UNITED STATES DEPARTMENT OF THE INTERIOR
Harold L. Ickes, Secretary

GEOLOGICAL SURVEY
W. C. Mendenhall, Director

Bulletin 849

INVESTIGATIONS IN ALASKA RAILROAD BELT, 1931

BY

PHILIP S. SMITH AND OTHERS

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1933

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IN THE
ANTHRACITE RIDGE DISTRICT
ALASKA

BY

RALPH W. RICHARDS and GERALD A. WARING

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For sale by the Superintendent of Documents, Washington, D.C. - - - - - - Price 5 cents

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NOTE.—Bulletin 849 will not be issued as a complete volume, but the last chapter will contain a volume title page and index for the use of those who may wish to bind together the separate chapters.

INVESTIGATIONS IN ALASKA RAILROAD BELT, 1931

FOREWORD

By Philip S. Smith

To help the mining industry of Alaska and to assist in the development of the mineral resources of the Territory have been the prime motives of the Geological Survey's investigations in Alaska during the past 35 years, in which nearly one half of the Territory has been covered by its reconnaissance and exploratory surveys. It was natural, therefore, that the Alaska Railroad, when it undertook intensive consideration of the problem of finding tonnage that would increase its revenues, should look to the Geological Survey to supply technical information as to the known mineral deposits along its route and to indicate what might be done to stimulate a larger production of minerals and induce further mining developments and prospecting that would utilize its service. Realization of the need for this information had long been felt by the officials responsible for the operation of the Alaska Railroad, and the need had been partly supplied by the Geological Survey, but funds to carry through an extensive inquiry of this sort had not been available until 1930, when a special committee of the Senate, composed of Senators Howell, Kendrick, and Thomas, visited Alaska, studied some of the railroad's problems, and successfully urged Congress to grant it $250,000 for investigations of this kind.

On the invitation of the Alaska Railroad the Geological Survey prepared various plans and estimates for the investigations that appeared to be most likely to contribute the desired information as to the mineral resources. Selection of the problems to be attacked proved difficult, because the choice necessarily was hedged about with many practical restrictions. For instance, each project recommended must give promise of disclosing valuable deposits—a requirement that was impossible to satisfy fully in advance, as it involved prophecy as to the unknown and undeveloped resources. Then, too, it was desirable that the search should be directed mainly toward disclosing deposits which if found would attract private enterprises to undertake their development in the near future. Finally, some of the deposits that might be worked profitably did not appear likely to afford much tonnage to be hauled by the railroad. Under these limitations it should be evident that the projects that could be recommended as worth undertaking with the funds available by no means exhausted the mineral investigations that otherwise would be well justified. In a large sense, all of Alaska may properly be regarded as indirectly contributory to the welfare of the railroad, but even in that part of Alaska contiguous to its tracks there are large stretches of country that are entirely unexplored and large areas that have had only the most cursory examination. Although areas of this sort might well repay investigation, they were excluded from the list of projects recommended because they were not known to contain mineral deposits of value, and it therefore seemed better to make the selection from other areas that had been proved to hold promise. Furthermore, several areas within the railroad zone were excluded because their value was believed to lie mostly in their prospective placers, which would not yield much outgoing tonnage; others because their lodes carried mainly base metals, for which development and the recovery of their metallic content in a readily salable condition were relatively expensive; and still others because their resources consisted mainly of granite, building stone, or some other product for which at present there is only a small local demand.

After careful consideration ten projects were selected, and the funds required for undertaking them were made available. The projects that were selected involved the examination of two areas principally valuable for their coal (Anthracite Ridge and Moose Creek), five areas likely to be principally valuable for gold (Fairbanks, Willow Creek, Girdwood, Moose Pass, and Valdez Creek), and three areas whose lodes consisted mainly of mixed sulphides (the Eureka area in the Kantishna district, Mount Eielson, formerly known as Copper Mountain, and the head of West Fork of Chulitna River). The general position of these different areas is indicated on the accompanying diagram (fig. 1). A general study of the nonmetalliferous resources of the entire region traversed by the railroad was included in the projects to be undertaken, but the results obtained were not such as to permit adequate determination of their extent at this time.

Examinations were made in the field in each of the selected areas, all the known prospects and mines being critically examined and sampled so far as time and other conditions permitted. The records thus obtained, together with all other information bearing on the problems, were then subjected to further study in the laboratory and office, in the course of which other Geological Survey specialists whose knowledge and experience could be of assistance were freely consulted. The outcome of all these lines of analysis has been the reports which make up this volume. Although each chapter is presented as embodying the latest and most authoritative information available regarding the districts and properties described up to the time field work in them

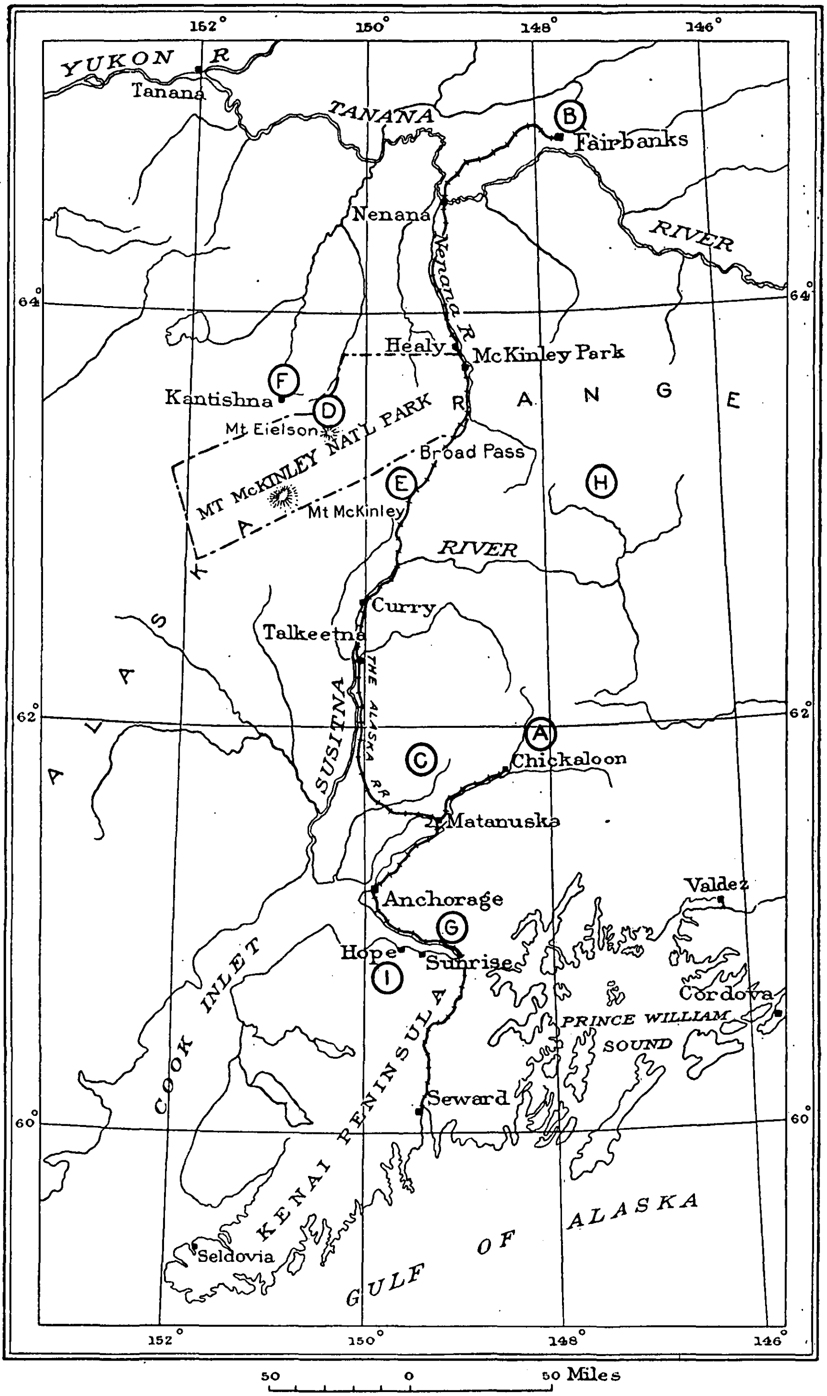


FIGURE 1.—Index map showing areas investigated in Alaska Railroad belt, 1931. A, Anthracite Ridge; B, Fairbanks; C, Willow Creek; D, Mount Eielson; E, West Fork of Chulitna River; F, Eureka and vicinity; G, Girdwood; H, Valdez Creek; I, Moose Pass and Hope

was finished, the authors make no claim that all the results they have presented are to be regarded as final nor as solving all the problems that have arisen. Actually none of the mines have been developed to such an extent as to furnish all of the evidence desired to solve the problems involved. At none of the properties is any considerable quantity of ore actually "blocked out" in the engineering sense of that term, so that instead of specific measurements as to the quantity and grade of ore the different camps will yield, the Survey geologists and engineers have necessarily had to make numerous assumptions and be content with estimates and generalizations as to the potential resources. Furthermore, the work was planned so as not to invade the proper field of the private mining engineer in the valuation of individual properties, but rather to occupy the open field of considering the districts as a whole.

In two of the districts, Anthracite Ridge and Moose Creek, whose value lay in their prospective coal resources, the examinations that could be made by ordinary geologic means were not adequate to arrive at a final judgment of the resources of the area but pointed to the desirability of further tests by drilling. As a consequence additional exploration of these districts by means of diamond drilling was authorized, and this work was undertaken in the season of 1932. The results of these tests were not available at the time the manuscripts of the other reports were completed, and rather than delay their publication until the later reports could be finished and incorporated in the volume these reports have been omitted here and will be published later elsewhere.

This is not the place to summarize the detailed findings of the geologists as to the merits of the different districts, as those findings are explained in detail and summarized in the respective chapters. Suffice it to say here that on the whole the principal purpose of the investigations was carried through satisfactorily and that while the studies in some of the districts indicate that they hold little promise of extensive mineral development in the near future, others appear to encourage development under existing conditions, and still others seem to be worth development when some of the existing factors such as transportation or price of base metals are improved. That conditions which are now temporarily retarding the development of some of the deposits will become more favorable cannot be doubted. The entire region is becoming more accessible each year, and as a result costs are being lowered and experience is being gained as to the habit of the various types of deposits, so that the conclusions expressed in this volume as to the resources of the different districts should be reviewed from time to time in the light of the then current conditions.

PROGRESS OF SURVEYS IN THE ANTHRACITE RIDGE DISTRICT

By Ralph W. Richards and Gerald A. Waring

ABSTRACT

Anthracite Ridge is in south-central Alaska, on the north side of the Matanuska River Valley, about 200 miles north of Seward, the coastal terminus of the Alaska Railroad.

The specific object of the investigations in this field during the summer of 1931 was to collect information regarding the character and extent of the anthracite deposits. These studies were carried on in connection with similar intensive studies of deposits of other kinds of minerals throughout the country tributary to the Alaska Railroad.

The coal basin is about 4 miles wide and 7 miles long and lies between the ridge and the Matanuska River. The basin is in general synclinal, sharply folded and faulted along its north border. The coal beds are in the Chickaloon formation, of Tertiary fresh-water deposits, intruded by igneous dikes and sills and unconformably overlying marine Upper Cretaceous beds.

The geologic section as partly exposed in the valleys of the creeks crossing the coal basin show that the coal-bearing formation consists chiefly of shales, with minor lenticular beds of sandstone and conglomerate. A dozen or more coal beds are found in a zone of several hundred feet belonging to either the lower or the middle portion of the Chickaloon formation.

Many of the coal beds range from a few inches to about 8 feet in thickness; but in one locality on the northwest border of the basin exceptional thicknesses of 34 and 24 feet were measured. These beds and others near by are of low-rank anthracite or semianthracite and are found in closely folded and faulted sediments further complicated by igneous intrusions. Most of the coal exposed in the southern and eastern parts of the basin is found in relatively thin beds and is of semibituminous to bituminous grade.

In the absence of actual development work scant reliable data are available from surface exposure for estimating the coal reserves of the basin. The most definite data are furnished by the locality showing the highest-rank coal, in the S½NW¼ sec. 12, T. 20 N., R. 7 E., where a conservative estimate indicates 750,000 tons of coal, which in this isolated locality can not be regarded as sufficient to justify an attempt at commercial development.

The synclinal area immediately adjacent on the south holds possibilities for development, although it is not yet proved that thick beds of coal of as high a rank as that in the hills to the north are included in this area. However, as it is part of the same basin of deposition and as the thin beds of lower-rank coal which are exposed on the south side of the basin may thicken and improve in quality across the area into the exceptionally thick beds on the north, it undoubtedly warrants further study.

Additional surface prospecting on the flanks of the syncline would only partly serve to clear up the problems involved, hence core drilling is regarded as the most practical means of reaching definite conclusions as to the presence of coal and as to its quality and extent.

Several sites were selected which promised the best possibility of determining the presence of low-rank anthracite within reasonable drilling depth, and a contract was entered into to obtain cores from these holes during the summer of 1932. These drill-hole samples should supply data for determining conclusively whether or not high-grade coal is present in sufficient amount to justify further investigation relative to its commercial development.

INTRODUCTION

LOCATION AND AREA

Anthracite Ridge (fig. 1) is in the south-central part of Alaska, on the north side of the eastern part of the Matanuska River Valley. It is best reached from the seacoast, at Seward, by the main line of the Alaska Railroad to Matanuska station, near the mouth of the Matanuska Valley, 151 miles from Seward, and thence up the branch line 37 miles to its terminus at Chickaloon. A trail leads thence eastward along the north side of the basin of the Matanuska River, and the south flank of Anthracite Ridge forms the northern boundary of the upper portion of the basin. The coal basin lies between the ridge and the river and has a width of about 4 miles. It is a structural basin limited on the east by the drainage basin of Packsaddle Creek and on the west by the drainage basin of Purinton Creek. This structural basin, traversed by the trail from Chickaloon, is about 20 miles east of that station. Its extent is about 7 by 4 miles, and its area about 25 square miles.

PREVIOUS SURVEYS

This area was first examined geologically in 1898, when it was traversed by a military expedition in charge of Capt. Edwin F. Glenn, Twenty-fifth Infantry, United States Army. To this party W. C. Mendenhall was attached as geologist, and the report of his observations was published in 1900.[1]

In 1905 the area was studied by G. C. Martin,[2] with special reference to the coal deposits, and in the following year by a party consisting of Sidney Paige and Adolph Knopf, geologists, and R. H. Sargent, topographer.[3]

In 1909 the lower part of the Matanuska Valley, including the area for 2 or 3 miles above Chickaloon, was mapped topographically by R. H. Sargent, and in the following year a detailed geologic survey of the area was made by G. C. Martin and F. J. Katz, assisted by Theodore Chapin.[4]

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

[2] Martin, G. C., A reconnaissance of the Matanuska coal field, Alaska, in 1905: U.S. Geol. Survey Bull. 289, 1906.

[3] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna Basins, Alaska: U.S. Geol. Survey Bull. 327, 1907.

[4] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U.S. Geol. Survey Bull. 500, 1912.

A topographic survey of the upper part of the Matanuska Valley, including the Anthracite Ridge district, was made by R. H. Sargent in 1913, and a geologic survey was undertaken by G. C. Martin and J. B. Mertie, Jr., assisted by R. M. Overbeck, with special attention to the coal resources. A preliminary report of their work was issued,[5] and also the results of further studies made by Martin[6] in 1917. In 1918 and 1919 additional data on coal mining near Chickaloon were obtained by Theodore Chapin.[7]

More comprehensive studies of the coal deposits and the mining at Chickaloon were made by Capt. W. P. T. Hill, T. E. Savage, and W. T. Foran, for the Navy Alaskan Coal Commission.[8]

In 1924, S. R. Capps, assisted by K. K. Landes, made further studies of the geology and mining developments in the area, with special attention to the structure and geology of the district.[9]

PRESENT INVESTIGATION

These earlier studies had shown the presence of anthracite and coals of lower rank in the Anthracite Ridge district, but their scope had not permitted intensive prospecting and tracing of the outcrops of the coal beds to determine their extent and thickness in sufficient detail to ascertain the commercial possibilities of the area.

In 1931 Congress requested and provided for a more thorough inventory of the natural resources of the region tributary to the Alaska Railroad, to facilitate the development of mineral deposits that might afford a source of sustaining revenue for the railroad. As the anthracite of this district, as shown by the analyses of the samples already obtained, compared favorably in quality with some anthracites of Pennsylvania, was in general superior to other grades of coal mined on the Pacific coast and far superior to the lower-rank coals now mined in the lower Matanuska Valley and Nenana River Valley, it appeared that intensive prospecting of this area might demonstrate that this high-rank coal, which was known to crop out at one locality in a bed over 30 feet thick, had a sufficient areal extent to justify exploitation. It was fully realized at the same time that, in addition to the question of tonnage, economic questions regarding utilization and markets would have to be considered before the expenditures involved in construction of additional transportation facilities could be regarded as warranted, but for the time it seemed essential to

[5] Martin, G. C., and Mertie, J. B., Jr., Mineral resources of the upper Matanuska and Nelchina Valleys: U.S. Geol. Survey Bull. 592, pp. 273–299, 1914.

[6] Martin, G. C., Geologic problems at the Matanuska coal mines: U.S. Geol. Survey Bull. 692, pp. 269–282, 1919.

[7] Chapin, Theodore, Mining developments in the Matanuska coal fields: U.S. Geol. Survey Bull. 712, pp. 131–167, 1920: Bull. 714, pp. 197–199, 1921.

[8] Hill, W. P. T., Final report of the Navy Alaskan Coal Commission to the Secretary of the Navy, 1922 (manuscript).

[9] Capps, S. R., Geology of the upper Matanuska Valley, Alaska, with a section on the igneous rocks, by J. B. Mertie, Jr.: U.S. Geol. Survey Bull. 791, 1927.

determine first of all how much high-rank coal was present in the area.

The specific object of the investigations here recorded was to collect all geologic information available from surface examination, in the hope that this information would permit a definite conclusion to be reached regarding the value of the anthracite deposits.

During the summer of 1931 two field parties, a topographic party in charge of L. O. Newsome, topographer, and a geologic party under R. W. Richards, geologist, were assigned to the area. Mr. Richards was assisted by G. A. Waring, geologist, during the second half of the field season. A base camp was established near Purinton Creek, on the bench on the south slope of Anthracite Ridge, at an elevation of 2,960 feet, on June 11, and maintained until September 13, 1931. Transportation connection with the railroad at Chickaloon was provided by a train of pack horses in charge of Len Oules, packer. Peter Sumanoff served as cook for the combined parties throughout the field season. The assistants to the topographic party were Fred Kubon, Sam Morgan, and Tom Scott. The laborers engaged in the prospecting work incident to the coal investigation for varied portions of the season were Hank Edwardson, foreman, Patrick McCullum, E. P. Shannon, Peter Toloff, Jake Angelo, and Frank Millich.

Outcrops of coal beds and blossom indicative of coal were examined during the season at many localities in the area; of these 72 are indicated on the accompanying map and briefly described in the list on pages 12–13. In addition, 40 localities, some of which are more fully described on pages 14–17, were prospected by pits or trenches to expose the coal beds more completely.

It was found impracticable because of thick overburden of alluvium and moss, to trace or correlate individual coal beds except for short distances, as in the case of the 30-foot anthracite bed, which was traced only about an eighth of a mile north and half a mile west of the principal outcrop, and consequently incomplete data were obtainable in the portion of the area lying on the south slope of Anthracite Ridge toward the Matanuska River, in which there is a possibility of high-rank coal being present at depth in sufficiently thick beds to afford commercial tonnage.

ACKNOWLEDGMENTS

The investigation was carried on under the general direction of S. R. Capps, geologist in charge of the projects in the Alaska Railroad belt, and his instructions and assistance, based upon his own previous experience in the area, were of the utmost value. Many courtesies were extended to the party by the Alaska Railroad, through the thoughtfulness and interest of Col. O. F. Ohlson, general manager. Special mention is due to the United States Bureau of Mines in affording prompt analytical service at the Anchorage laboratory, by

its chemist, Maurice L. Sharp. J. J. Corey, coal-mining engineer of the Anchorage office of the United States Geological Survey, rendered noteworthy assistance to the party at numerous times and places.

GEOGRAPHY

DRAINAGE

The Anthracite Ridge district (pl. 1) is drained by several creeks that flow southward from the crest of the ridge to the Matanuska River. In order eastward the principal ones are known as Purinton, Cascade, Winding, Muddy, and Packsaddle Creeks. All carry water throughout normal summers, derived chiefly from the melting snow of the uplands. Their headwaters have cut deep ravines in the steep upper slopes of Anthracite Ridge. In the middle portions of their courses, where they cross moderate slopes partly covered with glacial deposits, the streams have shallow winding channels. In their lower courses their gradients steepen again, and the streams have cut deep into the cliffs along the north border of the channel of the Matanuska River.

RELIEF

The valley of the Matanuska River, along the south border of the area under consideration, is from 1,100 to 1,300 feet above sea level. Cliffs 200 to 500 feet high border the north side of the river, and the surface thence rises at an average slope of 500 to 600 feet to the mile to the base of steeper slopes that in turn rise to the crest of the ridge, 5,000 to 6,000 feet above sea level. In its western part the fairly uniform southward slope of the surface is broken by several prominent east-west ridges and in its central part by minor ridges and hills.

CLIMATE

Although there is a range in elevation of 5,000 feet within this small area, the climate is not so different between its highest and lowest portions as might be expected, for the prevailing winds blow lengthwise of the Matanuska Valley, bringing storms from Cook Inlet. These sweep along the slopes of the ridge, with perhaps snow and sleet in the upper portions at the time of cold rain in the lower. The open season for the area as a whole is from about May 15 to September 15. About the middle of September in normal years the nights begin to be frosty, and two or three weeks later snow falls. The winter precipitation is not heavy, though 3 or 4 feet of snow may cover the ground until spring. June is perhaps the pleasantest month of the year; for in July, August, and early September there is likely to be a large proportion of days with rain and mist drifting up the valley from the inlet. The mean annual precipitation at Matanuska for 1917–21 was about 14 inches; the mean in the Anthracite Ridge district is probably somewhat higher. The records at Chickaloon for 1919–23 showed mean temperatures well below freezing for the months of November to March, but above 50° during June, July, and August.

VEGETATION

The lower half of the coal basin is partly timbered with spruce, with some birches and cottonwoods near the watercourses. Much of the southern portion has been burned over within recent years, however, and is covered with fallen timber and young second growth of birch and cottonwood. The timber line is at an elevation of about 2,800 feet, though along some of the shallow creek valleys spruce extends above 3,000 feet. The trees are nearly all less than 12 inches in diameter and because of their small size and distance from easy transportation have little commercial value.

In the sparsely timbered areas and on portions of some of the higher slopes there is sufficient grass in summer for the grazing of pack animals, but this feed is killed by the first sharp frost.

POPULATION AND ROUTES OF TRAVEL

In the basin of the Matanuska River above Chickaloon there were in 1931 no permanent inhabitants. There was a cabin on Boulder Creek occupied at times by hunters, a similar cabin beside the trail near Kutzkatna Creek, and one on upper Hicks Creek. Beside Tatondan Lake, near the mouth of Gravel Creek, on the south side of the Matanuska River, white hunters had established a camp. All these places were reached by the trail that leads northeastward from Chickaloon, parallel with Boulder Creek, and then swings south of east across the Anthracite Ridge district and eastward to the Nelchina gold-mining district, 40 miles away. The trail is kept in condition for pack-horse travel by the Alaska Road Commission.

GEOLOGY

PRINCIPAL FEATURES

In general the geology of the region represents three main groupings. The Chugach Mountains, south of the Matanuska River, are composed chiefly of granitic rocks, altered sedimentary rocks, and bedded volcanic materials. The Talkeetna Mountains, to the north of Anthracite Ridge, are composed largely of granitic rocks. Anthracite Ridge and the structural basin immediately south of it are composed of comparatively unaltered shales, sandy shales, and sandstones, and the basin includes also minor areas of intrusive igneous rocks, chiefly diabase.

STRATIGRAPHY AND STRUCTURE

Around the border of the basin marine Upper Cretaceous rocks (Matanuska formation) are exposed. These are mainly black shales, in which molluscan fossils have been found in a few places, and medium-grained indurated greenish-gray to brown sandstones. Over the main part of the basin dark-gray shales with minor beds of sandstone and conglomerate are exposed. Impressions of plant remains in many of the shale and sandstone beds and the presence of coal beds in some places show that the deposits are of fresh-water origin. These beds make up the Chickaloon formation, of Eocene age, which was first described by Martin and Katz [10] in 1912.

Considerable amounts of igneous rock, chiefly diabase, have been intruded into these sediments as sills. The larger masses exposed form prominent hills and ridges and are apparently 100 to 200 feet thick. Many of the smaller sills, however, are less than 20 feet thick, and some of the igneous bodies break across the bedding as dikes rather than sills. They are probably of Pliocene age.

The structure of the basin is synclinal, but with a broad upfold through the central part. On the north the beds are highly tilted, with faulting and close folding; and the rocks that form the crest of Anthracite Ridge are upfaulted above the beds of the lower slopes. The character of this folding and faulting is shown in the three cross sections of plate 2.

The folding along the flank of the eastern half of Anthracite Ridge is exhibited by a zone, 30 to 50 feet thick, of whitened conglomeratic sandstone underlain by whitened shale. This zone shows prominently on the bare slopes of dark shale and sandstone and is indicated on plate 1. Its extent and fairly uniform thickness suggest that the whitening was caused by heat generated from some source, possibly from intrusive igneous rocks. However, there are no evidences of an extensive sill which might have supplied the heat for this alteration of the rocks.

QUATERNARY DEPOSITS

During the glacial epoch the valley of the Matanuska River was evidently filled with ice, for glacial gravel is found on the slopes to an elevation of 4,500 feet and higher. The front of Matanuska Glacier, from which the Matanuska River issues, is about 8 miles east of the east border of the district under discussion. The lower portions of Packsaddle and Muddy Creeks cut through extensive deposits of glacial-moraine gravel and boulders, but the main part of the district is remarkably free from such material. For the most part only thin patches of gravel or scattered pebbles indicate the former presence of glacial ice over the whole valley.

[10] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U.S. Geol. Survey Bull. 500, pp. 42-52, 1912.

COAL

OUTCROPS

The only known mineral deposits of possible economic importance in the Anthracite Ridge district are the coal beds of the basin to the south of the ridge. This is structurally a separate basin from that of the Chickaloon area, to the west, where some mining of the coal has been done. Because of the presence of coal on the north side of the basin the area was surveyed by the United States General Land Office in 1915, and two tracts were designated as leasing units (nos. 18 and 19) of the Matanuska coal field. These were filed on by individuals, but no development work was done.

During the summer of 1931 about 40 prospecting openings were dug by the Geological Survey party in the area, mainly on obscure outcrops of the coal beds in an attempt to uncover concealed beds. From 14 of the openings 21 samples were collected by the writers and were analyzed by Maurice L. Sharp, chemist, of the United States Bureau of Mines, stationed at Anchorage. The results of his analyses are tabulated on page 22.

Outcrops of coal noted at other places in the area are shown on plate 1, and additional data concerning them are summarized in the following table:

Outcrops of coal in the Anthracite Ridge basin

Map no.	Location	Character	Total thickness Ft.	Total thickness in.	Dip of beds	Analysis no.	Rank
	T. 20 N., R. 7 E.						
1	NW¼SW¼ sec. 3	Coal, 5 beds	5		70° N. 25° E	4488	Semibituminous.
2	SE¼SW¼ sec. 3	Coal	2		70° N. 20° E		Unclassified.
3	SW¼NE¼ sec. 11	Coal, 3 beds	2	9	45° S. 30° W		Do.
4	NW¼SE¼ sec. 11	Coal	2		70° S	4484	Bituminous.
5	NE¼NW¼ sec. 12	do	4		45° S		Unclassified.
6	do	Coal, 4 beds	6	2	60° S		Do.
7	do	do	6	8	40° S. 20° W		Do.
8	SW¼NW¼ sec. 12	Coal	7	9	60° S. 25° E	4480	Semianthracite.
9	SE¼NW¼ sec. 12	Coal, 4 beds	8		30° S. 15° W	4490 (3′6″ bed)	Do.
10	do	Coal, 2 beds	5	10	25° S. 10° W	4487, 4390	Do.
11	do	Coal, 3 beds	6	4	30° S	4388, 4389	Do.
12	do	Coal, 4 beds	24		35° SW	4444, 4485, 4486.	Semianthracite and semibituminous.
13	SW¼NW¼ sec. 12	Coal	3		40° S		Unclassified.
14	SE¼NW¼ sec. 12	Coal, 6 beds	34		20° N. 20° E	4443, 4445, 4446, 4391	Semianthracite.
15	NE¼SW¼ sec. 12	Coal, broken	2		10° N. 30° E		Unclassified.
16	NW¼SE¼ sec. 12	do	6		30° S. 10° E		Do.
17	do	do	5		30° S		Do.
18	do	do	5		30° S. 10° E		Do.
19	do	do	3		30° S		Do.
20	do	do	2		30° S		Do.
21	NE¼SE¼ sec. 12	Coal	2		30° N. 20° E		Do.
22	SW¼NW¼ sec. 23	Coal and coaly shale.	3		70° N	4481	Bituminous.
23	NW¼SW¼ sec. 23	do	1		20° N. 20° E		Unclassified.
24	NE¼SW¼ sec. 23	Coal		6	20° N. 30° E		Do.
25	SE¼SW¼ sec. 23	Coal, 2 beds	3		50° N. 70° E		Do.
26	NW¼SE¼ sec. 25	Coaly shale	2		45° S. 80° E		Do.
27	NE¼NW¼ sec. 26	Coal, 6 beds	16	6	60° N. 20° E		Do.
28	do	Coal	1	6	60° E	4479	Semibituminous.
29	SW¼NE¼ sec. 26	Coal, 3 beds	1		50° S. 70° E		Unclassified.
30	NW¼SE¼ sec. 26	Coaly shale	1		10° NE		Do.

Outcrops of coal in the Anthracite Ridge basin—Continued

Map no.	Location	Character	Total thickness Ft.	in.	Dip of beds	Analysis no.	Rank
	T. 20 N., R. 8 E.						
31	SE¼NW¼ sec. 7	Coal	2		20° N., overturned		Unclassified.
32	NW¼SW¼ sec. 7	Coal and coaly shale.	4		30° N. 20° E		Do.
33	SW¼NE¼ sec. 7	Coal	2		80° N., overturned		Do.
34	SE¼NE¼ sec. 7	Coaly shale	2		20° N., overturned		Do.
35	NE¼SW¼ sec. 9	Coal		6	10° NW		Do.
36	SE¼SW¼ sec. 9	do	3		80° NW		Do.
37	SW¼SE¼ sec. 9	Coal, 5 beds, closely folded, on side of ridge.	8	3	80° N. 30° W.-80° S. 30° E.	4483	Bituminous.
38	SE¼SE¼ sec. 9	Coal, same as preceding, on crest of ridge.	20		60° N. 30° W		Unclassified.
39	do	Coal	2		50° S. 10° E		Do.
40	NW¼NW¼ sec. 15	Coal, 2 beds	1	6	Landslipped		Do.
41	SW¼NW¼ sec. 15	do	6		60° S., and faulted		Do.
42	NW¼SW¼ sec. 15	do	6		30° SW		Do.
43	SE¼SW¼ sec. 15	Coal	5		30° SW		Do.
44	NW¼NW¼ sec. 16	do	3		60° N		Do.
45	NE¼NW¼ sec. 16	do	3		60° N		Do.
46	do	Coal, several thin beds.	2		20° S. 20° E		Do.
47	NW¼NE¼ sec. 16	Coal, 4 beds	5	9	50° N. 30° W		Do.
48	NE¼NE¼ sec. 16	Coal	5		70° N. 20° W		Do.
49	SE¼NW¼ sec. 16	Coal, 8 thin beds	3		20° S.-80° N., overturned.		Do.
50	NE¼SW¼ sec. 16	Coal, several thin beds.	2		30° SW		Do.
51	do	Coal, also several thin beds.	6		30° SW	4489	Bituminous.
52	NW¼SE¼ sec. 16	Coal, several thin beds.	2		Landslipped		Unclassified.
53	NE¼NE¼ sec. 17	Coal	5		10° N. 10° E	4466	Bituminous.
54	NW¼NW¼ sec. 17	Coaly shale	2		60° SW		Unclassified.
55	NW¼NE¼ sec. 18	do	7		50° S		Do.
56	SW¼NE¼ sec. 19	do	1		30° S. 30° E		Do.
57	NE¼SW¼ sec. 19	do	1		10° S. 30° E		Do.
58	do	do	1		5° S. 30° E		Do.
59	NE¼NW¼ sec. 21	do	1		20° W		Do.
60	NE¼NE¼ sec. 21	do	1		10° NW		Do.
61	NE¼SE¼ sec. 21	Coal	2		30° S. 10° E		Do.
62	NW¼NW¼ sec. 22	Coal, 2 beds	10	1	20° NW	4482	Bituminous.
63	SE¼NW¼ sec. 22	Coaly shale	1		20° NW		Unclassified.
64	SW¼NE¼ sec. 27	Coal, 2 beds	2	9	60° W		Do.
65	NW¼SW¼ sec. 27	Coaly shale	1		30° NW		Do.
66	SE¼SW¼ sec. 27	Coal	1	4	30° N. 40° W		Do.
67	NW¼NE¼ sec. 30	Coaly shale		6	10° N. 30° E		Do.
68	SW¼NE¼ sec. 30	do	1		20° N. 30° E		Do.
69	SE¼NW¼ sec. 30	do		6	20° N. 30° E		Do.
70	NE¼NE¼ sec. 33	Coal	1		30° NW		Do.
71	NW¼NE¼ sec. 33	Coaly shale	1		40° N. 30° W		Do.
72	SE¼NW¼ sec. 33	do	5		40° N. 30° W		Do.

SECTIONS

Samples for analysis were taken mainly from pits in the NW¼ sec. 12, T. 20 N., R. 7 E., where the thickest beds and best quality of coal were found. The sections at nine of the ten localities listed in this quarter section and the beds sampled for analysis were as follows:

Sections in NW¼ sec. 12, T. 20 N., R. 7 E.

Locality 5

	Feet
Shale.	
Coal (semianthracite)	About 4
Shale.	

Locality 6

	Ft.	in.
Shale.		
Coal (semianthracite)	1	
Shale		6
Coal (semianthracite)	1	2
Bone		6
Coal (semianthracite)	3	
Bone		1
Coal (semianthracite)	1	
Bone		1
Shale, brown.		

Locality 7

	Ft.	in.
Shale.		
Coal (semianthracite)	3	
Diabase sill		6
Coal (semianthracite)	1	3
Shale		3
Coal (semianthracite)	1	3
Shale		2
Coal (semianthracite)	1	2
Shale, black.		

Locality 8

	Ft.	in.
Soil and broken coal.		
Coal (analysis 4480, of the 7 feet 9 inches of coal (semianthracite))	3	
Shale		3
Coal and clay	1	
Coal	4	9
Shale	2	

Locality 9

	Ft.	in.
Shale.		
Diabase sill	1	
Coal, broken, and shale	7	
Coal	1	
Shale		3
Coal	1	6
Shale		3
Coal	2	
Coal and shale	1	

Sections in NW¼ sec. 12, T. 20 N., R. 7 E.—Continued

Locality 9—Continued

	Ft.	in.
Coal (analysis 4490, semianthracite)	3	6
Shale	1	
Diabase sill	2	
Shale.		

Locality 10

	Ft.	in.
Shale.		
Coal (analysis 4487, semianthracite)	3	
Diabase sill	6–10	
Coal, broken	1	8
Shale, gray	1	2
Coal, broken		10
Bone		3
Coal (analysis 4390, semianthracite)	2	10
Shale.		

Locality 11

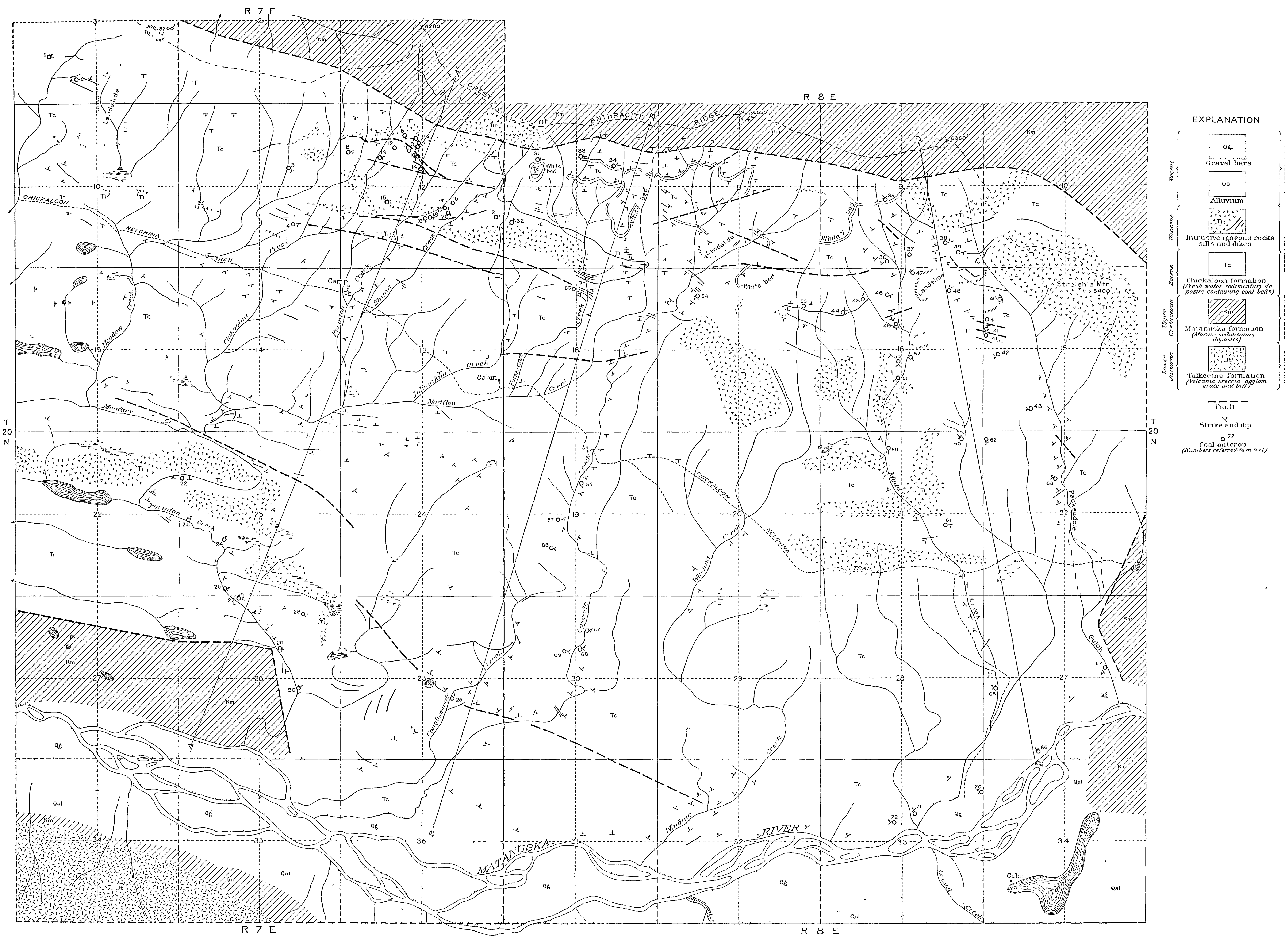
	Ft.	in.
Coal (analysis 4388, of the 3 feet 6 inches of coal, semianthracite)	2	8
Shale		3
Coal		10
Diabase sill		5
Coal (analysis 4389, semianthracite)	2	10
Shale.		

Locality 12

	Ft.	in.
Shale.		
Coal (analysis 4444, semianthracite)	10	
Coal (analysis 4486, of the 7 feet of coal (semianthracite))	3	
Shale		3
Coal	4	
Shale		4
Coal (analysis 4485, semibituminous)	7	
Shale	1	6

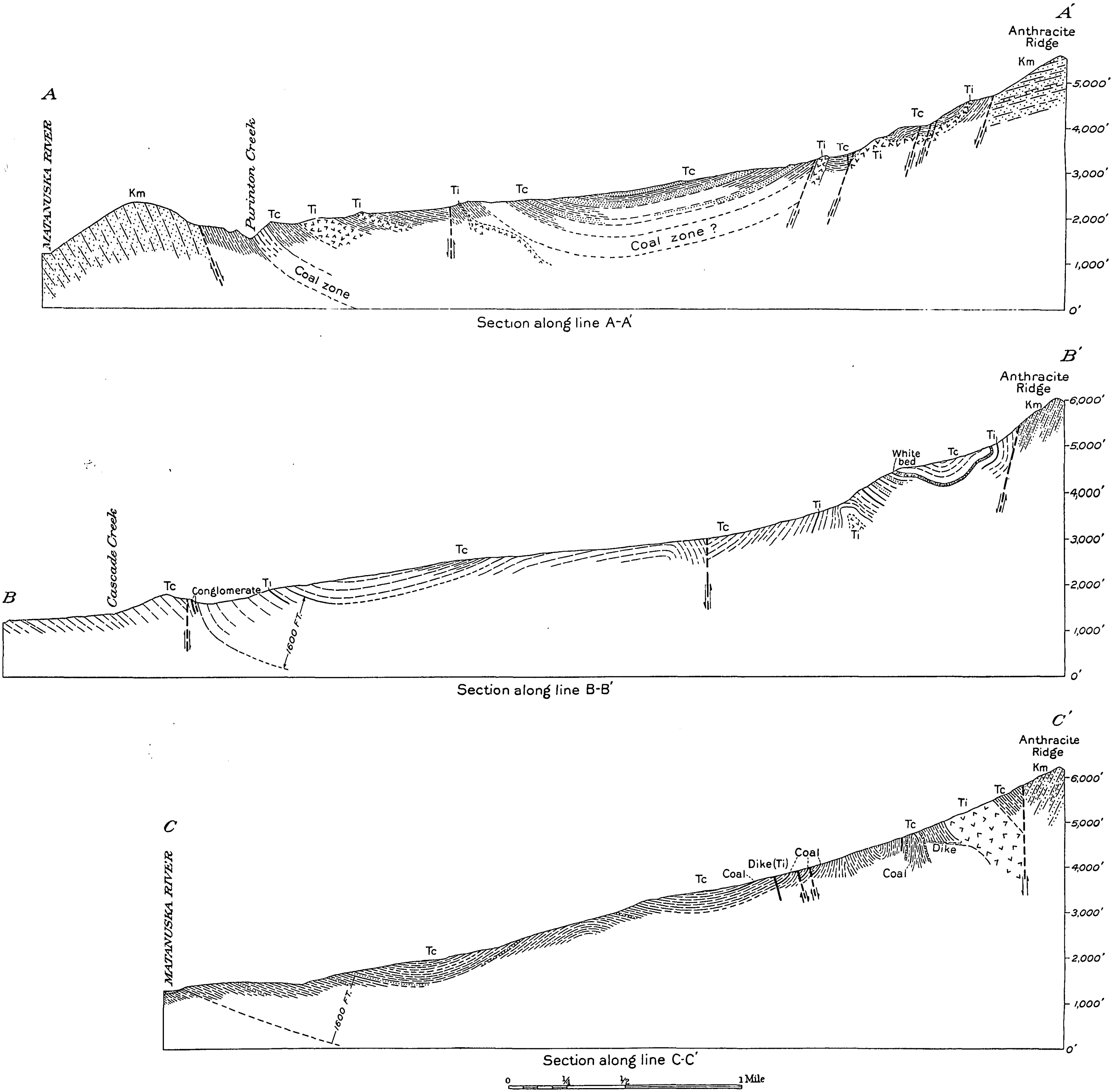
Locality 14

	Ft.	in
Shale.		
Coal (analysis 4443, of the 10 feet 6 inches of coal (semianthracite))	3	6
Shale		2
Coal	7	



GEOLOGIC MAP OF ANTHRACITE RIDGE DISTRICT.

For sections along lines A-A', B-B', C-C', see plate 2.



GEOLOGIC SECTIONS OF ANTHRACITE RIDGE DISTRICT.

For lines of sections see plate 1.

Sections in NW¼ sec. 12, T. 20 N., R. 7 E.—Continued

Locality 14—Continued

	Ft.	in.
Coal } analysis 4445, of the 6 feet 6 inches of coal (semianthracite)	3	
Bone }	1	2
Coal }	3	6
Coal with thin shales (analysis 4446, semianthracite)	7	
Coal (analysis 4391, semianthracite)	10	
Shale.		

To the west and south the sections at four localities from which coal samples were taken for analysis are as follows:

Section at locality 1, sec. 3, T. 20 N., R. 7 E.

	Ft.	in.
Shale.		
Coal shattered } analysis 4488, a composite of the five thin coal beds (semibituminous)	2	
Shale }		6
Coal }		6
Shale }		6
Coal }		9
Shale }		2
Coal }		10
Shale }		3
Coal }		10
Shale.		

Section at locality 4, sec. 11, T. 20 N., R. 7 E.

	Feet
Shale, black.	
Coal and coaly shale (analysis 4484, bituminous)	2
Shale, black.	

Section at locality 22, sec. 23, T. 20 N., R. 7 E.

	Feet
Shale, black.	
Coal and coaly shale, crushed (analysis 4481, bituminous)	3
Shale, gray; leaf impressions	2
Sandstone, gray-brown, thin-bedded.	

Section at locality 28, sec. 26, T. 20 N., R. 7 E.

	Ft.	in.
Diabase	20	
Shale, sandy	35	
Shale, gray	5	
Shale, black	1	
Coal, dirty		6
Shale, black	1	
Shale, gray	2	
Sandstone	8	
Shale, sandy	20	
Coal (analysis 4479, semibituminous)	1	5
Sandstone, brown		6
Shale, gray.		

The thickest section measured in the southern part of the basin was in the side of the canyon of Purinton Creek, in the NE¼NE¼NW¼ sec. 26, T. 20 N., R. 7 E., as follows:

Section exposed on north side of canyon of Purinton Creek, sec. 26, T. 20 N., R. 7 E., locality 27

	Ft.	in.
Gray shales alternating with brown ironstones	100	
Coal (bituminous)	2	
Gray shale	2	
Ferruginous sandstone	1	
Gray shale	3	
Coaly shale	3	
Gray shale	6	
Gray lenticular sandstone (dip 60° N.)	5	
Coal (bituminous)	1	6
Gray shale	15	
Coal, grading to coaly shale	5	
Gray shale with lenticular sandstones 6 inches to 3 feet thick	60	
Coal (bituminous)	2	
Gray shale with lenticular sandstone 6 inches to 3 feet thick	75	
Gray shale	2	
Ferruginous sandstone		6
Coal, shattered	2	
Gray shale, with several bands of ironstone concretions	125	
Gray sandstone (dip 85° N. 20° E.)	15	
Gray shale alternating with brown sandstones	38	
Brown shale	2	
Coal, shattered	4	
Gray shale, with thin ferruginous sandstone bands (beds nearly vertical at base of section, at creek)	75	
	544	

The sections at the four localities in the eastern part of the basin where coal samples were taken for analysis are as follows:

Section at locality 37, sec. 9, T. 20 N., R. 8 E.

[Measured southward along west side of ridge, to axis of sharp fold]

	Ft.	in.
Shale with thin sandstone beds.		
White sandstone	7	
Gray shale	14	6
Buff sandstone	2	
Shale	6	6
Coal		10
Shale		8
Black, siliceous shale	1	
Gray shale	4	10
Black shale	3	8
Gray shale	2	6
Coal		7
Gray shale	1	9
Coal		5
Shale and coaly shale	2	5
Coal		3
Black shale		3
Gray shale	1	8
Coaly shale		8
Black shale	1	
Gray shale	1	1
Coaly shale		9
Gray shale	5	2
Black shale	1	9
Coaly shale		7
Gray shale	5	4
Coal (analysis 4483, of the 6 feet 2 inches of coal (bituminous))	2	10
Shale		8
Coal	3	4
Gray shale (axis of sharp anticlinal fold)	6	8
	80	8

Section at locality 51, sec. 16, T. 20 N., R. 8 E.

	Ft.	in.
Top of bluff.		
Diabase sill	75	
Baked shale	4	
Gray shale	34	
Black shale, with 2 inches of coal	4	
Coal, lensing to bone	1	
Black shale	8	
Black sandy shale	8	
Thin-bedded black sandstone and black micaceous, sandy shale	10	
Black shale with thin sandstone	16	
Coal lens	2	6
Dark-gray shale	30	
Gray shale with ironstone	27	
Black shale with ironstone	15	
Gray to brown cross-bedded sandstone	8	
Dark-gray shale	15	
Gray cross-bedded sandstone lens	17	
Gray shale	23	
Black shale	3	
Ironstone	1	9
Coaly shale	4	
Coal } analysis 4489, of the 6 feet 2 inches of coal (bituminous)	3	
Shale } analysis 4489, of the 6 feet 2 inches of coal (bituminous)		4
Coal } analysis 4489, of the 6 feet 2 inches of coal (bituminous)	3	2
Dark-gray sandy shale	2	
Ironstone	2	
Gray sandstone	9	6
Coal and coaly shale		9
Gray shale	6	
Gray to yellow sandstone	1	6
Shale with thin sandstone	30	
Shale.		
	364	6

Section at locality 53, sec. 17, T. 20 N., R. 8 E.

	Ft.	in.
Gray shale, with thin gray sandstone and ironstone bands	100	
Coaly shale	5	
Coal and coaly shale	1	
Shale with ironstone bands	10	
Coal	1	3
Coaly shale	1	
Shale and coaly shale	4	
White sandstone	1	
Coaly shale		4
Ironstone		2
Coaly shale		4
Coal } analysis 4466, of the 4 feet 10 inches of coal (bituminous)	1	
Clay shale } analysis 4466, of the 4 feet 10 inches of coal (bituminous)		1
Coal } analysis 4466, of the 4 feet 10 inches of coal (bituminous)		10
Ironstone } analysis 4466, of the 4 feet 10 inches of coal (bituminous)		4
Coal } analysis 4466, of the 4 feet 10 inches of coal (bituminous)	3	
Coal and shale, broken	1	2
Shale with ironstone	4	
Sandstone	3	
Shale	40	
Diabase sill	10	
	197	6

Section at locality 62, sec. 22, T. 20 N., R. 8 E.

	Ft.	in.
Top of bluff.		
Gray shale	3	
Ironstone		6
Gray shale	22	6
Buff sandstone		10
Gray shale	5	3
Buff sandstone	1	
Gray shale	10	2
Black shale	2	6
Coal } analysis 4482, of the 7½ feet of coal	3	6
Shale } analysis 4482, of the 7½ feet of coal		4
Coal } analysis 4482, of the 7½ feet of coal	4	
Black shale	2	6
Gray shale	5	
Buff sandstone	1	
Gray shale	10	8
Ironstone		6
Gray shale	14	6
Black shale	1	8
Coal	1	4
Shale		1
Coal	1	3
Shale	1	2
Sandstone	1	6
Shale	2	
Sandstone	2	6
Thin-bedded sandstone	3	9
Black shale		8
Gray shale, with thin sandstone	43	
Gray sandstone	4	
Shale.		
	150	8

SYNCLINAL AREA SOUTH OF ANTHRACITE RIDGE

The diagrammatic structure section A–A′, plate 2, shows the writers' interpretation of the distribution and deformation of the rocks of the Chickaloon formation as exposed along Purinton Creek. The zone of complex folding, intrusion, and faulting on the southern slope of Anthracite Ridge in which the thick beds of hard coal are found is succeeded by (1) a synclinal area about 1½ miles wide, characterized by low dips, gradually steepening toward (2) a fault zone beyond which beds dipping at a low angle to the north continue to a zone of prominent intrusives, followed by (3) another zone of steeply dipping beds a quarter of a mile wide, containing coal beds and in fault contact with rocks of Upper Cretaceous age.

These southern coal beds may represent the coal zone on the south slope of Anthracite Ridge, but it is not possible to project them with certainty northward across the structure section or to estimate with any degree of accuracy the position they may occupy in the synclinal area. However, the outcrop of a 2-foot bed of bituminous coal, about half a mile west of the line of the structure section, at locality 4, sec. 11, T. 20 N., R. 7 E., approximately on the strike of the southernmost intrusive mass found on the north flank of the syncline, suggests the presence of a coal zone at moderate depth.

The synclinal structure of the area in the 1½-mile zone is clearly indicated by the attitude of the resistant sandstones protruding through the gravel and moss, which effectually conceal the softer beds.

The column of Chickaloon sediments forming the south limb of this syncline measured from the axis to a fault a few hundred feet south of the first intrusive sill on that side of the fold (where the dips change from about 60° to 10°) includes approximately 2,000 feet of beds in which no coal was found, although coal may be present in parts of the interval that are concealed. Continuing from this line of faulting nearly 3,000 feet of Chickaloon rocks crop out to the fault contact with the Upper Cretaceous. Presumably these beds represent the continuation of the beds measured in the 2,000-foot interval, repeated to an unknown extent by faulting. The absence of recognized key beds makes it impossible to estimate accurately, because of this faulted sequence, the total thickness of the Chickaloon formation before the faulting took place. Martin [11] estimated it at 2,000 feet or possibly more. The writers may be in error in attributing the additional 3,000 feet present in this area to repetition by faulting, and the total thickness may even be as much as 5,000 feet.

Evidently, however, sufficient Chickaloon beds are present in this synclinal area between the Matanuska River and Anthracite Ridge to include the same coal zone that is exposed on the south flank of the

[11] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U.S. Geol. Survey Bull. 500, p. 43, 1912.

ridge, especially if this coal zone happens to be faulted downward in addition to having been disturbed by marginal igneous intrusions. There is ample physiographic suggestion of marginal faulting along the base of Anthracite Ridge, as was first noted by Martin [12] and indicated by the writers in structure section A–A′. The amount of displacement has not been determined, but it is possibly several hundred to a thousand feet.

CLASSIFICATION

The coals found throughout the world are not susceptible of rigid classification, for the characteristics of the several kinds vary with their physical as well as their chemical properties, and coals that are chemically similar may differ so much in their physical characters that they are not suitable for the same commercial uses. In general, the percentage of carbon is a fair indication of the class of coal; but the fuel ratio (percentage of fixed carbon divided by the percentage of volatile matter) is more satisfactory for comparison of different coals and is used by Campbell and others. In this method of classification Campbell [13] says that the term "rank" is

> used to designate those differences in coal that are due to the progressive change from lignite to anthracite, a change marked by the loss of moisture, of oxygen, and of volatile matter. This change is generally accompanied by an increase of fixed carbon, of sulphur, and probably of ash. When, however, one coal is distinguished from another by the amount of ash or sulphur it contains, this difference is said to be one of grade. Thus "a high-grade coal" means merely one that is relatively pure, whereas "a high-rank coal" means one that is high in the scale of coals, or, in other words, one that has suffered devolatilization and that now contains a smaller percentage of volatile matter, oxygen, and moisture than it contained before the change occurred.

The several classes of coal have in general the following characteristics: [14]

Anthracite is a hard, bright, submetallic iron-black coal breaking with a conchoidal fracture and having a fuel ratio between about 60 and 10, percentage of fixed carbon about 85 to 95, and specific gravity 1.3 to 1.8. It ignites slowly, burns with little flame and smoke, and does not soften or swell on burning. Most of the known anthracite beds are in eastern Pennsylvania. Its peculiar quality has there been produced by regional metamorphism. Small areas of anthracite are found in other localities, but usually these are coals that have been converted to anthracite by the heat from some molten mass of igneous rock that has been intruded into the coal-bearing formation. Anthracite has been thus formed from low-rank bituminous coal in the Yampa coal field, in northwestern Colorado, and in the Cerrillos

[12] Martin, G. C., A reconnaissance of the Matanuska coal field, Alaska, in 1905: U.S. Geol. Survey Bull. 289, p. 18, 1906.

[13] Campbell, M. R., The coal fields of the United States, General introduction: U.S. Geol. Survey Prof. Paper 100A, p. 3, 1917; also published as ch. 1 of vol. 1, American fuels, by Bacon and Hamor, 1922.

[14] Idem, pp. 5–8. Cosgrove, J. F., Coal, its economical and smokeless combustion, ch. 1 and 2, 1916.

field, in New Mexico. Laboratory experiments indicate that this is accomplished at temperatures of 160° to 350° C. (320° to 662° F.),[15] which is considerably below the temperature of iron at a dull-red heat.

Semianthracite is a hard coal, though not as hard as anthracite, having a fuel ratio between about 10 and 6. The lower limit is not very definite, for some "hard" coals have a fuel ratio as low as 6, whereas some "soft" coals have a fuel ratio as high as 7. The percentage of fixed carbon is about 84. Semianthracite contains more gas, kindles more readily, and burns more freely than anthracite and makes a hot fire.

Semibituminous coal has a fuel ratio between 7 and 3. It has a relatively high percentage of fixed carbon, about 65 to 84. It ignites easily and burns freely and rapidly, giving intense heat with little smoke. It is considered the best kind of coal for use under steam boilers because of its quick and intense heat production.

Bituminous coals are of many varieties, but all have a maximum fuel ratio of about 3. The percentage of fixed carbon ranges from about 42 to 64. The relatively large amount of volatile matter may consist of gases, oils, and tars, as well as the usual organic matter; and these coals burn with yellow smoky flame. Many of the bituminous coals will coke. These are rich in hydrocarbons and are valuable for gas making. When heated they swell and fuse to a spongy mass overlying the fire. The noncoking coals do not melt; they hold their shape and burn freely.

Subbituminous coals are somewhat lower in fixed carbon than bituminous but may usually be best distinguished by their physical properties. On exposure to air subbituminous coal loses moisture and develops shrinkage cracks that cause it to break down or "slack" when subjected to alternate wetting and drying. Good bituminous coal will not thus break down, though owing to inherent fracturing, it may disintegrate into fine pieces. In the coals of bituminous rank each coal fragment remains fresh and unaltered for months or years, whereas the subbituminous coals undergo chemical as well as physical disintegration or breaking down.

Lignites, the coals of lowest rank, are readily distinguished from the subbituminous varieties, as they are brown and show either distinct woody or uniform claylike texture. Chemically the lignites contain a much greater percentage of moisture (20 to 40 percent) than the subbituminous coals. This reduces their heating value and usually prevents their extensive shipment, both because of the freight charges on the large amount of contained water and the fact that as much of this is rapidly lost on exposure to the air the lignites easily slack—that is, break down into a powder—and are susceptible to spontaneous ignition.

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[15] McFarlane, G. C., Igneous metamorphism of coal beds: Econ. Geology, vol. 24, no. 1, p. 10, 1929.

CHEMICAL DETERMINATIONS

The standard chemical analysis of coal determines the percentage of moisture, volatile matter, fixed carbon, and ash. These are usually figured in three ways—for the sample as received, for the sample air dried, and for the sample calculated on a moisture-free basis. However, inasmuch as the higher-rank coals as purchased contain nearly the same amount of moisture, tightly held in their pores, that they contain when mined, it is becoming common to consider the figures based on the moisture condition of the sample as received most representative of the coal. Lignites and low-rank bituminous coals absorb moisture on exposure for several months and slack. The volatile matter of coal consists of gases and tarry substances as well as the usual decayed vegetable material. The ash consists of earthy matter and other mineral impurities that will not burn. It is usually a mixture of silicates, oxides, and sulphates. The fusing temperature of the ash is sometimes determined, as it may be of value in judging the kind of clinker the coal will make. Ash that fuses above 2,700° F. rarely gives trouble, but ash that melts at a lower temperature may produce clinkers that will clog the grate. Hard clinker is formed by the melting of the ash itself, or some of its constituents. It hardens while in the ash or on the grates on cooling. It is formed by the combination of silica with fusible constituents of the ash. The percentage of sulphur is sometimes determined, as this substance has injurious effects on grates and flues. The Alaskan coals in general have low sulphur content, less than 1 percent, and no trouble from this substance has been experienced in their use.

CHARACTERISTICS

Such attempts as were made to burn fragments of the hard coals in the camp stoves were only partly successful, owing probably to the lack of suitable grates. A small amount of red ash similar to that obtained in burning red-ash Pennsylvania anthracite was observed, and it was inferred that under proper draft and grate conditions these coals are adaptable to the same uses as similar grades of anthracite. However, no thorough burning tests of coals from Anthracite Ridge were made during 1931.

ANALYSES

The analyses of the samples collected during geologic study in the summer of 1931 are given in the following table:

Analyses of coals from Anthracite Ridge area, Alaska

[By Maurice L. Sharp, chemist, U.S. Bureau of Mines, Anchorage, Alaska, August and September, 1931]

No. on map	Locality	Analysis no.	Coal as received: Moisture	Coal as received: Volatile matter	Coal as received: Fixed carbon	Coal as received: Ash	Coal as received: Sulphur	Calorific value: Calories	Calorific value: British thermal units	Specific gravity	Fuel ratio	Rank	Thickness sampled
	T. 20 N., R. 7 E.												*Ft. in.*
1	Sec. 3	4488	2.2	16.0	78.0	3.8	0.6	7,851	14,130	1.347	4.9	Semibituminous	3 5
4	Sec. 11	4484	7.2	26.3	57.7	8.8	.7	6,433	11,580	1.406	2.2	Bituminous	2
8	Sec. 12	4480	4.9	8.1	71.8	[a] 15.2	.7	6,495	11,690	1.522	8.9	Semianthracite	7 9
9	do	4490	4.5	9.4	70.9	15.2	.3	6,539	11,770	1.658	7.6	do	3 6
10	do	4487	8.7	8.9	69.0	13.4	.5	6,153	11,075	1.481	7.8	do	3
		4390	6.1	8.6	64.3	21.0	.5	5,957	10,720	[b] 1.666	7.5	do	2 10
11	do	4388	5.0	9.4	59.0	26.6	.5	5,465	9,835	[b] 1.785	6.3	do	3 6
		4389	5.3	8.4	75.4	[a] 10.9	.5	6,548	11,790	[b] 1.666	8.9	do	2 10
13	do	4444	7.2	9.1	75.4	8.3	.2	6,959	12,525	[b] 1.628	8.3	do	10
		4486	3.1	9.3	80.6	[a] 7.0	.7	7,457	13,425	1.478	8.7	do	7
		4485	5.0	14.4	71.5	9.1	.7	7,035	12,665	1.684	5.0	Semibituminous	7
14	do	4443	3.5	10.5	67.2	18.8	.2	6,299	11,340	[b] 1.684	6.4	Semianthracite	10 6
		4445	4.1	9.6	71.0	15.3	.5	6,584	11,850	[b] 1.408	7.4	do	6 6
		4446	5.0	10.0	65.3	19.7	.5	6,039	10,870	[b] 1.686	6.5	do	7
		4391	7.5	8.5	72.6	[a] 11.4	.5	6,592	11,865	[b] 1.681	8.5	do	10
22	Sec. 23	4481	6.8	29.9	54.1	9.2	.6	6,394	11,510	1.311	1.8	Bituminous	3
28	Sec. 26	4479	4.0	19.9	73.7	2.4	.7	7,665	13,795	1.423	3.8	Semibituminous	1 5
	T. 20 N., R. 8 E.												
37	Sec. 9	4483	4.0	29.2	44.2	22.6	.6	5,623	10,120	1.403	1.5	Bituminous	6 2
51	Sec. 16	4489	3.6	22.9	63.9	9.6	.5	7,144	12,860	1.310	2.7	do	6 2
54	Sec. 17	4466	3.9	31.5	47.4	17.2	.6	6,279	11,300	1.428	1.5	do	4 10
62	Sec. 22	4482	4.7	27.6	52.8	14.9	.6	6,376	11,475	1.345	1.9	do	7 6

[a] Determinations of softening temperatures of the ash by H. M. Cooper, chief chemist of U.S. Bureau of Mines, fuel testing division, Pittsburgh, Pa., as follows:

Analysis no.	Bureau of Mines laboratory no.	Softening temperature (°F.)	Analysis no.	Bureau of Mines laboratory no.	Softening temperature (°F.)
4480	76522	2,785	4389	76520	2,750
4486	76523	2,445	4391	76521	2,515

[b] Apparent specific gravity, determined on lump samples. Specific gravity of the other samples determined on powdered samples.

Local metamorphism has produced coal of higher rank in places, as shown by the semibituminous coal in sec. 3, T. 20 N., R. 7 E. (analysis 4488), and sec. 26, T. 20 N., R. 7 E. (analysis 4479). In each of these places this alteration to a higher-rank coal seems to be due to the effect of adjacent diabase sills. In other coal beds near but perhaps not so closely adjacent to sills the coal has been practically unaffected. This is shown by analyses 4481, 4466, and 4489 of coals in sec. 23, T. 20 N., R. 7 E.; and secs. 17 and 16, T. 20 N., R. 8 E. In the first two localities the coal lies about 50 feet above diabase sills. In the third the coal is about 230 feet below a 75-foot diabase sill, evidently too far away to be appreciably affected. However, in this locality there are several lenses of coal a few inches thick and less than 50 feet beneath the diabase, that have been in part altered to hard, shiny coal, probably of semianthracite rank. That appreciable alteration has not been everywhere caused by the close folding that has taken place along the north side of the basin is indicated by analysis 4483, of coal from the sharply folded bed in sec. 9, T. 20 N., R. 8 E., the fuel ratio of which is only 1.5.

The highest-rank coals found in the district are all confined to the S½NW¼ sec. 12, T. 20 N., R. 7 E., in an area that is intensely folded and faulted and intruded by masses of diabase. The combined effect of the heat of the intrusive rock and the heat and pressure produced by the deformation of the rocks may account for the higher rank of the coals in this small area. As shown by the analyses of 13 samples from this area, the coals are classed as semianthracite or low-rank anthracite.

The thickest outcrop of coal is that in the SE¼SE¼NW¼ sec. 12, T. 20 N., R. 7 E., where 34 feet of coal was measured, divided into three beds by partings. Four samples of this coal, each embracing about 8 feet of successive portions of the bed, showed on analysis fuel ratios ranging from 6.4 to 8.5. The earliest analysis of coal from this outcrop showed volatile matter 7.08, fixed carbon 84.32, and fuel ratio 11.91;[16] recalculated to volatile matter 7.75, fixed carbon 92.25, and fuel ratio 11.90.[17] A reanalysis of material from the sample, made several months later, showed volatile matter 5.26 and fixed carbon 86.15,[18] giving a fuel ratio of 16.4, owing to the loss of an appreciable amount of the volatile matter during the several months intervening between the analyses and to somewhat different methods of analysis used.[19]

[16] Martin, G. C., Preliminary statement on the Matanuska coal field: U.S. Geol. Survey Bull. 284, pp. 27, 97, 98, 1906; A reconnaissance of the Matanuska coal field, Alaska, in 1905: U.S. Geol. Survey Bull. 289, p. 30, 1906.

[17] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna Basins, Alaska: U.S. Geol. Survey Bull. 327, p. 60, 1907.

[18] Martin, G. C., and Mertie, J. B. Jr., Mineral resources of the upper Matanuska and Nelchina Valleys: U.S. Geol. Survey Bull. 592, p. 295, 1914.

[19] See U.S. Geol. Survey Bull. 290, pp. 29–30, 1906.

The following two other analyses of coal from the vicinity of the thick bed have been made, though they may not represent coal from the principal outcrop.[20]

Analyses of coal from Purinton Creek

[By the U.S. Bureau of Mines]

Analysis no.	As received: Moisture	Air dried			Fuel ratio
		Volatile matter	Fixed carbon	Ash	
A3539	3.2	8.1	85.8	4.2	10.6
A3540	4.7	9.2	81.4	6.3	8.9

The next thickest outcrop is about 1,000 feet to the northwest, in the NE¼SE¼NW¼ sec. 12, where 24 feet of clean coal was measured. The analyses of samples from the upper portion of this bed show fuel ratios of 8.3 and 8.7, but the lowest bench of the bed ran unexpectedly high in volatile matter (14.4) with lower fixed carbon (71.5), giving a fuel ratio of only 5.0.

The analysis showing the highest fuel ratio (8.9) was made on a sample taken directly under a 5-inch diabase sill from the outcrop of one of the benches of probably the same bed from which the samples for the preceding two analyses came, in the center of the NE¼SE¼NW¼ sec. 12. The fixed carbon (71.8) was not so high in this coal, however, as in the middle sample from the 24-foot bed, nor as in the coal from the westernmost pit, probably on the same bed, in the SE¼NW¼SW¼ sec. 3, T. 20 N., R. 7 E., which showed 78.0 per cent of fixed carbon; but this sample contained 16.0 per cent of volatile matter, giving it a fuel ratio of only 4.9.

The analyses of the samples collected in 1931 from the thick bed of sec. 12 show that the coal is inferior in both fuel ratio and ash to the earlier samples. Although the differences observed may be due in part to changed methods of analysis, they seem to indicate that long exposure to the atmosphere resulted in a loss of volatile matter in the earlier samples taken directly at the outcrop instead of from pits, and the possible inclusion of more bone in the 1931 samples may account for the higher percentage of ash.

Too great importance should not be given to these analyses of single samples, for the coals may easily vary appreciably within short distances along the beds. Actual burning tests on amounts of several hundred pounds would offer a sounder basis of comparing the relative fuel values of the coals from several localities.

The presence of low-rank coals in the Moose Creek, Eska, and Chickaloon districts, in the western part of the Matanuska Valley,

[20] Capps, S. R., Geology of the upper Matanuska Valley, Alaska: U.S. Geol. Survey Bull. 791, p. 84, 1927.

and of the higher-rank coal in the Anthracite Ridge district, in the eastern part of the valley, early suggested that there might be a progressive alteration of the coal eastward, produced by the intense folding and faulting along the north side of the valley. The more recent studies do not confirm this supposition, however, as the average-rank coals at Chickaloon have a fuel ratio of 3.5 and the easternmost outcrops that were sampled in the Anthracite Ridge district have fuel ratios as low as 1.5, 1.9, and 2.7.

QUANTITY

In the absence of development work, few reliable data are at hand for estimating the coal reserves of the district. In the S½NW¼ sec. 12, T. 20 N., R. 7 E., the thicknesses of coal exposed in the several pits indicate that within the small area bounded on the south by a fault and on the north by the upturned edges of the coal-bearing beds there may be about 750,000 tons of low-rank anthracite. This estimate is based on an irregular area of 20 acres, with an estimated average thickness of possibly workable coal running 19.3 cubic feet to the ton. This tonnage is not sufficient to justify commercial operation. Sufficient data are not available for estimating the amount of coal present in other parts of the district, but it is possible that reliable data can be obtained by core drilling in the more gently folded area immediately south of the outcrops of thick beds of high-rank coal.

POSSIBILITY OF UNDISCOVERED DEPOSITS

In the southern and eastern parts of the district the coal outcrops prospected in 1931 were all of lower rank than most of the coal found in sec. 12, T. 20 N., R. 7 E., and some of these coals, even where 3 to 7 feet in thickness, change laterally into coaly shales within short distances. However, fragments of hard shiny coal with metallic luster were seen scattered throughout the basin. In one place a bed of coal of this type over 1 foot thick was found on the south side of the basin (locality 28), in sec. 26, T. 20 N., R. 7 E. The coal of this bed closely resembled a semianthracite in color, hardness, and luster, but analysis showed it to be semibituminous. Possibly if it could be traced around the margin of the basin it would be found to represent one of the beds in the zone of thicker higher-rank coals which now seem to be limited in distribution to the north side, and the variation in thickness and quality would change proportionally to the distance from the north measurement of 34 feet and the south measurement of 1.5 feet, or midway the coal would have a thickness of about 17 feet, which might be considered the average for the area. Sufficient evidence that these coal beds persist across the area and that such an average thickness will be found is not now available, but a bed of that thickness would require an areal extent of only half a square mile to contain sufficient tonnage to provide a mine of 1,000-ton daily capacity enough coal to operate for a period of over 35 years, which would afford this branch of the Alaska Railroad a sustaining source of revenue.

TRANSPORTATION AND MARKETS

In 1931 there was no improved route of transportation between the Anthracite Ridge district and the railhead at Chickaloon, except the trail. Commercial development of the coal resources would necessitate suitable means of transportation, presumably by tramway or by extension of the railroad from Chickaloon. Further exploration should precede any attempt to open mines, in order to determine whether the available deposits are sufficiently great and the quality of the coal sufficiently high to justify such rail construction. The commercial possibilities lie chiefly in the production of a coal of higher rank than the bituminous coals of the lower Matanuska Valley and the lignite of the Nenana River Valley.

CONCLUSION

The field work of the summer of 1931 demonstrated that surface exploration alone is not adequate to prove the presence of workable bodies of anthracite in the Anthracite Ridge district. It did, however, suffice to show that such high-rank coal as is or may be present in the area is of somewhat lower rank than was anticipated—namely, semianthracite—but is of superior rank to the coals mined in the lower Matanuska Valley and other areas tributary to the Alaska Railroad.

Inasmuch as only a small area of semianthracite of the exceptional thickness found on the south flank of Anthracite Ridge would be required for the development of a commercial tonnage, it was regarded advisable to prospect intensively during the summer of 1932 the synclinal area adjoining the south flank of the ridge by drilling a series of core holes to indicate definitely the depth, thickness, quality, and distribution of such coal beds as may exist in a square mile of the most promising portion of the area.

The discovery of a thick bed of semianthracite in one or more of the four to six holes planned for the area, within less than 2,000 feet of the surface, will tend to confirm commercial possibilities unless water is encountered in such quantities that it can not be handled without undue expense—a contingent condition which is regarded as extremely remote.

Proposals and specifications were prepared by the Geological Survey for this drilling to be done by contract, under the supervision of the Alaska Railroad, and approved by the Secretary of the Interior December 9, 1931. Bids were opened at the Department of the Interior January 15, 1932, and a contract was entered into requiring the drilling of 8,000 feet prior to December 31, 1932. Equipment and drillers arrived in the area during March 1932, and drilling was started under the terms of the contract.

G. A. Waring, geologist, assisted by P. A. Davison, junior geologist, was detailed to the field as representative of the Geological Survey and placed in complete field charge of the Government's interest in the project. He will receive the cores, record measurements, and make any modifications of plans required to meet any contingencies which may arise. After the drilling is completed a more detailed report on the area will be prepared and published.

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