Geology and Coal Resources of the Beluga-Yentna Region Alaska

GEOLOGICAL SURVEY BULLETIN 1202-C

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By FARRELL F. BARNES

CONTRIBUTIONS TO ECONOMIC GEOLOGY

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A reconnaissance evaluation of the coal resources of the northwestern part of the Cook Inlet Tertiary basin

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1966

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

William T. Pecora, *Director*

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

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GEOLOGY AND COAL RESOURCES OF THE BELUGA-YENTNA REGION, ALASKA

By Farrell F. Barnes

ABSTRACT

The Beluga-Yentna region embraces the northwestern part of the Cook Inlet Tertiary basin of south-central Alaska. It extends northward from upper Cook Inlet between the Susitna River valley on the east and the Alaska Range on the west and north. The region is a broad lowland largely covered by glacial and alluvial deposits but is believed to be underlain principally by the coal-bearing Kenai Formation of Tertiary age and nonmarine origin. From this lowland rise several isolated mountain masses of bedded and intrusive rocks of Mesozoic age. The region lies mainly within the basins of the Beluga and Yentna Rivers.

Fieldwork for this report involved detailed examination and measurement of the few widely scattered exposures of coal-bearing rocks, supplemented by study of aerial photographs and aerial reconnaissance of intervening areas. Coverage of the large area, nearly 5,000 square miles, in two field seasons was made possible by the use of helicopter transportation.

The Tertiary rocks in most of the region consist of interbedded claystone, siltstone, sandstone, and some conglomerate; they also contain many coal beds. In the southwest part of the region at least 2,000 feet of finer grained coal-bearing strata is underlain by a possibly thicker deposit of poorly indurated conglomerate and pebbly sandstone that contain no significant coal beds. In the northwest part of the region a thick sequence of slightly consolidated conglomeratic beds overlies a coal-bearing sequence that presumably represents the typical coal-bearing part of the Kenai Formation. Because the conglomeratic sequences in both areas seem to be generally conformable with, and to grade into, the associated coal-bearing rocks, they are considered to be upper and basal members of the Kenai Formation. Plant fossils indicate a Miocene age for most of the formation, but some beds of Pliocene and Oligocene age may be included.

The structure of the Kenai Formation is uncomplicated throughout most of the region; strong folding and faulting is limited to areas adjacent to parts of the mountain front to the west and to the Castle Mountain fault zone in the southern part of the region. At least one major anticlinal fold is present southeast of the Castle Mountain fault.

Estimates of indicated coal reserves were arbitrarily limited to coal within half a mile of measured outcrops, except in beds of known greater extent, and under less than 1,000 feet of overburden. Estimated reserves total 2,400 million tons in beds more than 2.5 feet thick, of which 2,200 million tons is in beds more than 10 feet thick; 2,100 million tons is concentrated in an area of less than 400 square miles in the basins of the Beluga and Chuitna Rivers.

Analyses of samples from outcrops and from a few drill cores indicate that the coal ranges in rank from subbituminous B to lignite.

INTRODUCTION

PURPOSE AND SCOPE OF REPORT

The investigations on which this report is based were made by the U.S. Geological Survey as part of a program to appraise the coal resources of Alaska, determine their geologic features, and assist in the classification of public lands. Mapping was limited primarily to areas underlain by the coal-bearing Kenai Formation of Tertiary age. The main objectives of the investigation were to collect data from which to evaluate coal reserves, to locate areas favorable for coal mining, and to outline the broader aspects of the geology, particularly the stratigraphic and structural relations of the Kenai strata in different parts of the region to each other and to the underlying rocks.

Because the coal deposits of this region are completely undeveloped and are largely covered by surficial deposits, a thorough understanding of their stratigraphy and structure could be obtained only with the aid of a large amount of subsurface exploration. The present investigation was made to obtain a general understanding, through brief examination of the widely scattered outcrops, of the general character and distribution of potentially valuable coal deposits, which would serve as a guide for future prospecting or more detailed investigations.

LOCATION AND EXTENT OF REGION

The Beluga-Yentna region of south-central Alaska (fig. 1) is here defined as the broad lowland west of the lower Susitna River that is bounded on the north and west by the Alaska Range and on the south by upper Cook Inlet and the Chakachatna River valley (pl. 1). The area covered by the present investigation is about 4,800 square miles in extent, including several outlying mountainous areas underlain by older, noncoal-bearing rocks. The region embraces much of the central parts of the Talkeetna and Tyonek (1:250,000) quadrangles; its south end is about 20 miles west of Anchorage.

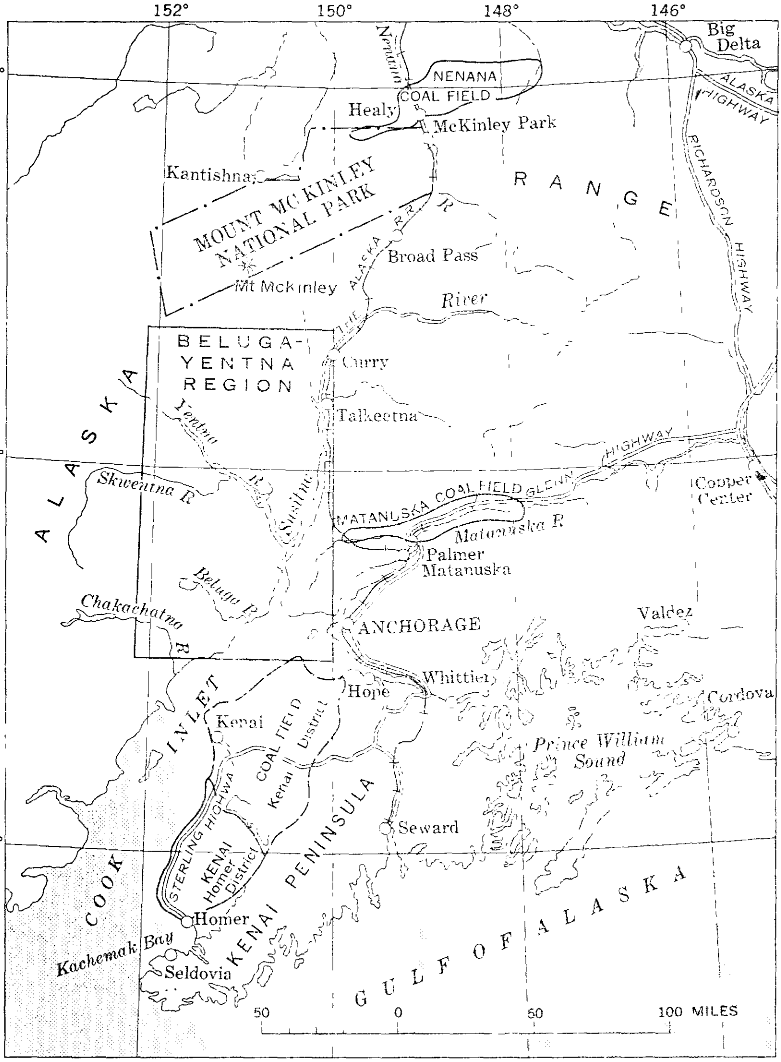


Figure 1.—Location of the Beluga-Yentna region and its relation to other coal fields in south-central Alaska.

FIELDWORK AND ACKNOWLEDGMENTS

Fieldwork for this report was done during the summers of 1961 and 1962, preceded by brief reconnaissance trips in 1949, 1953, and 1954. The writer was accompanied by E. H. Cobb in 1949 and by Daniel Sokol in 1953. He was assisted by A. W. Horstman and C. H. Slightam, Jr. in 1961, and by W. E. Yeend and M. T. Field in 1962. In addition, J. A. Wolfe, paleobotanist, and D. M. Hopkins,

geologist, spent several days in the field in 1962 collecting plant fossils and traversing the road from the Susitna River to the Cache Creek district. Wolfe's studies of these collections and of a few made by the writer in 1961 are the basis of the age assignments used in this report.

Fixed-wing aircraft were used for transportation between Anchorage and the project area. Helicopters were used to move and supply field camps at otherwise inaccessible locations in 1961, and to transport personnel during field work in 1962.

Geologic data were plotted in the field on aerial photographs at a scale of about 1:40,000 and transferred to topographic quadrangle maps at scales of 1:63,360 and 1:250,000. Data from the sparse outcrops were supplemented and projected into intervening areas by aerial observation and photointerpretation.

The writer wishes to acknowledge the assistance and courtesies of R. S. Warfield, engineer in charge of the coal-drilling project of the U.S. Bureau of Mines near Beluga Lake, particularly in maintaining radio communication between field camps and Anchorage in 1961. To personnel of the U.S. Fish and Wildlife Service in Anchorage, particularly Theron A. Smith and Mrs. Ethel Hoffman, thanks are also due for complete cooperation in maintaining logistic support and radio communications in 1962.

LAND SURVEYS

No conventional land surveys have been made in the Beluga-Yentna region; however, the locations of unmarked township and section lines have been determined by protraction by the Bureau of Land Management. This predetermined land-survey net is shown on the new topographic quadrangle maps prepared by the Geological Survey, which were used as bases for the geologic maps in this report.

PREVIOUS INVESTIGATIONS

The first geologists to report on observations in the Beluga-Yentna region were Eldridge (1900, p. 7–29) and Spurr (1900, p. 43–264), who in 1898 led exploratory expeditions up the Susitna and Skwentna Rivers, respectively. Eldridge described coal beds exposed along the beach near Tyonek and also reported the presence of thin coal seams near the present village of Susitna; Spurr reported the presence of coal on the Skwentna near the mouth of the Hayes River.

In 1902 Brooks (1911) traversed the region from Tyonek almost due northward to the Kichatna River, on which stream he mapped a small area of Kenai rocks near the foot of the mountains. In 1906 Atwood (1909, p. 117–121) examined and measured sections of coal-bearing rocks on the beach near Tyonek and on the Beluga River. The next geologist to visit the region was Capps (1913), who studied the geology and the placer deposits of the Yentna district and mapped several areas of coal-bearing rocks between the Yentna and Tokositna Rivers. In 1917 Mertie (1919, p. 233–264) studied the progress of mining in the Kahiltna River valley, including Cache and Peters Creeks. In 1926 Capps (1929) traversed from the mouth of the Beluga River to the Skwentna by way of the Talachulitna River valley, and up the Skwentna to its headwaters. In 1927 the same writer (1935) traversed from the coast south of Tyonek northwestward to Chakachamna Lake; he mapped an area of Kenai Formation on the headwaters of Straight Creek en route. In 1932 Tuck (1934) mapped a small area of coal-bearing rocks on the south side of Ruth Glacier, at the north end of the region.

As a result of the intense interest in the oil prospects of the Cook Inlet basin created by the discovery of oil on the Kenai Peninsula in 1957, many field studies of parts of the Beluga-Yentna region have been made by oil-company geologists. The results of these investigations are as yet largely unpublished.

In 1959–1961 the U.S. Bureau of Mines made a detailed investigation by diamond drilling in a small area of T. 15 N., R. 12 W., to determine the quality, attitude, and extent of a coal bed more than 50 feet thick that crops out in the west bank of Drill Creek (Warfield, 1963).

In 1961 and 1962 geologists of the U.S. Steel Corp. made field investigations of coal deposits in the Beluga and Chuitna River basins, and in 1962 and 1963 field parties of the Utah Construction and Mining Co. working in the same general area studied the coal deposits with the aid of a portable drill.

GEOGRAPHY

TOPOGRAPHY AND DRAINAGE

The Beluga-Yentna region consists mainly of a broad piedmont lowland of generally low relief, mantled by deposits of glacial origin, into which streams have cut valleys ranging from a few tens of feet to several hundred feet in depth. The lowland surface is further broken by a few isolated mountain masses that rise several hundred to a few thousand feet above the general level, which is mostly less than 1,000 feet above sea level but locally rises to as much as 2,000 feet near the front of the Alaska Range. Much of the lowland has very low relief and is covered by extensive bogs and marshes that contain countless lakes and ponds; other large areas have typical morainal topography, characterized by irregular ridges and depressions. Only areas near the larger streams are well drained.

Most of the drainage of the region flows into the Susitna River by way of the Yentna and its principal tributaries, the Skwentna, Kichatna, and Kahiltna, all of which head in large glaciers of the Alaska Range. The southern part of the region is drained by the Beluga River, which is also glacier fed, and by the Chuitna, Theodore, and Lewis Rivers, which are not. All these southern streams flow directly into Cook Inlet.

CLIMATE

The Beluga-Yentna region, being somewhat protected from the open ocean, has a climate intermediate between that of the coastal areas and the interior of Alaska. The most recent weather records available from the U.S. Weather Bureau for points within the region are from Susitna, on the Susitna River below the mouth of the Yentna, for the 12-year period ending in 1945, and from Skwentna, near the mouth of the Skwentna River, for the 16-year period ending in 1958. According to these records the average annual precipitation was 28.46 inches at Susitna and 29.83 inches at Skwentna, and the mean annual temperatures at the same stations were 36.0°F., and 32.4°F., respectively. At Talkeetna, on the Susitna River about 7 miles east of the northern part of the region, the corresponding figures for the 33-year period ending in 1961 are 28.85 inches and 33.2°F. At all three stations January is the coldest month, average temperatures ranging from 5.9°F. at Skwentna to 13.9°F. at Susitna; July is the warmest, averaging about 58°F. at the three stations. More than half of the annual precipitation at these stations falls between July 1 and October 31.

For the southern part of the region the only weather records available are from Tyonek for the 12-year period ending in 1910. During this period the mean annual temperature was 36.1°F. and the average annual precipitation was 22.8 inches.

VEGETATION

The vegetation of the Susitna lowland consists of intermixed forest, muskeg, and subalpine shrub tundra. The forests consist mainly of mixed birch and poplar and smaller amounts of spruce. They are densest on the lowlands bordering the Susitna River and become more open on the higher land to the west. Muskeg vegetation, including mosses, grasses, sedges, heath shrubs, and scattered black spruce, covers the flatter areas between the main streams and the floors of the many poorly drained abandoned glacial drainage channels. Grassland vegetation grows chiefly on slopes and rounded uplands. Intermixed with the forest and grassland types of vegetation are a variety of shrubs, including high-bush cranberry, wild rose, and devilsclub. Alders locally form dense thickets, particularly on valley sides.

LAND USE, SETTLEMENT, AND ACCESSIBILITY

The land resources of the Beluga-Yentna region are virtually untouched; there are no farms or homesteads. The only permanent inhabitants are in the small native villages of Tyonek and Susitna, and at the FAA station at Skwentna. Camps and lodges on some of the larger lakes, including Alexander, Coal Creek, Judd, and Chelatna Lakes, accommodate sportsmen during hunting and fishing seasons, and some mining activity was noted in the Yentna gold-placer district in the summer of 1962.

The chief industry of the natives in the southern part of the region is salmon fishing. Several oil companies were active in geophysical exploration and exploratory drilling along the coast south of the Beluga River in 1961, 1962, and 1963.

The road from the Susitna River opposite Talkeetna to the Cache Creek mining district, in the Yentna River basin, was the only public road in the region in 1962. Users of this road cross the river by ferry. In the southern part of the region, points a few miles up the Beluga River and along the coast to the south may be reached by barge. Access farther inland is mainly by air; there are no established roads or trails there. Wheel planes can land on a 3,000-foot runway at the FAA airport at Skwentna, and on small airstrips near Tyonek and at Petersville, Chelatna Lodge, and several points in the Cache Creek and Fairview Mountain mining districts. Float or amphibian planes can land on many lakes in the region, the largest of which are Beluga, Shell, and Chelatna Lakes.

The lack of roads has been a major deterrent to the development of the resources of the region. However, the Beluga and Chuitna River basins (pl. 5) are estimated to contain more than 2,000 million tons of coal (table 2), most of which is in relatively flat country and within 25 miles of the coast of Cook Inlet.

GEOLOGY

ROCKS OF JURASSIC AND (OR) CRETACEOUS AGE

UNDIFFERENTIATED METASEDIMENTARY ROCKS

The oldest known rocks in the Beluga-Yentna region consist of an assemblage of interbedded slate, graywacke, lava, tuff, and agglomerate that has been intensely folded and faulted and is probably many thousands of feet in total thickness. These rocks form the bulk of the bordering mountains to the west of the Susitna lowland, except where displaced by granitic intrusive masses; they also underlie some of the several outlying mountainous areas east of the mountain front. These rocks were first described by Spurr (1900, p. 149–155) and Brooks (1911, p. 85–90), both of whom considered them to consist of an older predominantly volcanic sequence, which Spurr named the Skwentna "series," and a younger shale-arkose-limestone sequence, which he named the Tordrillo "series." On the basis of later field work, however, Capps (1929, p. 83) concluded that the two units were not everywhere as distinct as where originally mapped and so could not be mapped separately without more detailed study.

These rocks are virtually barren of fossils, and it has therefore been impossible to subdivide them according to age, but on the basis of similarity to rocks of adjoining regions that contain abundant fauna it seems probable that they include beds ranging in age from Early Jurassic to Late Cretaceous (Capps, 1929, p. 84–86).

In the present investigation the older rocks were not mapped in detail but were briefly examined at several points near their contact with rocks of the Kenai Formation. North of the Skwentna River the older, bedded rocks appear to consist entirely of thin-bedded slate and graywacke. South of the Skwentna, similar rocks are associated with several types of rocks of igneous origin. The mountains drained by the headwaters of Coal Creek are carved in large part from bedded tuff or lava and fine-grained intrusive rocks. The mountain mass that culminates in Beluga Mountain is composed almost entirely of volcanic agglomerate and associated dense, locally porphyritic rocks of intermediate composition. Metasedimentary rocks were noted only on the extreme northern slope of these mountains. Between Coal Creek and the south end of the map area, the bedded rocks of the east front of the Alaska Range consist entirely of slate and graywacke.

INTRUSIVE ROCKS

The areas shown as intrusive rocks on the accompanying maps are underlain mainly by light- to medium-gray medium- to coarse-grained granitic rocks, which presumably were intruded into the older bedded rocks. Included also are a few small bodies of fine-grained, in part porphyritic, igneous rocks. The enclosing bedded rocks were not examined thoroughly in all parts of the map area, and some granitic rock probably is included in the areas mapped as bedded rocks.

Very little evidence of the age of the granitic intrusive rocks was found during this investigation. At only one point, on Contact Creek south of the Skwentna River, was granite found in contact with other bedrock. There, beds of the Kenai Formation resting with sedimentary contact on weathered granite attest the pre-Miocene age of the intrusive rock. According to Capps (1929, p. 89), granitic rocks on the upper Skwentna River intruded rocks of probable Late Cretaceous age, whereas similar granitic rocks in the Talkeetna Mountains to the east are generally considered to be, at least in part, as old as Middle Jurassic (Grantz and others, 1963a, p. 56–59). The age of the granitic rocks of Mount Susitna and other smaller outlying hills on the Susitna lowland therefore is probably somewhere between these limits.

A conical hill on the east slope of Beluga Mountain, in sec. 18, T. 19 N., R. 10 W. (pl. 1), appears to be a plug of dense black basalt intruded into volcanic agglomerate. The fresh appearance of this rock, and of fine-grained intrusive rocks noted elsewhere in the region, suggests a much younger age than that of the enclosing bedded rocks, but inasmuch as none of these intrusive rocks were found in association with beds of the Kenai Formation it is not known whether they are as young as Tertiary.

ROCKS OF TERTIARY AGE

KENAI FORMATION

The youngest bedrock unit in the Beluga-Yentna region is a sequence of interbedded claystone, siltstone, sandstone, and conglomerate that locally includes beds of subbituminous coal and lignite. This sequence is believed to be a northward extension, beneath the waters of upper Cook Inlet, of the Kenai Formation of Tertiary age that is typically exposed on the west side of the Kenai Peninsula (Barnes and Cobb, 1959; Dall, 1896, p. 788–797; Stone, 1906, p. 53–73).

CHARACTER AND DISTRIBUTION

The Kenai Formation in the Beluga-Yentna region consists of intergrading and generally lenticular layers of clastic rocks, ranging from claystone to coarse conglomerate, that generally are light gray to buff but locally are dark gray, particularly near coal beds. The rocks generally are slightly to moderately indurated but include a few resistant beds of calcareous siltstone. Concretions and irregular masses cemented by iron carbonate are locally present, particularly in the thicker sandstone beds. Beds of subbituminous coal and lignite as much as 50 feet thick are abundant in certain areas, and streaks and lenses of carbonized plant material are common throughout the formation. The abundant plant material, irregular bedding, and total absence of marine fauna indicate that the formation is of nonmarine origin.

Although the Kenai Formation is mostly covered by glacial, alluvial, and colluvial deposits, except locally along the major streams, the wide distribution of outcrops indicates that it probably underlies most of the lowland area of the Beluga-Yentna region. The southernmost exposure of the Kenai Formation is on the northwest shore of Cook Inlet about 6 miles southwest of the village of Tyonek (pl. 1, 5). On the Chuitna River, the easternmost exposures of Kenai rocks are at a point about 5 miles from the coast, above which point they are exposed more or less continuously in the stream bottom and valley walls all the way to the extreme headwaters. Outcrops along the rims of headwater valleys show that Quaternary deposits are thin or absent over large areas of the intervening uplands, which were therefore mapped as Kenai Formation (pl. 5). The section exposed along the Chuitna River southeast of the Castle Mountain fault includes one of the greatest concentrations of coal beds in the entire region.

West of the upper Chuitna River, a thick sequence of light-gray to buff pebbly sandstone and conglomerate, including some tuff, is exposed on the headwaters of Straight Creek and in the south wall of the Capps Glacier trough (pl. 1, fig. 2). These beds are poorly to moderately indurated and have been extensively tilted and faulted near the mountain front. Although little or no coal and no identifiable plant fossils were found, these beds are considered to be of Tertiary age on the basis of lithologic character and the common presence of carbonized plant remains, and because similar rocks exposed on several of the east-flowing headwater tributaries of the Chuitna River are conformably overlain by typical coal-bearing Kenai beds. On the basis of this relationship, supported by the general southeasterly dip of the beds on Straight Creek, the conglomeratic series is considered to be a basal member of the Kenai Formation.

Tertiary beds exposed along several northeastward-flowing streams between Capps Glacier and Lone Ridge (pl. 5) are intermediate in character between those on Straight Creek and on the Chuitna River. These beds include a large proportion of sandstone and conglomerate but also contain finer clastic rocks and a large number of thin coal beds; this composition suggests that they represent either a transition zone between the conglomeratic lower member and the coal-bearing middle member of the Kenai Formation, or lateral equivalents of predominantly conglomeratic beds to the west. These beds were mapped as part of the lower member.

The rocks exposed along the Beluga River consist mainly of typical coal-bearing Kenai beds. At locality 91 (pl. 5), however, gently dipping coal-bearing strata rest with distinct angular unconformity on well-indurated dark-brown pebble-cobble conglomerate that forms a narrow gorge and cataract in the river below this point. The conglomerate and the apparently overlying friable white pebbly sandstone have been compressed into folds that have dips of 35° to 50°. Although the more intense folding and greater degree of induration suggest a considerably greater age for the beds below the unconformity, these beds nevertheless are more similar in lithology to Tertiary rocks than to any known older rocks in the Cook Inlet basin; therefore, the unconformity here is believed to lie within the Kenai Formation as considered in this report. However, since the degree of induration suggests that the dark conglomerate is older than any other Tertiary rocks in the region, the unconformity may represent the considerable interval during which the thick conglomeratic sequence in the Straight Creek area was being deposited.

An angular unconformity judged to be intraformational and possibly of only local significance was noted on Straight Creek by Capps (1935, p. 62).

Another unusual facies of the Kenai is represented by a resistant bed of altered tuff at least 30 feet thick that forms a prominent east-facing escarpment overlooking the valley of Scarp Creek, along the west boundary of T. 14 N., R. 11 W. (pl. 5). Although neither top nor bottom of the tuff bed is exposed, its relation to nearby outcrops indicates that it is an interbed of the lower member of the Kenai Formation.

Bedded rocks exposed in the canyons of the Theodore and Lewis Rivers, northeast of the Beluga River, consist mainly of moderately to well-indurated buff sandstone and dark-gray conglomerate. The conglomerate is exceptionally resistant to erosion and closely resembles that exposed in the gorge of the Beluga River. Occasional streaks and lenses of coal and claystone indicate that these rocks are part of the Kenai Formation. The southward-dipping beds on the Lewis River appear to be basal beds deposited directly on granite. Because of this relation and their lithology, the beds on the Theodore and Lewis Rivers are included in the lower member of the Kenai Formation.

Dark-brown well-indurated conglomerate containing coal fragments is exposed in the east bank of the Susitna River at Susitna Station. Although no coal was seen in 1962, local residents stated that it was present but concealed by high water, and Capps (1929, p. 86–87) noted that lignitic coal had been mined on a small scale at this point and also on the south bank of the Yentna, 7 miles above Susitna Station. Capps' map (1929, pl. 1) shows coal-bearing rocks extending for several miles along both sides of the Yentna, upstream from a point about 6 miles above its mouth. In 1962 the only bedrock seen along this stretch of river consisted of occasional outcrops of granite or other pre-Tertiary rocks in river bluffs carved mainly in glacial deposits.

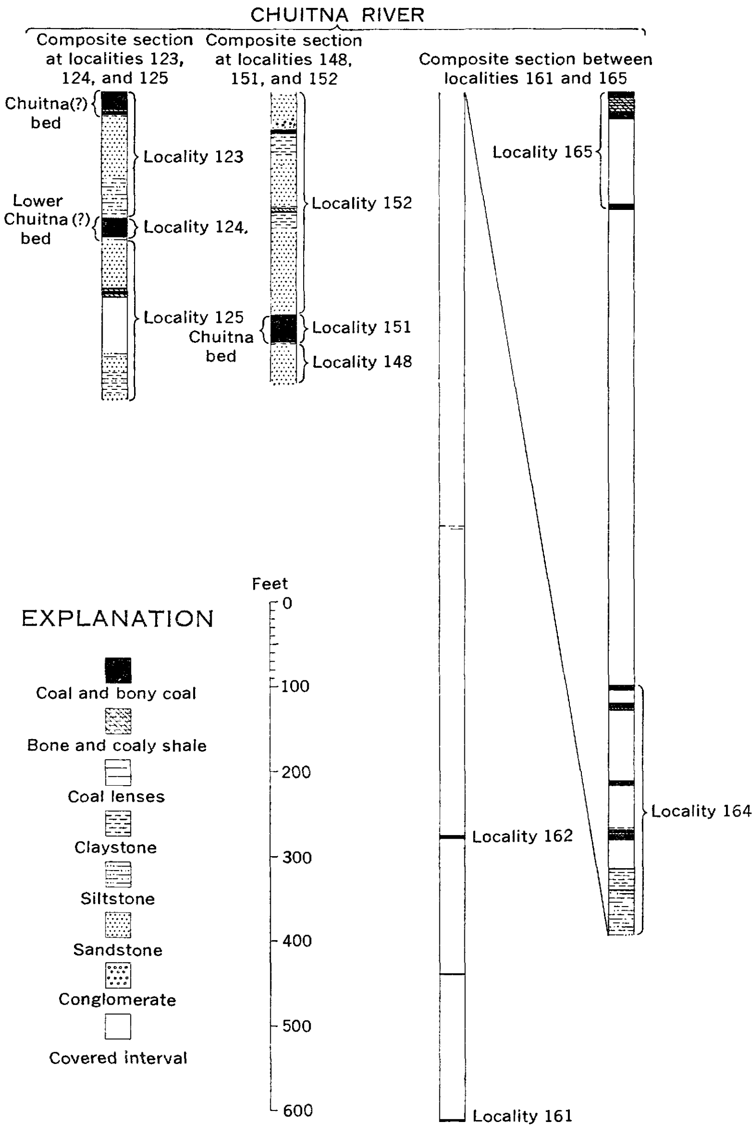
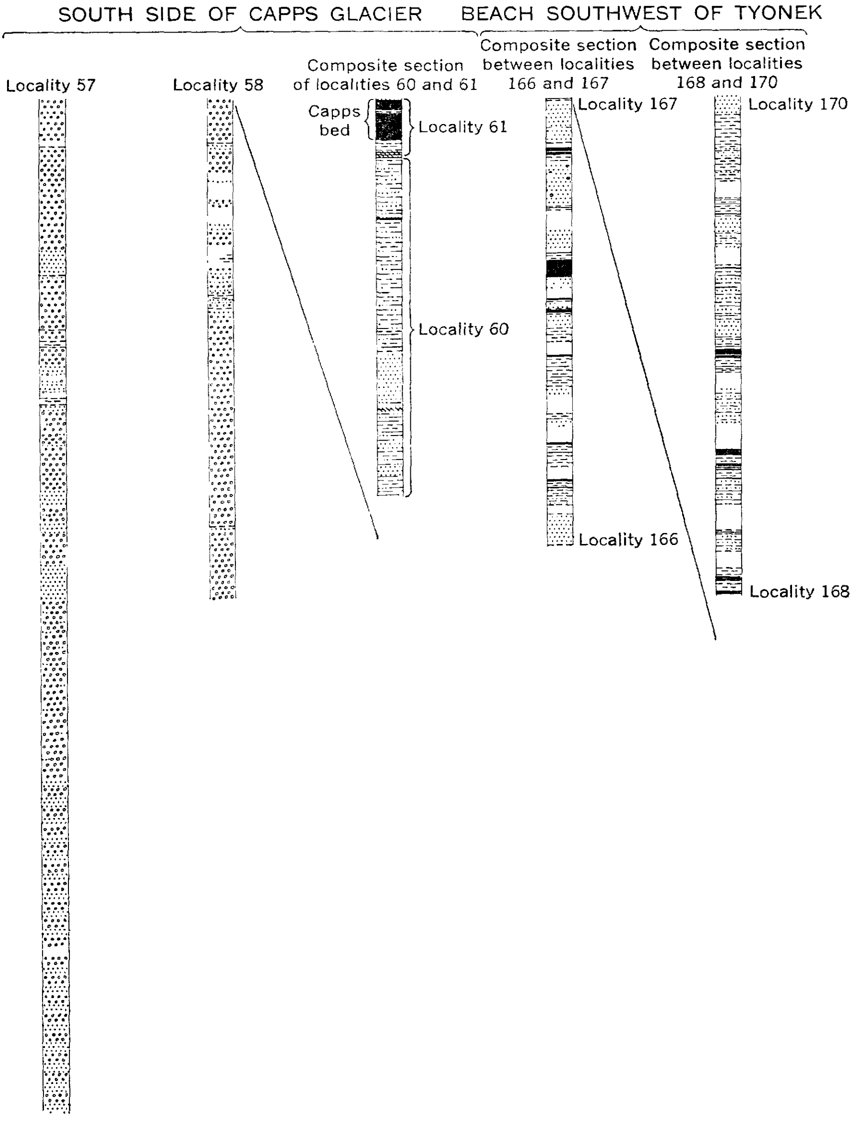


FIGURE 2.—Stratigraphic sections of the Kenai Formation in the Chuitna River and Capps Glacier areas and along the beach southwest of Tyonek. Location



of sections, with one exception, shown on plate 5; location of section 57, on the south side of Capps Glacier, shown on plate 1.

However, abundant coal float on the river bars supports the probability that rocks of the Kenai Formation are locally present but concealed by high water and by slumping of the overlying Quaternary deposits.

North of the latitude of Beluga Lake, exposures of Kenai Formation are few and mostly of small extent. Sandstone and finer clastic rocks, including a few coal beds, are exposed at several places on Coal and Drill Creeks, and at a few places on Wolverine Creek, at the base of the northwest slope of Mount Susitna. In the Talachulitna River basin Kenai beds, including some coal, were mapped for a few miles along the main stream and also on Friday and Saturday Creeks, west of Beluga Mountain.

On Canyon Creek (pl. 2), a southern tributary of the Skwentna River, Kenai beds, including some thick coals, probably underlie the entire basin south of the main forks beneath a cover of Quaternary deposits. To the northwest on the Skwentna River, a thick section of steeply tilted beds, including several thick coals, is exposed in the south bank near the mouth of the Hayes River, and a small exposure including one or two thin coal beds also was mapped a little farther upstream on the north bank.

In the northern part of the Beluga-Yentna region, outcrops of the Kenai Formation, though mostly of small extent, are so widely distributed as to leave little doubt that the formation underlies much of the lowland area beneath a mantle of Quaternary deposits. However, significant coal occurrences were found at only a few places, notably at localities 14 and 15 (fig. 4) on Johnson Creek, a west tributary of the Yentna (pl. 2), and at localities 2, 3, 4, 8, 9, and 10 (fig. 4) in the Fairview Mountain area (pl. 2). Most of the exposed Tertiary rocks in this part of the region consist of poorly indurated conglomerate that rests conformably on finer clastic rocks and associated coal beds (fig. 3) that are limited chiefly to the northwest slope of Fairview Mountain. Although no fossils were found in the conglomeratic beds, they have undergone the same tilting and folding as the underlying coal-bearing rocks and are considered to be an upper conglomeratic member of the Kenai Formation. Weathered outcrops of the poorly indurated conglomerate are easily confused with Quaternary gravel, but the conglomerate can generally be distinguished by the greater degree of induration and by the common presence of thoroughly decayed pebbles. The upper conglomeratic member is best exposed on the upper slopes of Fairview Mountain and on the hills northwest of Pass Creek, where it consists of easily eroded rusty pebble-cobble conglomerate. Similar rocks are exposed on Bluff Creek, just south of Ruth Glacier at the north end of the map area (pl. 1); on the upper southeast slopes of the

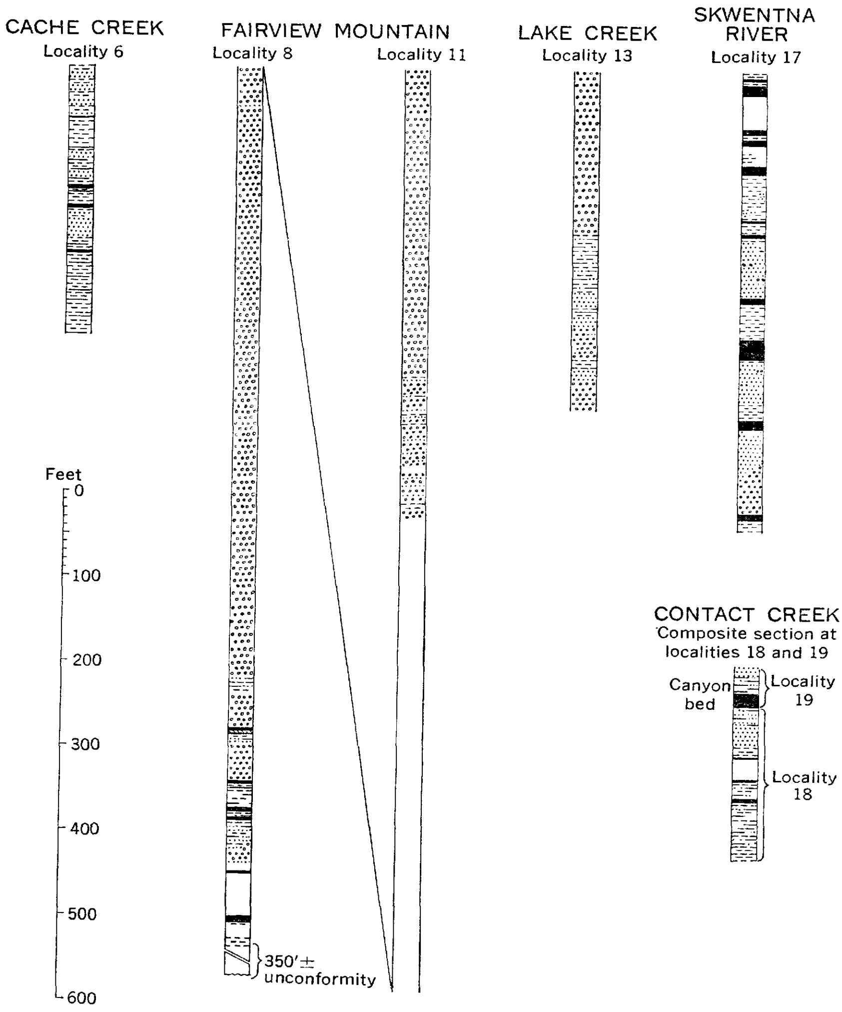
Dutch Hills; at the head of Treasure Creek; and at several points along the Nakochna and Kichatna Rivers and Johnson Creek, all western tributaries of the Yentna River.

Farther east in the northern part of the region, a few scattered outcrops along the Kahiltna River and Lake, Cache, and Peters Creeks, and along the road from Talkeetna to the Cache Creek district show this broad lowland area to be underlain mainly by sandstone and minor siltstone and claystone, and a few thin beds of coal.

The stratigraphic relations of the Kenai rocks in different parts of the Beluga-Yentna region are not completely known. The conglomerate unit exposed in the southwest part of the region clearly underlies the coal-bearing rocks of the Beluga and Chuitna River areas, and the conglomerate unit of the Fairview Mountain area definitely overlies coal-bearing beds. Elsewhere in the region very little evidence is available from which to determine the relative age of the many isolated exposures of Tertiary rocks. Inasmuch as the principal coal-bearing sections occur in an intermittent belt near the western margin of the Tertiary basin, it seems likely that they were all laid down during the same general period of deposition and that the coal-bearing rocks of the northern part of the region are correlative with at least part of the much thicker coal-bearing section in the southern part. This conclusion is supported by the rather scanty paleontological evidence now available from a few collections of plant fossils (Wolfe and others, 1965, p. 49).

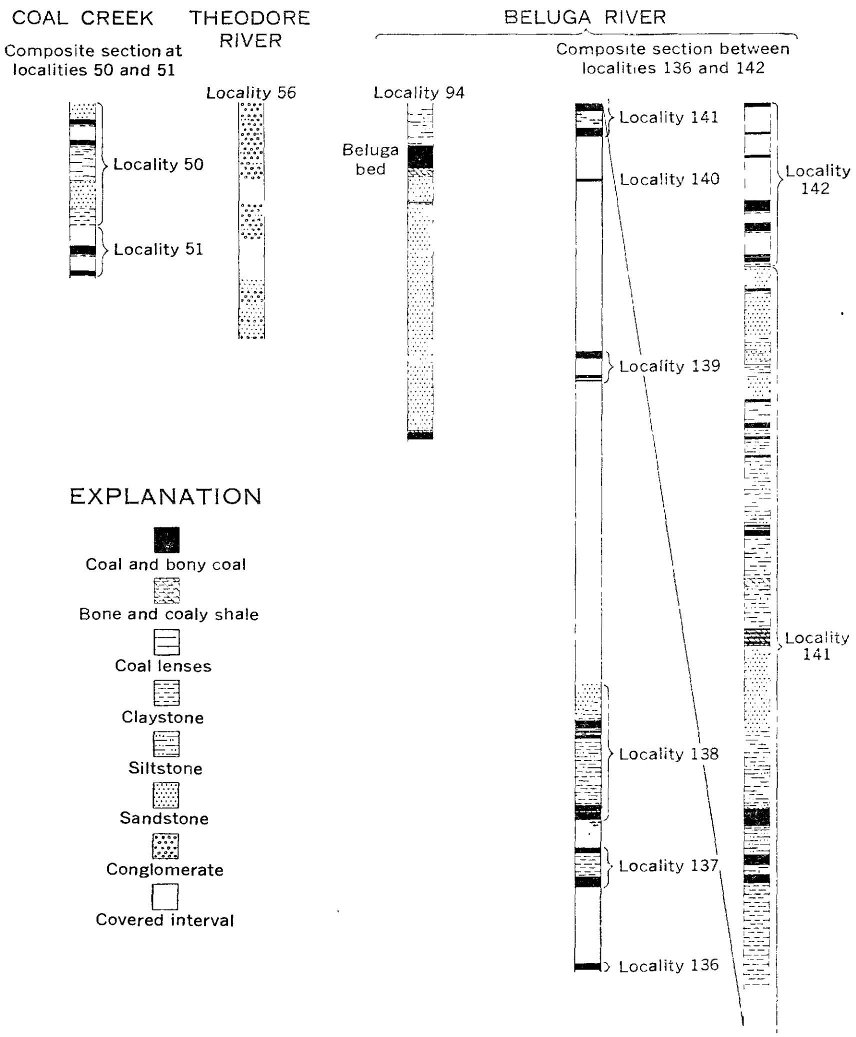
STRUCTURE

The details of the structure of the Kenai Formation in the Beluga-Yentna region are imperfectly known, because broad covered intervals separate the few widely distributed outcrops. Study of these outcrops, however, permits some general conclusions. First, fairly simple structure is the general rule; tilting, folding, and faulting occur only in a few rather restricted areas. In most of the lowland areas away from the bordering or outlying mountains, the dips are flat to gentle, rarely exceeding 15°. One notable exception to this generalization occurs in a belt trending northeastward from the mouth of Straight Creek, across the upper Chuitna River, along the steep southeast face of Lone Ridge, across the Beluga River near Felt Lake, and on along the southeast base of Mount Susitna. This belt is believed to represent the southwest continuation of the Castle Mountain fault, which follows the north side of the Matanuska Valley (Barnes and Payne, 1956, p. 9) and has been traced southwestward along the Little Susitna River (Barnes and Sokol, 1959, p. 126). It is marked by steeply dipping and locally sheared beds on the Chuitna, Beluga, and Theodore Rivers (pls. 1, 5), and, with a few exceptions, separates



A

FIGURE 3.—Stratigraphic sections of the Kenai Formation. *A*, Yentna River basin. *B*, Beluga River area. Location of sections 6, 13, 17, 56 shown on plate 1; 8, 11 shown on plate 2, Fairview Mountain area; 18, 19 shown on



B

plate 2, Canyon Creek area; 50, 51 on plate 2, Coal Creek area; 94, 136–142 on plate 5.

conglomeratic beds of the lower member of the Kenai Formation to the northwest from the coal-bearing middle member to the southeast. Elsewhere in the lowland areas steep dips are almost invariably accompanied by evidence of faulting, as at locality 52 on Drill Creek (pl. 2) and at localities 132 and 134 on the Beluga River (pl. 5). Where evidence of faulting is lacking, steep or irregular and divergent dips at many places are the result of slumping of large blocks of Kenai Formation, particularly where it includes a large proportion of claystone.

A second notable exception to the generally simple structure of the Tertiary beds of the region is an anticlinal fold that crosses the Chuitna River about 6 miles above its mouth (pl. 5). Attitudes measured along the river indicate that an anticline which has a gently dipping east limb and a moderately to steeply dipping west limb trends north-northeastward in line with similarly trending fault zones that cross the Beluga River at localities 132 and 134 (pl. 5). Because all the strata exposed along this part of the Beluga dip southeastward, the anticline either dies out before reaching the Beluga, or its west limb has been completely cut out by faulting. Although no evidence of a major fault was found on the Chuitna River west of the anticline, the possibility that one exists is raised by paleobotanical evidence (Wolfe and others, 1965, p. 63, fig. 5) indicating that the beds exposed near the axis of the anticline are younger than the nearly horizontal beds exposed a few miles upstream. For the latter beds to underlie those at the anticlinal axis would require either a rather abrupt synclinal fold or a fault west of the anticline. Although no evidence of either was found, such evidence could be concealed in a poorly exposed interval that extends upstream for more than a mile from locality 158 (pl. 5). Of the two possibilities, a fault seems to be the more likely, as it is doubtful that a syncline of the necessary magnitude could be completely concealed in this narrow interval. Additional evidence for a fault in this vicinity is provided by the results of an aeromagnetic survey of the Cook Inlet area (Grantz and others, 1963b, p. 126, 127, pl. 18), which indicate that a trend line, termed the "Moquawkie magnetic contact," crosses the Chuitna River a short distance upstream from, and parallel to, the northeast-trending anticlinal axis. This contact is interpreted as the boundary between nonmagnetic rocks to the southeast and predominantly magnetic rocks to the northwest (Grantz and others, 1963b, p. 126)—conditions which would exist along a major fault with the northwest side upthrown.

A third zone of complex structure extends along the foot of the mountains that form the western border of the Susitna lowland from the vicinity of Chelatna Lake to the head of Canyon Creek. At several places within these limits, rocks are exposed that have been strongly folded and faulted parallel to the mountain front. This deformation, together with the general dip of the Tertiary beds toward the center of the Cook Inlet basin, is believed to have resulted from general uplift of the bordering mountains during Tertiary time. Although uplift to the west was predominant, the direction of relative movement was reversed locally, notably along Pass Creek northwest of Fairview Mountain and along upper Canyon Creek (pl. 2), where older rocks on the east side of major faults have been upthrown against Tertiary rocks.

South of Canyon Creek the mountain front is less well defined, and evidence of strong deformation along the border of mountains and lowland is lacking, except just south of Capps Glacier where granitic rocks of the rugged mountain front have been faulted against Kenai beds of the upland to the southeast (pl. 1). Here also, although the net effect of displacement has obviously been uplift of the granitic mountains on the northwest side of the fault, the most recent movement appears to have been uplift on the southeast side, as shown by drag of Tertiary beds that dip steeply northwestward toward the fault.

THICKNESS

The total thickness of the Kenai Formation in the Beluga-Yentna region is difficult to determine. No single exposure shows more than a small part of the total thickness, and the wide separation and scarcity of outcrops, together with a lack of key beds, preclude reliable correlation of exposures in different parts of the region.

The thickest continuously exposed section is on the Beluga River at localities 141 and 142 (pl. 5), where more than 1,100 feet of strata, including several thick coal beds, is exposed in a high bluff on the east side of the river. This section is immediately underlain by an incompletely exposed coal-bearing section at localities 136–140 which, barring duplication by undetected faults, adds at least 1,000 feet to the measured thickness of coal-bearing rocks, so that the total thickness represented in this area may be more than 2,000 feet (fig. 3*B*). Sections including several hundred feet of coal-bearing rocks were measured in many other parts of the region, but many of these sections, particularly those on the lower Chuitna River and along the beach southwest of Tyonek, probably are correlative with parts of the Beluga River section.

The thickest exposed section of the conglomeratic beds that underlie the coal-bearing part of the Kenai Formation was measured at locality 57, near the mountain front in the south wall of the trough occupied by Capps Glacier (pl. 1, fig. 2). This section contains 1,200 feet of conglomeratic beds, but projection of bedding from other outcrops suggests that the total thickness below the coal-bearing part may be several thousand feet. The conglomeratic beds that overlie the coal-bearing rocks in the Fairview Mountain area have an apparent thickness of at least 2,500 feet, barring duplication by faulting on the southeast slope of Fairview Mountain. According to Capps (1913, p. 31), the topography of the head of Twin and Mills Creeks (pl. 2, Fairview Mountain area) suggests the presence of faults parallel to the one on Pass Creek, but examination of the area in 1962 failed to reveal any direct evidence of such faults.

By assuming a thickness of 2,500 feet for the upper conglomerate member in the Fairview Mountain area, 2,000 feet for the coal-bearing middle member as measured on the Beluga River, and 3,000 feet for the lower conglomerate member south of Capps Glacier, a minimum aggregate thickness of 7,500 feet for the Kenai Formation is obtained, although it is recognized that all three units were not necessarily deposited in full thickness at any one place. This figure compares with the thickness of about 10,000 feet of Kenai Formation revealed by drilling in the Swanson River oil field, across Cook Inlet on the Kenai Peninsula, as reported by Kelly (1963, p. 286). Kelly further stated (p. 285) that the maximum thickness in the deepest part of the Cook Inlet basin probably exceeds 18,000 feet.

AGE AND CORRELATION

On the basis of fossil plants, the coal-bearing Tertiary deposits that occur in many parts of Alaska have long been considered to be of Eocene age. More recent studies of new collections, including spores and pollen, and restudy of older collections, indicate that these deposits probably range in age from Paleocene to Miocene or Pliocene (Wolfe and others, 1965, p. 1). Collections made during the present investigation indicate that the coal-bearing beds on the lower Chuitna River are probably of late Miocene age, and that the rocks including the Chuitna and Capps beds to the northwest are somewhat older, probably early Miocene. No fossils were found in the conglomeratic upper and lower members of the formation, so the maximum age range is not known.

The proximity of the coal-bearing rocks of the Beluga-Yentna region to the lithologically and structurally similar rocks of the Kenai Formation at its type locality on the Kenai Peninsula immediately suggests that the rocks are correlative and continuous beneath the waters of Cook Inlet. This conclusion has been confirmed by paleobotanical evidence of similar age (Wolfe and others, 1965, p. 49) and by offshore drilling at intermediate points in Cook Inlet.

Records of oil wells in the Swanson River field on the Kenai Peninsula show that the Kenai Formation in that area comprises an upper 4,500-foot unit consisting largely of sandstone and coarse conglomerate and minor amounts of coal and carbonaceous shale and siltstone; a middle 6,000-foot unit composed of carbonaceous shale and siltstone, fine to medium sandstone, and many conspicuous beds of coal; and a lower unit consisting of 650 to 750 feet of sandstone and coarse conglomerate (the productive Hemlock zone) underlain by 200 to 670 feet of cyclically interbedded sandstone, siltstone, and coal (Parkinson, 1962, p. 181–183). Although much more information is needed before the stratigraphic sections of the Beluga-Yentna and Kenai Peninsula regions can be reliably correlated, the gross similarity of the two sections, particularly the abundance of coal in their middle units, suggests the possibility that the upper and lower units on the Kenai Peninsula may be represented along the western margin of the Tertiary basin by the upper and lower conglomeratic members in the Beluga-Yentna region.

PYROCLASTIC DEPOSITS

An area of about 17 square miles south of Capps Glacier is covered by dark-gray lapilli tuff and volcanic breccia that is locally well stratified (pl. 1). The deposits as exposed in the south wall of the Capps Glacier trough include at least one resistant bed dipping about 20° SW. near locality 58 (pl. 5) and apparently are several hundred feet thick, although the bedding is obscured by surface material farther west. The base of the deposits was not seen, but they clearly overlie, apparently with strong angular unconformity, beds of the lower conglomeratic member of the Kenai Formation at locality 58. To the south, near locality 69, similar deposits show nearly horizontal bedding and rest on gently dipping coal-bearing rocks. Elsewhere, bedding, as well as the contact with the underlying Kenai Formation, is concealed by loose surface material, but the pyroclastic deposits appear to thin out southward along the divide between the headwaters of Straight Creek and the Chuitna River. No fossils or other direct evidence of the age of these deposits were found, but inasmuch as the steep dip noted near Capps Glacier shows that some beds are older than the final episode of mountain-building deformation in this region, they are considered to be at least in part of Tertiary age. The less deformed beds may have been deposited in Pleistocene or even Recent time.

ROCKS OF QUATERNARY AGE

Unconsolidated deposits of several types cover the greater part of the Beluga-Yentna region and effectively mask the underlying bedrock in many large areas. Glacial deposits, both morainal and outwash, cover the greatest area; alluvial deposits of Recent age are limited to the present stream valleys. In some areas the coarse glacial deposits are underlain by very fine banded plastic clay, which was obviously deposited in quiet water. Such deposits are well exposed on lower Coal Creek, along the lower few miles of Bishop Creek, and on small streams flowing into Lower Beluga Lake from the east, where they probably were deposited in a higher stage of Beluga Lake in Pleistocene time. Similar deposits were noted along lower Lake Creek and the Kahiltna River and locally in Cache Creek valley, where they seem to fill an older canyon of Cache Creek now covered with glacial drift.

Other types of Quaternary deposits include talus, other colluvial deposits, and landslide masses. All the Quaternary deposits were mapped as a single unit, with the exception of the larger landslide masses, which were mapped separately because their recognition is necessary to the interpretation of local structure and stratigraphy of the coal-bearing rocks in which most of the landsliding has occurred.

The thickness of the Quaternary deposits is in general much less than expected in a region that has been so extensively glaciated. Maximum thicknesses measured were about 300 feet at a few places along the Beluga and Chuitna Rivers and the lower courses of Peters and Lake Creeks in the Yentna River basin. Elsewhere the thickness varies greatly, from a few feet to 200 feet, and in several large areas bedrock is covered only by a thin soil cover. The variation in thickness is due in part to irregular deposition on a surface of considerable relief and in part to postglacial erosion.

LANDSLIDE DEPOSITS

Landslides, most of which involve beds of the Kenai Formation, are fairly common in the Beluga-Yentna region, particularly in the southern part. Most of them have occurred on valley sides or on the flanks of mountains where oversteepening by erosion or uplift has promoted mass movement of the weaker Tertiary rocks. Two large slides on the south side of Mount Susitna (pl. 1) may have resulted from recent movement along the Castle Mountain fault, which has displaced Quaternary deposits a few miles to the northeast and whose trace follows the base of the mountain front.

Several landslide masses were mapped along the Chuitna River in the southern part of T. 13 N., R. 13 W. (pl. 5), where they complicated the tracing and correlation of several thick coal beds. The largest single landslide mass in the region lies south of the toe of Capps Glacier, in T. 14 N., Rs. 13–14 W. This slide, with an area of more than 5 square miles, involved coal-bearing rocks that underlie the plateau to the west drained by Capps Creek. The surface of the slide is characterized by typical slump topography and includes many large blocks of coal-bearing rocks showing divergent attitudes; the blocks obviously have been disturbed by mass movement. The slide area is bounded on the west and southeast by prominent escarpments 100–500 feet high that separate it from the upland to the southwest. The comparatively recent origin of the slide is attested by the fact that the troughlike valley at the head of Chuit Creek is obviously beheaded by the northeast-trending escarpment.

On the Beluga River a landslide mass extends for about 2 miles along the west side of the gorge opposite Felt Lake (pl. 5); on Coal Creek, coal-bearing rocks have slumped down the northeast side of the valley 2 miles northwest of Coal Creek Lake (pl. 2).

Farther north, two large slides, characterized by arcuate ridges, lie on opposite sides of Saturday Creek in the northern part of T. 18 N., R. 13 W. (pl. 1). They consist of glacial deposits underlain by coal-bearing rocks that have slumped down the sides of a preglacial valley in Mesozoic rocks. In the Canyon Creek basin several small slides, also involving glacial deposits underlain by coal-bearing strata, occur on headwater tributaries near the contact with older rocks. Larger slides occur on both sides of the canyon of the main stream for 2 miles above the mouth of Contact Creek, where they may be related to the fault along Canyon Creek (pl. 2).

The only landslide of significant size mapped in the northern part of the region is on the northwest wall of the Cache Creek gorge in T. 28 N., R. 9 W. (pl. 1). Many other smaller landslides are included in areas mapped as undifferentiated Quaternary deposits.

ECONOMIC GEOLOGY

COAL

CHARACTER AND DISTRIBUTION OF COAL BEDS

The coal of the Beluga-Yentna region occurs in a large but undetermined number of beds ranging from a few feet to more than 50 feet in thickness, interbedded with claystone, siltstone, sandstone, and conglomerate of the Kenai Formation. Because most exposures are in isolated outcrops of small extent, little is known directly of the continuity and uniformity of individual beds. However, inasmuch as the coal-bearing rocks of this region are considered to be correlative with similar rocks well exposed for miles along the shores of Cook Inlet and Kachemak Bay on the Kenai Peninsula, they are presumed to have been deposited under similar conditions and to have the same lenticular character, marked by rapid lateral changes in both thickness and composition.

As nearly as can be determined from widely separated and only roughly correlated stratigraphic sections, coal beds are rather uniformly distributed through the middle member of the Kenai Formation, but are rare or lacking in the conglomeratic lower member exposed on Straight Creek and the upper Chuitna, and in the conglomeratic upper member in the northern part of the Beluga-Yentna region. This vertical distribution of coal beds agrees with that noted in the logs of oil wells on the Kenai Peninsula (Parkinson, 1962, p. 180–183), where coal occurs in a relatively few thin beds in the upper and lower units and is most abundant in the middle unit. Geographically, coal beds of possible economic value are limited mainly to the southeastern parts of the Beluga and Chuitna River basins and to the upland just south of Capps Glacier. The thickest and most widely exposed coals mapped are the Chuitna bed, ranging from 20 to 52 feet in thickness, which was traced for about 7 miles along the Chuitna River; the Capps bed, with a maximum thickness of at least 50 feet, which was traced for about 4 miles along the face of the escarpment south of Capps Glacier; and the Beluga bed, with a maximum thickness of 30 feet, which was traced for about a mile along the east wall of the Beluga River gorge near Felt Lake (pl. 5). A large but undetermined number of generally thinner beds, represented only by isolated outcrops, are present in the same general areas as the named beds. The thick measured section on the lower Beluga River, between localities 136 and 142 (fig. 3*B*, pl. 5), contains at least 20 coal beds ranging from 3 to 20 feet in thickness in a stratigraphic interval of about 2,100 feet (pl. 6). Other occurrences of potentially valuable coal are on (1) Drill and Coal Creeks, east and north of Beluga Lake, respectively, (2) on Canyon Creek, south of the Skwentna River, (3) on Johnson Creek, and (4) in the Fairview Mountain area north of the Yentna River (pl. 2); there are other occurrences on (5) the Skwentna near the mouth of the Hayes River and (6) on the Nakochna River, near the foot of the Alaska Range west of the upper Yentna (pl. 1). Detailed sections of coal beds at the above localities are shown in figures 4, 5 and plates 3, 4, 6, 7. The results of diamond drilling by the U.S. Bureau of Mines in the vicinity of locality 54 on Drill Creek have been reported by Warfield (1963).

PHYSICAL AND CHEMICAL PROPERTIES

The coal of the Beluga-Yentna region is generally dull black but locally includes a few thin layers and lenses of bright vitrain. Coal exposed in thick beds at localities 2 and 3, in the Fairview Mountain area, has a brownish tinge. In general, the coal has an irregular or hackly fracture and a rough parting parallel to the bedding. Only the thicker vitrain layers show conchoidal fracture. Many beds contain flattened coalified logs, some of which retain the original grain structure and splinter like wood. In weathered exposures the coal is dark gray, and its woody texture is emphasized.

The analyses in table 1 show that the coal ranges in rank from lignite to subbituminous B, but most samples are subbituminous C. The samples from localities 54 and 151 were standard channel samples; all the rest were grab samples of the freshest blocks available at outcrops, taken primarily for determination of rank, and, consequently, probably show a lower ash content than representative channel samples. The sample from the Bureau of Mines trench at locality 54 is probably the only one that was almost unweathered.

BURNING OF COAL BEDS

Burned coal beds were noted at several places in the Beluga-Yentna region. They are marked by zones of yellow to brick-red shale that has been baked to flinty hardness and locally fused to dark-red or purple clinker. The burned coal itself is generally represented by a layer of soft yellow ash at or near the base of the zone. The Chuitna bed is burned for several hundred yards both upstream and downstream from locality 152, and the position of this bed is marked by baked shale at two points on Chuit Creek about 1½ miles above its mouth. Coals that probably represent the Chuitna and some underlying beds are burned in the gully below locality 128, and lower beds are also burned along the Chuitna River near localities 115 and 119 and in the gully below locality 108.

In the Capps Glacier area, either the Capps bed or closely associated coal beds are locally burned on both the north and main forks of Capps Creek, and the small hill in the NE¼ sec. 27, T. 14 N., R. 14 W. (pl. 5) is apparently the result of differential erosion of resistant baked shale and clinker formed by the burning of the Capps or closely overlying coal beds. On the Beluga River at least one of the four coal beds at locality 132 (pl. 5) is burned a short distance downstream on the north side of the river, and at locality 141 several of the uppermost and lowermost coals in the thick section exposed in the high bluff east of the river are burned along parts of their outcrops. On Coal Creek, the coal exposed at locality 46 (pl. 2) is locally burned on the north side of the creek, and just below locality 48 smoke and fumes issuing from slumped terrace gravels indicated that the coal bed exposed just upstream was burning in 1961. North of Coal Creek the only evidence of burning of the coal beds was noted at locality 37 on

TABLE 1.—*Analyses of coal from Beluga-Yentna region, Alaska*

[Analyses by U.S. Bur. Mines, Pittsburgh, Pa. Condition of sample: 1, as received: 2, moisture-free; 3, moisture- and ash-free. Rank according to standards of ASTM, 1939 Book of ASTM Standards, pt. 3, p. 1-6]

Source of sample	Sample	Rank	Calculated moist mineral-free heating value (Btu)	Condition of sample	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Heating value (Btu)
Locality 2, in sec. 26, T. 27 N., R. 12 W., outcrop on Sunflower Creek.	H-38955	Lignite	8, 200	1	32. 9	37. 6	27. 4	2. 1	0. 1	8, 020
				2	------	56. 1	40. 8	3. 1	. 1	11, 960
				3	------	57. 9	42. 1	------	. 1	12, 340
Locality 15, in sec. 30, T. 23 N., R. 14 W., outcrop on Johnson Creek.	H-38953	Subbituminous C.	8, 700	1	27. 1	33. 2	33. 2	6. 5	. 2	8, 060
				2	------	45. 5	45. 6	8. 9	. 2	11, 060
				3	------	49. 9	50. 1	------	. 3	12, 140
Locality 19, in sec. 32, T. 21 N., R. 13 W., outcrop on Contact Creek.	H-38958	do	8, 500	1	28. 2	34. 4	33. 9	3. 5	. 1	8, 140
				2	------	47. 9	47. 3	4. 8	. 2	11, 330
				3	------	50. 3	49. 7	------	. 2	11, 910
Locality 37, in sec. 2, T. 18 N., R. 13 W., outcrop on Saturday Creek.	H-38952	do	8, 900	1	25. 4	34. 1	36. 8	3. 7	. 2	8, 510
				2	------	45. 7	49. 4	4. 9	. 3	11, 400
				3	------	48. 0	52. 0	------	. 3	11, 990
Locality 38, in sec. 1, T. 17 N., R. 9 W., Outcrop on Wolverine Creek.	H-38960	Subbituminous B.	9, 800	1	21. 1	39. 9	36. 7	2. 3	. 4	9, 520
				2	------	50. 6	46. 5	2. 9	. 6	12, 070
				3	------	52. 1	47. 9	------	. 6	12, 430
Locality 54, in sec. 11, T. 15 N., R. 12 W., Bulk channel sample from Bureau of Mines trench.	----------	Subbituminous C.	8, 700	1	24. 4	30. 1	28. 7	16. 8	. 2	7, 160
				2	------	39. 8	38. 0	22. 2	. 2	9, 470
Locality 61, in sec. 10, T. 14 N., R. 14 W., Outcrop of Capps bed.	H-38951	do	9, 200	1	23. 4	36. 3	33. 9	6. 4	. 2	8, 570
				2	------	47. 4	44. 2	8. 4	. 2	11, 190
				3	------	51. 7	48. 3	------	. 2	12, 210
Locality 94, in sec. 34, T. 14 N., R. 11 W., Outcrop of coal 300 feet below Beluga bed.	H-38959	Subbituminous B.	9, 550	1	20. 5	33. 7	31. 6	14. 2	. 2	8, 070
				2	------	42. 3	39. 8	17. 9	. 2	10, 150
				3	------	51. 5	48. 5	------	. 3	12, 360

Locality 117, in sec. 28, T. 13 N., R. 13 W., Outcrop of Chuitna bed.	H-38954	do	9, 800	1	19. 7	36. 2	40. 6	3. 5	. 2	9, 490
				2	------	45. 1	50. 5	4. 4	. 3	11, 820
				3	------	47. 2	52. 8	------	. 3	12, 360
Locality 120, in sec. 25, T. 13 N., R. 13 W., Outcrop on tributary of North Fork Chuitna River.	H-38961	Subbituminous C.	9, 100	1	24. 7	36. 7	36. 6	2. 0	. 1	8, 930
				2	------	48. 7	48. 6	2. 7	. 1	11, 850
				3	------	50. 0	50. 0	------	. 1	12, 180
Locality 131, in sec. 3, T. 13 N., R. 11 W., Outcrop of Beluga bed.	H-38957	do	9, 100	1	24. 2	35. 3	36. 0	4. 5	. 2	8, 690
				2	------	46. 5	47. 6	5. 9	. 3	11, 460
				3	------	49. 5	50. 5	------	. 3	12, 190
Locality 132, in sec. 10, T. 13 N., R. 11 W., Outcrop of lowermost of 4 coal beds in steep bluff.	H-38956	Subbituminous B.	9, 550	1	23. 1	35. 7	35. 0	6. 2	. 3	8, 900
				2	------	46. 4	45. 5	8. 1	. 3	11, 570
				3	------	50. 5	49. 5	------	. 4	12, 600
Locality 151, in sec. 1, T. 12 N., R. 13 W., Channel samples of outcrop of Chuitna bed:										
Upper 12 feet	H-17382	Lignite	7, 650	1	33. 1	32. 9	26. 4	7. 6	. 3	7, 030
				2	------	49. 2	39. 4	11. 4	. 4	10, 510
				3	------	55. 5	44. 5	------	. 4	11, 860
Middle 8 feet	H-17383	do	7, 900	1	32. 1	34. 0	27. 5	6. 4	. 2	7, 330
				2	------	50. 1	40. 5	9. 4	. 2	10, 800
				3	------	55. 3	44. 7	------	. 3	11, 920
Lower 11 feet	H-17384	do	7, 800	1	33. 1	32. 9	27. 6	6. 4	. 1	7, 260
				2	------	49. 1	41. 3	9. 6	. 2	10, 850
				3	------	54. 3	45. 7	------	. 2	11, 990
Locality 153, in sec. 1, T. 12 N., R. 13 W., Outcrop of Chuitna bed.	H-17381	do	8, 200	1	31. 6	35. 1	29. 1	4. 2	. 1	7, 790
				2	------	51. 2	42. 6	6. 2	. 2	11, 380
				3	------	54. 6	45. 4	------	. 2	12, 130

Saturday Creek (pl. 1), at locality 26 at the head of Canyon Creek (pl. 2), and at locality 14 on Johnson Creek (pl. 2). At each of these places the coal is burned for a short distance along the outcrop.

At none of the burned localities, with the possible exception of the small hill near the head of Capps Creek, does the burning appear to have been extensive enough to greatly reduce the reserves of coal.

ESTIMATES OF RESERVES

Estimated coal reserves in the Beluga-Yentna region total about 2,400 million tons in beds more than 2.5 feet thick. Of this amount, 2,300 million tons is in beds more than 5 feet thick, and 2,200 million tons is in beds more than 10 feet thick. These reserves are concentrated in the southern part of the region, where 2,100 million tons lies within an area of less than 400 square miles south of the latitude of Beluga Lake.

In computing reserves, the area underlain by a flat or gently dipping coal bed was determined in most instances by assuming that an outcrop establishes continuity for half a mile in all directions, except where the bed is known to be terminated at a shorter distance by thinning, faulting, or erosion. The areas of the few beds that were traced for more than a mile along the outcrop were determined by assuming that each bed extends back from the outcrop for a distance equal to half the known outcrop length. The extent of more steeply dipping beds was assumed to be limited by a line beyond which the beds are under more than 1,000 feet of cover; consequently, no coal under more than 1,000 feet of overburden is included in the estimates. The thickness figures used in computing the reserves are the weighted averages of all measurements of each bed, determined by the method prescribed by the Geological Survey (Averitt, 1961, p. 19). In computing tonnages an acre-foot of coal was assumed to weigh 1,750 short tons.

The reserves computed by the above methods are considered to be in the indicated category (Averitt, 1961, p. 22). Undoubtedly many of the coal beds extend well beyond the assumed limits, and additional reserves several times the estimated amounts probably are present; however, because of the general lack of information on the number, continuity, and stratigraphic relations of the coal beds, most of which were identified in a single outcrop, no attempt was made to compute reserves in the inferred category. Estimated reserves, separated into three thickness categories, are reported by township and bed in table 2.

TABLE 2.—*Estimated reserves of coal in the Beluga-Yentna region, Alaska*

Coal bed at loc.—	Indicated reserves (millions of short tons)			
	Bed thickness (ft)			Total
	2.5-5	5-10	>10	
T. 27 N., R 12 W.				
2, 3			19. 42	19. 42
4	1. 18			1. 18
Total	1. 18		19. 42	20. 60
T. 27 N., R 10 W.				
5	1. 12			1. 12
T. 27 N., R 9 W.				
6 (lowest coal)	1. 57			1. 57
6 (next to lowest coal)	1. 79			1. 79
Total	3. 36			3. 36
T. 26 N., R 12 W.				
8 (6 beds)	13. 80	5. 38		19. 18
T. 23 N., R 14 W.				
14		3. 22		3. 22
15			8. 45	8. 45
Total		3. 22	8. 45	11. 67
T. 22 N., R 15 W.				
16	1. 61			1. 61
T. 22 N., R 14 W.				
17 (11 beds)	0. 63	2. 49	3. 16	6. 28
T. 21 N., R. 13 W.				
18–21 (Canyon bed)			28. 20	28. 20
18 (Coal below Canyon bed)	1. 61			1. 61
18 (lowest coal)	1. 99			1. 99
Total	3. 60		28. 20	31. 80

795-845—66——3

TABLE 2.—*Estimated reserves of coal in the Beluga-Yentna region, Alaska*—Con.

Coal bed at loc.—	Indicated reserves (millions of short tons)			
	Bed thickness (ft)			Total
	2.5-5	5-10	>10	
T. 20 N., R. 14 W.				
22			18.50	18.50
23			4.37	4.37
24			7.85	7.85
Total			30.72	30.72
T. 20 N., R. 13 W.				
27–32 (Canyon(?) bed)			37.90	37.90
T. 19 N., R. 13 W.				
35	.76			.76
T. 18 N., R. 13 W.				
37 (2 beds)			13.95	13.95
T. 16 N., R. 13 W.				
41			5.58	5.58
42, 43			14.50	14.50
44 (lower bed), 45		3.60		3.60
44 (upper bed), 46			7.25	7.25
47, 48			5.04	5.04
Total		3.60	32.37	35.97
T. 15 N., R. 13 W.				
49, 50 (2 beds)	2.24	3.36		5.60
51 (2 beds)		2.62	4.45	7.07
Total	2.24	5.98	4.45	12.67
T. 15 N., R. 12 W.				
54 (drilled by U.S. Bur. Mines)			20.00	20.00
55 (drilled by U.S. Bur. Mines)			8.86	8.86
U.S. Bur. Mines drill holes 5, 11 (E½ SE¼ sec. 11)			16.50	16.50
U.S. Bur. Mines drill holes 25, 29, 30 (E½ sec. 10)			18.40	18.40
Total			63.76	63.76

TABLE 2.—*Estimated reserves of coal in the Beluga-Yentna region, Alaska*—Con.

Coal bed at loc.—	Indicated reserves (millions of short tons)			
	Bed thickness (ft)			Total
	2.5–5	5–10	>10	
T. 14 N., R. 14 W.				
Capps bed			366.00	366.00
67–70, 73–76			30.90	30.90
Total			396.90	396.90
T. 14 N., R. 13 W.				
88 (2 beds)	3.14			3.14
T. 14 N., R. 11 W.				
89 (2 beds)			10.50	10.50
90 (3 beds)		10.40		10.40
91	1.72			1.72
Beluga bed			10.60	10.60
94 (coal below Beluga bed)			3.12	3.12
Total	1.72	10.40	24.22	36.34
T. 13 N., R. 14 W.				
96		4.14		4.14
97		4.80		4.80
Total		8.94		8.94
T. 13 N., R. 13 W.				
101		2.15		2.15
102	0.82			.82
103 (2 beds)	1.06			1.06
104, 105			4.26	4.26
106 (2 beds)			2.50	2.50
107			19.50	19.50
Chuitna bed			184.00	184.00
110			4.37	4.37
112			6.56	6.56
113, 114			17.80	17.80
115, 116			10.90	10.90
118			9.60	9.60
119			17.00	17.00
120			14.00	14.00
Lower Chuitna bed			45.70	45.70
126			15.20	15.20
127			17.50	17.50
128 (2 beds)		3.74		3.74
129		1.52		1.52
Total	1.88	7.41	368.89	378.18

TABLE 2.—*Estimated reserves of coal in the Beluga-Yentna region, Alaska*—Con.

Coal bed at loc.—	Indicated reserves (millions of short tons)			
	Bed thickness (ft)			Total
	2.5–5	5–10	>10	
T. 13 N., R. 12 W.				
Chuitna bed (projected)	--------	--------	29.00	29.00
T. 13 N., R. 11 W.				
Beluga bed	--------	--------	1.68	1.68
132 (4 beds)	--------	2.35	17.60	19.95
135	0.97	--------	--------	.97
136	--------	3.58	--------	3.58
137 (2 beds)	--------	2.69	5.37	8.06
138 (3 beds)	1.14	2.91	5.38	9.43
139 (2 beds)	1.01	2.69	--------	3.70
140	1.49	--------	--------	1.49
141–143 (10 beds)	5.64	10.39	43.30	59.33
Total	10.25	24.61	73.33	108.19
T. 12 N., R. 14 W.				
Chuitna bed (projected)	--------	--------	24.40	24.40
T. 12 N., R. 13 W.				
Chuitna bed	--------	--------	729.00	729.00
Lower Chuitna bed	--------	--------	22.90	22.90
128 (2 beds)	--------	1.97	--------	1.97
129	0.99	--------	--------	.99
144, 145	--------	--------	42.00	42.00
152, 153 (coal above Chuitna bed)	1.60	--------	--------	1.60
152 (second coal above Chuitna bed)	1.74	--------	--------	1.74
Total	4.33	1.97	793.90	800.20
T. 12 N., R. 12 W.				
Chuitna bed	--------	--------	277.00	277.00
157	2.69	--------	--------	2.69
158 (4 beds)	1.25	1.01	1.68	3.94
159 (2 beds)	.47	.94	--------	1.41
160	.84	--------	--------	.84
Total	5.25	1.95	278.68	285.88

TABLE 2.—*Estimated reserves of coal in the Beluga-Yentna region, Alaska*—Con.

Coal bed at loc.—	Indicated reserves (millions of short tons)			
	Bed thickness (ft)			Total
	2.5-5	5-10	>10	
T. 12 N., R. 11 W.				
161	1.25			1.25
162	1.35			1.35
163	2.24			2.24
164 (4 beds)		6.42	3.80	10.22
165 (3 beds)		7.72		7.72
Total	4.84	14.14	3.80	22.78
T. 11 N., R. 11 W.				
166	0.75			0.75
167	.72			.72
168	.84			.84
169	.84			.84
170		0.95		.95
171		5.33		5.33
Total	3.15	6.28		9.43
Grand total	62.86	96.37	2,235.50	2,394.73

COAL OCCURRENCES BY TOWNSHIPS

Outcrops of coal beds in the Beluga-Yentna region are described on the following pages by townships, in order from west to east, beginning with the northernmost tier. Detailed graphic sections of coal beds in each township are shown on the illustrations indicated in the text and are identified by the locality numbers appearing in the text and on the geologic maps.

T. 28 N., R. 9 W.

The only significant coal occurrence mapped in the township is at locality 1 on Cache Creek (pl. 1), where a 60-foot section includes 5 feet of coal (fig. 4) in 5 beds ranging from 6 inches to 1.5 feet in thickness. Their only importance is as a possible local source of fuel.

T. 27 N., R. 12 W.

At locality 2 (fig. 4), an exceptionally thick coal bed that includes woody layers of brownish coal, crops out in the south bank of Sunflower Creek (pl. 2, Fairview Mountain area). A thickness of 55 feet, without noticeable partings, was measured, and neither roof nor floor was exposed. The upper part of the bed dips 27° SE., and

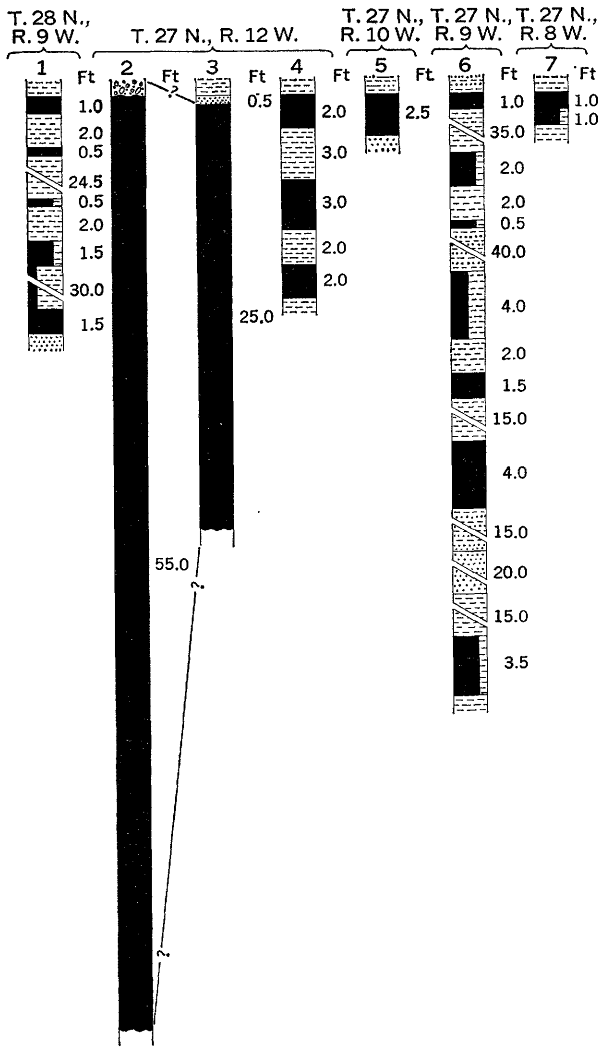


FIGURE 4.—Sections of coal beds in northern part of the Beluga-Yentna region. Locations of sections 1, 5–7, 12 are shown on plate 1; 2–4, 8–10 are on plate 2, Fairview Mountain area; 14–15 are on plate 2, Johnson Creek area.

the lower, or upstream, part appears to dip about 50° SE. The coal is poorly exposed and the lower part may be slumped—a condition which could be the reason for the steeper dip and also could give an exaggerated apparent thickness. This bed evidently is near the base of the Kenai Formation, inasmuch as Mesozoic rocks crop out a few hundred feet upstream.

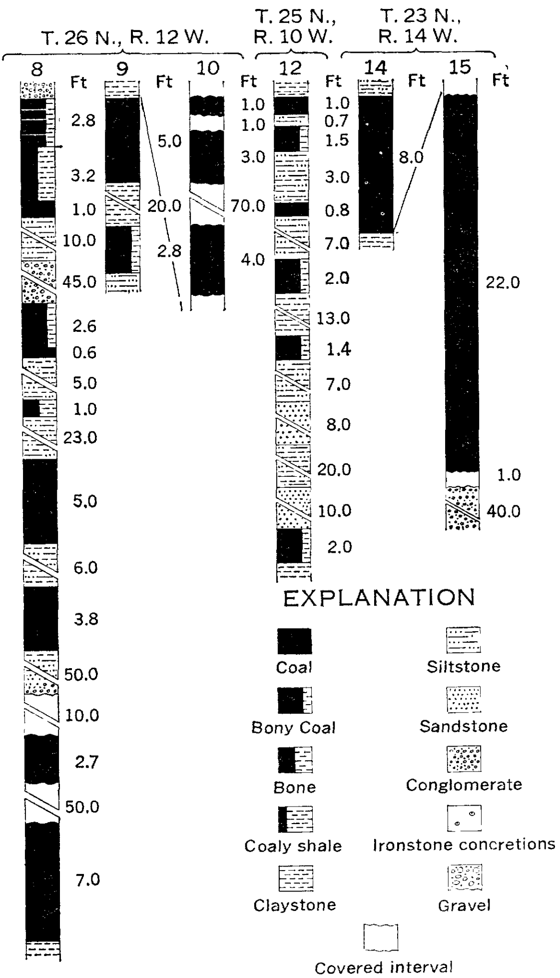


FIGURE 4.—Continued.

A possible continuation of the bed at locality 2 is exposed at locality 3 on Camp Creek, about a mile to the southwest, where at least 25 feet of brownish woody coal lies on the projected strike of the bed at locality 2 and dips 35° SE. Abundant float suggests that the measured section may be underlain by an additional 15–20 feet of coal. At locality 4, half a mile downstream from locality 3 on Camp Creek, a section including three thin coal beds apparently overlies the coal exposed at locality 3.

T. 27 N., R. 10 W.

At locality 5 (pl. 1), a 25-foot section of northwest-dipping Kenai beds exposed in the east bank of Cache Creek includes a 2.5-foot bed of brown woody coal that has many shale lenses.

T. 27 N., R. 9 W.

At locality 6 (pl. 1), four beds of impure woody coal ranging from 2 to 4 feet in thickness (fig. 4) are included in a 160-foot section of southwest-dipping shale and sandstone exposed in the east wall of lower Cache Creek canyon. These beds are cut off to the north by a northeast-trending fault that apparently has dropped overlying sandstone and conglomerate beds against the coal-bearing section.

T. 27 N., R. 8 W.

The only coal exposure noted in the township is at locality 7 on Peters Creek (pl. 1), where a 2-foot coal bed (fig. 4) is exposed at the base of a 75-foot bluff beneath well-indurated silty sandstone. The lower half of the coal is woody and dirty. This exposure is unusual in that the dip of the bedding is not only unusually steep, but is to the northwest toward the nearby Peters Hills, rather than gently away from them as at most other outcrops near their base. This anomalous attitude may be related to an undetected fault.

T. 26 N., R. 12 W.

The thickest coal-bearing section in the northern part of the Beluga-Yentna region is exposed on the northwest slope of Fairview Mountain (pl. 2). At locality 8 (fig. 4), at least six coal beds ranging from 3 feet to more than 7 feet in thickness are included in about 230 feet of strata (fig. 3). The two upper beds contain many thin shale partings, and the two lower beds are incompletely exposed so that their full thickness is not known. At locality 9 (fig. 4), two coal beds are overlain by 11 feet of claystone, which in turn is overlain by at least 35 feet of poorly indurated conglomerate. These coals may be correlative with the two lower coals at locality 8 (fig. 4), which also are overlain by conglomerate and have about the same attitude. At locality 10, two poorly exposed beds, each containing at least 4 feet of coal (fig. 4), probably are correlative with the uppermost beds at locality 8. At both localities the coal dips southeastward beneath the thick conglomerate that caps Fairview Mountain.

T. 25 N., R. 10 W.

At locality 12 on Lake Creek (pl. 1), six beds of mostly dirty coal, none more than 2 feet thick, were measured in a 100-foot section (fig.

4) of Kenai beds that dip 34° W. The moderately steep dip to the west suggests that these beds may be on the west flank of an uplifted belt of Mesozoic rocks represented by the Peters Hills to the north and the Yenlo Hills to the south. Slate is exposed on Lake Creek about 5 miles downstream from locality 12, opposite the north end of Willow Mountain.

T. 24 N., R. 14 W.

The only coal noted in the township is on the Nakochna River near the west edge of the lowland, less than half a mile east of the township line (pl. 1). The coal, which was seen only from the air, appears to be at least 10 feet thick and interbedded with fine-pebble conglomerate and pebbly sandstone that crop out at several points along the lower Nakochna River. The estimated dip of the coal is about 40° E., and a short distance upstream the Tertiary rocks are cut by a strong fault that has brought dark slate to the surface a short distance to the west. The fault is marked by a rusty zone in steeply southeast-dipping beds.

T. 23 N., R. 15 W.

A coal bed about 10 feet thick and dipping about 30° S. is exposed on the west side of Johnson Creek near the south boundary of section 23 (pl. 2). This bed was observed only from the air, but the prevailing gentle southeast dip of other nearby Tertiary beds suggests that its attitude may be due to slumping or faulting. Near the center of section 22 a highly sheared rusty zone in nearly vertical Tertiary beds indicates a major fault about 1 mile east of the contact with dark slate to the west. This fault probably is the same as the one noted on the Nakochna River in T. 24 N., R. 14 W.

The 22-foot coal bed described at locality 15 in T. 23 N., R. 14 W. probably extends a short distance into this township before being cut off at the base of Quaternary deposits.

T. 23 N., R. 14 W.

Coal beds exposed on the south side of Johnson Creek at localities 14 and 15 (pl. 2, fig. 4) apparently lie near the base of a thick section of fine-pebble conglomerate and pebbly sandstone that is exposed for several miles along Johnson Creek and the Nakochna River, and that is similar to the conglomeratic series that overlies the coal-bearing section in the Fairview Mountain area. The bed at locality 14, which dips 8° E., contains 8 feet of generally dull coal that has a few bright lenses and some ironstone nodules. Part of the outcrop is burned.

The bed at locality 15 contains at least 22 feet of dull platy coal with no apparent partings. Both roof and floor are concealed, but the 15° E. dip indicates that the bed closely overlies conglomerate beds exposed a little farther upstream and that it lies several hundred feet stratigraphically below the coal at locality 14. The position and attitude of these beds show that they each probably underlie a considerable area at fairly shallow depth on both sides of Johnson Creek. Their continuation was not found in the shallow valley of Red Creek to the south, where all bedrock is concealed by surficial deposits.

T. 22 N., R. 15 W.

At locality 16 (pls. 1, 3), Kenai beds exposed in the north bank of the Skwentna River include one coal bed several feet thick and several overlying thinner ones, all dipping about 15° NE. The thicker bed contained about 4 feet of coal above river level when examined in 1962, but the full thickness was not determined. Capps (1929, p. 87) reported one coal bed 10 feet thick and one 2 feet thick at this locality.

T. 22 N., R. 14 W.

Coal-bearing rocks are exposed intermittently for at least half a mile upstream from locality 17 in the southeast bluff of the Skwentna River (pl. 1). The beds farthest upstream are nearly horizontal and include a bed of woody coal at river level that is at least 3 feet thick. In a steep bluff, at locality 17, 11 coal beds ranging from 2.5 to 24 feet in thickness are well exposed in a stratigraphic interval of about 500 feet (pl. 3). The beds dip 35°–80° NE. and locally are vertical. A study of the crossbedding in sandstone layers revealed that the beds are overturned. At the northeast end of the exposure the base of the coal-bearing section is faulted against highly sheared Mesozoic sedimentary rocks, and the coal beds themselves have undergone considerable shearing and faulting.

The extent of these coal beds to the northwest is not known, for bedrock is completely concealed by Quaternary deposits on the opposite side of the river. To the southeast, bedrock is also concealed, but less than half a mile from the river a high ridge extending across the projected strike of the coal indicates the presence of resistant older rocks that would limit the extent of the coal in that direction.

T. 21 N., R. 13 W.

At locality 18 (pl. 2), three coal beds between 2 and 4 feet thick (pl. 3) and the lower 5 feet of the overlying Canyon bed crop out beneath the capping glacial gravel on the south side of Contact Creek. The dip is 22° NE. At locality 19 the lower three beds have dipped below creek level, and the Canyon bed is exposed in its full thickness of 16 feet. About 500 feet downstream the Canyon bed also disappears below creek level. At locality 20, a ledge of coal dipping 37° W. projects through the gravel of the stream bottom, and just downstream a second ledge dips 47° W. The ledges each contain about 5 feet of coal and are separated by a 15-foot covered interval. This coal probably represents the Canyon bed that has been dragged up along the fault that follows the east side of Canyon Creek above this point.

At locality 21, a coal bed at least 23 feet thick is exposed in the west wall of Canyon Creek. Neither roof nor floor is exposed. Inasmuch as this coal dips 21° W. and is approximately on the strike of that at locality 20, it is almost certainly the same bed and hence probably also represents the Canyon bed. Upstream from locality 21 the coal extends along the west bank of the creek to the township line.

T. 20 N., R. 14 W.

The coal occurrences in the township are unusual in that they include several exceptionally thick beds (pl. 3) of apparently very small areal extent. At locality 22 (pl. 2), an exposure on the south side of the narrow gorge contains at least 55 feet of solid coal, with neither roof nor floor exposed, that dips 16° SE. The upper part of the south wall consists of Mesozoic rocks which limit the extent of the coal in that direction, probably at a fault. The upland to the north is covered by Quaternary deposits beneath which the coal may extend for a considerable distance. At locality 23, a 15-foot bed of dull coal containing a few clay partings and dipping 30° NE. crops out in the creek bank beneath glacial till. At locality 24, a partly exposed bed of unknown extent contains at least 18 feet of coal and dips 5° S.

Coal-bearing rocks at localities 25 and 26 have apparently been infolded or down-faulted into older rocks, for they are highly deformed and occur in a narrow belt surrounded by igneous rocks. At locality 25, a coal bed at least 55 feet thick with no partings was measured; both roof and floor are covered. This bed apparently grades southward into a series of interbedded coal and claystone that has locally been deformed into several small tight folds. At locality 26, a 6-foot coal bed dips 15° SE. These beds are of unknown but obviously small extent and hence were not included in reserve calculations.

T. 20 N., R. 13 W.

All the coal exposed in the township probably represents the Canyon bed. The coal partly exposed at locality 27 (pls. 2, 3) and at a few other points a short distance farther up Canyon Creek are in landslide areas and are belived to be blocks of the Canyon bed that have slumped down the east wall of the valley away from the Canyon Creek fault. The beds at localities 28 and 29 probably also represent the Canyon bed, because examination of the fairly complete section exposed along Contact Creek indicates that the Canyon bed is the only coal bed in this vicinity that is more than 4 feet thick; furthermore, the position and attitude of these beds with respect to the underlying granite that forms the ridge to the west suggests that they are at about the same stratigraphic position as the Canyon bed. For the same reasons the coal exposed at localities 30, 31, and 32 is believed to be the Canyon bed. This coal, which was traced almost continuously along Canyon Creek, dips directly into Mesozoic rocks forming the east wall of the valley, from which it is evidently cut off by a major fault, probably a continuation of the Canyon Creek fault farther north.

T. 19 N., R. 14 W.

Beds of the Kenai Formation are exposed for half a mile along a headwater tributary of Canyon Creek in section 1 (pl. 2); at locality 33, thicknesses of 7 feet and 2 feet of platy dull coal were measured (pl. 3) in two partly exposed beds dipping 17° NW. A few hundred feet downstream, a bed containing at least 5 feet of coal dips 8° NW. beneath more than 100 feet of glacial till. This locality is almost surrounded by hills of Mesozoic rocks and is evidently near the southern limit of Tertiary rocks in the Canyon Creek basin. The coal at this locality was not included in reserve estimates.

T. 19 N., R. 13 W.

At locality 34 (pls. 2, 3), the upper 16 feet of a bed of dull platy coal is exposed at the base of the bluff. The dip is 14° E. Small landslide areas farther downstream probably are underlain by other Kenai beds. The presence of Mesozoic rocks in the surrounding hills shows that the extent of the coal at this locality is very small.

At locality 35 on Friday Creek (pl. 1), a 4-foot bed of coal is included in a 40-foot section of nearly horizontal interbedded claystone and sandstone. The claystone and sandstone beds are bounded a short distance to the north by Mesozoic rocks, but Kenai beds, including some coal, are exposed at intervals for about 4 miles downstream from locality 35.

T. 19 N., R. 12 W.

At locality 36 on the Talachulitna River (pl. 1), a 30-foot section of Kenai beds includes 8 feet of coal in four incompletely exposed beds (pl. 3) that dip 19° N. To the south, these beds are faulted against Mesozoic rocks which were traced less than half a mile southward to a second fault. Beyond this point Kenai rocks without significant coal beds were traced about 2½ miles farther south in the bluff east of the river. The top of a coal bed of unknown thickness which has a dip of 5° NW. is exposed at stream level at the sharp bend near the south end of the bluff exposure in the NW¼ sec. 27. None of the coal in the township was included in reserve estimates.

T. 18 N., R. 13 W.

Kenai beds were mapped for about 2 miles along Saturday Creek in the northeast corner of the township (pl. 1). The thickest section is exposed in a high bluff at locality 37 (pl. 3), where a 16-foot coal bed, including a 1-foot parting, crops out 50 feet above the stream; a second bed, of which only the upper 17 feet is exposed, crops out at the base of the bluff. The dip of the lower bed is 23° NE. The large landslide areas south and west of locality 37 are probably underlain by coal-bearing rocks.

T. 17 N., R. 9 W.

The only coal-bearing rocks exposed in the township are on Wolverine Creek, along the foot of the northwest flank of Mount Susitna (pl. 1). At locality 38, two 3-foot coal beds were measured (pl. 3), but both occur in slump blocks and may be the same bed. At locality 39, a 2-foot bed of impure coal occurs in a slump block of Kenai rocks. At locality 40 an apparently undisturbed section of Kenai Formation includes a 4-foot bed of clean coal, but inasmuch as it dips steeply into the mountain front, it probably also lies in a slump block.

T. 16 N., R. 13 W.

At locality 41 (fig. 5), coal is exposed in a 30-foot bluff on the south side of Coal Creek (pl. 2). An upper 9-foot bench of dull platy coal, with the roof concealed, is separated by a 3-foot covered interval, consisting at least in part of claystone, from a lower bench that includes at least 13 feet of coal containing scattered ironstone nodules. The floor of the lower coal bed is concealed below creek level. This coal, which dips 15° SE., could not be traced in either direction from this outcrop, for bedrock is concealed to the northeast by glacial deposits and to the southwest by stream gravels.

At locality 42, the top of a horizontal coal bed at least 6 feet thick is exposed at water level on Coal Creek. At locality 43, a bed of dull woody coal at least 14 feet thick, which has a claystone roof and a floor concealed below creek level, dips about 3° SE. The similarity in general appearance and attitude suggests that this is the same bed as the one at locality 42.

Isolated exposures of Kenai rocks along Coal Creek for half a mile below locality 43 indicate a change to a westerly dip that increases from 4° just downstream from locality 43 to 17° at the west boundary of section 14. Accordingly, the thick coal at locality 43 should reappear downstream on the east limb of a syncline, and may

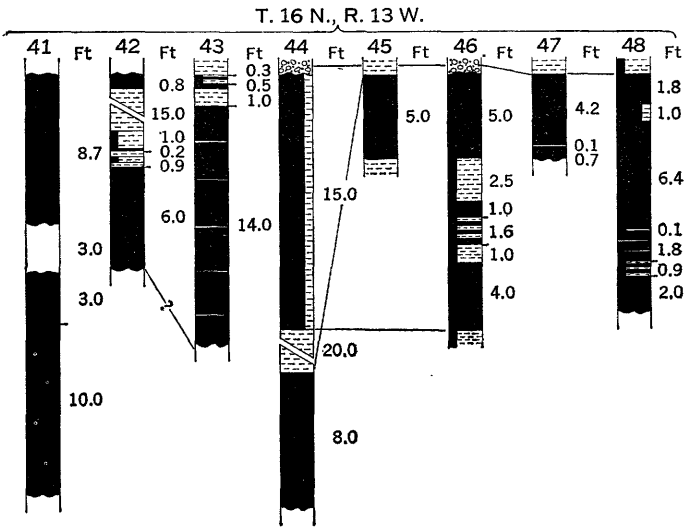
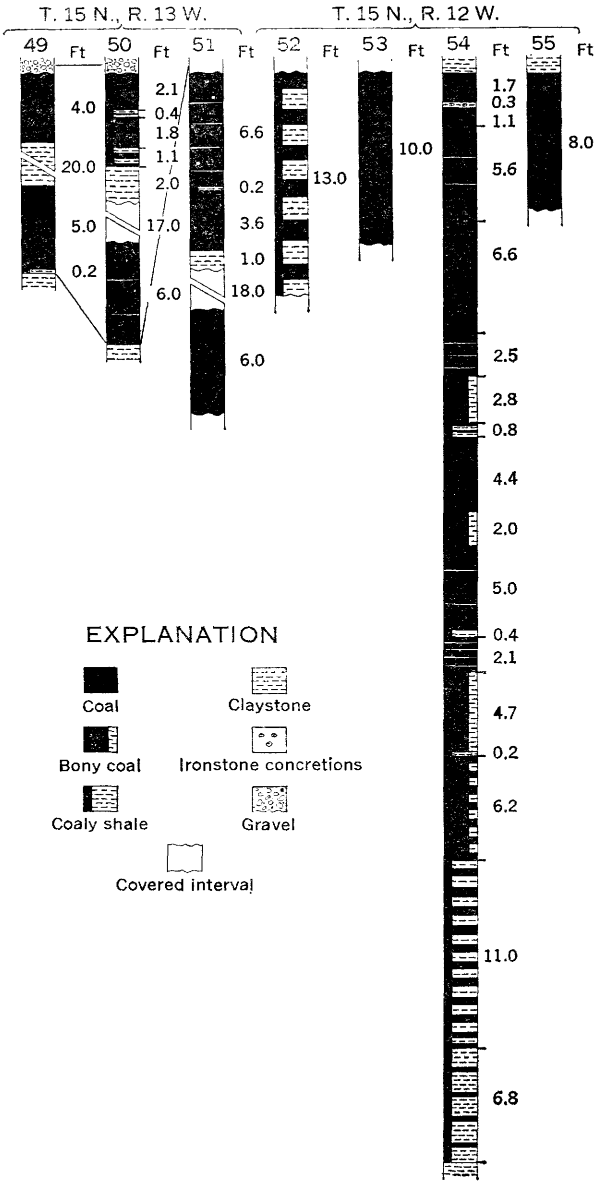


FIGURE 5.—Sections of coal beds in the Coal Creek



area. Locations of sections are shown on plate 2.

be represented by scattered ledges of coal in the creek bottom near the east boundary of section 15.

The only exposures for about 3 miles farther downstream along Coal Creek consist of thick deposits of Quaternary gravel. In the northern part of sections 35 and 36, bedrock is exposed intermittently for about a mile and includes two coal beds. A 5- to 8-foot bed of dull platy coal is exposed at localities 44 and 45, where it dips about 7° S. Just upstream from locality 45 this bed is truncated by glacial gravel. A 15-foot coal bed that lies about 20 feet stratigraphically higher than the 5- to 8-foot bed was traced between localities 44 and 46. At locality 46 the upper and lower several feet of this bed are reasonably clean, but the middle part contains much coaly shale. The bed dips 6° S. at locality 46 and 8° N. at locality 47, and is horizontal at locality 48.

T. 15 N., R. 13 W.

The only coal-bearing rocks exposed in the township are in section 1 on lower Coal Creek (pl. 2). At localities 49 and 50, two beds containing 4–6 feet of coal and separated by 20 feet of claystone (fig. 5) have been folded into a southeast-plunging syncline that has a gently dipping northeast limb and a moderately dipping southwest limb. At locality 51, a partly exposed bed containing at least 10 feet of coal and a few thin partings and ironstone nodules lies an estimated 115 feet below the lower bed at locality 50 and is in turn underlain, beneath a 19-foot largely covered interval, by a fourth partly exposed bed of clean coal at least 6 feet thick. The two lower beds dip about 35° NE.

T. 15 N., R. 12 W.

At locality 52 (pl. 2), a cut bank on the north side of Drill Creek exposes a 13-foot sequence of interbedded coal and coaly shale (fig. 5) that has been folded into a northeast-trending anticline; the sequence is broken by a fault on the west limb of the fold. At locality 53, one exposure shows 10 feet of coal dipping 7° NW., but just to the south the strata appear to be crumpled into an anticlinal fold plunging steeply northeastward.

At locality 54, a coal bed more than 50 feet thick that crops out in the south bank of Drill Creek was exposed in a sampling trench dug by the U.S. Bureau of Mines in 1960. Drilling by the Bureau of Mines in 1959, 1960, and 1961 showed that this bed underlies an east-northeast-trending elliptical area of about 240 acres centering roughly on the common corner of sections 10, 11, 14, and 15. It lies in a shallow synclinal basin in which the depth to the coal ranges from 7 to 226 feet (Warfield, 1963, p. 10, 20, table 1).

A second, rather impure, coal bed ranging from 17 to 52 feet in total thickness was shown by drilling to lie about 250–350 feet stratigraphically below the main bed on Drill Creek (Warfield, 1963, p. 11). It was found in three drill holes in the E½ sec. 10 at depths decreasing northward from 180 feet at Drill Creek to 113 feet near the north section line, in two holes south of Drill Creek in the SE¼ sec. 11 at depths of 95 and 200 feet, and in one hole in the NE¼ sec. 15 at a depth of 100 feet.

At locality 55, the upper 8 feet of a coal bed that dips about 3° S. is exposed in the south bank of Drill Creek. Warfield (1963, p. 13, 97) correlated this bed with a bed containing 18 feet of bony coal at a depth of 76 feet in a drill hole 500 feet to the south.

T. 14 N., R. 14 W.

The township contains a large number of coal exposures (pl. 4), including several of the exceptionally thick and persistent Capps bed. This bed was traced for about 4 miles along the north- and east-facing escarpments of the plateau south of Capps Glacier (pl. 5).

Capps bed.—At locality 59 (pl. 5) the Capps bed crops out near the top of the south wall of the Capps Glacier trough. Although it is partly covered, examination of several closely spaced exposures indicates that it is at least 50 feet thick, has few partings, and contains much glossy coal with conchoidal fracture. The lower 8 feet of an overlying bed is exposed above a 30-foot coaly shale and covered interval. A few poor exposures and coaly wash on the slope to the west show that the Capps bed rises within a short distance to the upland surface, where it is truncated by Quaternary deposits.

At locality 61, a 70-foot section includes at least 45 feet of coal; the two upper benches, totaling about 40 feet, probably represent the Capps bed. At locality 60, a vertical cliff at the edge of Capps Glacier shows a 400-foot section of siltstone and sandstone beneath the Capps bed containing no thick coals—only a few thin beds and coaly zones.

The Capps bed was traced, by helicopter, along the face of the escarpment that trends southeastward from the toe of Capps Glacier, but the bed was readily accessible for measurement at only a few places. The lower part of the section at locality 65 may represent the upper part of the Capps bed. At locality 66, a 23-foot coal exposure is believed to represent only the middle part of the Capps bed, which is considerably thicker both to the north and to the south. At locality 78, the probable full thickness of the bed is exposed in an inaccessible cliff, where it is estimated to be about 55 feet thick. The roof is concealed by soil, but probably little or no coal has been eroded. At this point the coal dips about 7° N.; it rises to the south and is cut off by erosion at the upland surface in the northwest corner of section 25.

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At locality 72, a 70-foot section includes at least 35 feet of coal in three or four beds, only one of which is completely exposed. The dip is 15° N. at this locality but decreases to 8° N. at locality 73 and to horizontal near locality 75. Projection down the dip of the thick coal section at locality 72 would seem to carry it a little below the Capps bed at the west boundary of section 24; however, the well-exposed section at locality 60 (fig. 2), only 2 miles to the north, shows no thick coals within several hundred feet beneath the Capps bed, and the coal at locality 72 is therefore believed to represent the Capps bed.

Other beds.—The coal beds at locality 64 and in the upper part of the section at locality 65 are believed to closely overlie the Capps bed. The 10-foot coal bed exposed at localities 67, 68, 69, and 70 probably overlies the Capps bed and may be correlative with coal at localities 73, 74, 75, and 76, which definitely overlies the Capps bed. The stratigraphic position of the thin coal at locality 80 and the thick dirty coal at localities 81 and 82 is uncertain. The only coal beds in this township that appear definitely to underlie the Capps bed are those at localities 62, 77, and 79. The extent of these beds is unknown and they were not included in the reserve calculations. The 10-foot block of coal measured at locality 63 is part of the large landslide that has involved the eastward extension of the Capps bed and associated coals.

T. 14 N., R. 13 W.

Coal sections (pl. 4) at localities 83 and 84 (pl. 5) show irregular dips and have obviously been disturbed by slumping. The exceptional thickness of the large block of coal measured at locality 83 suggests that the block may have come from the Capps bed. The section at locality 85 does not appear to be greatly disturbed, but the surrounding topography shows that it lies within the landslide area.

The only undisturbed coals in the township are the thin beds measured at localities 86, 87, and 88. The sections at these localities include a large proportion of standstone and conglomerate, which, together with the scarcity of coal, suggests that these beds are near the base of the coal-bearing part of the Kenai Formation and are transitional to the thick series of pebbly sandstone and conglomerate exposed to the west in the Straight Creek area.

T. 14 N., R. 11 W.

Coal beds are exposed at several places in the gorge of the Beluga River in the southern part of the township (pl. 5). At locality 89 (pl. 6), two coal sections were measured in the west wall of the gorge, one about 150 feet above the other and separated by a covered interval. A general similarity of the two sections suggests the possibility that they are the same, the lower one having been dropped either by a fault or in a slump block, although neither slumping nor faulting could be confirmed on the largely soil-covered slope.

At locality 90, an 80-foot section includes three moderately thick coal beds that have few partings and probably underlie the beds at locality 89. At locality 91, a 5-foot coal bed with a dip of 7° S. lies a few feet above strongly folded white pebbly sandstone and underlying dark-brown well-indurated pebble-cobble conglomerate, from which it is apparently separated by an angular unconformity. Although the gorge downstream from locality 91 was not traversed, helicopter reconnaissance showed that the overlying gently folded coal-bearing beds and the underlying dark conglomerate continue downstream for at least half a mile. A poorly exposed coal section at locality 93 may represent the same bed as the one at locality 91 although the section probably has slumped. The coal at locality 92 apparently lies somewhat higher in the Kenai Formation.

On the east side of the Beluga River, the Beluga bed was traced from a point a little north of locality 94 southward along the wall of the gorge, across the township line, and into the gully south of locality 131 (pl. 5). This bed lies in a gently eastward-plunging syncline that has an almost flat bottom but moderately steep limbs, both of which are truncated at the bedrock surface by Quaternary deposits 50 to 100 feet thick. At locality 94 the Beluga bed contains about 25 feet of clean coal and is underlain by about 300 feet of sandstone, below which the upper 9 feet of a second coal bed is exposed. At locality 131, just south of the township line, a partial section of the Beluga bed includes less than 20 feet of coal, but a little farther south the bed is exposed in its full thickness of about 30 feet. Because of the eastward plunge of the syncline the Beluga bed is not present west of the river.

T. 13 N., R. 14 W.

All the coal noted in the township (pl. 5) occurs in thin nearly horizontal beds that are exposed along several western headwater tributaries of the Chuitna River at localities 95–100 (pl. 7). These coals are underlain to the south and east by conglomeratic beds of the lower part of the Kenai Formation and are overlain to the west by volcanic deposits. The coals are exposed only in isolated small outcrops in stream bottoms and no reliable correlations could be made.

T. 13 N., R. 13 W.

Most of the northern half of the township (pl. 5) is underlain by the lower, conglomeratic part of the Kenai Formation and consequently contains very little coal. The southern half, as shown by exposures along the Chuitna River and its tributaries, contains several potentially valuable coal beds, including the exceptionally thick and extensive Chuitna bed.

Chuitna bed.—The Chuitna bed, which is best exposed along the Chuitna River just downstream from the southern township line probably underlies most of the township south of the river and also a small area north of the river in the southeast corner of the township. This bed is well exposed in both walls of the Chuitna River valley in sec. 2, T. 12 N., R. 13 W., but upstream from these exposures it is concealed for at least a mile by landslide deposits, which mantle much of both valley sides.

At locality 123, an exposure just below the south rim of the valley shows a coal bed more than 20 feet thick, which is tentatively correlated with the Chuitna bed. Correlation is based on (1) projection of the Chuitna bed upstream across the landslide area parallel to the bedding of several apparently undisturbed outcrops at intermediate points along the river and (2) a general similarity in stratigraphic relations, particularly the presence of a second thick coal bed 120 feet lower in the section at locality 123, corresponding to the Lower Chuitna bed which is about 150 feet below the Chuitna bed at locality 146.

The correlation is strengthened by the presence at localities 108, 109, and 117 of thick coal beds whose positions and attitudes agree well with the projected positions of the Chuitna bed. At localities 108 and 109 the coal is underlain by a distinctive zone of white-weathering claystone and sandstone, which was noted wherever the base of the Chuitna bed is exposed farther downstream. At locality 108 the Chuitna(?) bed is so close to the upland surface that it probably is eroded a short distance farther west; furthermore, highly sheared and steeply dipping beds at localities 103–106 probably mark the position of the Castle Mountain fault zone, which would cut off the Chuitna and all underlying beds. Upstream from the fault zone pebbly sandstone and conglomerate are the only bedrock exposed for about 3 miles.

No outcrops identifiable as the Chuitna bed were found on the north side of the Chuitna River valley upstream from locality 146. In section 35 the coal is probably present but concealed by surficial material; farther northwest, projection of the bed as exposed on the south side of the valley would carry it above the upland level. On Chuit Creek the Chuitna bed is exposed at several places in section 36, and it may be represented by the coal at locality 130.

Lower Chuitna bed.—The Lower Chuitna bed was first noted cropping out in the bed of the Chuitna River on the sharp bend above locality 147 (T. 12 N., R. 13 W.), where several feet of coal dip about 5° E. It is more completely exposed at locality 146, but even here only the upper 20 feet is visible above stream level. Farther upstream it is covered by landslide and other surface material for about a mile on both sides of the valley, but it is believed to be represented by coal sections measured at localities 121, 122, 124, and 125, all of which are 100–150 feet below nearby outcrops of the Chuitna(?) bed. The Lower Chuitna bed presumably extends northwestward to the Castle Mountain fault, although it was not reliably identified west of locality 121.

As far as could be determined, the Lower Chuitna bed is not exposed on the north side of the Chuitna River above locality 146. If the southeast-dipping coal at locality 130 on the east fork of Chuit Creek is the Chuitna bed, the partly exposed coal farther upstream at locality 120 may represent the Lower Chuitna bed.

Other beds.—Outcrops along the Chuitna River above locality 146 indicate that the Lower Chuitna bed may be underlain by as many as six coal beds more than 20 feet thick, but the small extent of individual outcrops and the prevalence of slumping along the valley walls precluded accurate correlation and determination of stratigraphic intervals. However, despite several variations in attitude, probably at least in part the result of slumping, the prevailing dip appears to be southeast at less than 10°. Accordingly, the beds at localities 129, 127, 126, 119, 118, and 116 appear to be progressively lower in the section, in that order. The bed at locality 115 is probably the same as the one at locality 116. Its westward extension is marked by a thick zone of clinker and baked shale along the south valley wall. Although no more than 20 feet of coal is exposed in the measured section, the position and thickness of the burned zone indicate that the bed may be much thicker.

Upstream from locality 115 the dips of the coal-bearing rocks become irregular in both degree and direction, and the relative stratigraphic positions of the several coal beds are uncertain. This irregularity in attitude may relate in part to proximity to the Castle Mountain fault zone, but slumping may also have been a factor. The thick coals partly exposed at localities 112–114 have a general northerly dip, which could be caused by either folding or rotation of landslide blocks moving down the north valley wall. The coal at locality 112 lines up with the burned zone representing the coal at locality 115 and therefore may be the same bed if in place. The coal at localities 113 and 114 crops out in prominent cliffs on the north valley wall and is definitely higher in the section. The coals at localities 110 and 111 crop out in the gully below the Chuitna(?) bed at locality 108 and hence would appear to be correlative with beds exposed along the river above locality 146. However, the coal at locality 111 lies in a northeast-trending anticline that has limbs which dip 30°, and the strata exposed just upstream on both sides of the river dip 40° E., a relationship which indicates either strong folding or slumping of large blocks. Inasmuch as beds just under the south rim of this part of the valley retain the prevailing gentle southeast dip of beds farther downstream, slumping appears to be the most likely cause of the deformation of the beds at localities 110 and 111.

At locality 107, a partly exposed coal bed shows 30 feet of coal above river level. This bed has been slightly folded but in general dips gently northeastward. At locality 106, steep bluffs on the south side of the river expose two thick coal beds that dip more than 60° NW. At locality 105, a similar exposure shows a 20-foot coal bed underlain by sandstone and conglomerate, all dipping 63° NW. and truncated by a horizontal bedrock surface beneath 50 feet of glacial gravel. These beds, as well as the immediately underlying section at locality 106, apparently have been tilted and sheared by deformation along the Castle Mountain fault, whose trace is believed to be marked by abnormally steep dips of coal-bearing rocks at localities 101–104.

T. 13 N., R. 12 W.

No coal beds crop out in the township, but the Chuitna bed is estimated to underlie at least 1 square mile in the southwest corner.

T. 13 N., R. 11 W.

Bedrock exposures in the township are confined to the canyons of the Beluga River and Coffee Creek (pl. 5). The Beluga bed, described in T. 14 N., R. 11 W., extends a short distance into this township along the east side of the Beluga River, where the coal bends upward abruptly, just south of locality 131, to dip 30° NW. before being cut off at bedrock surface beneath about 100 feet of glacial gravel.

At locality 132, four coal beds are exposed in steep bluffs on the south side of the Beluga River (pl. 6). These beds dip southward and southeastward at angles ranging from 35° to 50°, and they are cut off near the west end of the exposure by a northeast-trending major fault of unknown displacement. To the northeast, the lower part of this coal section trends across the Beluga River, where at least one burned coal bed appears as a brick-red shaly zone beneath 200 feet of glacial gravel.

At locality 133 several thin coal beds (pl. 6) are exposed in the walls of the scar at the head of a large mudslide. On the north side of the exposure these beds dip gently southeastward, but in the south wall they bend over into a much steeper dip, and at the river edge they are vertical. At locality 134, just downstream from the vertical beds, successive sections including thin coal beds dip 70° SE. and 66° NW., outlining an apparent syncline but doubtless representing strong deformation along a northeast-trending major fault. Because of their disturbed condition, the beds at these two localities were not included in reserve calculations. Farther downstream, toward locality 135, similar beds are locally disturbed by slumping but appear to have a general low dip to the southwest.

A series of southeast-dipping coal beds is incompletely exposed along the south bank of the Beluga River at localities 136–140 (pl. 6). Because the coal is more resistant to erosion than most of the enclosing rocks, the coal beds generally appear as projecting ledges separated by covered intervals. Projection of the bed at locality 140 indicates that it closely underlies the section at locality 141 on the east side of the river. Only the lower part of the thick section exposed in the high bluffs downstream from locality 141 was accessible for detailed measurement because the upper part is exposed only in nearly vertical faces rising directly from the river margin. However, an approximate section showing estimated thickness and spacing of overlying coal beds is shown in figure 3. This section includes at least 5 coal beds, ranging from 3 to 6 feet in estimated thickness, that were not included in reserve calculations. The beds measured at locality 142 (pl. 6) are the continuation of the uppermost coals exposed in the bluffs downstream from locality 141, where they are partly burned. At locality 143, several coal beds separated by covered intervals are incompletely exposed in the channel of Coffee Creek, where they dip 38°–42° SE. Projection along the strike indicates that these beds are at about the same stratigraphic position as those at locality 142.

T. 12 N., R. 13 W.

Bedrock is exposed in the township only in the extreme northeast corner, along the Chuitna River (pl. 5). In the remainder of the township, it is covered by glacial and alluvial deposits. Although Tertiary rocks doubtless are truncated by the 400-foot escarpment along the northeast side of Nikolai Creek, the few exposures visible through the heavy vegetative cover appeared from the air to consist entirely of glacial deposits.

The Chuitna bed is exposed at several points along both the Chuitna River and Chuit Creek, generally where the streams swing against the valley walls. The best exposures are on the north side of the river just below locality 146, at locality 149, and at the sharp hairpin bend above locality 152, and on the south side at localities 147, 150, and 153 (pl. 7). A thick section of the Kenai Formation, including the Chuitna bed, is well exposed at locality 152; however, all but the lower foot of the Chuitna bed is burned. Baked shale float on the valley side indicates that the Chuitna bed is burned for several hundred yards in both directions from this locality. On Chuit Creek the Chuitna bed is well exposed in the west wall at locality 151 and partly exposed on both sides of the valley at locality 148.

The only other coal exposed in this township is just below the south rim of the Chuitna River valley at localities 144 and 145. At locality 144, a partly exposed bed includes an upper bench containing at least 18 feet of platy dull coal that is underlain by two thinner benches separated by 2-foot claystone partings, all dipping 5° SE. At locality 145, only 10 feet of coal is exposed beneath glacial gravel, but the position and nearly horizontal attitude of this coal suggest that it may represent the lower part of the bed at locality 144. This coal is about 300 feet above the Chuitna bed at locality 147.

T. 12 N., R. 12 W.

The Chuitna bed is exposed at several places on both sides of the Chuitna River in the northwest corner of the township, where it has a general southerly dip of 5°–10°. It is completely exposed only at locality 156 (pl. 5), where it is 22 feet thick and dips 10° S. Its easternmost outcrop is in the SE cor. sec. 8, where a dip of 5° S carries it below the valley floor. The section at locality 155 includes the lower part of the Chuitna bed overlain by glacial gravel; that at locality 154 may include the upper part of the Chuitna bed.

At locality 157, the upper part of a horizontal coal bed is exposed in the channel and south bank of the river. This coal presumably overlies the Chuitna bed but possibly is an eastward continuation of the bed.

At localities 158–160, coal thicknesses of 3–10 feet were measured in 7 beds included in partly exposed sections in the south bank of the Chuitna River. These beds, which dip 50°–65° W, are on the west limb of a northeast-trending asymmetric anticline. The structural relations of these beds to those farther upstream are not known, but paleobotanical evidence indicates that they are younger and therefore stratigraphically higher (Wolfe and others, 1965, p. 63, fig. 5).

T. 12 N., R. 11 W.

Sections measured at localities 161–165 along the Chuitna River (pl. 5) include at least 11 coal beds more than 2.5 feet thick (pl. 7), most of them only partly exposed, distributed through a largely concealed stratigraphic interval of about 2,000 feet. Measured thicknesses range from 3 to 9 feet. These beds are all on the east limb of the anticline described in T. 12 N., R. 12 W., with dips ranging from 15° to 35°. Downstream from locality 165, bedrock is completely covered by glacial and alluvial deposits.

T. 11 N., R. 11 W.

Beds of the Kenai Formation are exposed for almost 2 miles beneath Quaternary deposits in the beach bluffs at the west side of this township and for a short distance into T. 11 N., R. 12 W. (pl. 5). Eldridge (1900, p. 21) and Atwood (1909, p. 120) reported that at least 36 coal beds were exposed along the beach in this area and a sketch map by Atwood (1909, fig. 4) shows coal outcrops distributed over a distance of nearly 3 miles; however, in the present investigation, coal-bearing rocks were mapped for a distance of less than 2 miles and only about a third as many coal beds were noted. The reason for this discrepancy is believed to be extensive slumping of the actively eroding beach bluffs, which has apparently shortened the length of bedrock exposure and concealed many coal beds visible in 1898. Although the attitude of some of the exposed beds has been disturbed by slumping, the general dip is east to northeast at angles ranging from 6° to 35°. Coal beds ranging from 2 to 8 feet in thickness, some separated by thin partings, were measured at localities 166–171 (pl. 7).

OIL AND GAS POSSIBILITIES

The Beluga-Yentna region lies within the Cook Inlet Tertiary province, one of 13 possible petroleum provinces in Alaska defined by Miller and others (1959, p. 47–51). Seismic investigations and drilling in this province begun by oil companies in 1954 have resulted in the development of two producing fields on the Kenai Peninsula—the Swanson River oil field, discovered in 1957, and the Kenai gas field, discovered in 1959. Continued geophysical and geological investigations and exploratory drilling to 1963 indicated the probable presence of a second oil field beneath the waters of upper Cook Inlet and of a gas field on the northwest shore of Cook Inlet near the Beluga River. Several test wells have been drilled along the shore and a few miles inland in the vicinity of the Chuitna and Beluga Rivers. This work has undoubtedly yielded much information on the subsurface but, because of its potential economic value, little of this information had been made public by the end of 1963.

Evidence gained from surface mapping of the Beluga-Yentna region indicates that, except in the area south of the Castle Mountain fault zone, possibilities for oil and gas are not encouraging. The occurrence of outcrops of pre-Tertiary rocks at many points in the lowland areas suggests that the Kenai Formation north of the fault is relatively thin and thus not likely to have trapped large quantities of oil or gas. Furthermore, all the older rocks exposed in the region are either intrustive or extensively metamorphosed; thus the chances for deeper sources of oil and gas are limited to the possibility that suitable rocks are concealed beneath Tertiary or Quaternary deposits.

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Contributions to Economic Geology 1964

GEOLOGICAL SURVEY BULLETIN 1202

This volume was published as separate chapters A–C

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

William T. Pecora, *Director*

Library of Congress Catalog—Card No. GS 66–186

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