, but in some localities they have suffered considerable deformation. The Kenai is the great coal-bearing horizon of Alaska. Its coals are usually characterized by the presence of fossil resin, or amber.

Tertiary horizons younger than the Kenai have as yet been only locally differentiated in the province, but the evidence points to considerable development of Miocene or Pliocene beds. Spurr[a] described some lignite-bearing sands and clays on Mission Creek near the Yukon, under the name "Twelvemile beds," and some cross-bedded gravels

[a] Geology of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 197 and 199.

and sands at the Palisades, which he called the "Palisade conglomerate." These two occurrences he regards as probably of Miocene or Pliocene age.

Fine silt deposits are widely distributed along the Yukon and many of its tributaries. These occur as terraces along the valley walls, and the bluffs formed by the undercutting by the river of these terraces are conspicuous features of the landscape of the Yukon. Within the limit of glaciation these silts are found mantling the till. The silt has a thickness of from 50 to 200 feet or more.

These beds have been described by various writers, but more especially by Spurr,[a] who named them the Yukon silts. Typically, the terrane is made of buff-colored silts, often resting on basal gravel beds, which may or may not be of the same age. The Yukon silts are for the most part of Pleistocene age,[b] as is shown by both vertebrate and invertebrate fossils. The silts are found resting unconformably on all of the older formations, except possibly some gravels which may be of Pliocene and Miocene age. They are separated by an unconformity from the Kenai series. The silts, though entirely unconsolidated, are in places thrown up into broad, open folds, and at one locality faulting was observed. This deformation usually makes it easy to separate them from the recent alluvium deposits, but in some cases the recent and older silts are entirely conformable and can not be differentiated. It is probable that more detailed studies will show that a part of what is now regarded as Yukon silt will be found to belong to one of the later Tertiary horizons. Some impure lignite beds have been found in these silts.

The youngest water-laid deposits here to be considered are the alluviums of the river and stream valleys. These are often very similar to the Pleistocene silts, but are usually of a darker color. They are found in the flood plains of the river and form extensive deposits in the broad lowland known as the Yukon Flats. In places where the Yukon silts have been warped down below the present level of the river the alluviums rest conformably upon them, but usually the relation is one of unconformity.

Some areas of volcanic rocks are found on the Yukon below the mouth of the Koyukuk. These are lavas and tuffs of andesitic and basaltic nature. Basaltic or andesitic dikes are not uncommon in the pre-Miocene sediments. Spurr[c] has discussed similar occurrences in the Yukon Basin at some length, and suggested the early Miocene or late Pliocene age of these extrusives. Local deposits of lignite,

[a] Geology of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 200–221.

[b] Spurr, op. cit., p. 199; Brooks, A reconnaissance in the Tanana and White River basins: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1899, p. 475.

[c] Geology of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 242–250.

usually of poor quality and of no economic value, are common in these tuffs. At a point about 50 miles above Kaltag an attempt has been made to exploit them.

THE COAL.

GEOGRAPHIC DISTRIBUTION AND CHARACTER.

Coal of commercial importance is found in two different geologic horizons along the Yukon, namely, in the Upper Cretaceous and in the Kenai series. The Yukon silts contain some impure lignites, but they have no value. It will be shown below that coal seams which have been opened up near Nation River may be of Permian age, but these appear to be of little future importance. From the standpoint of the coal miner, therefore, all of the Yukon coal can be said to be of either Cretaceous or Tertiary age. On the map (Pl. II) the areal distribution of the coal-bearing series along the Yukon is given as far as it has been determined, but it has not been found feasible, from the data at hand, to differentiate the Cretaceous coals from those of Tertiary age. The map also shows the areas of non coal-bearing rocks as far as known. These are divided into four classes, the first comprising the metamorphosed sediments, the second the Yukon silts, and the third the recent alluvium, while the areas occupied by igneous rocks comprise a fourth class. The coal prospector should confine his search for merchantable coals to the areas occupied by coal-bearing rocks.

It has been noted that the Kenai series occurs in small, isolated areas along the Yukon above the mouth of the Tanana. These in some cases represent remnants of larger areas, which are now infolded with the older beds; in other cases they probably represent separate basins of deposition. Outside the region under consideration the Kenai series, occurring in small basins, has been found to be one of the most widely distributed formations in Alaska. These coal-bearing beds rest unconformably on nearly all the older formations that have been identified in Alaska, and their conglomerates contain pebbles derived from them. The coal beds are not confined to any one definite horizon in the Kenai. In some instances they are known to be near the bottom of the formation; in others they lie near the top. This irregularity is what may reasonably be expected, for if the Kenai sandstones were deposited in fresh-water basins that were usually not connected, the formation of coal beds would probably not occur in all the basins at the same time, nor would the coal beds hold the same position in the series in all cases. All the coals examined in the Kenai basins along the Yukon above Tanana are lignites, or at least are lignitic in character.

The Upper Cretaceous, which is the lower coal-bearing horizon, is extensively developed on the lower Yukon. It outcrops along the

north bank for about 200 miles below the mouth of Melozi River, being interrupted only here and there by silt deposits or by narrow belts of extrusive rocks. It is intimately associated with Kenai beds in this region. This area probably extends westward to Norton Sound, where coal-bearing beds have been found.

In the Upper Cretaceous coal occurs in the lowest as well as the highest beds, as indicated by the fossil plants. The Upper Cretaceous coals have higher fuel ratios than the Eocene coals and are of somewhat better quality.

DESCRIPTIONS OF LOCALITIES.

INTRODUCTION.

The region under discussion falls naturally into an upper division, extending along the river from the boundary to the Yukon Flats; a middle division, extending from the lower end of the flats to Melozi River, and a lower division, extending from the Melozi to the mouth of the Yukon. These divisions can be conveniently described under the headings Circle province, Rampart province, and Nulato province.

Under Circle province will be considered all the known coal-bearing areas along the Yukon between Circle and Fortymile. With one exception these coals resemble one another both in character and in mode of occurrence. This province includes the coal beds at Cliff Creek and Coal Creek, in Canadian territory near Fortymile, and for the sake of comparison a brief note regarding these Canadian localities will here be included.

The Rampart province will be made to embrace the scattered coal-bearing areas between the Yukon Flats and the Melozi, including the lignite beds of the Yukon silt formation which occur at the Palisades. The coals of this province resemble those of the Circle province.

The coal deposits along the Yukon from Melozi River to the delta will be discussed under the caption Nulato province. These coals have common characteristics in composition and mode of occurrence, differing from those of the Circle and Rampart provinces.

Some compiled information showing the extent of the coal-bearing formation within the Yukon Basin in regions not examined by the writer will be presented in connection with the descriptions of contiguous divisions of Yukon River.

CIRCLE PROVINCE.

The greater part of this province is in Alaska, though the only coal mine at present in operation is within Canadian territory. From the international boundary to Circle, a distance of about 150 miles, the Yukon flows with a swift current, and receives several tributaries of

considerable size. Fortymile River, Seventymile River, and Charlie River, tributaries entering from the south, are navigable for small boats and canoes. Sheep Creek (Tatandu River), Nation River (Tahkandit River), and Charlie Creek (Kandik River) are the larger tributaries from the north.

The two important towns in the province are Circle, the supply point for the Birch Creek mines, and Eagle, at which place Fort Egbert, a United States military post, the United States custom-house, and the United States district court are located. Eagle is also the supply point for a number of placer mines located on the tributaries of Mission Creek and Seventymile River. It is also the Yukon terminus of the Valdes mail route. A view of the town is given in Pl. III, *B*. A number of small settlements, depending for their support on small placer mining camps, are scattered along the river between these points. Dawson, in Canadian territory, is about 100 miles up the river from Eagle; Fort Yukon, an important fur-trading post, and the point of departure for the Koyukuk winter trail, is 80 miles below Circle, at the mouth of Porcupine River.

Below Circle the Yukon flows for 300 miles through the Yukon Flats. Here the river spreads out in many channels and navigation is difficult. A characteristic view in the flats is given in Pl. III, *A*.

An examination of the map (Pl. II) will show that a belt of coal-bearing beds stretches from Klondike River northwestward nearly to the Yukon. This belt seems to be extended to the northwest by several isolated areas, which probably at one time formed a continuous belt. These Kenai terranes—for these beds all belong to that horizon—carry workable coal beds, which have been exploited at several localities.

Coal beds have been opened, or partially opened, by prospectors on two "Coal" creeks in Canadian territory and on American Creek, Wolf Creek, and Washington Creek in American territory. Coal is known to occur, but has not been opened to any extent, on Coal Creek, a small tributary of the Yukon 60 miles above Circle; on Bonanza Creek, a tributary of Charlie River; and on a tributary of Seventymile River known as Washington Creek. The more important of these localities were visited by the writer and will be described in detail. Coal has also been reported from the upper Fortymile region, from Seventymile, and from the Porcupine, but the information is too vague to make it worthy of inclusion in this report.

Coal in Canadian territory.—A coal seam was opened up near Five Finger Rapids on Lewes River many years ago. This seam has been recently developed under the name Five Finger mine,[a] and is now supplying the Dawson market. As this coal is used in competition with the Yukon coals, it seems best to include some notes on it, though

[a] Brooks, A. H., Coal resources of Alaska: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, p. 559.

the locality was not visited by the writer. This mine is about 200 miles above Dawson, on the north bank of the Lewes. Cretaceous fossils have been found in the vicinity, though their relation to the coal formation is not known to have been definitely determined. The coal seam mined is reported to be slightly less than 2 feet in thickness. The following analysis was made from a sample taken by the writer from a large pile of this coal on the electric light company's dock at Dawson:

Analysis of coal (sample No. 311) from Five Finger mine.

[Analyst, E. T. Allen, U. S. Geol. Survey.]

	Per cent.
Water	3.58
Volatile combustible matter	41.05
Fixed carbon	43.11
Ash	12.26
	100.00
Sulphur	.38
Fuel ratio	1.05

The sample of coal taken shows many check seams containing small, light, knife-edge veinlets, both parallel to the bedding and across it, and these probably account for the high percentage of ash. Coal from this mine is burned on river steamers, and a considerable amount is shipped to the Dawson market, where it seems to be preferred to Cliff Creek coal.

Coal of anthracite nature is reported from the vicinity of White Horse Rapids,[a] and lignite is found on Nordenskiold River,[b] near the railway.

The most important coal mine on the Yukon within the Circle province is at Cliff Creek, which enters the Yukon from the north, about 9 miles below the town of Fortymile and 30 miles above the international boundary.

The following is quoted from the Canadian geological survey reports[c] regarding the coal basin:

> Lignite-bearing beds outcrop on Klondike River, 6 miles below Flat Creek, and extend in a north-northwesterly direction in a long, narrow basin or series of basins to Cliff Creek, a distance of 60 miles, and probably for some miles beyond. They follow in a general way the course of the Yukon Valley, from which they are separated by a narrow strip of the older rocks. Wide valleys are cut across them by all the streams entering this portion of the Yukon from the northeast, but owing to their soft character exposures are infrequent. In their normal condition the beds consist of soft, slightly coherent sandstones and conglomerates, alternating with light and dark-colored clays and shales. In places where the beds have been strongly folded the clays and sands are altered into sandstones and shales. The age of the lignite beds is uncertain, as no fossils were found in them, but they probably belong to the Tertiary.

[a] Brooks, A. H., Coal resources of Alaska: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, p. 559.
[b] Ibid.
[c] McConnell, R. G., A summary report of the Geol. Survey Dept. for the year 1900, Ottawa, No. 26, p. 45.

A lignite horizon, with one or more seams, occurs in this formation at a number of widely separated points, and apparently accompanies it throughout its whole extent. Lignite seams outcrop on Rock Creek and its tributary Coal Creek, at the northern end of the area, on Cliff Creek at the southern end, and on Twelvemile Creek, Fifteenmile Creek and Coal Creek at intermediate points, and are reported from a number of other localities. The total area underlain by lignite is estimated to considerably exceed 200 square miles.

The Alaska Exploration Company has taken up a block of coal lands on Coal Creek, and has commenced mining operations at a point a little over 7 miles from Klondike River, following Coal Creek and Rock Creek valleys, and about 20 miles from Dawson. * * * The workings of the mine consist of an incline about 400 feet in length, descending in a southeasterly direction at an average angle of about 25° for the first 200 feet, beyond which the angle gradually decreases to about 4°. A short drift has been driven in a northeasterly direction, following the seam, at a point 225 feet from the mouth of the incline. The seam dips to the northeast in a drift at angles of from 3° to 10°.

The strata in the upper part of the incline have been disturbed and faulted to some extent, and the lignite beds occur in a broken condition. In the lower part of the incline and in the drifts the beds are continuous, although the dips are still irregular. * * * Two seams of lignite are present in the lower part of the incline and in the drifts. The upper seam shows 3 feet of hard lignite and the lower from 2 to 3 feet. The two seams are separated by a clay parting about a foot thick and are roofed and floored with clay. The lignite is hard and compact and shows no traces of the woody fiber so common in lignites. * * * It is of good quality, burns freely, and can be used both for heating and steam purposes.

The following analyses of the two seams have been furnished by Dr. Hoffmann:

Lignite from upper seam, Coal Creek mine.

	Per cent.
Hygroscopic water	18.31
Volatile combustible matter	34.96
Fixed carbon	40.88
Ash	5.85
	100.00
Coke, percentage (noncoherent)	46.73

Lignite from lower seam, Coal Creek mine.

	Per cent.
Hygroscopic water	19.37
Volatile combustible matter	33.85
Fixed carbon	37.45
Ash	9.33
	100.00
Coke, percentage (noncoherent)	46.78

* * * * * *

The North American Trading and Transportation Company has opened up a group of lignite seams at Cliff Creek, a small stream which enters the Yukon from the right 55 miles below Dawson. The workings are situated about a mile and three-quarters from the mouth of the creek and consist of two long tunnels with a number of drifts and upraises. The lower tunnel is on the right side of the creek and the upper a short distance farther up the creek on the left side. The distance along the zone from the mouth of the first tunnel to the end of the second is 2,800 feet, and the seams appear to be continuous for this distance and probably extend much farther.

The tunnel at the upper workings has been driven mostly along the lignite zone for a distance of 800 feet. At one point, 225 feet from the mouth of the tunnel, the

coal seams are bent to one side and probably faulted. The lignite zone, consisting of alternating beds of lignite, clay, and carbaceous shale, measures over 40 feet in thickness in places. The included lignite seams vary in thickness from a few inches up to 5 feet. A section 300 feet from the mouth of the tunnel showed over 11 feet of coal in seams separated by clay partings and beds, as follows:

	Ft.	in.
Lignite	1	6
Thin parting		
Lignite	0	5
Carbonaceous shale	0	3
Lignite	0	6
Shale	0	1
Lignite	2	0
Clay	1	3
Lignite	1	3
Clay	3	0
Lignite	1	0
	11	3

The beds have a nearly east and west strike, and dip in a southerly direction at angles of from 50° to 75°.

A section in the lower workings showed:

	Ft.	in.
Shales		
Lignite, one thin parting	9	0
Shales	2	0
White clay	2	9
Alternating clays and shales	3	0
Grayish clay	13	0
Carbonaceous clay	3	3
Lignite, one parting	3	0
Carbonaceous shales and clays	6	0
Soft sandstone with layers of grit	10	0
	52	0

The dip of the beds in the lower workings is much less than in the upper, and in places they are almost horizontal.

The Cliff Creek lignite is very similar in appearance to the Rock Creek variety. It is dark in color, compact, and probably somewhat harder than the latter, as the inclosing rocks are more indurated. Dr. Hoffmann describes it as a lignite of superior quality closely approaching to a lignite coal. The following analyses were made in the laboratory of the Survey:

Lignite from upper and lower working, Cliff Creek.

	Upper working.	Lower working.
	Per cent.	*Per cent.*
Hygroscopic water	8.57	10.58
Volatile combustible matter	42.04	40.10
Fixed carbon	45.77	46.74
Ash	3.62	2.58
	100.00	100.00
Coke	49.39	49.32

Analysis by fast coking.

Coke of lignite from upper working, feebly coherent, tender.

Coke of lignite from lower working, noncoherent.

A considerable quantity of coal from Cliff Creek mines was shipped to Dawson during the past season for heating purposes, and it is also used by a number of the river steamers with satisfactory results. The coal is sold on the wharf at the mouth of Cliff Creek for $10 a ton, and in Dawson for $20 a ton and upward. A narrow-gauge railway has been built from the workings to the river, and the mine is now in a condition to supply a large demand.

The writer visited Coal Creek in the course of the present investigation. This stream joins the Yukon from the right, about 4 miles above the mouth of Cliff Creek. It flows nearly west, and forks about 6 miles from the Yukon. Coal has been located on both forks. The localities visited by the writer are on the main or east fork about 10 to 12 miles from the Yukon.

The coal-bearing sandstones lie unconformably on the edges of older schistose rocks which are exposed occasionally along the trail from the river up to within a mile of the coal croppings.

The main creek, where it cuts the coal-bearing beds, flows approximately west and probably follows the axis of an anticline.

Coal seams were examined in three places. In the upper opening a tunnel 100 feet long runs into the hill south of the creek on a coal bed which has been crushed and broken either by a local surface slide or by a fault. About one-fourth of a mile west of this point a slope tunnel (dip 33° S., strike N. 60° E.) was being driven into the south bank of the creek, in which the following section was exposed:

Section on south bank of Coal Creek.

	Ft.	in.
Coal	0	6
Clay parting	0	2
Coal	4	6

Above the coal is a soft, slippery shale, which the miners called "soapstone." The floor of the coal bed is a similar "soapstone," below which there is harder sandstone containing fossil leaves.

One-half mile west nearly 20 feet of coal outcrops in the north bank of the creek, with the following section:

Section on north bank of Coal Creek.

	Ft.	in.
Coal with 5 mining partings, all under 1 inch	14	0
Bony coal	2	0
Clay	1	0
Coal	0	18

A comparison with these two sections suggests that there are two workable coal seams in this locality.

The soft sandstone underlying this bed and the clay seam included in it carried abundant fossil leaves, the most common species being conifers, referred by Knowlton to the Upper Eocene. The coal can,

therefore, be considered Kenai. The coal contains much amber or fossil resin. Some specimens were almost one-half amber in grains distributed through the mass. In this respect they resemble the coals found on Washington Creek, in American territory.

Analyses made of the samples from the 5-foot seam above described were made by E. T. Allen. They are as follows:

Analysis of coal (sample No. 26) from Coal Creek, near foot wall of seam.

	Per cent.
Water	10.58
Volatile combustible matter	38.42
Fixed carbon	31.54
Ash	19.46
	100.00
Sulphur	.80
Fuel ratio	.82

Analysis of coal (sample No. 25) from Coal Creek, middle of seam.

	Per cent.
Water	12.57
Volatile combustible matter	39.54
Fixed carbon	41.98
Ash	5.91
	100.00
Fuel ratio	1.06

No coal has yet been mined on a commercial scale on Coal Creek. On the main fork of the creek the openings into the coal are low, and the dip will no doubt throw the coal below water level. Exploitation of the seams will therefore require hoisting and pumping, and a railroad not less than 10 miles in length to carry the coal to the landing on the river.

In working the Cliff Creek mine it is found that the frost in the coal extends to a depth of 150 feet below the surface. The unfrozen is of better quality than the frozen coal.

Mission Creek.—Mission Creek enters Yukon River from the west at the town of Eagle, 12 miles below the international boundary. The creek flows eastward and has a length of about 15 miles. An area of coal-bearing rocks from 3 to 4 miles wide extends back from the Yukon for a distance of 6 or 7 miles on the south side of this creek. The northern and southern limits of this basin are fairly well known, but whether its western end is connected with the similar coal-bearing rocks reported to occur on Seventymile River could not be determined in the brief time at the writer's disposal. Attempts have been made to open coal mines within this field on American Creek and Wolf Creek, southern tributaries of Mission Creek.

The coal seams of the Mission Creek field are contained in gray shales associated with conglomerates varying from incoherent gravel to hard

conglomerate, in which the pebbles break before the cement. Lumps of coal and knife-edge seams of lignite were found in this conglomerate. A few specimens of fossil plants were obtained from the shales, showing that they probably belong to the Kenai series and are certainly not older than the middle of the Cretaceous.

The coal-bearing formation rests unconformably on an older series of rocks made up of green slates, cherts, tuffs, and limestones, tentatively correlated by the writer with the Rampart series and believed to be of Devonian age. These are well exposed in the bluff immediately below Eagle, which extends along the north side of Mission Creek in an almost straight east-west line, suggesting a fault scarp. The coal-bearing rocks seem to end abruptly at the foot of this bluff, but they overlap the older rocks to the south and are found forming the hilltops, but have been removed by erosion in the valleys. The structure seems to consist of low open folds.

The coal of this belt is black, has a conchoidal fracture, and shows no traces of woody structure. In 1897 E. C. Barnard collected a sample from American Creek which had the following composition:

Analysis of coal from American Creek, 3 miles from Eagle.[a]

[Analyst, W. F. Hillebrand, U. S. Geol. Survey.]

	Per cent.
Water	6.75
Volatile combustible matter	39.13
Fixed carbon	37.59
Ash	16.53
	100.00
Sulphur	3.40
Fuel ratio	.96

This coal was noncoking.

Attempts have been made to open coal veins on American Creek and also on Wolf Creek, but during the summer of 1902 nothing was being done at either place and no definite information could be obtained regarding the coal seams.

It is reported that a coal bed outcropping a short distance below the crossing of the Eagle-Valdes trail has been opened up and abandoned twice. About 4 miles up Wolf Creek, in the material thrown out of a prospect hole near the creek, there were pieces of coal probably having a high percentage of ash, and some soft sandstone. A coal seam is reported to have been located on a small western tributary of Wolf Creek near this locality.

At the present time these coal deposits are unopened and are of no economic importance except as indicating the extent of the coal-bearing rocks in Alaska. The United States military post at

[a] Brooks, Coal Resources of Alaska, p. 565.

Eagle would afford a market for a limited amount of coal, and it is not probable that workable beds would be neglected if they had been found.

Seventymile River.—This river enters the Yukon 25 miles below Eagle and 37 miles below the international boundary. It has a length of about 75 miles and flows nearly due east to its junction with the Yukon. Coal is reported to have been found on this river and its tributaries several miles from the Yukon, but the writer was unable to obtain definite information regarding the occurrence. A great thickness of Kenai sandstone, not known to be coal bearing, is exposed at the mouth of Seventymile River. These coals of Seventymile River, if there be any, are undeveloped and are not known to be of economic importance.

Washington Creek.—This stream, which is about 40 miles long, enters the Yukon about 80 miles below the international boundary. Its headwaters oppose those of Seventymile River.

The accompanying sketch map (fig. 1) shows the geologic relations of the three formations exposed along the creek. Near the Yukon is a broad belt of black slates of Lower Cretaceous age. These rocks overlie (see fig. 1) an intricate succession of limestones and tuffs belonging to the Rampart series, which occupy a belt about 2 miles wide, through which the creek has cut a narrow gorge. Both series are closely folded, the axes of the folds running about east and west. To the south is an area of coal-bearing sandstones, conglomerates, and shales, whose southern limits were not determined. These beds are thrown up into broad, open folds, with dips of less than 45°, and overlie the older rocks unconformably. No fossils were found in this arenaceous series, but on lithologic and structural grounds it is correlated with the Kenai. This view is substantiated by both the character and the mode of occurrence of the coal. These coal-bearing rocks first outcrop about 9 miles from the Yukon, in a great bluff of slightly consolidated conglomerate, rising about 100 feet from the creek bed. The strike here is to the northeast, and the dip at a low angle to the southeast. This is believed to be the base of the coal formation, since, if the dips are continuous, it underlies the area of coal-bearing rocks. Above this point the valley of Washington Creek broadens out into a wide, flat basin, with little relief, within which the creek meanders through long, quiet pools, with small ripples between. Few exposures of bed rock occur, although there is a great quantity of float coal on the gravel bars for a distance of 5 or 6 miles above, which is as far as the writer traversed the creek. The prospect holes have caved in, so that for details of the coal sections the writer has been obliged to depend on the measurements made by prospectors. Their reports show a series of coal seams interbedded with soft sandstone and shale in several places, resembling, in a general

way, the coal seams at Cliff Creek and Coal Creek, in Canadian territory, which have been described.

At a point 1½ miles above the beginning of the coal-bearing forma-

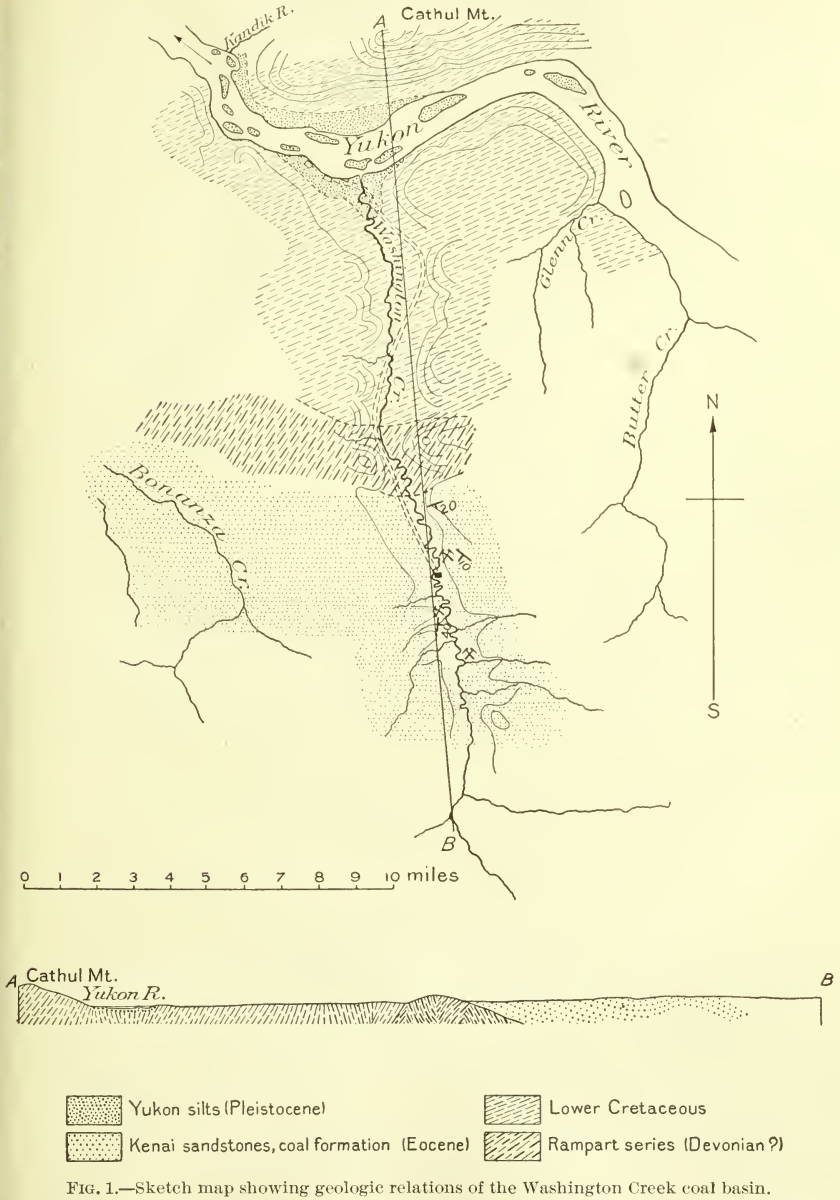


FIG. 1.—Sketch map showing geologic relations of the Washington Creek coal basin.

tion Messrs. Walter Stanford, J. W. Pratt, W. S. Layman, and F. L. Jewett opened a coal bed on the right bank of the creek and took out 5 tons of coal, which were hauled by dog teams to the river bank for the purpose of a steaming test on the river. The work was done

in the winter, without timbering, so that the opening caved in with the summer thaw. The beds dip southeast at 35°, and the following section is reported:

Section on Washington Creek.

	Ft.	in.
Coal	1	0
Clay	0	1
Coal	1	6
Clay	0	1
Coal	4	0
Fire clay	0	1
Coal	1	6
Carbonaceous shale	12	0
Clean coal	4	0

About 2 miles above this point, on the left bank of the creek, the Alaska Coal and Coke Company has opened coal beds in a hill rising from 100 to 300 feet above the creek, where the following section is reported:

Section at coal mine of Alaska Coal and Coke Company on Washington Creek.

	Feet.
Sandstone	
Coal	5
Thin bands of shale and coal	20
Coal	4

The coal outcrops for 700 feet along the strike, and the dip is about 45° SE.

Between these two points outcrops of coal were seen by the writer in the creek bank, which is about 15 feet high and capped with gravel covered by a deep tundra growth. The coal seemed to lie nearly horizontal in the cropping.

Mr. N. B. La Brie, of the Alaska Coal and Coke Company, reported a section on the creek showing about 30 feet of coaly shale, in the middle of which there are two seams of clean coal with 2 feet of "dirt" between. The lower seam is 4 feet thick and the upper from 2 to 3 feet. There is no apparent difference in the character of the coal of the two seams. The coal dips to the east at an angle of 40°.

On the right bank of the creek, some distance above the workings of the Alaska Coal and Coke Company, a section is reported to have shown 30 feet of coal and shale, but only 12 feet were exposed at the time of the writer's visit. The rocks dip 45° SW. and show the following section:

Section on right bank of Washington Creek above Alaska Coal and Coke Company's mine.

	Ft.	in.
Clean coal, with several small streaks of clay	5	6
Dirty coal	2	6
Sandstone	2	0
Shale	0	2
Coal	2	0

The coal beds where examined showed no signs of crushing or faulting. The evidence in hand points to the conclusion that there is a large area of coal-bearing sandstone on Washington Creek containing one or more thick zones of coaly material, in which there are several seams of clean coal that are not injured by faulting or crushing. The greater part of this coal, however, lies below the level of the drainage of the region, and in its development pumping and hoisting plants will probably be necessary.

Samples of the coal were taken at several places, both from the prospect pits and from the float in the creek gravel. These samples show a general similarity. The coal, though black and glossy and exhibiting a conchoidal fracture, has a lignitic appearance, often showing a woody structure. It is characterized throughout by grains and streaks of amber, or fossil resin. Large pieces of float coal, some weighing 50 pounds, were found on the gravel bars of the creek and showed little tendency to check or slack.

Analyses were made by Dr. E. T. Allen, United States Geological Survey, of one sample, taken by the writer from a 5-ton lot mined by Messrs. Stanford, Pratt, Layman, and Jewett, and hauled to the Yukon to be tested on a river steamer; and of another collected by Kasper Ellingen from one of the prospects of the Alaska Coal and Coke Company, on Washington Creek, about 1½ miles above the locality where the first sample was taken.

Analysis of coal (No. 75) from Washington Creek, 10 miles from Yukon River.

[Sample taken by the writer from a 5-ton sample mined for steam test.]

	Per cent.
Water	13.48
Volatile combustible matter	43.74
Fixed carbon	39.68
Ash	3.20
	100.00
Sulphur	.24
Fuel ratio	.91

Analysis of coal (No. 313) from Washington Creek, 12 miles from Yukon River.

[Sample taken by Kasper Ellingen, of Alaska Coal and Coke Company.]

	Per cent.
Water	11.13
Volatile combustible matter	42.57
Fixed carbon	44.20
Ash	2.10
	100.00
Sulphur	.26
Fuel ratio	1.04

Neither of these samples was sealed up immediately on being taken from the mines, and it is probable that the percentage of moisture in freshly mined coal would be somewhat higher than is here shown.

The 5-ton sample, above referred to, was tested on the Northern Commercial Company's steamer *Sarah*, and is reported to have given entire satisfaction, as compared with the other Yukon River coals.

Coal was discovered on Washington Creek by Mr. N. B. La Brie in 1897, and soon after coal claims were staked along the west side of the creek. Later these locations were turned over to the Alaska Coal and Coke Company, of which Mr. La Brie is manager. Several years later claims were staked on the east side of the creek by Messrs. Stanford, Layman, Pratt, and Jewett.

Developments are as follows: The Alaska Coal and Coke Company has a drift tunnel 60 feet long and a slope tunnel 106 feet on the coal bed at a point about 12 miles from the Yukon. Five tons of coal have been mined from workings that have since caved in at a point about 10 miles from the Yukon. A good winter trail has been opened from the landing on the Yukon, near the mouth of the creek, to the coal beds, a distance of 10 to 12 miles, along which coal can be sledded with horses or dog teams during the winter. Should the demand for coal on the Yukon justify it, a railroad can easily be built into the coal basin.

Bonanza Creek.—This stream, which parallels the Yukon at a distance of about 6 miles from it, is an eastern tributary of Charlie River. The coal field reported on it is probably within 6 miles in a direct line from the Yukon, but by way of Charlie River the distance is much greater. The position of the creek on the accompanying map (Pl. II) is taken from a map by E. J. Chamberlain.

The bed rock along the Yukon consists of dark slates (Lower Cretaceous), which probably extend southward for some distance, but in the divide between the Yukon and Bonanza Creek there are some rough hills, suggesting the rocks of the Rampart series. The coal-bearing rocks probably overlie these harder rocks, making the geologic relations on Bonanza Creek similar to those found on Washington Creek.

The writer has been informed by many prospectors who have visited this region that extensive beds of coal are exposed, but owing to their distance from the Yukon no attempt has been made to exploit them.

Coal Creek.—This stream is a tributary of the Yukon, entering from the south side about 45 miles above Circle and 105 miles below the international boundary. The coal reported is 6 miles from the Yukon, and was not visited by the writer. Coal Creek probably has a length of about 30 miles. For some distance up from the mouth of the creek the bed rock is slate, resembling that along the lower part of Washington Creek, and is believed to be of Lower Cretaceous age. The coal is probably contained in Kenai sandstones and conglomerates which overlie this slate.

Specimens of float coal were picked up on the gravel bars of Coal

Creek, which show the character of the coal to be similar to that of Washington and Cliff creeks, in that it contains fossil resin, or amber. The coal on Coal Creek is not known to be of economic importance, and attempts to exploit it have been abandoned.

Nation River mine.—Tahkandit or Nation River enters the Yukon from the north about 52 miles below the international boundary. On the published maps of the Yukon this river has been called Tahkandit. It is more generally known at the present time as Nation River, and the coal mine formerly operated there is known as Nation River mine. It is located on the left bank, about 1 mile from the Yukon. Coal has been found at one locality only, though a formation probably identical with that which carries the coal extends down the Yukon for a distance of at least 10 miles, and it is probable that coal will be found at other places.

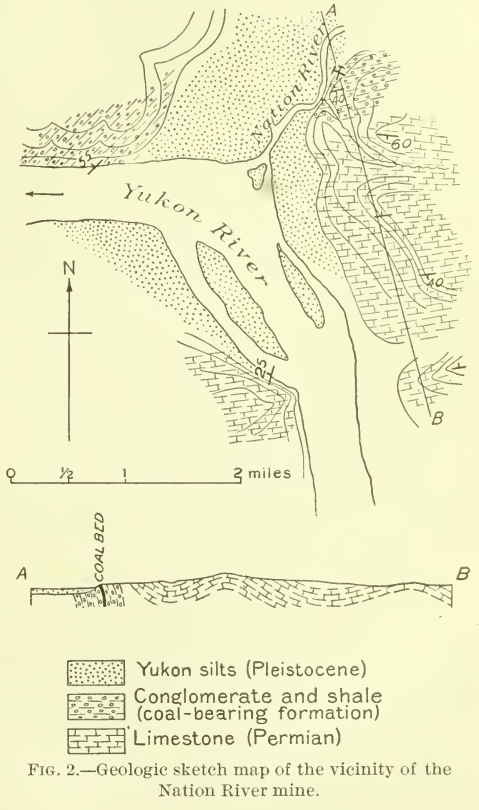


FIG. 2.—Geologic sketch map of the vicinity of the Nation River mine.

The coal at Nation River occurs in gray shales interbedded with heavy conglomerates. Both the coal and the inclosing rocks show the effects of intense crushing. In the conglomerate this is evinced by a cleavage developed in the quartz and chert pebbles of which it is composed. The geologic relations, as far as they are known, are shown on the accompanying sketch map and section (fig. 2). The coal-bearing rocks outcrop in the face of a bluff which rises about 200 feet from the creek bed. The strike here is approximately N. 60° E., and the dip is southeast, at an angle of 40°. About half a mile south of this point massive limestones outcrop, striking N. 70° E., and dipping southeast at an angle of 60°. These limestones form a belt of broad, open folds that lie south of the coal-bearing rocks and carry fossils of Permian age. Unless there has been faulting, of which there is some evidence, the Permian limestones overlie the coal-bearing formation. There is no direct paleontologic evidence as to the age of the coal-bearing rocks, as no fossils were found in them. In similar sandstones, how-

ever, several miles up the river from this place, plant fossils, possibly Paleozoic, were found.

The weight of the evidence seems to point toward a Permian age of the coal, though it is possible that the beds are of later age, infolded and overthrust by the Permian limestone. The following facts point to the latter conclusion:

First. The Eocene coals of this region generally are found in shales interbedded with conglomerates which are similar to these, except for the extreme crushing here shown.

Second. There is a great deal of heavy conglomerate and interbedded shale along the Yukon in this vicinity, varying greatly in the degree of consolidation, but showing a general lithologic similarity, and fossil plants from some of these rocks have been determined definitely to belong to the Kenai formation.

Third. Both above and below Nation River the sandstones and conglomerates are intensely folded and faulted, and the formations are often overturned. A few miles above Nation River, conglomerates which are younger than the Carboniferous are overlain by belts of Carboniferous age. This relation has been brought about by a thrust fault. In this vicinity the conglomerate sandstone series shows an overturned fold, which has brought slates believed to be Paleozoic above them. A similar explanation may account for the relations of the conglomerate and Permian beds at Nation River.

Fourth. Mr. W. E. Williams, who was manager of the Nation River coal mine while it was in operation, reports that in following the coal downward the dip became vertical and afterwards overturned, so that the dip, which at the surface was to the southeast became northwestward.

More extended and more detailed work in this vicinity is required to determine definitely the age of this coal. Should it be found to be of Carboniferous or Permian age, which seems doubtful, it would be important as indicating the possible presence on the Yukon of deposits of the older coals. In 1899 Brooks found a series of Carboniferous strata about 240 miles southwest of this locality that contained beds of impure coal, which he described as follows:[a]

> Coal has been reported from the region of the upper White and Tanana rivers, but during our reconnaissance of the past season we saw no beds of coal which would be of commercial value. At a number of places carbonaceous shales of Carboniferous age were found, but none of these were sufficiently pure to use for fuel. One of these was about 10 miles west of Kershaw River, near our route of travel. At this locality beds of carbonaceous material some 20 or 30 feet in thickness were exposed. Much of it had been altered to graphite by dynamic metamorphism. Near the upper end of Lake Kluane similar beds were found. On Kletsan Creek carbonaceous shales containing a little bituminous coal were found, but the coal was too impure to have any fuel value.

[a] Reconnaissance from Pyramid Harbor to Eagle City, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 382.

The fossils collected by Brooks at this time were of a fauna similar to that of the Nation River limestones, and Schuchert, who examined them, and who has also examined the larger collections made on the Yukon by the writer and the collection made in the Copper River Basin by W. C. Mendenhall, is now of the opinion that these beds should be correlated with the limestones at Nation River.

Only one bed of coal has been found at Nation River. The mine workings are abandoned, and, having caved in, could not be examined. The face of the bluff on which they are located is subject to local slides, by which the outcrops of coal are covered. A recent prospect hole near the top of the bluff showed about 2 feet of crushed coal and shale standing nearly vertical.

W. E. Williams, who was superintendent of the mine, informed the writer that the coal bed here was never well defined. The coal was found in pockets and kidneys often as large as 8 feet thick and 13 feet long. When the mine was abandoned a large body of this kind that had been located was left unmined. Large pieces of this coal were found in the creek bed before the coal body was located.

The coal mined at Nation River is distinct in character from any other coal mined on the Yukon. It is a bituminous coal, containing a low percentage of water, and showing no traces of woody structure. If these coals prove to be of Kenai age, the differences in their composition may be accounted for by the greater degree of deformation which they have suffered. An analysis was made of a sample taken from a large pile, probably 100 tons, mined in 1898. It had been exposed to the weather on the river bank since that time, but apparently was not greatly altered. It had the following composition:

Analysis of coal (sample No. 68) from Nation River mine.

[Analyst, E. T. Allen, U. S. Geol. Survey.]

	Per cent.
Water	1.39
Volatile combustible matter	40.02
Fixed carbon	55.55
Ash	3.04
	100.00
Sulphur	2.98
Fuel ratio	1.39

This coal makes a good coke in the laboratory. A large part of the coal was dry and unfrozen and of good quality, while a smaller part was frozen and almost worthless as fuel. The distribution of the frost was probably due to the circulation of water through the bodies of coal.

In 1897 the Alaska Commercial Company attempted to open a coal mine at this place, and about 2,000 tons[a] of coal were mined and

[a] For estimates of the amounts of coal produced at points along the Yukon the writer is indebted to Mr. W. E. Williams, a mining engineer, who has operated coal mines on the Yukon since 1897.

sledded to the Yukon, to be burned on river steamers or transported to the Dawson market. Owing to the irregularity of the coal deposit and the consequent uncertainty of the supply, and to the expense of mining, it was abandoned several years ago. During the summer of 1902 one man was prospecting and attempting to relocate the coal bed. This coal is of better quality than that of any other mine of the region, except for the large percentage of sulphur, but the disturbed condition of the seam makes it doubtful whether it can be worked at a profit.

RAMPART PROVINCE.

Under this heading the coal deposits of the Yukon between the flats and the mouth of the Melozi[a] will be considered.

Below Circle the Yukon for 200 miles meanders by numerous channels through a broad lowland known as the Yukon Flats. It then enters a more constricted portion of its valley, known as the Ramparts, which it leaves again at the mouth of the Tanana. Below the mouth of the Tanana the Yukon Valley broadens out. Within the flats the Yukon receives, from the north and east, Porcupine, Chandlar, and Dall rivers, and from the south, Birch Creek and Beaver Creek, besides many small streams. Below the flats, Ray River, Salt Creek, Sheflin Creek, Tozi (Tozikakat) River, and Melozi River are tributary to the Yukon from the north, and Hess Creek, Minook Creek, and Tanana River from the south.

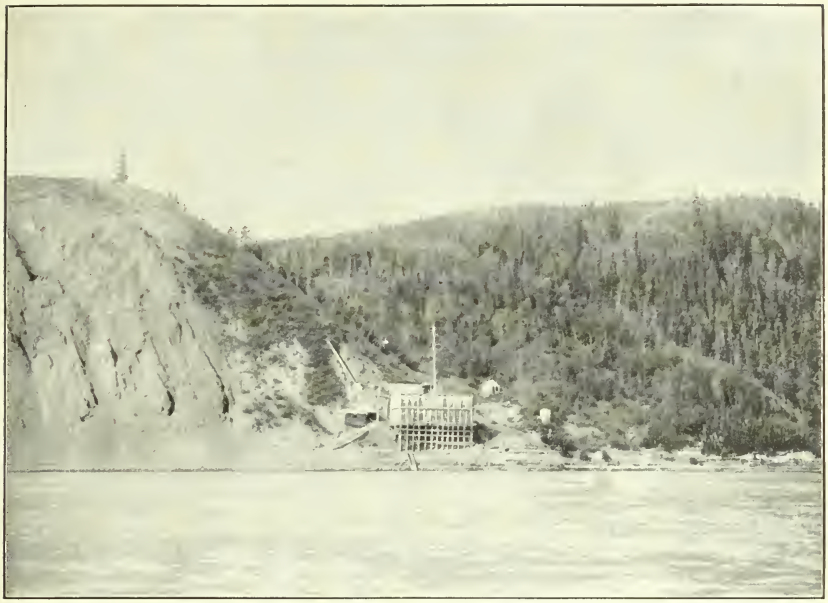
The important settlements within this province are Rampart, the distributing point for a large placer-mining region, and Tanana, where the United States military post, Fort Gibbon, is located. During the summer of 1902 the United States Army maintained a telegraph line from St. Michael to Rampart. Telegraph stations were distributed along the river between these points at intervals of 40 miles.

One of the first attempts to mine coal on the Yukon was made about 25 miles above the present town of Rampart, on the site of what is now known as the Drew mine. Attempts to open coal mines have been made on Minook Creek near Rampart, on the Yukon 2 miles below Rampart, and on the Yukon 30 miles below Tanana.

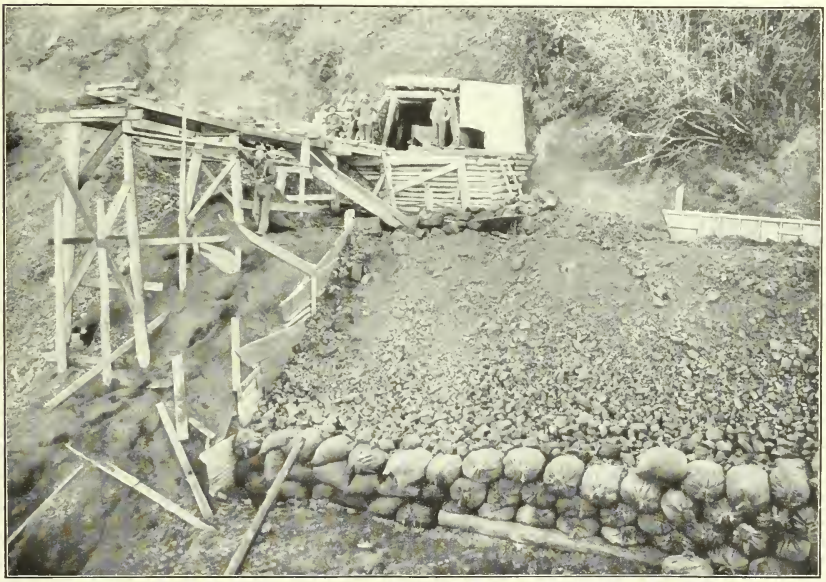
Coal has been found on Dall River, which enters the Yukon at the lower end of the flats, and is reported by prospectors from Salt Creek, which enters the Yukon 20 miles below Dall River. Extensive coal beds also occur on Cantwell River, a southern tributary of the Tanana, about 100 miles south of Rampart. Several areas of sandstone correlated with the Kenai occur along the Yukon in this province in which coal has not yet been discovered.

The coal which has been developed in the Rampart province occurs

[a] This river is known in Alaska as the Melozikakat. Melozi is here used in accordance with the decision of U. S. National Board on Geographic Names, "kakat" being merely a native name for river.



A. DREW COAL MINE, 25 MILES ABOVE RAMPART, ON YUKON RIVER.



B. WILLIAMS COAL MINE, 90 MILES BELOW NULATO, ON YUKON RIVER.

in a sandstone series which, from its fossil plant remains, has been assigned to the Kenai. These beds are found in a small area near the town of Rampart, where they are over 5,000 feet thick and rest unconformably on indurated cherts and tuffs belonging to the Rampart (Devonian) series. Some of the beds are compact sandstones and conglomerates, while others are almost unconsolidated. Several other small areas of Kenai beds have been found in this part of the Yukon Valley, as is indicated on the map, Pl. II. An unsuccessful attempt has been made at mining a lignite seam which occurs in unconsolidated beds that contain Pleistocene fossils.

Drew mine.—The Drew mine is situated on the left bank of the Yukon, 25 miles above Rampart and opposite the mouth of Hess Creek. It is probably the oldest coal mine on the Yukon, and has been known, at different times, as the Miller mine and the Pioneer mine. It is the only coal mine that has been operated in the Rampart province, and there are no promising deposits of coal known along the main river within 300 miles either above or below it, so that it is probably the most important point for coal mining on the Yukon. A view of this mine, as it is seen from the river, is shown in Pl. V, *A*.

The coal-bearing formation at this place is confined to a great bend of the Yukon, and its known extent is not over 4 square miles. (See fig. 3.) Opposite the Drew mine the banks of the Yukon are low, and a broad flood plain extends for several miles up the valley of Hess Creek. The coal-bearing sandstones are probably continued beneath these flood-plain deposits, and may be connected with the coal-bearing formations exposed near Rampart, which have been described.

From Fort Hamlin to within a mile of this mine the Yukon flows in a canyon cut in a system of diabases and tuffs interbedded with the more or less cherty slates of the Rampart series. One mile above the Drew mine the rocks of the Rampart series are succeeded by a great thickness of sandstones, carrying fossil plants which have been referred to the Kenai series. Near the point of contact of these formations the Rampart rocks are hard, siliceous slates, with interbedded tuffs, striking N. 30° E. and dipping southeast at an angle of 70°, but the immediate contact is not exposed. The strike and dip of the sandstones appear to agree with those of the slates. Sandstone beds stand at a high angle, dipping away from the underlying rocks. From this point to the coal mine, a distance of 1 mile, there are frequent though not continuous exposures of sandstone standing at high angles. At the coal mine the sandstones are nearly vertical. If there is no close folding or faulting, with consequent repetition of these beds, their thickness should exceed 5,000 feet. The areal distribution and stratigraphic relations are shown in the sketch map and section, fig. 3.

In the lower 4,000 feet of this section no coal seams have yet been found. This portion is made up of fine-grained sandstones and shales

and a small amount of conglomerate. Fossil leaves, mostly of dicotyledonous plants, are distributed through it. In the upper part of the section coal seams are abundant and outcrop along the river bank. The coal is interbedded with fire clay and fine-grained sandstone. If there is no folding and consequent duplication of these beds, of which no evidence was observed, there are at least seven such coal seams dis-

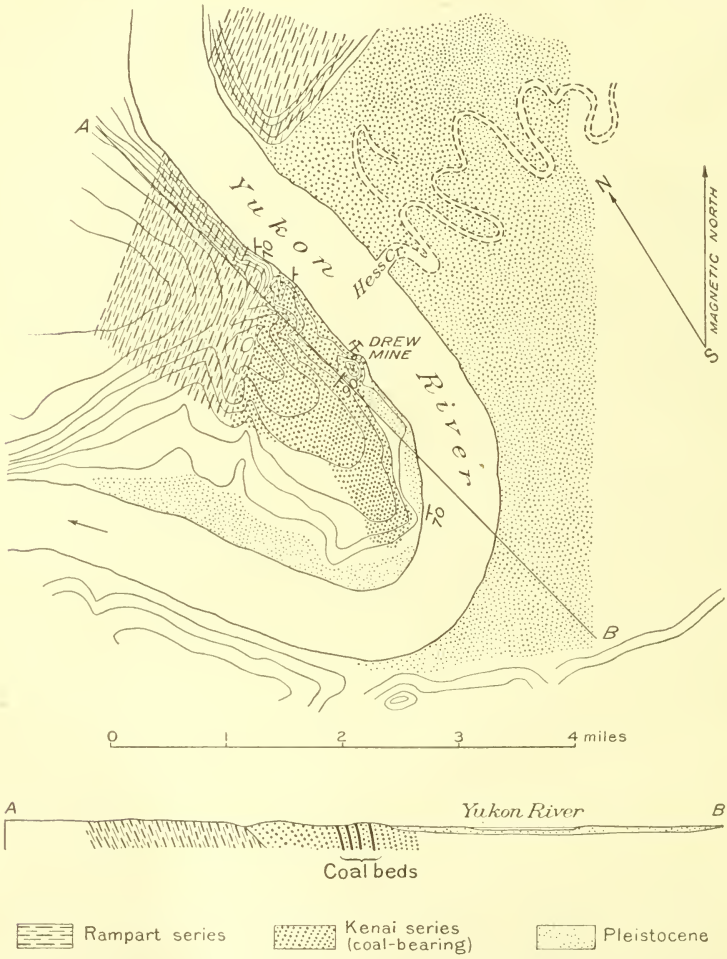


FIG. 3.—Geologic sketch map of the vicinity of the Drew mine.

tributed through less than 1,000 feet of sediments. Above these coal measures there are some heavy beds of coarse sandstone and conglomerate, aggregating in thickness 200 or 300 feet.

Although the outcroppings indicate that there are probably seven seams of coal at this place, only one of them has been exploited. The croppings of this seam in the river bank showed solid coal above the water line at the high stage of the river that prevailed at the time of

the writer's visit. The other seams were indicated only by broken coal or coal smut mixed with fire clay, although it is reported that at low stages of water several of these seams present measurable exposures at the water's edge.

The bed that has been opened is believed by the writer to be the sixth one from the bottom of the coal series. Within the mine this bed was found to consist of two seams, aggregating 38 inches of clean coal, contained in about 19 feet of coaly material. The section was as follows:

Section at Drew mine.

	Ft.	in.
Yellow, shaly sandstone	--	--
Bone and black shale	1	8
Coal	2	1
Black shale and bone	4	0
Coal	1	1
Black shale or bone coal	2	0
Coal	0	2
Black shale	4	0
Bony coal	4	0

Analyses by Dr. E. T. Allen of samples from each of the two seams of clear coal are as follows:

Analysis of coal (No. 137) from 13-inch seam, Drew mine.

	Per cent.
Water	9.58
Volatile combustible matter	36.87
Fixed carbon	39.83
Ash	13.72
	100.00
Sulphur	0.33
Fuel ratio	1.08

Analysis of coal (No. 138) from upper 25-inch seam, Drew mine.

	Per cent.
Water	9.54
Volatile combustible matter	40.09
Fixed carbon	37.35
Ash	13.02
	100.00
Fuel ratio	0.93

These analyses show a rather high percentage of ash, otherwise the coal compares well with that mined on the upper Yukon. The samples show some small specks of fossil resin, or amber.

About 100 yards north of the main workings of the Drew mine prospect holes have been sunk on another coal seam, probably the fifth of the series here exposed. About 7 feet of crushed coal is exposed in the pit, which tapers at the bottom to 4 feet of coal, also crushed and yielding no solid pieces. Grains of fossil resin, or amber,

are common in this seam. A sample of this weathered coal was analyzed and showed the following composition:

Analysis of sample (No. 312) of croppings of lower coal bed, Drew mine.

[Analyst, E. T. Allen, U. S. Geol. Survey.]

	Per cent.
Water	14.44
Volatile combustible matter	47.15
Fixed carbon	33.77
Ash	4.64
	100.00
Fuel ratio	0.72

This analysis shows a lower percentage of ash than the coal from the seam which has been worked. The higher percentage of water is in all probability partly the result of weathering of the coal at the outcrop.

Coal was first discovered at the Drew mine and developed by Oliver Miller in 1897. Spurr reports that in that year a tunnel 40 feet in length had been driven into the hill on a 2-foot seam, probably the 2-foot seam of the present mine.[a] Drew worked the mine several years since that time, but it is now closed under an attachment suit instituted by the Northern Commercial Company.

The equipment of this mine consists of a shaft 75 feet deep, cribbed, housed, and provided with steam hoisting gear. Bunkers of 80 tons capacity are conveniently situated with chutes to reach the decks of steamers moored at the river's bank. The shaft was found to be in good condition and the mine free from water and of ice except for 6 inches at the bottom. A gangway about 20 feet long from the bottom of the shaft crosscuts the sandstone to the coal bed, and then turns and follows the coal for several hundred feet. The writer was prevented from reaching the end of this gangway by a cave-in in the old workings, about 40 feet from the turn. The coal from the 2-foot seam has been stoped out above this gangway. An air duct which has been driven along the 13-inch seam represents all the work on this smaller seam.

About 1,200 tons of coal have been taken out of the Drew mine, the greater part of which was used on river steamers. The coal has not given entire satisfaction for this purpose. This dissatisfaction was due, in part, no doubt, to the inexperience of the firemen and the unsuitable grates which were used. It is also reported that the coal was carelessly mined, so that as supplied at the bunkers it contained a great deal of unnecessary dirt, but it nevertheless sold readily at $15 per ton. The following statement regarding it, by Mr. H. N. Wood, assistant engineer, United States Revenue-Cutter Service, is taken from Mr. Brooks's paper on Coal Resources of Alaska (p. 564):

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

[a] Spurr, J. E., Geology of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, p. 381.

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 sifting 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 equal 2,000 to 2,500 pounds of Yukon coal, equal 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.

At the point where this mine was opened a low hill rises about 200 feet above the river, affording a considerable amount of coal above the river level that could be stoped down into a main gangway driven in directly from the river bank. Behind this hill there is a broad depression, nearly one-fourth mile wide, cutting off the greater part of this coal seam. Beyond this depression there is again high ground, reaching an elevation of from 400 to 600 feet above the river. The greater part of the coal above water level in the hill near the river has probably been mined. In extending the mine along the strike of the bed there will be a limited amount of coal to be mined above the gangway at the present level until the higher hill is reached. Here, if this bed holds its thickness and is not displaced by faulting or folding, a large amount of coal will be found that can be readily stoped down into a gangway at the present level. It is also probable that further prospecting may show some of the other coal beds here exposed to be of economic importance. Most of these beds are well situated topographically for yielding a continuous supply of coal.

Minook Creek.—This creek enters Yukon River from the south side, about 1 mile above the town of Rampart. It has a length of about 20 miles, heading in the Yukon-Tanana divide, opposite the head of Baker Creek, which flows to the Tanana. Sandstones carrying some coal seams outcrop along the left bank of the Yukon for 3 or 4 miles above Minook Creek and also about 2 miles below the town of Rampart. They form the floor of Minook Creek Valley for 2 miles above its junction with the Yukon. They are best exposed in a bluff along the left bank of the Yukon for several miles above the mouth of Minook Creek. The strike of the beds at this place is constant, N. 70° E., while the dip increases from 20° near the northern end of the outcrop to 50°

near the southern end. They consist of almost incoherent sands and gravels.

Fossil leaves collected in the bluff along the Yukon above the mouth of Minook Creek were assigned by Knowlton to the Kenai series represented at the Drew mine, and the rocks are, therefore, probably continuous between the two points, though this connection has not been established by actual observation. The lithologic character of the Minook beds differs widely from that of the sandstone at the Drew mine, and without the fossil evidence would suggest that they belong to a younger horizon. At both localities the coal-bearing sandstones rest unconformably on rocks belonging to the Rampart series. Impure lignites occur in these sandstones at several points above Rampart. On Minook Creek about 2 miles from the town of Rampart these lignite beds are reported to have occasionally been on fire. Attempts have been made to open a coal mine at the latter place, but Mr. Paige, of the Geological Survey party, who visited the locality, reported that the workings had caved in, so that the thickness of the bed could not be determined. A sample of the coal was taken for analysis from the dump of the old prospect hole.

The coal is a glossy lignite which tends to break up into small cubical grains on drying. The analysis is as follows:

Analysis of coal (No. 310) from junction of Hunter and Minook creeks.

[Analyst, E. T. Allen, U. S. Geol. Survey.]

	Per cent.
Water	11.21
Volatile combustible matter	44.32
Fixed carbon	38.64
Ash	5.83
	100.00
Fuel ratio	.87

The percentage of water in freshly mined coal from this locality would probably be considerably higher than the analysis shows, since the sample analyzed had lain out on the dump all summer and was very much checked up by drying. Samples of coal from this locality have been tested for heating purposes by the miners at Rampart, and are reported to have been rather unsatisfactory in that the coal needed a certain amount of wood mixed with it to make it burn well.

Two miles below Rampart, on the left bank of the Yukon, a similar coal outcrops. This has been prospected to some extent, but the workings are at present abandoned and the tunnel has caved in. A sample taken from the dump of the old tunnel showed physical characters similar to that from Minook Creek.

The analysis is as follows:

Analysis of coal (sample No. 160) from left bank of Yukon 2 miles below Rampart.

[Analyst, E. T. Allen, U. S. Geol. Survey.]

	Per cent.
Water	16.43
Volatile combustible matter	41.09
Fixed carbon	35.22
Ash	7.26
	100.00
Fuel ratio	.86

Coke noncoherent.

Between Rampart and the mouth of the Tanana, on the north side of the Yukon, there are two large areas of sandstones and conglomerates that have been correlated with the Kenai, which have been reported to carry beds of coal, but no coal of economic importance has yet been found in them.

Dall River.—On Dall River, about 70 miles from its junction with the Yukon, coal occurs which resembles the Rampart coal. The following description is quoted from Mendenhall's report:[a]

In the bed of Coal Creek, about 1 mile above its confluence with Dall River, there is an outcrop of lignite with irregular clay streaks, which measures, as far as can be determined from the imperfect exposures, approximately 11 feet in thickness. At the base of the exposure are 4 or 5 feet of firm, bright lignite, while the remainder is soft, dirty, and of poor quality. Blocks of the coal have been washed down the creek and some distance down Dall River without breaking up; but certain portions of the seam slake rapidly when exposed to the atmosphere. Although no opportunity was afforded for making practical tests, the lower 4 or 5 feet of this seam are believed to be lignite of good quality, while the remainder is probably of no value. This coal is contained in soft, gray, buff, or black shales, which are supposed to be Tertiary (Kenai series).

Salt Creek.—Coal has been reported on Salt Creek by prospectors. Little definite information was obtained regarding it. These seams are said to be about 25 miles from the Yukon and may occur in an extension of the same area of coal-bearing rocks as those of Dall River described by Mendenhall.

Palisade lignite beds.—On the left bank of the Yukon 35 miles below Tanana bluffs of buff-colored silt and gravel rise to a height of 150 feet above the river. This locality has been named the Palisades, but on account of the occurrence in the silts of abundant bones of the mammoth and other large mammals it is more popularly known as the Bone Yard. Silts of practically the same age occur in many places along the river. They are not known to carry lignite beds except at the Palisades.[b] These silts contain not only bones of the mammoth

[a] Mendenhall, W. C., Reconnaissance from Fort Hamlin to Kotzebue Sound: Prof. Paper U. S. Geol. Survey, No. 10, 1902. See also Brooks, A. H., Coal resources of Alaska: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, p. 558.

[b] Spurr, J. E., Geology of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 199 and 207.

and other mammals, but shells of fresh water and land gasteropods, represented by species now living, and cones of *Picea* resembling the present spruce of the Yukon Valley, which show that the silts are of Pleistocene or late Pliocene age. The material in these bluffs is mostly extremely fine silt, greenish gray in color, forming when wet a fine sticky clay and showing scarcely any traces of stratification. At intervals in this deposit there are thick beds of vegetable material containing wood in all stages of change from pliable sticks to brittle brown lignite. These beds vary in thickness and also in the nature of their material; usually, however, they contain trees, some of considerable size.

Near the upper end of the Palisade Cliffs a tunnel has been run on one of the lignite beds. In the summer of 1902, however, this tunnel had caved in, and the bed could not be examined underground. Mr. N. H. Wood,[a] assistant engineer, U. S. Revenue-Cutter Service, is authority for the statement that a vein 20 feet thick was reported here.

The lignite from this locality is of inferior quality, scarcely changed from wood or peat. Where examined by the writer this peat is mixed with red sand. Samples were taken, but no analyses of them have been thought necessary, as in the present stage of Alaskan development these beds have no value.

Cantwell River.[b]—This river is tributary to the Tanana from the south, about 130 miles from the Yukon. The Cantwell has its source well within the Alaskan Range, which it leaves through a narrow valley cut into metamorphic rocks. The front of the range is about 40 miles from the Tanana. At the northern flank of the mountains these metamorphic rocks are mantled over by coal-bearing, friable sandstones, which find topographic expression in a series of low hills running parallel to the front of the range. Lithologically the rock is chiefly soft, friable sandstone, often of an almost snow-white color, with some intercalated conglomerate and shale strata. The basal beds are usually conglomeratic. The entire series probably measures several hundred feet in thickness. Lithologically it closely resembles the Kenai beds exposed near Rampart on the Yukon. The series is either entirely undisturbed or is thrown up into broad, open folds. Faulting was observed at several localities.

The coal-bearing beds outcrop for about 15 miles along the river, and were traced about 4 miles to the east. The area of this coal field can be safely estimated at 60 square miles at least, and may be many times that. The beds are seldom exposed except along the river and stream valleys, for elsewhere they are usually deeply buried under Pleistocene gravels. These coal-bearing terranes were proba-

[a] Brooks, Coal resources of Alaska: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, p. 557.

[b] This note was furnished by Mr. Alfred H. Brooks, in advance of the publication of his report to be entitled, "A Reconnaissance in the Mount McKinley Region, Alaska."

bly deposited in an isolated fresh-water basin. No fossils have been obtained from these rocks, but they are believed to belong to the upper part of the Kenai series or to a younger Tertiary horizon.

What promises to be workable coal beds were found at two localities during the hasty reconnaissance on which these notes are based. The most important of these are on Healy Fork, an easterly tributary of Cantwell River, which it joins from the east about 40 miles from the Tanana. The coal beds are well exposed in precipitous bluffs along the north valley wall of this stream. The strong contrast between the white sandstone and the black coal seams makes them very conspicuous features even from a distance. While the beds are largely made up of sandstone, yet the layers lying immediately adjacent to the coal are most often clay and sandy shales. One bluff about 2 miles from the Cantwell was examined in some detail. In this section 200 feet of sandstone and conglomerates formed the basement member, and rested unconformably on the phyllites of the metamorphic series. This bed was overlain by about 250 feet of soft sandstone shales and coal. In the entire section the coal aggregated about 125 feet in thickness, contained in about fifteen seams. Of this 125 feet probably 60 feet were of a fairly good grade of lignite. The largest seams were 20 feet in total thickness, but included considerable bone and shale. In character the coal varied from a fibrous, impure lignite, which is entirely worthless, to lignites which may have commercial value. The lignite of better grade is of a lustrous black color, and has a conchoidal fracture. The seams were accessible only along the outcrop, where they were made up of noncoherent lignite. A sample taken almost at random from one of the larger seams was analyzed by Dr. E. T. Allen, of the United States Geological Survey, with the following result:

Analysis of coal from Healy Fork of Cantwell River.

	Per cent.
Moisture	13.02
Volatile matter	48.81
Fixed carbon	32.40
Ash	5.77
	100.00
Fuel ratio	0.66

This analysis shows that the coal is a fairly good lignite. In considering it, it should be borne in mind that the short time given to the study of the locality makes it quite possible that seams of better grade were overlooked.

The second locality where lignites were found is on Lignite Creek, so-called, a few miles north of Healy Fork. At this place the croppings show fewer seams and these are of less thickness. These lignites, as far as determined, were of no higher grade than those of Healy

Fork. North of Lignite Creek, and apparently higher in the series, seams of fibrous impure lignites and carbonaceous shales are not uncommonly interbedded with the sandstones. It is not likely that any of these have any prospective commercial value. In the opinion of the writer the best coals in the basin are near the base of the sandstone series.

Topographically these coal seams are exceptionally well located for mining. Though they have been known since 1898, the isolation of the locality has precluded any possibility of their development. Should a railway ever be built through Caribou Pass from Cook Inlet, as has been proposed, it is quite possible that this coal field might receive development.

NULATO PROVINCE.

Under this heading the coal beds included in the large area of sandstone and shale extending from the Melozi to the mouth of the Yukon will be described. Within this province the Yukon flows with a slow current and is often divided into several channels. Along the right bank there is a series of bluffs and hills, rising generally to a bench from 100 to 400 feet above the river. On the left bank the flood plains extend back for a distance of from 5 to 20 miles, and the hills are usually not visible from the river. The writer does not know of any outcrops of bed rock along the left bank of the Yukon within this province. The most important tributaries from the north side are the Koyukuk, which is the largest, Nulato, Kaltag, Anvik, and Clear (or Andreafski) rivers. Yuka, Kaiyuh, and Innoko rivers are important southern tributaries. Nulato, the largest Indian village in the interior of Alaska, and the principal town in the province, is about 25 miles below the mouth of the Koyukuk. A trading post has been maintained here for many years. There is also a mission maintained by the Roman Catholic Church. A view of this village is shown in Pl. VI, *B*.

At Kaltag, a small trading post and post-office about 40 miles below Nulato, the telegraph line and winter mail route leave the Yukon and follow Kaltag River nearly to its head, then cross the divide to Unalaklik River, and extend down that river to Norton Sound. At Koserefski the Holy Cross Catholic mission is the chief institution. Below Koserefski, Pimute, and Russian Mission are Eskimo villages, and Andreafski furnishes winter quarters for a large part of the fleet of Yukon steamers.

In this field coal beds are found along the Yukon for a distance of 200 miles. These coal beds resemble one another both in the character of the coal and in its mode of occurrence, and in these particulars they differ from the upper Yukon coals. The coal-bearing sandstones outcrop along the right bank of the Yukon, which forms the south-

eastern boundary of this field, while south of the Yukon low flats extend for several miles to the foothills, which are composed of rocks believed to be older. Northward the field extends up Koyukuk River for a distance of at least 35 miles, and it extends westward probably to Norton Sound. At its northern and western boundaries it is overlain by younger effusives and sediments.

The coal occurs in beds which are not known to have great extension. These will be described under the headings Nahoclatilten coal bed, Pickart coal mine, Nulato coal bed, Bush mine, Blatchford mine, Williams (Clemens Thein) mine, Coal mine No. 1, and Halls Rapids coal. Reported coal prospects not visited by the writer will be mentioned under the headings upper Koyukuk and Anvik River.

Nahoclatilten coal bed.—Bluffs of sandstone extend up the west bank of the Yukon from Nahoclatilten[a] for about 20 miles, nearly to the mouth of Melozi River, and are coal bearing about 5 miles above the village. These coal seams were examined at only one locality by the writer. Coal has probably also been found at a number of places in this vicinity, which is roughly located about 50 miles above Nulato and on the right bank of the Yukon.

The geologic relations of these coals are of exceeding interest, though at the present time only imperfectly known. The coal seams were found about one-fourth of a mile from the river in sandstones and shales carrying Kenai fossils, and hence of Eocene age. This sandstone stands nearly vertical, and from it an ancient slide extends to the river. From the foot of this slide on the river bank fossil plants referable to the Middle or Lower Cretaceous were collected, as well as fossils referable to the Kenai. About one-fourth of a mile up the river from this point there is a high bluff composed in part of calcareous sandstone and in part of intrusive basalt. From the sandstone abundant marine fossils referable to the Upper Cretaceous have been collected.

Two beds of coal were seen by the writer at this place, and two more are reported to have been uncovered in prospecting. The largest observed seam has a thickness of 1 foot. Below this seam there are about 5 feet of bony coal or coaly shale with stringers of coal. There are reported to be three smaller beds in the foot wall, each having a thickness of 10 inches. Owing to the apparent rather intense folding of these beds it is impossible to place much reliance on these statements.

The coal in the 1-foot seam is not crushed, although the beds are much disturbed in position. The following analysis shows it to be a bituminous coal of good quality. It is reported to have given satisfactory results in a blacksmith's forge.

[a] The United States military telegraph post here located was officially known by this name in 1902, but in 1903 the name was changed to Louden.

Analysis of coal (No. 241) from 1-foot seam 5 miles above Nahoclatilten.

[Analyst, E. T. Allen, U. S. Geol. Survey.]

	Per cent.
Water	6.88
Volatile combustible matter	41.82
Fixed carbon	48.93
Ash	2.37
	100.00
Sulphur	.65
Fuel ratio	1.17

Coke slightly coherent.

These coal beds have been known for several years, and various attempts have been made to open here coal beds of commercial importance, but thus far no seams thicker than 12 inches have been found.

Upper Koyukuk.—Near Tramway Bar, on the upper Koyukuk, a large coal bed has been reported by Schrader[a] and others. Tramway Bar is on the Middle Fork, 569 miles by river from the junction of the Koyukuk with the Yukon. It is 130 miles above Bergman and 50 miles above Bettles, and about 20 miles from the seat of placer-mining operations near Cold Foot. The following description of the geologic relations and extent of the coal-bearing formation is quoted from Schrader's report:

On the Middle Fork of the Koyukuk, about 5 miles above Tramway Bar, the metamorphic rocks give way to a younger rock series composed of impure sandstone, arkose, grit, and conglomerate, indiscriminately carrying more or less lignite and remains of fossil plants. On account of its fossil contents and its resemblance to the Kenai found elsewhere in the Yukon district this formation is provisionally referred to the Kenai, which is regarded by Dr. Dall as Upper Eocene. In some localities the beds are quite firmly consolidated, especially the sandstones, while in others they are sufficiently soft to be readily plucked away with a pick or hammer. In nearly all localities the beds show more or less disturbance and some faulting and folding. Above Tramway Bar they have a southerly dip. At Tramway Bar they consist of a belt of firmly consolidated conglomerates, 3 or 4 miles wide, through which the river has cut a canyon about 80 feet deep.

From Tramway Bar to below the Arctic Circle frequent exposures of sandstone, soft shale, and mud rock, carrying more or less imperfect plant remains, are met with. * * * Their attitude often varies, and they nearly always show more or less disturbance.

From this description it will be seen that coal-bearing rocks are exposed along the Koyukuk here for a distance of about 130 miles, though coal has been found at only one locality. In 1901 Schrader found that this series of sandstones extends up John River northward from the Koyukuk for 20 miles, and in the gravels of that stream he found pieces of coal of good quality.[b]

[a] Schrader, F. C., Reconnaissance along Chandlar and Koyukuk rivers, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, pp. 441–486.

[b] Schrader, F. C., A reconnaissance in northern Alaska: Prof. Paper U. S. Geol. Survey No. 20 (in press).

From comparison with similar sandstones seen in the Colville River drainage that year, Schrader came to the conclusion that the sandstones of the upper Koyukuk are probably of Upper Cretaceous age.[a]

The coal bed at Tramway Bar is described as having a thickness of nearly 12 feet, the middle 9 feet being comparatively pure lignite.

The following analysis was made of a sample collected by Schrader at this time:[b]

Analysis of coal from bed at Tramway Bar.

[Analyst, George Steiger, U. S. Geol. Survey.]

	Per cent.
Moisture	4.47
Volatile matter	34.32
Fixed carbon	48.26
Ash	12.95
	100.00
Fuel ratio	1.40

The coal does not make a coherent coke. From this analysis it will be seen that this coal should be grouped with the bituminous coals of the lower Yukon. The coal bed is practically undeveloped, but the coal has been locally used to some extent for blacksmithing purposes.

Pickart coal mine.—This mine, one of the oldest on Yukon River, is located 10 miles above Nulato, on the right bank, and 12 miles below Koyukuk River. Below the Koyukuk the Yukon flows nearly west to within a mile of the coal mine; then it turns abruptly to the south and follows along the foot of a series of sandstone bluffs, in which the coal is contained, and which are almost continuous to Nulato.

These sandstones carry plant fossils which have been referred to the Upper Cretaceous. At the coal mine these are probably fresh-water deposits, but they rest conformably on marine sandstones carrying abundant fossils, also referable to the Upper Cretaceous. The coal bed at the Pickart mine is stratigraphically about 75 feet above the contact of the marine and fresh-water beds. The sandstones between the coal beds and the marine beds are continuously exposed and show considerable cross bedding, but no evidence of unconformity or faulting. Above the Pickart coal there is a great thickness of sandstone carrying fossil plants, and one small coal seam. About 1 mile up the river fragments of sandstone carrying marine fossils of Upper Cretaceous age were found, which probably came from the sandstone overlying the coal bed, though they were not traced to their bed-rock source. These sandstones are exposed continuously along the river for 1 mile above the coal mine. In this distance the strike and dip frequently change, and there is probably some faulting as well as folding. Along this stretch the cliff face rises about 100 feet above the

[a] Schrader, F. C., A reconnaissance in northern Alaska: Prof. Paper U. S. Geol. Survey No. 20 (in press).

[b] Coal Resources of Alaska, p. 565.

river, and from the cliff the hill slopes back more gently to an elevation of about 600 feet above the river, as shown by Gerdine's map of the mouth of the Koyukuk.[a]

At the Pickart mine one coal seam has been exploited, which strikes N. 75° E. and dips N. 35°. Two rolls, or horsebacks, are reported to occur in the floor of the coal bed. Whether these are in the nature of faults, due to movement of strata along the coal bed, or irregularities in deposition of the sediments constituting the floor, the writer was unable to determine. Near these rolls the coal shows considerable crushing, which suggests that the roll is caused by deformation. The Pickart coal bed has a thickness of 30 inches at a distance of 300 feet from the entrance to the mine, but at the end of the main gangway, 600 feet from the entrance, near one of the rolls above referred to, the seam measured only 18 inches. Mr. W. E. Williams, manager of the Pickart mine, reports that in mining this coal a roll was encountered in the workings above the main gangway, in which the floor of the bed was raised up, pinching the coal down to a knife-edge thickness. This roll extended in a nearly straight line and approached the gangway at the rate of about 1 foot in 20. On cutting through this roll good coal was found, having a thickness of 3 feet, which continued for about 20 feet, when another roll parallel to the first was encountered. The second roll has not been passed through in the workings of the mine. The coal near these rolls is crushed and impure and the bed pinches down to a knife-edge thickness. It is probable that coal will be found beyond the second roll in the floor, so that the commercial extent of the seam in this territory has not been determined, nor has it been traced below the river level.

The Pickart coal makes a good coke and must be classed as distinctly bituminous. Samples were taken from the main gangway 300 feet from the surface and from the end of the gangway 600 feet from the surface, and these were analyzed by Allen, of the United States Geological Survey. The second sample is interesting as showing the character of the coal in the vicinity of the rolls in the floor, which led to the abandonment of the mine.

Analysis of coal (No. 252) from Pickart mine, 200 feet from entrance.

	Per cent.
Water	1.02
Volatile combustible matter	27.33
Fixed carbon	65.03
Ash	6.62
	100.00
Sulphur	0.60
Fuel ratio	2.38

Coke compact.

[a] Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pl. lx.

Analysis of coal (No. 253) from Pickart mine, 600 feet from entrance.

	Per cent.
Water	1.64
Volatile combustible matter	24.98
Fixed carbon	58.18
Ash	15.20
	100.00
Fuel ratio	2.33

Coke compact.

This coal has been used for steaming purposes on the river boats for the last five years, but the reports regarding its steam-producing capacities vary greatly. Some engineers speak highly of it; others were dissatisfied with it. It should be borne in mind that, wherever coals have been tried for steaming purposes on the Yukon, they have been burned in grates designed primarily for wood, and that the firemen have, as a rule, been inexperienced with coal. Further, much of the coal has been mined within a few feet of the surface, where it was frozen when extracted, and after thawing it tended to break up into small pieces. In very few instances has the development of the mines gone far enough to obtain coal unaffected by atmospheric influences. The entire product of this mine was sold readily at from $10 to $15 a ton. The coal in the small 1-foot seam mentioned as occurring above the Pickart bed is similar in quality to the Pickart coal. It has no commercial importance. The analysis is as follows:

Analysis of coal (No. 251) from small vein above Pickart coal.

	Per cent.
Water	2.22
Volatile combustible matter	24.76
Fixed carbon	50.38
Ash	22.64
	100.00
Sulphur	0.56
Fuel ratio	2.03

Coke slightly coherent.

Mining was begun at this locality by the Pickart brothers[a] in 1898. A drift tunnel was first started from the river bank at such a level that it was flooded during high-water stages. Later the present tunnel was driven above high-water mark. About two years ago this mine passed into the hands of the Alaskan Commercial Company, and was worked by them under the management of W. E. Williams up to the middle of the summer of 1902, when it was abandoned on account of the difficulty caused by rolls in the floor of the coal bed. The development and equipment consist of the two tunnels mentioned

[a] Schrader, F. C., Preliminary report on a reconnaissance along Chandlar and Koyukuk rivers, Alaska, in 1899: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 485.

above, a powder house, and an office building at the mouth of the mine. No bunkers were used. The coal was piled on the river beach at the mouth of the mine and loaded on steamboats and barges with wheelbarrows. During one season the high water which comes at the breaking up of the ice is reported to have carried away a large amount of coal mined during the winter. The dwellings and other buildings of the miners were of a temporary nature, and have nearly all been removed with the abandonment of the mine. These buildings were located about one-fourth of a mile up the river from the mine. The main gangway has a length of 600 feet. Above this nearly all the coal available in the present state of development of the mine has been taken out.

Nulato coal bed.—Between the Pickart mine and Nulato it is reported that attempts have been made to open coal beds in several places,[a] only one of which was examined by the writer. This seam is about a mile above the village of Nulato, and is contained in sandstones carrying fragmentary fossil leaves. The sandstone strikes N. 10° E. and dips 40° NW., and about 1 mile to the southwest there are marine beds probably overlying it, from which a few fossils were collected, which seem to be of the same age as the marine beds stratigraphically below the Pickart coal. The stratigraphic section between this coal bed and the marine sandstone has not been minutely examined. If there are no faults or unexposed folds between these points, this coal bed is of Upper Cretaceous age. As far as the writer could determine, the marine sandstone rests on the fresh-water leaf- and coal-bearing beds. These observations are in accordance with those of Dr. Dall,[b] who spent the winter of 1865–66 at Nulato, and thus had opportunity to study the section in detail. The coal seam is contained between sandstone floor and roof, and has a thickness of 2½ feet. The seam contains only about 6 inches of clean coal, the rest being made up of bone coal and some clay partings. No analysis of coal from this bed has been made. The writer saw some of the coal from the more impure part of the bed in use in a blacksmith's forge at Nulato. Except for the high percentage of ash, the coal seemed to be of good quality, comparing well with the coals along the Yukon.

Bush mine.—This mine is situated on the right bank of the Yukon 4 miles below Nulato. The mine opens on the slough behind the first island below Nulato. At this place there is a small bench about 50 feet high, which has probably been formed by a slide from the main hill. Back of the bench is a well-marked escarpment, rising to a flat-topped hill about 30 feet above. When the locality was visited the

[a] Schrader, F. C., Reconnaissance along Chandlar and Koyukuk rivers, Alaska, in 1899: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 485.

[b] Dall, W. H., and Harris, G. D., Correlation papers, Neocene: Bull. U. S. Geol. Survey No. 84, 1892, p. 247.

development consisted of a tunnel about 30 feet long driven into this slide.

The coal is contained in sandstones carrying fossil leaves determined as Upper Cretaceous. The coal was broken and very much weathered, so that it was difficult to obtain any large pieces which did not crumble to fine dirt on exposure to the air. It was impossible to determine the thickness of the bed, although the crushed material was often over 4 feet in thickness. A sample of the coal from the end of the tunnel yielded the following analysis:

Analysis of coal (sample No. 254) from Bush mine, 4 miles below Nulato.

[Analyst, E. T. Allen, U. S. Geol. Survey.]

	Per cent.
Water	11.17
Volatile combustible matter	29.48
Fixed carbon	52.02
Ash	7.33
	100.00
Sulphur	.44
Fuel ratio	1.76

Coke, noncoherent.

A blacksmith at Nulato, who was attempting to use this coal for welding, reported that it was inferior to the coal from the prospect a mile above Nulato, or from the Blatchford mine, 9 miles below. This inferior quality is no doubt in part due to the weathered condition of the coal.

The owners of this prospect reported to the writer that they had contracted to deliver 400 tons of this coal on the river bank for use by river steamers next summer. The coal will be mined and sledded over the ice to a suitable landing on the main channel of the river.

Blatchford[a] *coal mine.*—This mine is located on the right bank of the Yukon 9 miles below Nulato. The Yukon banks are low for about 2 miles above the mine, where the flats are extended up a small creek. Below the mouth of this creek a cliff of Pleistocene silt 50 feet high extends along the river for about a quarter of a mile, below which sandstone cliffs rise to a height of about 100 feet.

The coal bed of the Blatchford mine outcrops at the water's edge, near the upper end of this sandstone bluff. The strike throws the outcrop of the seams below the silt cliffs on the one hand and below the river bed on the other, and no other exposure of it is known.

The sandstones at the Blatchford mine dip to the northwest at a high angle. Immediately above the coal bed they are dark and shaly, containing rather abundant fossil plants, which are probably Upper Cretaceous, and above these shaly sandstones are hard gray sandstones,

[a] This name is also sometimes spelled Blatsford. The writer does not know which spelling is correct.

forming the greater part of the cliff. In this sandstone there is considerable evidence of crushing and shearing along bedding planes. Two small seams of coal, which vary in thickness, but nowhere exceed 6 inches, occur in this harder sandstone. The variation in thickness is probably due to shearing.

The one coal seam which has here been worked outcrops below water level. When the locality was examined the opening to workings was under water and the coal was not seen in place. On the river bank, above high-water mark, there was a large pile of coal, mined last winter, but not yet used by steamers on account of the poor landing. This coal is very much crushed, so that from a pile of several hundred tons no large pieces could be obtained. The coal seam is reported to be irregular. Large masses, 8 feet in diameter, have been found and quickly mined out. Its irregularity is believed by the writer to be due to the shearing of the inclosing sandstones along the coal bed.

This coal has been pronounced by some engineers of river steamers to be the best on the Yukon. In the blacksmith's forge it gives good satisfaction. A sample for analysis was taken from a pile containing 40 to 50 tons mined during the winter.

Analyses of coal (sample No. 258) from Blatchford mine, 9 miles below Nulato.

[Analyst, E. T. Allen, U. S. Geol. Survey.]

	Per cent.
Water	1.36
Volatile combustible matter	22.44
Fixed carbon	73.98
Ash	2.22
	100.00
Sulphur	.52
Fuel ratio	3.30

It will be seen from this analysis that the coal is a high-grade bituminous, approaching semibituminous. The fuel ratio, 3.3, and the low percentage of water and ash make it by proximate analysis the best coal seen by the writer on the Yukon.

In 1866 Dall examined a coal cropping below Nulato in this immediate vicinity, if not this identical bed. His description is as follows:

About 7 miles from Nulato, on the south side of a level space or flat, a small bluff appears, at the extreme end of which the sandstones are nearly vertical. Here, between two contorted layers of shaly rock, a small coal seam was examined in December, 1866. It has been squeezed out above and below, forming a mere pocket about 2 feet thick and not over 20 feet long on the exposed face. The shales contained obscure vegetable remains, but were much altered, probably by the heat evolved at the time they were folded. The average dip is north 45°. The coal is good, but there are apparently only a few tons of it. The shales are conformable with the brown sandstone, which, however, is a marine formation in which this deposit of lignite is a very exceptional incident.[a]

[a] Bull. U. S. Geol. Survey No. 84, 1892, p. 247.

The Blatchford mine has no visible development or equipment. The workings lie below the level of the river, and the opening is covered with water during the summer months. The coal that has been mined has been taken after the river was frozen. The ice filling the upper part of the workings is first mined out, after which the coal is reached. The excavations probably do not exceed 40 feet in depth. The "mine" is controlled by some employees of the Northern Commercial Company. It is leased, usually for the season, by one or two miners, who are satisfied if they can produce 100 tons of coal during the winter. Probably not over 300 tons have been mined since this coal was discovered.

Williams mine.—This mine is located on the right bank of the Yukon 50 miles below Kaltag and about 100 miles below Nulato. About 5 miles above the mine the river, after dividing into a number of channels, comes together at the foot of a series of bluffs, chiefly of sandstone, but also containing conglomeratic and shaly beds, which extend approximately north and south and continue for a mile below the coal mine. The sandstone bluffs rise from the river to an elevation of 150 feet, which elevation extends back from the river to the limit of vision.

The sandstones in which the coal occurs carry fossil plants, which have been determined as Eocene (Kenai), and show the coal to be undoubtedly younger than the coal beds near Nulato. A mile or more above the mine there is an abundant fresh-water fauna in some of the sandstone beds. Some evidence of faulting appears in the bluffs about one-half mile above the coal mine and renders it difficult to estimate the thickness of the section. A study of the exposures indicates that the coal bed is overlain by at least 2,000 feet of sandstones, conglomerates, and black shales. At the coal bed the strike is N. 70° W. and the dip is 45° N. At the upper end of the bluffs the strike is about N. 30° W. and the dip is variable, but less than at the mine.

One coal bed of workable thickness has been found at this place, but below this bed there are probably other seams of possible commercial importance. The coal seam which is being worked has a thickness of 39 inches and is divided into two nearly equal benches by a clay parting about three-fourths of an inch thick. The quality of the coal in the two benches is very similar. In the upper bench the coal appears dry and carries streaks of "mineral charcoal." In the bottom of the lower bench a small amount of fossil resin, or amber, occurs.

This bed has been followed 400 feet into the hill by the mine workings, and shows no variation in strike or thickness.

Samples of the coal from the upper and lower benches were analyzed, with the following results:

Analyses of coals (samples Nos. 283 and 284) from Williams mine.

[Analyst, E. T. Allen, U. S. Geol. Survey.]

	Upper bench.	Lower bench.
	Per cent.	*Per cent.*
Water	7.17	6.15
Volatile combustible matter	33.05	40.46
Fixed carbon	51.15	49.86
Ash	8.63	3.53
	100.00	100.00
Sulphur	.40	.53
Fuel ratio	1.54	1.23

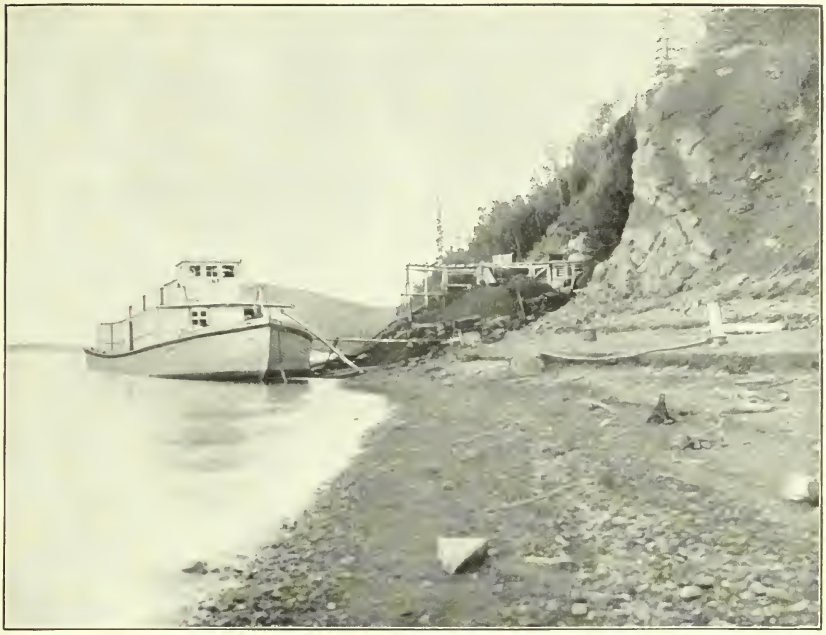
Coke, noncoherent.

The analysis shows the coal to be bituminous. Since the coal mined is all from near the croppings and subject to surface influences, it varies very greatly in quality as it is supplied at the mouth of the mine. Probably much coal of an inferior quality has been sold. However, the coal has generally given satisfaction for steaming purposes, and the entire product of the mine has found a ready sale to the river steamers.

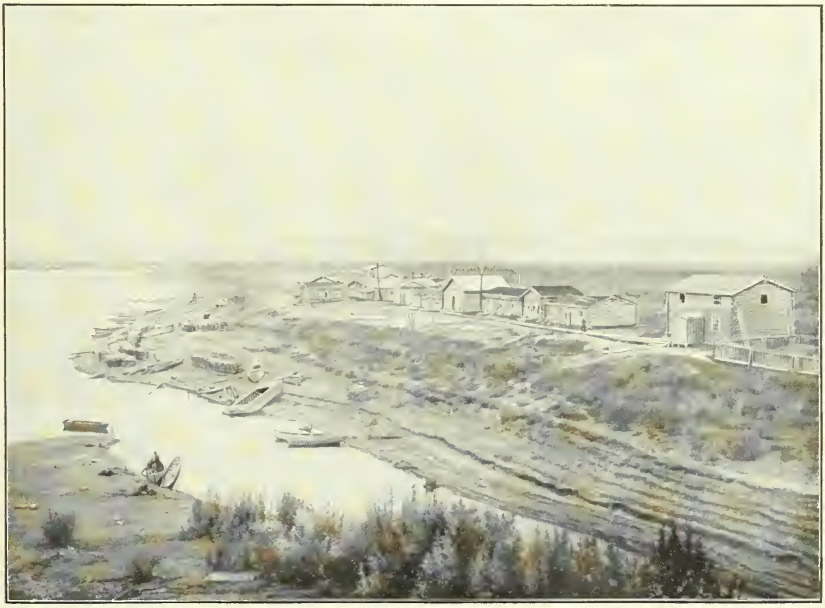
This mine was first opened up as the Thein mine,[a] and in 1900 produced some coal. Early in 1902 it passed into the hands of the present owners, and is being developed by Mr. W. E. Williams. In all, about 1,700 tons of coal have been produced.

The development consists of a drift 400 feet long in the river bank above high water. The greater part of the available coal has been stoped out above this tunnel. The coal cars bring the coal to the mouth of the mine, where it is piled up on the river bank to be loaded on the steamers with wheelbarrows, as no bunkers have as yet been built. The other buildings, such as mess house, office, etc., are of a temporary nature. Pls. V, *B* and VI, *A* show the appliances at the mouth of this mine and the method of loading the fuel on steamers. About fifteen men in all are employed during the summer season, while the mine is in operation. These miners are mostly men who have had some experience in the coal mines of the State of Washington. Should the demand for coal warrant it, a slope will probably be driven to lower levels and a hoisting and pumping plant be provided. With such an equipment this mine could no doubt supply all the demand for coal on this part of the Yukon for many years to come.

[a] Coal Resources of Alaska, p. 556.



A. BARGE LOADING COAL AT WILLIAMS MINE.



B. NULATO, INDIAN VILLAGE, SHOWING WOOD PILES ON RIVER BEACH.

Coal mine No. 1.—This mine is situated on the right bank of the Yukon 25 miles below the Williams mine. Above and below this place for several miles there are sandstone bluffs rising about 50 feet above the river. At the coal mine the bluffs recede and a bench about 50 feet high appears between them and the river. The opening to the coal mine is located on this bench.

The sandstones containing this coal also carry fossil plants, but the collection made was too meager to permit determination of their age.

These beds strike N. 60° W., and at the coal mine dip 35° SW. About 1 mile above this place the sandstones have the same strike, but dip to the northeast at an angle of 25°, indicating an anticlinal structure, with the coal bed exposed on the southwestern limb.

The coal seam has a thickness of from 2½ to 3 feet. The following analysis of a sample taken from the croppings of this vein near the old entrance to the mine indicates a good quality of bituminous coal. The croppings where the sample was obtained were exposed to the sun, and in all probability the amount of water in freshly mined coal would be somewhat greater than this analysis shows:

Analysis of coal (sample No. 288) from coal mine No. 1, 80 miles below Kaltag.

[Analyst, E. T. Allen, U. S. Geol. Survey.]

	Per cent.
Water	4.82
Volatile combustible matter	34.62
Fixed carbon	55.65
Ash	4.91
	100.00
Sulphur	0.21
Fuel ratio	1.61

Coke sinters slightly.

The Alaskan Commercial Company attempted to open a coal mine here in the winter of 1898. W. E. Williams was manager of these operations, and 900 tons were produced, but the mine was abandoned the same year on account of the difficulty of keeping out water. The mine buildings still left include one frame building and two cabins. The workings included a 9 by 7 foot slope tunnel, which at the time of the writer's visit was full of water.

Halls Rapids.—These so-called rapids, which are merely a slight acceleration of the sluggish current of the Yukon, are about 50 miles above Anvik. There a series of bluffs composed of white and yellowish tuffs, containing some impure lignite seams, extends along the right bank of the Yukon. Some of these lignite beds have been opened by shallow prospect tunnels. About one-half mile below the so-called rapids a seam of coal about 6 inches thick was seen in this tuff. This cropping has been traced several hundred feet, but the bed is probably not very extensive. The coal has a compact, lignitic appearance and

a conchoidal fracture. The analysis indicates a fuel of good quality, but the coal is not believed to have any economic value because of its limited extent.

Anvik River.—Mr. J. W. Chapman, missionary at Anvik, reported to the writer the occurrence of coal on Anvik River about 50 miles above its mouth. This point is probably about 10 miles back from the Yukon, and in a general way west of the sandstone bluffs in which the Williams mine coals occur, and probably represents a western extension of the same field. No attempt has been made to open this coal, but it finds a limited use among the natives in their manufacture of black paint.

CLASSIFICATION OF YUKON COALS.

The coals of the Yukon Basin occur in sandstones of Tertiary and Cretaceous age and present great variations in quality, due probably in part to primary differences in composition and in part to metamorphic influences which have acted more or less locally. They range from high-grade lignites to semibituminous coals.

In the classification of the Yukon coals some uncertainty and confusion arise from the distinction to be made between lignites and bituminous coals. The same confusion prevails in regard to the coals of western United States.[a]

The geologists who first studied the coal fields of the Rocky Mountain region, finding that the coals were contained in rocks younger than the Carboniferous, classed as lignites all of the post-Paleozoic coals. The same classification, based on stratigraphic position rather than character of the coal, has been carried to Alaska, and many coals shown by their analyses to be bituminous have been classed as lignites.[b] The table of analyses on page 61 shows that many of the Yukon coals compare favorably with coals classed as bituminous in eastern United States.

The fuel value of coal is to a certain extent indicated by the fuel ratio.[c] This varies from less than 1 in lignites and some cannel coals to more than 20 in some anthracites. In lignites, as the fuel ratio decreases the percentage of water increases. In general,[d] it may be

[a] Knight, Wilbur C., Coals and coal measures of Wyoming: Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 4, 1895, pp. 208–215. Hills, R. C., Coal fields of Colorado: Mineral Resources U. S. for 1892, U. S. Geol. Survey, 1893, pp. 319–365. Taff, J. A., Preliminary report on Camden coal field of southwestern Arkansas: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 313–329. Taff and Adams, Geology of eastern Choctaw coal field, Indian Territory: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 257–311. Storrs, L. S., The Rocky Mountain coal fields: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, pp. 422–471. Hayes, C. W., Coal fields of the United States: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, p. 19.

[b] Dall, W. H., Report on coal and lignite of Alaska: Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, pp. 763–908. Brooks, Alfred H., Coal resources of Alaska: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, pp. 515–571. Summary Report Geol. Survey of Canada, 1901, pp. 46–48.

[c] The fuel ratio is the quotient obtained by dividing the percentage of fixed carbon by the percentage of volatile combustible matter.

[d] Hayes, C. W., Coal fields of the United States: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, p. 19.

stated that an anthracite has a fuel ratio above 10 and a bituminous coal has a fuel ratio between 1 and 5. There are two grades between the bituminous and the anthracite: Semianthracite, with a fuel ratio from about 7 to 10; and semibituminous, with a fuel ratio from 5 to 7. Cannel is a variety of bituminous coal which is characterized by a low fuel ratio, often less than 1.

In distinguishing between the lignite and bituminous grades of coal the problem is more complex, and three elements must be considered: First, fuel ratio; second, content of water; and third, physical character of the coal, as shown by the presence or absence of woody structure. Dr. Hayes has suggested to the writer that a lignite may be distinguished from a bituminous coal by its having a water content above 10 per cent and a fuel ratio less than 1.[a] The relation of the two elements can be expressed by the quotient of the water content divided by the fuel ratio. This might well be called the lignite ratio, and is above 10 for a lignite and less than 10 for a bituminous coal. By the use of this ratio, the physical character of the coal being neglected, it is found that nearly all the coals that have been classed as lignites by physical character alone fall readily into that class, while the bituminous coals are as certainly distinguished.

As there is no definite dividing line between bituminous and anthracite, so the variation from lignite to bituminous is gradual, and an intermediate division or grade is often required between the typical lignite, with a water content above 15 per cent and a fuel ratio not above 0.5, and the typical bituminous coal, with a fuel ratio near 1.5 and a water content under 7 per cent. If the above-mentioned lignite ratio be accepted as the basis of separation, it will be seen that typical lignites and typical bituminous coals can be recognized from their analyses by inspection. It is only in doubtful cases that the lignite ratio is required to determine the grade of the coal. The writer would suggest that, where a definite classification is required, doubtful cases in which the lignite ratio falls between 9 and 11 should be classed as intermediate between the lignites and the bituminous coals.

In the grades of coal between bituminous and anthracite the terms semibituminous and semianthracite are both made use of as trade names in the United States. A logical classification and nomenclature would require a similar use of the terms semilignite and semibituminous for the grades of coal between lignite and bituminous. Such use seems to have been made of the term semibituminous in the coal fields of the Rocky Mountain region.[b]

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[a] The same statement is made by J. A. Taff, Preliminary report on the Camden coal field of Arkansas: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 326.

[b] Storrs, S. L., Rocky Mountain coal fields: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, p. 424. Hills, R. C., Coal fields of Colorado: Mineral Resources U. S. for 1892, U. S. Geol. Survey, 1893, pp. 319–365. Knight, W. C., Coal fields of Wyoming: Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 4, 1895, pp. 208–215.

To avoid confusion with the usages in the eastern coal fields of the United States, the writer in the following classification has made use of the term lignitic coal for those grades which by approximate analysis fall between typical lignite and typical bituminous. The lignitic coals of the following table are coals in which the quotient of the fuel ratio divided by the percentage of water falls between 9 and 11 in value.

In the following table of analyses (p. 61) of coals from the Yukon Basin many heretofore published analyses have been added to those made for the writer from samples collected the past season. The authority for these old analyses is given. The samples collected by the writer and analyzed by Dr. E. T. Allen, of the United States Geological Survey, were treated as follows: On being collected they were placed as soon as possible in tin cans, with tight-fitting covers, to prevent escape of moisture. The samples, however, were collected under extremely varying conditions, some being taken from the breasts and faces of the mines, some from mine dumps and from piles of coal already delivered to the consumer, and some from surface croppings of undeveloped coal beds. On their arrival in the laboratory it was found that the amount of moisture contained in the cans with the samples varied greatly, depending on the condition of the samples when collected, whether from wet or dry places in the mines, or, if from mine dumps, whether taken on rainy or fair days. To secure uniform conditions the samples for analyses were spread on a table in a vacant room, of which the outside windows were open, and left exposed to the air for about twenty-four hours. They were then crushed and prepared for analysis in the ordinary way.

In the second table a comparison is made between the Yukon River coals and some from Washington and British Columbia.

Table of proximate analyses of coals from the Yukon Basin, arranged in geographic sequence, proceeding down the river.

Locality.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Fuel ratio.	Character of carbon residue.	Character of coal.	
Lewes River, 5½ miles above Rink Rapid [a b]	6.03	36.92	49.03	8.02	.....	1.33	.....	Bituminous.	
Five Fingers mine [c]	3.58	41.05	43.11	12.26	0.38	1.05	Slightly coherent	Do.	
Coal Creek (Klondike River), upper seam [a d]	18.31	34.96	40.88	5.85	.....	1.17	"Coking"	Lignite	Circle province.
Coal Creek (Klondike River), lower seam [a d]	19.37	33.85	37.45	9.33	.....	1.11	.....	do	
Coal Creek (Yukon River), middle of, 5-foot bed. [c]	12.57	39.54	41.98	5.91	.....	1.06	Slightly coherent	do	
Coal Creek (Yukon River), bottom of, 5-foot bed. [c]	10.58	38.42	31.54	19.96	.80	.82	do	do	
Cliff Creek, upper working, Yukon River [a e]	8.57	42.04	45.77	3.62	.....	1.08	"Coking"	Bituminous (?)	
Cliff Creek, lower working, Yukon River [a e]	10.58	40.10	46.74	2.58	.....	1.16	.....	Lignitic	
Cliff Creek, Yukon River [a f]	18.0	44.3	33.6	3.1	.82	.75	.....	Lignite	
Do. [a f]	16.0	35.5	38.5	10.0	Trace.	1.08	.....	do	
Do. [a f]	16.6	42.9	25.5	15.0	.....	.59	.....	do	
Do. [a f]	12.5	37.5	34.6	15.4	.....	.92	.....	do	
Do. [a f]	9.98	44.08	40.99	4.95	2.37	.93	.....	Lignitic	
Cliff Creek, lower workings [c]	10.71	41.33	45.33	2.63	1.06	1.10	Slightly coherent	do	

[a] Brooks, Alfred H., Coal resources of Alaska: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, p. 565.
[b] Dawson, George M., Exploration in the Yukon District and British Columbia: Geol. Survey Canada, 1887–88, new series, vol. 3, pt. 1, p. 149 B. Analysis by G. C. Hoffmann, Geol. Survey Canada.
[c] Samples collected by Arthur J. Collier. Analysis by E. T. Allen.
[d] McConnell; op. cit., p. 46. Analysis by Geol. Survey Canada.
[e] McConnell, R. G., Summary Report for 1901, Geol. Survey Canada, p. 48. Analysis by Geol. Survey Canada.
[f] North American Trading and Transportation Company.

Table of proximate analyses of coals from the Yukon Basin, arranged in geographic sequence, proceeding down the river—Continued.

Locality.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Fuel ratio.	Character of carbon residue.	Character of coal.	
Small creek emptying into Yukon below Coal Creek.[a b]	6.24	43.94	47.74	2.08	.....	1.08	.....	Bituminous	Circle province.
American Creek, Yukon River[a c]	6.75	39.13	37.59	16.53	3.40	.96	"Noncoking"	Bituminous (?)	
Nation River mine, Yukon River[d]	1.39	40.02	55.55	3.04	2.98	1.39	Firmly coherent[e]	Bituminous	
Washington Creek, 10 miles from Yukon[d]	13.48	43.74	39.68	3.20	.24	.91	Not coherent	Lignite	
Washington Creek, 12 miles from Yukon[d]	11.13	42.58	44.20	2.10	.26	1.04	.....do	Lignitic	
Miller's mine, nearly opposite mouth of Hess Creek, Yukon River.[a b]	7.29	37.38	36.91	18.42	.....	.98	.....	Bituminous (?)	Rampart province.
Drew mine, 13-inch bench[d]	9.58	36.87	39.83	13.72	.33	1.08	Not coherent	Lignitic	
Drew mine, 25-inch bench[d]	9.54	40.09	37.35	13.02	.....	.93	.....do	.....do	
Drew mine, lower bed[d]	14.44	47.15	33.77	4.64	.....	.72	.....do	Lignite	
Minook Creek, 2 miles from Yukon River[d]	11.21	44.32	38.64	5.83	.....	.87	.....do	.....do	
Yukon River, 2 miles below Rampart[d]	16.43	41.09	53.22	7.26	.....	.86	.....do	.....do	
Cantwell River, below Rampart.[f]	13.02	48.81	32.40	5.77	.16	.66	.....do	.....do	
Nahoclatilten, 55 miles above Nulato[d]	6.88	41.82	48.93	2.37	.65	1.17	Slightly coherent	Bituminous	Nulato province.
Upper Koyukuk[a g]	4.47	34.32	48.26	12.95	.....	1.40	"Noncoking"	.....do	
Twelve miles above Nulato on the Yukon[a g]	0.86	25.75	66.51	6.88	.....	2.22	"Coking"[e]	.....do	
Pickart mine, 200 feet from entrance[d]	1.02	27.33	65.03	6.62	.56	2.37	Compactly coherent[e]	.....do	
Pickart mine, 600 feet from entrance[d]	1.64	24.98	58.18	15.20	.....	2.32	.....do.[e]	.....do	
Small coal bed above Pickart mine[d]	2.22	24.76	50.38	22.64	.56	2.03	Slightly coherent	.....do	
Bush coal, 4 miles below Nulato[d]	11.17	29.48	52.02	7.33	.44	1.76	Not coherent	.....do	
Blatchford mine, 9 miles below Nulato[d]	1.36	22.44	73.98	2.22	.52	3.29	Slightly coherent	.....do	
Williams mine, upper bench[d]	6.15	46.46	49.86	3.53	.53	1.22	Not coherent	.....do	

Williams mine, lower bench[d]	7.17	33.05	51.15	8.63	.40	1.52	....do	....do
Coal mine No. 1[d]	4.82	34.62	55.65	4.91	.21	1.60	Slightly coherent	....do
Halls Rapids[d]	8.23	37.88	51.08	2.81	.42	1.35	Not coherent	....do

[a] Brooks, Alfred H., Coal resources of Alaska: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, p. 565.
[b] Spurr, J. E., Geology of the Yukon gold district: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, p. 382. Analysis by H. N. Stokes, U. S. Geol. Survey.
[c] Barnard, E. C., Maps and descriptions of Alaska, U. S. Geol. Survey, 1898, p. 81. Analysis by U. S. Geol. Survey.
[d] Samples collected by Arthur J. Collier. Analysis by E. T. Allen.
[e] Will probably make a coke of commercial value.
[f] Samples collected by Alfred H. Brooks. Analysis by E. T. Allen.
[g] Schrader, F. C., Reconnaissance along Chandlar and Koyukuk rivers, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 485–486. Analysis (not published) by George Steiger, U. S. Geol. Survey.

Comparison of average analyses of coals from Yukon River, southern Alaska, British Columbia, and Pacific coast.

	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Fuel ratio.
Average composition of 9 Yukon River lignites	11.89	41.11	40.82	6.20	0.89
Average composition of 9 Yukon River bituminous coals	4.69	32.05	55.89	6.97	1.85
Average composition of 5 Cook Inlet lignites [a]	11.59	49.03	31.64	7.73	0.64
Average composition of 4 Alaska Peninsula coals [a]	2.05	39.23	49.92	8.77	1.27
Composition of Lisburne coal [b]	3.75	43.75	47.39	5.11	1.08
Average composition of 3 coals from vicinity of Controller Bay [a]	.76	13.42	81.68	4.12	6.06
Average composition of 15 Vancouver Island coals, chiefly from Nanaimo and Comax [a]	.....	30.33	60.23	9.44	1.98
Average composition of 10 standard coals from the State of Washington [c]	4.43	31.60	56.01	7.45	1.77

[a] Brooks, A. H., Coal resources of Alaska: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, p. 552.

[b] Ibid., p. 566.

[c] Smith, G. O., Coal fields of the Pacific coast: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, p. 490.

SUMMARY.

CHARACTER AND VALUE OF YUKON COALS.

The coals that have been mined in the Yukon Basin are high-grade lignites and rather low-grade bituminous coals. With the exception of that at Nation River all the coals examined in the Circle and Rampart provinces are lignites, or at least lignitic, those of the Circle province probably being of a little higher grade than those of the Rampart province. All the coals examined in the Nulato province fall within the bituminous grade.

In the Circle province the best coal by proximate analysis is that mined a few years ago at Nation River. This is a bituminous coal rich in hydrocarbons and having a low percentage of water and ash. Its percentage of sulphur, however, is higher than that of any other coal examined by the writer, and the supply is limited and uncertain. Some rather low-grade bituminous coal, with a high percentage of ash, has been mined at the Five Finger mine, on Lewes River, 200 miles above Dawson and beyond the limits of the Circle province. The main coal supply of this province, however, is to be found in the lignite-bearing areas. At Cliff Creek, in Canadian territory, these lignites have been developed and yield an abundant supply of coal which gives good satisfaction for steaming purposes. The limits of

this coal field have not been determined, but there are probably between 50 and 100 square miles of coal land contiguous to this mine, the greater part of which lies some distance from the Yukon.

In American territory, on Washington Creek, about 12 miles from the Yukon, there is another large field, which will probably yield a considerable supply. This coal is a lignite, and is, so far as the analyses show, of slightly lower grade than that at Cliff Creek.

In the Rampart province the coal field of the Drew mine is the only one which has immediate value, and it is of very limited extent, the area of coal-bearing rocks probably not exceeding 4 square miles. The coal is a lignite, containing higher percentages of water and ash than the standard coals of the Circle province.

In the Nulato province coal has been exploited at a number of localities in the coal-bearing rocks which extend along the Yukon for 200 miles. The coal beds are usually rather thin, none of them measuring over 4 feet, and some of the seams are so crushed by shearing faults of the inclosing strata that systematic mining is difficult. At Williams mine, 90 miles below Nulato, in this belt, the coal bed is regular and holds a uniform thickness as far as development has gone. The conditions are favorable for producing a large amount of coal. With proper development the mine can probably supply all the coal that will be required on this part of the Yukon for many years. The coal here is bituminous, having a fuel ratio of from 1.2 to 1.5 and a water content below 7.5 per cent.

Coal of a better grade is found at the Pickart mine and at the Blatchford mine, also in this province, but the beds are faulted and the conditions for producing coal are not favorable. At the latter mine the coal is by proximate analysis the best found by the writer on Yukon River, having a fuel ratio of 3.3, water content below 2 per cent, and ash below 3 per cent.

Many steamboat men prefer the lignitic coal from Cliff Creek mine to the coals from the vicinity of Nulato. This is probably to be accounted for in part by the character of the grates on which it is burned, since the Cliff Creek coal burns more freely and produces heat more quickly than do the coals of the lower river.

The lignites of the Circle and Rampart provinces are contained in sandstones of Eocene age, correlated with the Kenai series. The bituminous (Nation River) coal of the Circle province is probably of Permian age, while the bituminous coals of the Nulato province are contained in a series of sandstones in part Upper Cretaceous and in part Eocene in age, which has not yet been separated on stratigraphic or lithologic grounds. The Pickart and Blatchford coals are Upper Cretaceous, while the Williams coal is Eocene, in age.

PRESENT DEVELOPMENT AND METHODS OF MINING.

In 1866 Dall examined a bed of coal 7 miles below Nulato, but up to the time of the discovery of gold on Klondike River, in 1897, little was done toward opening coal mines on the Yukon. With this discovery and the consequent influx of people, the Cliff Creek mine, in Canadian territory, and the Nation River, Drew, Pickart, Blatchford, and Whelp & Thein (Williams) mines, and Coal mine No. 1, were opened up, and have supplied a limited amount of coal, both for steaming on the Yukon and for domestic purposes at Dawson.

The methods of mining coal heretofore employed have been most primitive, and the workings of very limited extent, largely because the demand for coal is supplied by small amounts delivered on the river bank during the months from June to September, inclusive. Timber is convenient, and ventilation is easily obtained by air shafts to the surface, for in this climate there is always a great difference in temperature between the air in the mine and that outside. No trouble with gas has yet been experienced, and safety lamps have not been required. This may be accounted for by the fact that the workings have not penetrated beyond the zone of perpetual frost. Care must be exercised with the lignites of the Circle and Rampart provinces to prevent spontaneous combustion after the coal is mined. Instances are reported where the beds have been on fire, but none came under the observation of the writer. With the exception of the Drew mine, near Rampart, none of the mines along the Yukon, in American territory, are equipped with bunkers or other conveniences for loading the coal on steamers. The coal is piled on the river bank and loaded with wheelbarrows. Most of the mines are so situated that mine cars convey the coal directly to the river's edge at the mine's mouth. At Nation River the coal was mined about 1½ miles from the river and sledded over the snow in winter to the landing. On Washington Creek a similar plan is proposed until a railroad can be built. At Cliff Creek, the North American Transportation and Trading Company's mine, there is a narrow-gage railroad from the river bank to the mine, a distance of 2½ miles. At the Blatchford mine, 9 miles below Nulato, the coal is mined in the winter, for the opening to the mine is below the water at ordinary stages of the river, and during the summer months the mine is flooded. After the freeze-up the ice is mined out before the coal is reached. The coal from the mine must be sledded to ground above the high waters that occur on the breaking of the ice in the spring.

Since the Yukon coal beds have been worked only for the last five years, and then in a desultory way, the whole amount of coal produced in American territory has not been great, probably not exceed-

ing 9,000 tons, which has been sold at from $10 to $20 a ton. Probably the average price paid for such coal has not been far from $14 a ton, representing a value of about $76,000.

FUTURE DEVELOPMENT.

The coal mined on the Yukon has been burned principally on river boats for steaming purposes. A smaller amount has been consumed for domestic purposes at Dawson and other points along the Yukon. The coal has been used in competition with wood cut along the river, and as the supply of wood becomes exhausted the demand for coal will naturally increase. There is, however, sufficient timber conveniently accessible along the Yukon to supply wood to meet the present demands for some years to come. The important advantage of coal over wood for steaming purposes consists in its more compact form, so that a greater amount of fuel can be taken on at one time. It is also loaded more quickly than wood, even by the primitive methods in vogue at the present time. At Dawson coal from the Five Finger mine or from Cliff Creek is worth from $15 to $20 a ton. The Electric Lighting Company had contracted for 1,500 tons of the former coal at $15. Wood sells at about $10 a cord at Dawson. Coal delivered at the river bank from the Yukon mines brings from $10 to $12 a ton. Cord wood varies very greatly in price, but probable averages about $8 a cord.

During the summer of 1902 coal could be obtained at only two points on the Yukon below Dawson. These points were nearly 1,000 miles apart, and there were no conveniences for loading at either of them. With the development of the oil fields in southern California and the consequent cheapening of crude oil as a fuel, some of the companies operating steamers have begun making arrangements to use this oil for steaming purposes on the Yukon. Should the use of oil prove practicable, it will retard the development of the Yukon coal mines. The oil can probably be purchased and transported to depots along the Yukon at an expense little, if any, greater than the cost of coal or wood at present prices. After these depots are established from three to four hours daily will be saved, which, under the present arrangement, is spent in taking on wood or coal. Since oil can readily be made to flow on board from the oil tanks, and as the oil burners are self-feeding, the services of a large force of deck hands and firemen will be dispensed with.

The coal beds of the Yukon will probably never supply coal for exportation, because of their limited extent, the character of the coal, the cost of mining, and the distance from a market, but with proper development they will probably be sufficient to supply all local demands that are at present foreseen.

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PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Bulletin No. 218.]

The serial publications of the United States Geological Survey consist of (1) Annual Reports, (2) Monographs, (3) Professional Papers, (4) Bulletins, (5) Mineral Resources, (6) Water-Supply and Irrigation Papers, (7) Topographic Atlas of United States—folios and separate sheets thereof, (8) Geologic Atlas of United States—folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists may be had on application.

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