

CONTRIBUTIONS TO ECONOMIC GEOLOGY, 1927

PART II. MINERAL FUELS

THE GILLETTE COAL FIELD, NORTHEASTERN WYOMING

By C. E. DOBBIN and V. H. BARNETT

With a chapter on the Minturn district and the northwestern part of the Gillette field, by W. T. THOM, JR.

INTRODUCTION

This report presents the results of a geologic examination of an area in northeastern Wyoming embracing more than 3,000 square miles, lying on the east side of the Powder River Basin, a broad structural depression between the Black Hills and the Big Horn Mountains. The Gillette field as here defined lies principally within Campbell County but includes also parts of Crook, Weston, Niobrara, and Converse Counties. (See fig. 1.) The land forms or physiography of the area and the stratigraphy and structure of the sedimentary rocks are described briefly, and the thickness and distribution of the coal beds and the quality of the coal are discussed in detail.

The examination was made primarily to obtain data for the classification of the public lands of the area, but because of interest in the exploitation of the coal beds in the vicinity of Gillette the data originally collected have been reviewed and revised and are here presented with supplementary observations.

The field mapping of coal beds within the greater part of the area covered by the present report was done during the field seasons of 1910 and 1911 by V. H. Barnett, assisted in 1910 by C. L. Baker, J. J. Galloway, and S. D. Green and in 1911 by A. W. Stickney, R. Z. Pierce, Frank Elliott, and Bernard Jackson. In 1910 the work was under the general supervision of A. R. Schultz, and in 1911 of E. G. Woodruff. This early mapping was reviewed and revised by C. E. Dobbin during the summer of 1924 in the course of a study of the stratigraphy of the coal-bearing formations, the results of which are presented herewith.

A part of the field east of Gillette, lying within the Donkey Creek Valley near Minturn, on the Chicago, Burlington & Quincy Railroad, was examined in detail by W. T. Thom, jr., in the summer of 1923, and some data covering the occurrence of coal in the same area had been gathered by Stone and Lupton¹ in 1908. A report by Mr. Thom on this area is given on pages 50-64.

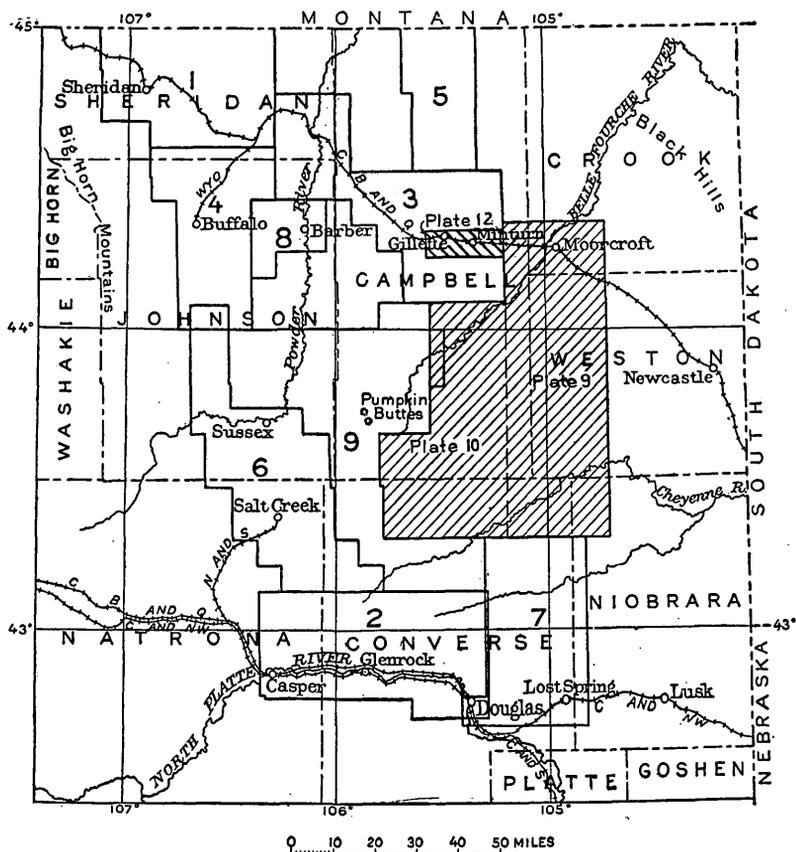


FIGURE 1.—Map of northeastern Wyoming showing relation of Gillette coal field to other coal fields. 1, Sheridan field (U. S. Geol. Survey Bull. 341); 2, Glenrock field (Bull. 341); 3, Powder River field (Bull. 381); 4, Buffalo field (Bull. 381); 5, Little Powder River field (Bull. 471); 6, Sussex field (Bull. 471); 7, Lost Spring field (Bull. 471); 8, Barber field (Bull. 531); 9, Pumpkin Buttes field

GEOGRAPHY

Location and extent of the field.—The area described in this report, exclusive of the northwestern part of the field, embraces Tps. 39 to 42 N., Rs. 66 to 74 W.; Tps. 43 to 47 N., Rs. 66 to 72 W.; and Tps. 48 to 50 N., Rs. 66 to 69 W. The rocks are part of a great series of

¹ Stone, R. W., and Lupton, C. T., The Powder River coal field, Wyoming, adjacent to the Burlington Railroad: U. S. Geol. Survey Bull. 381, pp. 115-136, 1910.

formations that cover the larger part of the Powder River Basin and extend westward to Sheridan and northward into eastern Montana and western Dakota.

Accessibility and settlement.—All points in the Gillette field are within 60 miles of the nearest railroad shipping point, the northern part of the field being traversed by the Chicago, Burlington & Quincy Railroad and the southern border lying approximately 25 miles north of the Chicago & Northwestern Railway line between Casper and Lusk. The accessibility of parts of the field is largely modified by the escarpment which extends from the vicinity of Rozet southward. Travel from the region east of this escarpment goes normally toward Moorcroft or Newcastle; that from the plateau above and west of the escarpment goes naturally toward Gillette or Douglas.

Gillette, the county seat of Campbell County and a division point on the Chicago, Burlington & Quincy Railroad, is in the northwest corner of the Gillette coal field as the term is used in this report. The town has a population of about 1,200 and is one of the important trading centers of northeastern Wyoming. Moorcroft, also on the Chicago, Burlington & Quincy Railroad, near the northeast corner of the Gillette field, has a population of about 400 and is an active trading center. General stores, combined with post offices, are maintained at Hampshire, near the mouth of Black Thunder Creek, in sec. 32, T. 42 N., R. 65 W.; at Wright, in sec. 7, T. 43 N., R. 71 W.; and at Maysdorf, in sec. 13, T. 47 N., R. 72 W. There are also post offices at Dillinger, in sec. 35, T. 48 N., R. 69 W.; at Four Horse, in sec. 34, T. 47 N., R. 68 W.; at Rochelle, in sec. 24, T. 42 N., R. 68 W.; at Lawver, in sec. 23, T. 45 N., R. 70 W.; at Hilight, in sec. 14, T. 44 N., R. 71 W.; at Hidivide, in sec. 2, T. 43 N., R. 70 W.; at Teckla, in sec. 35, T. 42 N., R. 71 W.; at Dull Center, in sec. 22, T. 40 N., R. 68 W.; at Verse, in sec. 27, T. 40 N., R. 71 W.; and at Bill, in sec. 25, T. 39 N., R. 70 W.

The Custer Battlefield Highway is the most traveled road of the field and crosses its extreme northern part. The Black and Yellow Trail diverges from the Custer Battlefield Highway at Moorcroft and follows the railroad southeastward toward Thornton. These two roads are kept in excellent condition and bear heavy tourist traffic during the summer. Roads extend southward from Gillette, Moorcroft, and Upton into the northern and eastern portions of the field. Parts of the field are also accessible from Newcastle on the east and from Douglas on the south. In the more broken and unsettled areas east of the Rochelle Hills escarpment the roads are generally in poor condition and difficult to travel with an automobile, even in the summer. They are especially poor along the South

Fork of Cheyenne River, where there are wide stretches of wind-blown sand on either bank of the river and quicksand in its bed. West of the escarpment and north of Antelope Creek the main north-south roads leading to Gillette and Douglas traverse section lines over country of moderate relief and generally are kept in good condition.

The roads shown on Plates 9 and 10 are the principal ones of the field and are probably without exception traversable by automobile. Their alinement has been copied from field sheets prepared by the writers, from the United States Geological Survey's topographic map of the Moorcroft quadrangle, from county surveyors' maps of Campbell and Converse Counties, and from plats of the United States General Land Office.

Topographic features.—The Gillette coal field lies in the Northern Great Plains, and in a general way its eastern part may be described as a dissected plain separated from a higher plateau by a rugged, irregular eastward-facing escarpment, locally eroded into badlands, which crosses the Gillette field from north to south. This escarpment, which is 300 to 400 feet high, is a striking and persistent topographic feature frequently referred to by the residents of the country as the Rochelle Hills. (See pl. 1, *A*.) It owes its presence and preservation to a protective capping of porcellanite or clinker formed by the baking of the rocks resulting from the burning of the thick Roland coal bed (bed D). The red color of the clinker contrasts pleasingly with the gray of the sandstone and clay beneath it and with the green of the pine trees that grow upon it in many places.

East of the escarpment the surface is rather broken and dissected by deep and narrow stream channels (see pl. 2, *A*), but west of it the surface is a rolling grass-covered prairie in which a few prominent clinker-capped buttes rise about 100 feet above the general level (see pls. 1, *B*, and 2, *A*).

Altitudes in the field range from about 4,050 feet in the Belle Fourche River Valley, at the northern boundary of the field, to about 5,000 feet in the central and southern parts.

Drainage and water supply.—The Gillette coal field lies almost wholly within the drainage basins of the South Fork of Cheyenne River and of Belle Fourche River, but a few square miles in the vicinity of Gillette, in the northwest corner of the field, is drained by tributaries of Little Powder River. All three of these streams have their sources in the plains region east of the Big Horn Mountains and carry little or no surface flow during the summer. Pools filled with water from spring floods or from occasional thundershowers are present at many places along the main drainage ways and serve

as the principal sources of water for livestock. Other present sources of water supply are dug and drilled wells and springs issuing from coal beds. Small lakes are also fairly common on the rolling plains west of the escarpment (see pl. 1, *C*) but are less numerous east of it. Many of these lakes are intermittent, though containing water for considerable parts of the year. All are shallow, and they range in size from mere ponds to lakes a mile or two across.

No flowing artesian wells were observed in the Gillette field, though water rises toward the top of the casing in wells drilled in the vicinity of Gillette and constitutes a considerable part of the local water supply. It is reasonably to be expected that wells drilled to the Fox Hills sandstone or the lower part of the Lance formation in the lower parts of the Belle Fourche and South Cheyenne Valleys may yield flowing water.

GEOLOGY

STRATIGRAPHY

GENERAL SECTION

The Gillette field is in a region of slightly flexed stratified rocks of Upper Cretaceous and early Tertiary age, which lie on the southwest flank of the Black Hills uplift and slope at a gentle angle westward from the uplift. The coal-bearing formations that cover the greater part of the field are of fresh-water origin and grade downward through brackish-water and marine sandstones into marine shale, exposed in the northeastern part of the field.

Remarkable examples of cross-bedding and local unconformities are common within the field at many horizons in the Lance and Fort Union formations. One such example is exposed in the south bank of the South Fork of Cheyenne River in sec. 30, T. 41 N., R. 67 W. (See pl. 2, *B*.) This feature has some of the characteristics of an erosional unconformity, but close inspection shows that sandstone bands below the steeply dipping layers are continuous into the overlying sandstone and are of the same character and texture. Several examples of apparent erosional unconformity within the Fort Union formation are also exposed along Belle Fourche River in T. 46 N., R. 71 W.

The general characteristics, range in thickness, and age of the several formations exposed in the Gillette field are summarized in the following table:

Geologic formations in the Gillette coal field, Wyoming

Age	Group and formation		Character	Thick- ness (feet)
Quaternary.			Late terrace gravel and alluvium.	0-25
Tertiary (?).			Early terrace gravel.	15
Tertiary (Eocene).	Wasatch formation.		Soft gray shale, thin grayish-white sandstone, and coal beds. Formation nowhere well exposed in the field.	500-1,000
	Fort Union formation.	Tongue River member.	Light-gray sandy shale and thin sandstone, with a few fairly thick and persistent coal beds. Roland coal at top. Crops out along the Rochelle Hills escarpment.	250-400
		Lebo shale member.	Dark clay containing many discontinuous lenses of ferruginous concretions and thin beds of impure coal.	250-400
	Tertiary (?) (Eocene ?).	Lance formation.	Tullock member.	Yellowish fine-grained unconsolidated sand and sandy shale, containing thin beds of hard calcareous sandstone and numerous thin beds of impure coal.
Hell Creek member.			Light to dull gray and brown sandy shale, dark-gray gritty clay, and massive buff sandstone containing <i>Triceratops</i> bones.	800
Cretaceous (Upper Cretaceous).	Montana group.	Fox Hills sandstone.	Light-gray to brown fossiliferous marine sandstone and sandy shale, grading downward into Pierre shale. Usually crops out in an escarpment.	200
		Pierre shale.	Dark-gray to black marine shale with many calcareous concretions yielding a typical Pierre fauna. Only upper part of formation exposed in the Gillette coal field.	200+

MONTANA GROUP

PIERRE SHALE

The Pierre shale is the lowest formation exposed in the Gillette coal field. It is a dark-colored marine shale, containing zones of calcareous concretions which yield fossils typical of the formation. Only the upper part of the shale is exposed in the field, and its contact with the overlying Fox Hills sandstone is gradational. The total thickness of the formation is not known but probably is between 2,100 and 3,300 feet, thicknesses measured, respectively, north of Moorcroft² and south of the field in the Lance Creek area.³

² Rubey, W. W., U. S. Geol. Survey press notice 17915, Nov. 14, 1924.

³ Hancock, E. T., The Lance Creek oil and gas field, Niobrara County, Wyo.: U. S. Geol. Survey Bull. 716, p. 95, 1921.

The Pierre shale in this area contains a large fauna. In the uppermost part a small admixture of such Fox Hills species as *Discoscaphites conradi* (Morton) and *Inoceramus fibrosus* (Meek and Hayden) indicates a transition zone, though the greater part of the fauna is a normal Pierre assemblage. Prominent species are the cephalopods *Scaphites nodosus* Owen and its varieties, *Baculites ovatus* Say, *Baculites grandis* Hall and Meek, and the pelecypod *Inoceramus barabini* Morton.

FOX HILLS SANDSTONE

The Fox Hills sandstone crops out in the northeastern part of the field, and where the formation dips steeply its outcrop is less than a mile wide, although locally attaining a width of 3 miles. The sandstone commonly forms a distinct escarpment, though it is so concealed by vegetation as to preclude a detailed study of parts of the formation. The contact of the Pierre shale and the Fox Hills sandstone is transitional and consists of a gradation from fissile marine shale to platy marine sandstone overlain by massive light-gray and brown sandstone in which concretionary structure is well developed. The Fox Hills merges upward into the Lance formation, the contact between the two not being a distinct line. A bed of carbonaceous shale 2 feet thick was taken as the bottom of the Lance. The beds above this shale, while not differing markedly from those below, were regarded as Lance in age on paleontologic evidence, invertebrate fossils identified as Fox Hills forms being found below the shale and a bone identified as belonging to a Lance dinosaur being found just above it. The general constitution and thickness of the Fox Hills are indicated by the following section:

Section of Fox Hills sandstone in the NE. ¼ sec. 20, T. 48 N., R. 66 W

	Feet
Sandstone, light brown-----	38
Shales, light and dark gray, sandy-----	83
Sandstone, light brown-----	27
Shales, tan and blue-gray, sandy, transitional into Pierre shale.-----	38
	186

The Fox Hills sandstone in this area has yielded a large fauna of invertebrates, mostly from the lower part. The species in the middle and upper parts show the presence of both marine and brackish-water deposits, but those from the lower part are strictly marine. The most characteristic species are the cephalopods *Discoscaphites conradi* (Morton), *D. nicolleti* (Morton), *D. abyssinus* (Morton), and *Sphenodiscus lenticularis* (Owen) and the pelecypod *Veniella humilis* Meek and Hayden.

LANCE FORMATION

In the Gillette field, as elsewhere in northeastern Wyoming and eastern Montana, the Lance formation is divisible into a lower member consisting of sandy shale, dark gritty clay, and massive sandstone containing dinosaur bones, and an upper member composed of fine-grained yellowish sandy shale interbedded with thin layers of hard calcareous sandstone and numerous thin carbonaceous beds. These members are respectively correlated with and are directly traceable northward into the Hell Creek and Tullock members of the Lance formation as recognized in eastern Montana.⁴ The Hell Creek member is also traceable southeastward into the "*Ceratops* beds" of the Lance Creek area, described by Hatcher⁵ and by Stanton and Knowlton.⁶

HELL CREEK MEMBER

The composition of the lower or Hell Creek member of the Lance formation is well indicated by the following quotation from Hatcher:⁵

The *Ceratops* beds are made up of alternating sandstones, shales, and lignites, with occasional local deposits of limestones and marls. The different strata of the series are not always continuous, a stratum of sandstone giving place to one of shales and vice versa. This is especially true of the upper two-thirds of the beds. The lack of continuity has rendered it well-nigh impossible to establish any definite horizons in the upper members of the series. All the deposits of the *Ceratops* beds of this region bear evidence of having been laid down in fresh waters. Among the invertebrate fossils found in them, only fresh-water forms are known. * * *

The sandstones largely predominate in the lower members of the beds. They are always fine grained, massive to well stratified, and nearly white to yellowish brown in color. They are occasionally compact and hard, but for the most part quite soft and friable. * * * Almost everywhere in the sandstones are numerous concretions of varying size and shape. Some are almost perfect spheres and vary from the size of a marble to 18 to 20 feet in diameter. Others are from a few inches to several feet in transverse diameter and sometimes several hundred feet in length, a cross section forming a nearly perfect circle. Others still are very irregular in form. These concretions usually show no concentric structure, and while they sometimes inclose foreign objects, as a *Triceratops* skull or a single bone as a nucleus, they are for the most part simply centers of solidification and not true concretions. This is frequently shown by the cross-bedding in them, so often seen in the sandstones themselves.

⁴ Thom, W. T., and Dobbin, C. E., Stratigraphy of Cretaceous-Eocene transition beds in eastern Montana and the Dakotas: Geol. Soc. America Bull., vol. 35, pp. 481-506, 1924. Rogers, G. S., Geology of the Tullock Creek coal field, Mont.: U. S. Geol. Survey Bull. 749, pp. 29-34, 1923.

⁵ Hatcher, J. B., The *Ceratops* beds of Converse County, Wyo.: Am. Jour. Sci., 3d ser., vol. 45, p. 137, 1893; The *Ceratopsia*: U. S. Geol. Survey Mon. 49, p. 180, 1907.

⁶ Stanton, T. W., and Knowlton, F. H., Stratigraphy and paleontology of the Laramie and related formations in Wyoming: Geol. Soc. America Bull., vol. 8, pp. 127-156, 1897.

Hatcher says further:

The *Ceratops* beds are thought to afford evidence in themselves of having been deposited not in a great open lake, but in a vast swamp, with occasional stretches of open water * * * connected by a network of watercourses constantly changing their channels. The intervening spaces were but slightly elevated above the water level or at times submerged. The entire region where the waters were not too deep was covered by an abundant vegetation, and inhabited by the huge dinosaurs (*Triceratops*, *Torosaurus*, *Claosaurus*, etc.), as well as by the smaller crocodiles and turtles and the diminutive mammals, all of whose remains are now found embedded in the deposits.

In this area the Hell Creek member is about 800 feet thick.

TULLOCK MEMBER

The upper or Tullock member of the Lance formation in the Gillette field includes 400 to 600 feet of light-colored calcareous sandstone and sandy shale with numerous thin beds of coal or carbonaceous shale. Thin beds of hard calcareous sandstone are numerous in the Tullock member and characteristically form scarps, which contrast strongly with the rolling lowlands and irregular rocky buttes developed by erosion from the dark clay and massive lenticular sandstone of the Hell Creek member.

The Lance formation in this area has yielded fresh-water invertebrates, of which the most abundant are *Campeloma multilineata* Meek and Hayden, *Goniobasis tenuicarinata* Meek and Hayden, and *Tulotoma thompsoni* White. It has also yielded fragmentary remains of reptiles and a considerable flora, most of the species of which occur also in the Fort Union formation.

FORT UNION FORMATION

In the Gillette field, as in areas to the north, the Fort Union formation is divisible into two members, the Lebo shale below and the Tongue River member above.

LEBO SHALE MEMBER

Within the Gillette field the Lebo shale member consists of 250 to 400 feet of soft gray to black clay and shale with numerous but nonpersistent beds of ferruginous concretions and of impure coal and carbonaceous shale. This member crops out in a belt of relatively low relief at the base of the escarpment formed by the Tongue River member, and along the main drainage lines it has been dissected into almost impassable badlands. (See pl. 2, A.)

TONGUE RIVER MEMBER

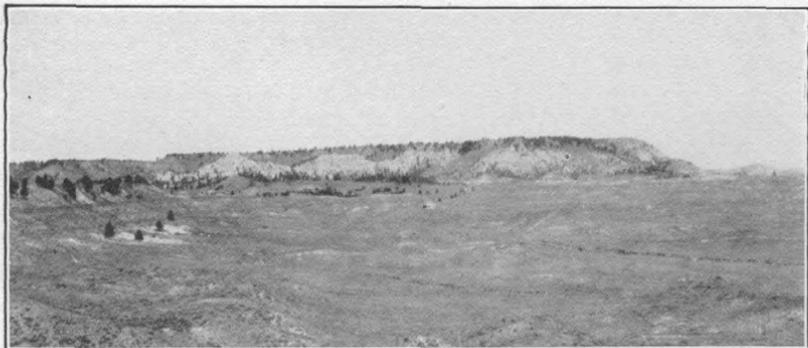
The Tongue River member of the Fort Union formation, which is at least in part equivalent to the sandstone of Great Pine Ridge, in the Sussex area,⁷ consists in this field of 250 to 400 feet of

⁷ Wegemann, C. H., The Sussex coal field, Johnson, Natrona, and Converse Counties, Wyo.: U. S. Geol. Survey Bull. 471, pp. 441-471, 1912.

bluish-white sandstone, gray sandy shale, and coal beds exposed in the Rochelle Hills escarpment (see pl. 1, A), which is capped by clinker produced by the burning of the Roland coal bed, the top of which is the top of the Tongue River member. Beds of highly ferruginous sandstone are common features of the Tongue River member in this field and usually contain an abundance of fossil leaves. (See pl. 2, C.) The general composition and thickness of the Tongue River member are indicated by the following section:

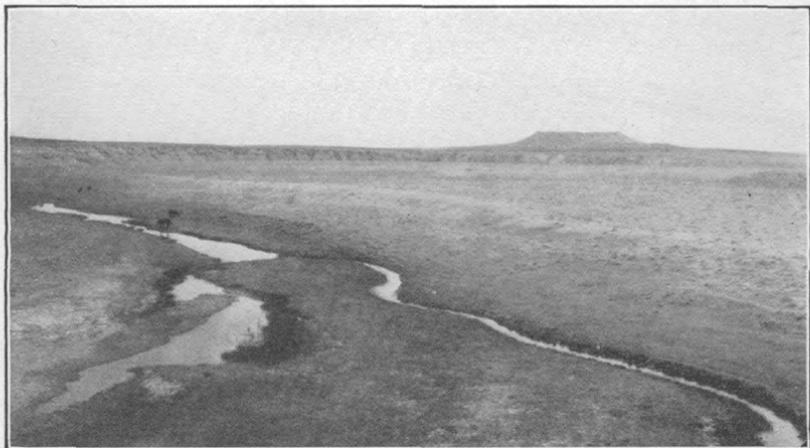
Section of part of the Tongue River member of the Fort Union formation, between sec. 21, T. 43 N., R. 69 W., and Little Thunder Creek in sec. 34

Clinkers of Roland coal bed (top of Tongue River member).	Ft. in.
Shale, blue-gray, sandy-----	10
Shale, carbonaceous, containing fossil leaves-----	6
Coal-----	5
Shale, carbonaceous, and bone-----	1 9
Shale, blue-gray, carbonaceous-----	10
Sandstone, gray, friable, with hard brown sandstone concretions containing fossil leaves-----	5
Shale, carbonaceous-----	1 4
Shale, sandy, and sandstone, friable, with hard sandstone concretions-----	33
Shale, dark, carbonaceous-----	9
Shale, gray, sandy-----	7
Sandstone, gray, friable, with 1-inch concretionary band at top-----	15
Shale, dark bluish gray, sandy, with a few hard brown sandstone concretions-----	16
Sandstone, yellowish gray, friable, with a few bands of carbonaceous shale-----	38
Shale, dark blue, with fossil leaves and with selenite crystals in upper part-----	7
Shale, brown, carbonaceous, with fossil leaves and fragments of conifers-----	10
Shale, dark blue-----	1 2
Shale, bluish gray, with brown sandstone concretions-----	12 6
Sandstone, yellowish gray, friable-----	11
Shale, bluish gray-----	8
Shale, brown to black, with lenses of bright coal in upper part-----	2
Sandstone, yellowish, friable-----	6
Shale, blue, with 1-foot lens of black carbonaceous shale near the middle-----	11
Clay, yellow, sandy, with brown sandstone concretions near the base-----	5
Shale, bluish gray-----	11
Shale, brown, carbonaceous-----	10
Concealed-----	6
Sandstone, gray, friable, with 1-foot brown concretionary band at top-----	8 10
Largely covered but sandstone and shale exposed in places-----	108



A. ROCHELLE HILLS ESCARPMENT, T. 46 N., R. 71 W., WYOMING

Formed by strata of Tongue River member of the Fort Union formation rising above lowlands made by the Lebo shale member



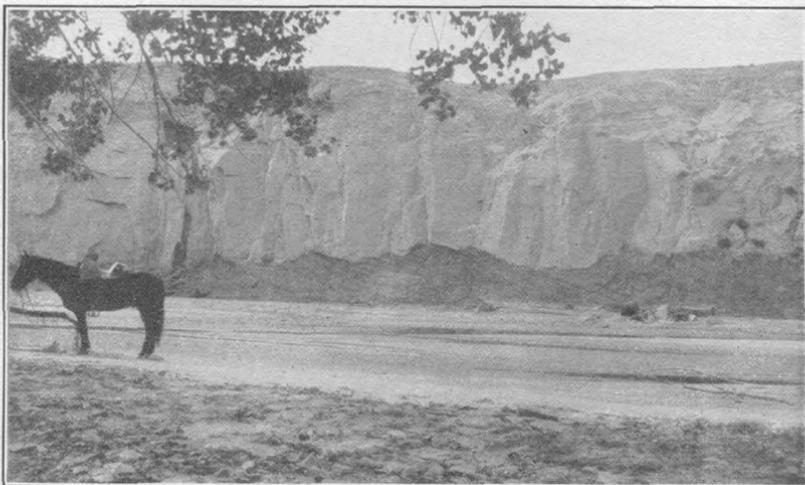
B. TOPOGRAPHY ALONG BELLE FOURCHE RIVER WEST OF THE ROCHELLE HILLS ESCARPMENT



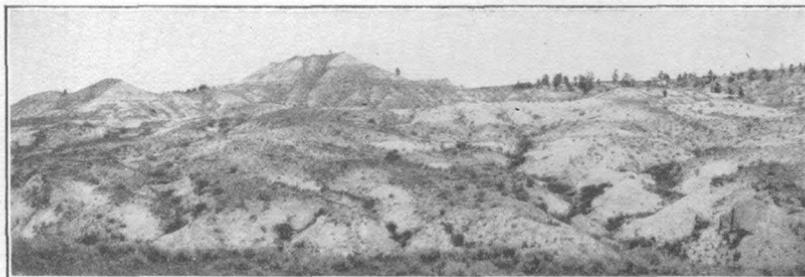
C. SHALLOW LAKE ON THE ROLLING PLAINS WEST OF THE ROCHELLE HILLS ESCARPMENT



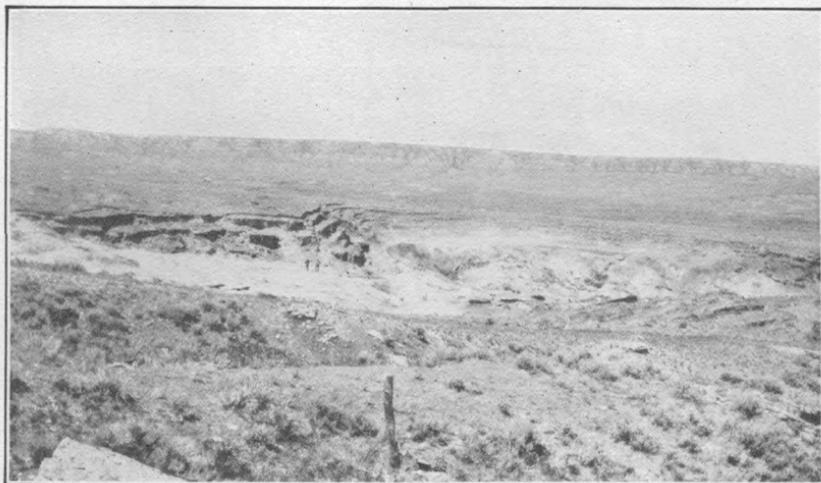
A. BADLANDS DEVELOPED IN SOMBER-COLORED CLAYS OF THE LEBO SHALE MEMBER OF THE ROCHELLE HILLS ESCARPMENT, NORTHWESTERN PART OF T. 39 N., R. 70 W., WYOMING



B. LOCAL UNCONFORMITY BETWEEN MASSIVE SANDSTONE AND CROSS-BEDDED SANDY SHALE, SOUTH BANK OF THE SOUTH FORK OF CHEYENNE RIVER, SEC. 30, T. 41 N., R. 67 W., WYOMING



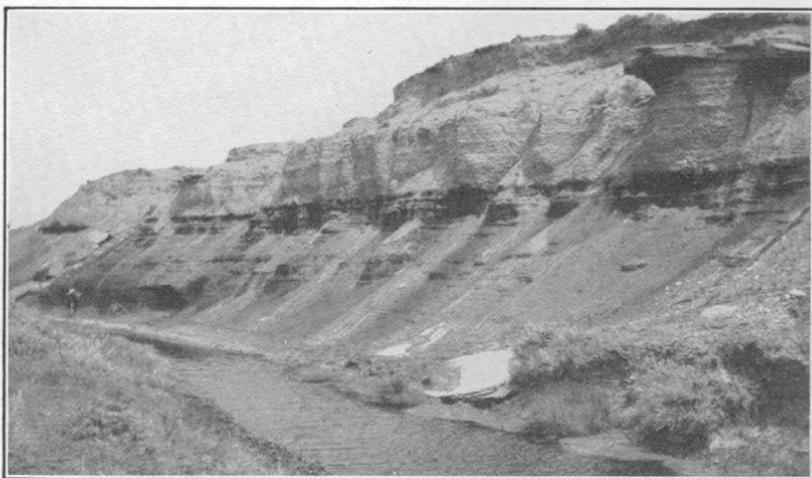
C. LIGHT-COLORED FERRUGINOUS SANDSTONE AND CLAY OF THE TONGUE RIVER MEMBER OF THE FORT UNION FORMATION BELOW THE ROLAND (D) COAL BED, NORTH SIDE OF CABALLO CREEK, SEC. 32, T. 43 N., R. 70 W., WYOMING



A. SLUMPING DUE TO BURNING OF ROLAND (D) COAL BED, SEC. 36, T. 47 N.,
R. 71 W., WYOMING



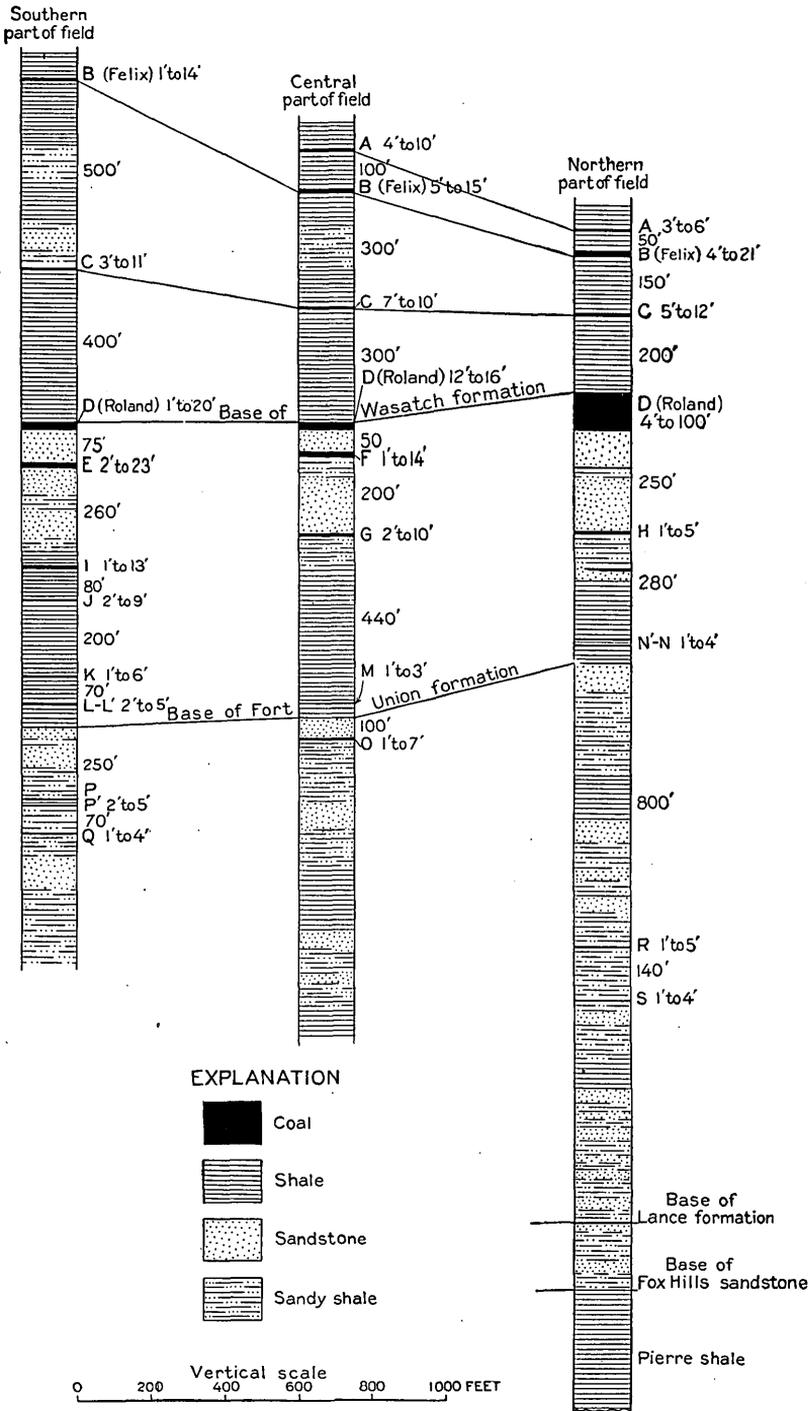
B. SLUMPING OF MASSIVE SANDSTONE DUE TO BURNING OF COAL BED I,
SEC. 21, T. 39 N., R. 68 W., WYOMING



A. OUTCROP OF COAL BED B AT LOCATION 391, NW. $\frac{1}{4}$ SEC. 6, T. 45 N., R. 72 W., WYOMING



B. OUTCROP OF ROLAND (D) COAL BED AT LOCATION 534, SW. $\frac{1}{4}$ SEC. 25, T. 47 N., R. 71 W., WYOMING



STRATIGRAPHIC SECTIONS IN THE GILLETTE COAL FIELD, WYOMING, SHOWING POSITION OF COAL BEDS

FOSSILS

The Fort Union formation in this area has yielded fresh-water invertebrate fossils, of which the most abundant are *Acroloxis minutus* Meek and Hayden, *Goniobasis* aff. *G. tenera* (Hall), and *Viviparus raynoldsianus* Meek and Hayden. It has also yielded a large flora.

WASATCH FORMATION

The top of the thick and persistent Roland coal (bed D) is the base of the Wasatch formation in this field, and the eastern margin of the area of Wasatch rocks is marked by the clinkered zone that caps the Rochelle Hills escarpment and was formed by the burning of the Roland bed at the outcrop. West of this escarpment is a region of low relief and poor exposures, within which such outcrops as are present reveal gray shale and thin grayish-white sandstone, with some coal beds and thick beds of gravel and sand, especially in the immediate vicinity of Gillette. No exposures of variegated clays such as have yielded Wasatch fossils near Sussex^s were observed within the Gillette field.

EARLY TERRACE GRAVEL

Within parts of the Gillette field, beds of loosely consolidated gravel cap terraced surfaces as much as 100 feet above the present valley floors and clearly belong to an erosion cycle prior to that now in progress. Because of this fact these gravel deposits are regarded as doubtfully Tertiary, although no specific evidence as to their age was obtained. The gravel is well developed in secs. 1, 12, and 13, T. 48 N., R. 69 W., and in T. 46 N., Rs. 71 and 72 W. One gravel bed in sec. 33, T. 46 N., R. 69 W., near the highest point in the field, consists of boulders and pebbles of pre-Cambrian and Paleozoic rocks such as might be derived from the Black Hills or from the Big Horn or Laramie Mountains.

LATE TERRACE GRAVEL AND ALLUVIUM

Minor terrace deposits and alluvial tracts border the courses of the streams and are classed as Quaternary because of their topographic position and because bones identified by J. W. Gidley as belonging to an extinct bison of Pleistocene age have been obtained from the base of the flood-plain deposits along Donkey Creek near Minturn.

^s Wegemann, C. H., Wasatch fossils in so-called Fort Union beds of the Powder River Basin, Wyo., and their bearing on the stratigraphy of the region: U. S. Geol. Survey Prof. Paper 108, pp. 57-60, 1918.

STRUCTURE

The rocks of the Gillette field have a general southwestward or westward dip, away from the Black Hills uplift and into the broad structural depression of the Powder River Basin. The beds are most steeply tilted near the northeast corner of the field, showing a maximum inclination of about 30° near Moorcroft, with a progressive diminution of slope away from the Black Hills. In general the geologic structure of the field is very simple, although some slight minor flexures are present, notably in Tps. 45 and 46 N., R. 70 W., and near Minturn. (See pl. 10.)

No faults of considerable magnitude were observed within the field. A normal fault with a throw of about 35 feet was observed in sec. 28, T. 49 N., R. 67 W.; a small thrust fault is exposed in a deep coulee in sec. 19, T. 47 N., R. 67 W.; and several other small faults were noted.

ECONOMIC GEOLOGY

PORCELLANITE OR "CLINKER"

Baked clay or slag, variously referred to as porcellanite, "clinker," and "scoria," is widely distributed within the coal field and is of considerable economic value as railroad ballast, road metal, and to some degree as building material. The Chicago, Burlington & Quincy Railroad Co. has been obtaining "clinker" for track ballast from a pit near Minturn, in sec. 27, T. 50 N., R. 71 W., since the building of the railroad in 1890. The baked rock is there 40 to 50 feet thick and is mined by steam shovel, crushed, and loaded into cars. More than 75,000 acres of land within the Gillette field is covered by "clinker" beds (see pls. 9 and 10) containing an aggregate volume of several billion cubic yards, and this material is being constantly augmented by fires now burning near the outcrops of the coal beds.

COAL

DISTRIBUTION

The coal of the Gillette field occurs in the Lance, Fort Union, and Wasatch formations, the areal distribution of which within the field is shown by Figure 2. The Wasatch contains the principal reserves of the area, though minor beds are present within the Tongue River and Lebo members of the Fort Union, and thin lenses of impure coal are present in the Tullock member and the top part of the Hell Creek member of the Lance. The coal occurs at several horizons, whose approximate vertical distribution is indicated by Plate 5, which also shows the general convergence of the beds as they are traced from south to north.

Beds R and S and several thin lenses, few of which exceed 3 feet in thickness, occur near the top of the Hell Creek member of the Lance formation and were mapped along Belle Fourche River and its tributaries west and southwest of Moorcroft. Beds P, P', and Q are the thickest beds in the Tullock member in the southern part of the field and where mapped average about 3 feet in thickness. Bed O crops out rather persistently 60 feet below the top of the Tullock

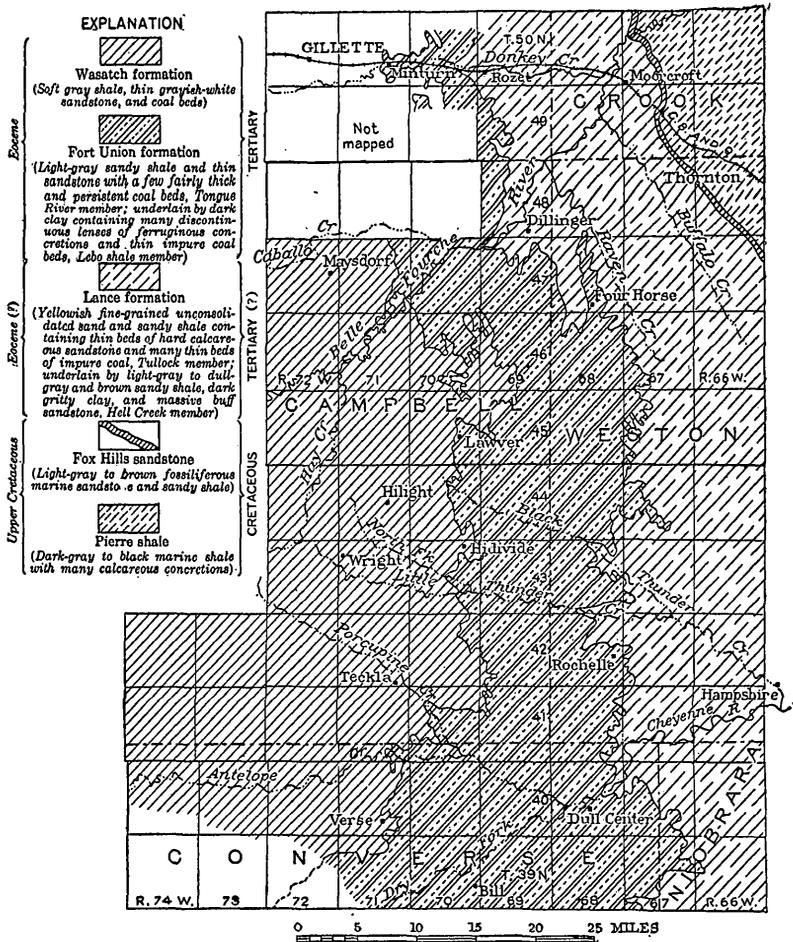


FIGURE 2.—Geologic map of the Gillette coal field, Wyoming

member in the central part of the field and also has an average thickness of about 3 feet. Only disconnected outcrops of beds averaging slightly more than 2 feet in thickness were found in the Tullock member in the northern part of the field.

Beds I, J, K, L, and L' occur in the Lebo shale member of the Fort Union in the southern part of the field. Bed I is represented by three disconnected lenses, the outcrops of which are 5, 13, and 14

miles long and lie near the top of the member. Its maximum thickness of 13 feet 6 inches occurs at location 24, in sec. 18, T. 39 N., R. 68 W. Bed J is 80 feet below bed I and was traced almost continuously from the southern boundary of the field northward to sec. 5, T. 41 N., R. 68 W., where it is replaced by shale. Its average thickness is about 5 feet. Bed K is about 200 feet below bed J and has a maximum thickness of about 6 feet at location 8, in sec. 30, T. 39 N., R. 67 W. Bed L occurs about 60 feet above the base of the Lebo member and 25 feet above bed L'. Beds L and L' have a maximum thickness of about 5 feet each. Beds G and M are the only commercially important beds in the Lebo shale in the central part of the field. Bed G lies near the top of the Lebo and extends northward from the center of sec. 18, T. 43 N., R. 68 W., into sec. 4, T. 45 N., R. 68 W. The graphic sections on Plates 6 and 7 show that it averages a little over 2 feet in thickness. Bed M is probably equivalent to bed L. It crops out only in the northeast corner of T. 43 N., R. 68 W., where it attains a maximum thickness of 3 feet 4 inches at location 244, in sec. 2. Beds H, N, and N' occur in the Lebo shale in the northern part of the field. Bed H is exposed in T. 47 N., R. 69 and 70 W., where its outcrop was mapped for about 6 miles. It averages about 3 feet in thickness and is very lenticular. Beds N and N' are about 30 feet apart and occur near the base of the Lebo member. These beds range in thickness from 1 foot 11 inches at location 406, in sec. 2, T. 46 N., R. 68 W., to 3 feet 8 inches at location 403, in sec. 24 of the same township.

Beds E and F are the only two beds of any value mapped in the Tongue River member of the Fort Union. As mapped, these beds occur respectively in the southern and central parts of the field, and they may actually be the same bed, though bed E as mapped is 75 feet below bed D, and bed F is 50 feet below bed D. Bed E crops out in Tps. 40 and 41 N., R. 70 W., and averages about 5 feet in thickness, although a thickness of 23 feet was measured at location 167, in sec. 32, T. 41 N., R. 70 W. Further detailed tracing of this bed was rendered impossible because of the great amount of slag from the burned outcrop of bed D. Bed F crops out for a distance of about 4 miles in T. 44 N., R. 69 and 70 W., and T. 45 N., R. 69 W. Its maximum thickness of 5 feet 4 inches occurs at location 365, in sec. 20, T. 45 N., R. 69 W.

Bed D, or the Roland bed, is the top bed of the Fort Union formation, and its outcrop extends almost across the field from north to south. (See pls. 9 and 10.) It underlies almost the entire western half of the field, and the eastern margin of the area underlain by it is nearly everywhere marked by natural slag produced by the burning of the bed. Its maximum observed thickness is about 100 feet

in the vicinity of the Peerless mine, $5\frac{1}{2}$ miles east of Gillette. The bed contains numerous shale partings in some localities and where very thick may be divisible into benches of greater and less purity.

Bed C as mapped probably consists of a zone of coal lenses which lie 200 to 400 feet above bed D. The thickest of these lenses contains about 11 feet of coal at location 178, in sec. 4, T. 41 N., R. 72 W. Bed C is characterized by shale partings and a tendency to pinch out and be replaced by shale within short distances. Bed B, next to bed D, is the most valuable coal bed in the Gillette field and is correlated with the Felix bed of the Gillette area. Bed B attains a maximum thickness of 21 feet at location 538-A, in sec. 27, T. 47 N., R. 72 W., and its minimum thickness is 1 foot at location 182, in sec. 4, T. 41 N., R. 74 W. Bed A is the highest coal in the field and lies about 50 feet above bed B. The several isolated outcrops of the bed, though not correlated definitely, appear to occupy the same relative position. Graphic sections on Plate 8 show that it ranges in thickness from 4 to 8 feet.

DEVELOPMENT

Except for the mines in the vicinity of Gillette described on pages 62-64, the few small drifts and open pits shown on Plates 9 and 10 constitute the only developments in the field, coal for domestic use commonly being mined by the ranchers from the nearest outcrop, usually a bluff along some stream where the weathered coal is kept washed away by freshets.

PHYSICAL PROPERTIES

The coals of this field are roughly similar in character, adaptability, and geologic age to those of the Lost Spring and Sheridan fields, which are used by the Chicago & Northwestern Railway and the Chicago, Burlington & Quincy Railroad, respectively, in specially built locomotives.

The coal of the Gillette field is of low subbituminous rank and belongs to a class of coal which has been often referred to as black lignite. Its luster is either shiny or dull black on a fresh surface, but if shiny it quickly becomes dull upon exposure to the air. The coal is generally rather tough, and some of it shows the structure of the wood from which it originated. This woody coal, when struck with a hammer, resounds with a dull thud very similar to that produced by striking a water-soaked board. The coal burns readily, at first emitting white smoke, but when combustion has continued for a short time the smoke is almost imperceptible. The stoking quality of the coal is poor, as a fresh piece exposed to the open air will

soon check and fall to pieces. This checking is accompanied by a snapping sound and results from loss of moisture. Accessory substances found in the coal include a few small globules of resin and in places pyrite in the form of concretions.

CHEMICAL PROPERTIES

Owing to the lack of deep mines within the greater part of the Gillette field and to the deteriorated condition of the coal near its outcrop, due to weathering or adjacent burning, only 12 analyses of unweathered coal are available, all of which represent coal from operations in the Donkey Creek Valley. (See fig. 3.) The air-dried samples show an average of 18.8 per cent of moisture, 7.2 per cent of ash, and 0.68 per cent of sulphur and have an average heating value of 9,465 British thermal units.

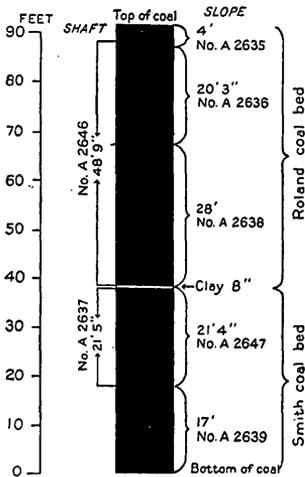


FIGURE 3.—Diagram showing parts of Roland and Smith coal beds represented by laboratory samples from Peerless mine, Gillette coal field, Wyoming. For analyses of these samples see p. 17

In the table given below the analyses are given in four forms, marked A, B, C, and D. Form A is the analysis of the lignite exactly as it comes from the mine. Form B represents the sample after it has been dried for a certain length of time at a standard temperature. Form C is a theoretical analysis of the sample after all moisture has been eliminated. Form D is also computed and is the analysis of the sample, after all moisture

and ash have been theoretically removed. Neither of the two conditions last mentioned exists in nature, but form C is used by mechanical engineers, and form D is valuable for comparing the quality of the pure lignite substance and the effect on its heating value of the impurities present, and it is also used by petroleum geologists as an index of the degree of regional metamorphism at the point of sampling.

Analyses of coal samples from the Gillette field and of representative samples from near-by fields

Laboratory No.	Coal bed and locality	Air-drying loss	Form of analysis	Proximate					Ultimate				Heating value	
				Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	Hydrogen	Carbon	Nitrogen	Oxygen	Calories	British thermal units
12466	Prospect on coal bed S, location 551, SE ¼ sec. 29, T. 48 N., R. 67 W., Wyo. Coal unweathered.	14.0	A	26.1	31.0	36.9	6.01	0.6	-----	-----	-----	-----	4,645	8,370
			B	14.0	36.1	42.9	6.99	.6	-----	-----	-----	-----	5,405	9,730
			C	-----	42.0	49.9	8.13	.8	-----	-----	-----	-----	6,285	11,320
			D	-----	45.7	54.3	-----	.8	-----	-----	-----	-----	6,840	12,320
12392	Local coal lens, location 559, NW ¼ sec. 29, T. 48 N., R. 68 W., Wyo. Coal slightly weathered.	17.2	A	30.0	28.8	34.5	6.7	.9	-----	-----	-----	-----	4,280	7,700
			B	15.4	34.8	41.7	8.1	1.1	-----	-----	-----	-----	5,170	9,300
			C	-----	41.1	49.3	9.6	1.3	-----	-----	-----	-----	6,110	11,000
			D	-----	45.5	54.5	-----	1.4	-----	-----	-----	-----	6,760	12,170
11442	Coal bed D, location 115, SE ¼ sec. 33, T. 40 N., R. 72 W., Wyo. Coal weathered.	19.6	A	27.4	30.9	33.2	8.5	.4	-----	-----	-----	-----	4,370	7,870
			B	9.7	38.5	41.3	10.5	.4	-----	-----	-----	-----	5,440	9,790
			C	-----	42.6	45.7	11.7	.5	-----	-----	-----	-----	6,025	10,850
			D	-----	48.2	51.8	-----	.6	-----	-----	-----	-----	6,820	12,280
A2635	Roland coal bed in slope of Peerless mine, 5½ miles east of Gillette, Wyo. (See fig. 3 for part of bed sampled.)	16.6	A	31.9	31.8	30.6	5.7	.4	-----	-----	-----	-----	4,390	7,900
			B	18.4	38.2	36.5	6.9	.5	-----	-----	-----	-----	5,260	9,470
			C	-----	46.7	44.9	8.4	.6	-----	-----	-----	-----	6,450	11,610
			D	-----	51.0	49.0	-----	.7	-----	-----	-----	-----	7,040	12,670
A2636	do-----	15.3	A	31.1	30.4	31.9	6.6	.6	-----	-----	-----	-----	4,400	7,920
			B	18.7	35.9	37.6	7.8	.7	-----	-----	-----	-----	5,195	9,350
			C	-----	44.2	46.2	9.6	.9	-----	-----	-----	-----	6,390	11,500
			D	-----	48.9	51.1	-----	1.0	-----	-----	-----	-----	7,070	12,720
A2638	do-----	18.6	A	32.6	31.4	29.6	6.4	.6	-----	-----	-----	-----	4,320	7,780
			B	17.2	38.6	36.3	7.9	.7	-----	-----	-----	-----	5,310	9,560
			C	-----	46.6	43.9	9.5	.9	-----	-----	-----	-----	6,415	11,550
			D	-----	51.5	48.5	-----	1.0	-----	-----	-----	-----	7,090	12,760
A2647	Smith coal bed in slope of Peerless mine, 5½ miles east of Gillette, Wyo. (See fig. 3 for part of bed sampled.)	17.1	A	32.9	28.0	34.3	4.8	.3	-----	-----	-----	-----	4,505	8,100
			B	19.0	33.8	41.4	5.8	.4	-----	-----	-----	-----	5,440	9,790
			C	-----	41.7	51.2	7.1	.5	-----	-----	-----	-----	6,710	12,080
			D	-----	44.9	55.1	-----	.5	-----	-----	-----	-----	7,220	13,000
A2639	do-----	21.5	A	36.9	27.6	30.9	4.6	.3	-----	-----	-----	-----	4,120	7,420
			B	19.7	35.1	39.3	5.9	.4	-----	-----	-----	-----	5,250	9,450
			C	-----	43.7	49.0	7.3	.5	-----	-----	-----	-----	6,540	11,770
			D	-----	47.1	52.9	-----	.5	-----	-----	-----	-----	7,050	12,690

GILLETTE COAL FIELD, WYO.

Analyses of coal samples from the Gillette field and of representative samples from near-by fields—Continued

Laboratory No.	Coal bed and locality	Air-drying loss	Form of analysis	Proximate					Ultimate				Heating value	
				Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	Hydrogen	Carbon	Nitrogen	Oxygen	Calories	British thermal units
A2965	Composite analysis of Nos. A2635, A2636, A2638, A2647, and A2639.	17.8	A	33.0	29.7	31.5	5.8	0.5	6.9	45.7	0.7	40.4	4,310	7,760
			B	18.4	36.1	38.5	7.0	.6	6.0	55.6	.8	30.0	5,245	9,440
			C	-----	44.3	47.1	8.6	.8	4.8	68.2	1.0	16.6	6,435	11,580
A2646	Roland coal bed in shaft of Peerless mine, 5½ miles east of Gillette, Wyo. (See fig. 3 for part of bed sampled.)	16.6	A	31.6	29.2	33.3	5.9	.6	-----	-----	-----	-----	4,545	8,180
			B	18.0	35.0	40.0	7.0	.8	-----	-----	-----	-----	5,450	9,810
			C	-----	42.7	48.7	8.6	.9	-----	-----	-----	-----	6,645	11,960
A2637	Smith coal bed in shaft of Peerless mine, 5½ miles east of Gillette, Wyo. (See fig. 3 for part of bed sampled.)	18.2	A	34.0	28.4	32.0	5.6	.4	-----	-----	-----	-----	4,270	7,690
			B	19.3	34.7	39.2	6.8	.5	-----	-----	-----	-----	5,220	9,400
			C	-----	42.9	48.6	8.5	.6	-----	-----	-----	-----	6,465	11,640
A2966	Composite analysis of Nos. A2646, A2637, and A2639	18.8	A	34.0	28.5	31.9	5.6	.5	6.9	44.9	.6	41.5	4,300	7,740
			B	18.8	35.0	39.3	6.9	.7	5.9	55.3	.8	30.4	5,295	9,530
			C	-----	43.2	48.4	8.4	.8	4.7	68.1	1.0	17.0	6,520	11,740
A2641	Roland bed at Hensley mine, 3 miles southeast of Gillette, Wyo., sec. 31, T. 50 N., R. 71 W.	11.5	A	27.0	34.2	29.1	9.7	1.4	-----	-----	-----	-----	4,590	8,260
			B	17.5	38.6	32.9	11.0	1.6	-----	-----	-----	-----	5,190	9,340
			C	-----	46.8	39.9	13.3	2.0	-----	-----	-----	-----	6,290	11,320
A2643	Smith bed at Eveland mine, 3 miles southeast of Gillette, Wyo., sec. 14, T. 50 N., R. 71 W.	13.6	A	32.0	30.1	32.8	5.1	.5	-----	-----	-----	-----	4,450	8,010
			B	21.2	34.9	38.0	5.9	.6	-----	-----	-----	-----	5,150	9,270
			C	-----	44.3	48.2	7.5	.7	-----	-----	-----	-----	6,540	11,770
A2642	Felix bed at Campbell mine, 3 miles west of Gillette, Wyo., sec. 20, T. 50 N., R. 72 W.	15.6	A	32.8	31.2	29.4	6.6	.6	-----	-----	-----	-----	4,300	7,740
			B	20.4	37.0	34.8	7.8	.7	-----	-----	-----	-----	5,095	9,170
			C	-----	46.4	43.8	9.8	.9	-----	-----	-----	-----	6,400	11,520
Average of 20 samples from Sheridan field, Wyo.	10.4	A	23.3	32.2	41.1	3.5	.3	-----	-----	-----	-----	5,195	9,350	
		B	14.3	35.9	45.9	3.9	.4	-----	-----	-----	-----	5,800	10,440	
		C	-----	41.9	53.6	4.6	.5	-----	-----	-----	-----	6,770	12,190	
Average of 20 samples from Sheridan field, Wyo.	10.4	D	-----	43.9	56.1	-----	-----	.5	-----	-----	-----	-----	7,090	12,755

	Average of 5 samples from Douglas field, Wyo.....	11.9	A	26.8	28.6	35.7	8.8	.9	-----	-----	-----	-----	4,375	7,675
			B	16.9	32.5	40.6	10.0	1.0	-----	-----	-----	-----	4,970	8,970
			C	-----	39.1	48.8	12.0	1.3	-----	-----	-----	-----	5,985	10,775
			D	-----	44.2	55.6	-----	1.4	-----	-----	-----	-----	6,805	12,255
A3292	Rosebud bed at strip pit of Northwestern Improvement Co., Colstrip, Mont. (Forsyth field).	10.5	A	24.6	28.2	39.5	7.7	.4	-----	-----	-----	-----	4,915	8,850
			B	15.7	31.5	44.1	8.7	.5	-----	-----	-----	-----	5,495	9,890
			C	-----	37.4	52.3	10.3	.6	-----	-----	-----	-----	6,520	11,740
			D	-----	41.7	58.3	-----	.6	-----	-----	-----	-----	7,265	13,080

In common with the subbituminous coals of other fields, the coal of the Gillette field tends to take fire spontaneously when exposed to the weather in outcrop or in large storage or culm piles. In consequence of this tendency and of the disintegration produced by the loss of moisture when the coal is exposed to the air, bulk storage of the coal presents special technologic problems.

Burning is in progress in a number of places in the field, and at one place in T. 39 N., R. 68 W., visited in 1911, the heat developed was so intense that the overlying rocks were partly fused. At every place where the coal was burning, slumping of the overlying beds occurred from time to time, and cracks were thus formed in the surface of the ground (pl. 3, *A, B*). In some places these fissures opened so as to produce a sort of natural furnace where the coal burns with renewed vigor. In other places where the coal is overlain by a heavy sandstone it burns out from under the rock until the sandstone falls of its own weight in huge blocks. Several acres of one coal bed near the T 7 ranch, in T. 47 N., R. 71 W., have been burned by a fire reported to have been in progress since at least as early as 1844.

TONNAGE

The estimated total quantity of coal in all except the northwestern part of the Gillette field is shown by townships below. Estimates for the northwestern part of the field are given on page 56 and make the total for the field 14,441,600,000 short tons.

Estimated tonnage of coal in the Gillette field, exclusive of its northwestern part

	Short tons		Short tons
T. 39 N., R. 66 W----	1, 100, 000	T. 46 N., R. 68 W----	14, 800, 000
T. 40 N., R. 66 W----	700, 000	T. 47 N., R. 68 W----	13, 200, 000
T. 41 N., R. 66 W----	50, 000	T. 48 N., R. 68 W----	650, 000
T. 42 N., R. 66 W----	150, 000	T. 49 N., R. 68 W----	10, 000, 000
T. 43 N., R. 66 W----	100, 000	T. 39 N., R. 69 W----	186, 300, 000
T. 39 N., R. 67 W----	20, 800, 000	T. 40 N., R. 69 W----	84, 000, 000
T. 40 N., R. 67 W----	14, 000, 000	T. 41 N., R. 69 W----	120, 000, 000
T. 41 N., R. 67 W----	38, 000, 000	T. 42 N., R. 69 W----	72, 800, 000
T. 42 N., R. 67 W----	8, 500, 000	T. 43 N., R. 69 W----	7, 000, 000
T. 43 N., R. 67 W----	20, 000, 000	T. 44 N., R. 69 W----	46, 000, 000
T. 44 N., R. 67 W----	27, 000, 000	T. 45 N., R. 69 W----	148, 000, 000
T. 45 N., R. 67 W----	25, 600, 000	T. 46 N., R. 69 W----	87, 300, 000
T. 46 N., R. 67 W----	5, 600, 000	T. 47 N., R. 69 W----	11, 600, 000
T. 47 N., R. 67 W----	2, 300, 000	T. 48 N., R. 69 W----	1, 600, 000
T. 39 N., R. 68 W----	316, 500, 000	T. 39 N., R. 70 W----	86, 400, 000
T. 40 N., R. 68 W----	13, 400, 000	T. 40 N., R. 70 W----	172, 700, 000
T. 41 N., R. 68 W----	28, 300, 000	T. 41 N., R. 70 W----	145, 150, 000
T. 42 N., R. 68 W----	67, 200, 000	T. 42 N., R. 70 W----	243, 350, 000
T. 43 N., R. 68 W----	5, 500, 000	T. 43 N., R. 70 W----	199, 000, 000
T. 44 N., R. 68 W----	500, 000	T. 44 N., R. 70 W----	273, 600, 000
T. 45 N., R. 68 W----	32, 400, 000	T. 45 N., R. 70 W----	337, 200, 000

	Short tons		Short tons
T. 46 N., R. 70 W----	179, 000, 000	T. 43 N., R. 72 W----	497, 700, 000
T. 47 N., R. 70 W----	13, 300, 000	T. 44 N., R. 72 W----	518, 400, 000
T. 39 N., R. 71 W----	17, 750, 000	T. 45 N., R. 72 W----	533, 000, 000
T. 40 N., R. 71 W----	490, 750, 000	T. 46 N., R. 72 W----	373, 250, 000
T. 41 N., R. 71 W----	504, 500, 000	T. 47 N., R. 72 W----	373, 250, 000
T. 42 N., R. 71 W----	186, 600, 000	T. 39 N., R. 73 W----	50, 100, 000
T. 43 N., R. 71 W----	228, 100, 000	T. 40 N., R. 73 W----	100, 800, 000
T. 44 N., R. 71 W----	311, 000, 000	T. 41 N., R. 73 W----	103, 700, 000
T. 45 N., R. 71 W----	287, 000, 000	T. 42 N., R. 73 W----	373, 250, 000
T. 46 N., R. 71 W----	255, 700, 000	T. 39 N., R. 74 W----	150, 500, 000
T. 47 N., R. 71 W----	242, 000, 000	T. 40 N., R. 74 W----	16, 600, 000
T. 39 N., R. 72 W----	20, 150, 000	T. 41 N., R. 74 W----	44, 150, 000
T. 40 N., R. 72 W----	269, 600, 000	T. 42 N., R. 74 W----	228, 100, 000
T. 41 N., R. 72 W----	249, 000, 000		
T. 42 N., R. 72 W----	165, 900, 000		9, 691, 600, 000

TOWNSHIP DESCRIPTIONS

In the following pages the coal resources of each township examined by the writers are described in detail. These descriptions are presented in order, beginning at the southeast end of the field and proceeding from south to north along each range of townships. The localities at which coal sections were measured are numbered on Plates 9 and 10, and the sections, correspondingly numbered, are shown graphically in Plates 6, 7, and 8. or given in the text.

Information concerning the thick coal beds present near Minturn and Gillette, in the northwestern part of the field, is given by W. T. Thom, jr., on pages 50-64.

TPS. 39 TO 50 N., R. 66 W.

No coal beds of economic importance are believed to occur in Tps. 39 to 50 N., R. 66 W. Some thin lenses of coal are present in the Hell Creek and Tullock members of the Lance in the southern part of this tier of townships, but the formations exposed in the central and northern parts of the tier (see fig. 2) are entirely barren of commercially valuable coal.

Beds of carbonaceous shale containing lenses of coal 1 foot or less in thickness occur along the western border of T. 39 N., R. 66 W., and are sketched on Plate 9. Beds P and Q crop out in the northwestern part of T. 40 N., R. 66 W. (See pl. 9.) Bed P is about 3 feet thick at location 63. At location 58 bed Q contains less than 1 foot of coal. Other measurements of bed Q are shown graphically in Plate 6. The strata below bed Q are generally barren of coal in this township except for some very thin and impure lenses, such as the one shown in the following section:

Section at location 55, in the NE. ¼ sec. 25, T. 40 N., R. 66 W. (lens)

Shale.	Ft.	in.
Coal, very impure-----	1	4
Sandstone-----	10	
Coal and shale-----	1	2
Clay and carbonaceous shale-----	3	
Total coal-----	2	6

A coal bed 2 feet thick crops out at location 121, in sec. 11, T. 41 N., R. 66 W., in the broken land north of the North Fork of Cheyenne River, and its outcrop as traced is shown on Plate 9. It is believed that no other coal beds occur in the township, as in the main the surface rocks are older than those that are generally coal-bearing in the Gillette field.

Although rock exposures are generally good throughout T. 42 N., R. 66 W., the one thin coal bed observed within it was traceable for only about a mile. At location 183 this bed contains 1 foot 9 inches of impure coal; at 184, 1 foot 8 inches; at 185, 2 feet 1 inch; and at 186, 2 feet 9 inches.

The thickest coal bed observed in Tps. 43 and 44 N., R. 66 W., was less than 17 inches thick. A coal bed 10 inches thick crops out in the NW. ¼ sec. 19, T. 45 N., R. 66 W. Another lens 9 inches thick is exposed at location 392, in sec. 7, T. 46 N., R. 66 W. No coal beds were observed in T. 47 N., R. 66 W.

More than half of T. 48 N., R. 66 W., and all of Tps. 49 and 50 N., R. 66 W., are underlain by marine formations of Upper Cretaceous age and contain no coal.

T. 39 N., R. 67 W.

The only coal bed of economic importance in T. 39 N., R. 67 W. is bed K, which crops out in the western part of the township and averages about 5 feet in thickness. Sections of bed K are shown graphically in Plate 6. A local lens of coal below bed K at location 6 in sec. 35 contains 4 feet of impure coal. Clinker produced by the burning of bed J caps a pine-clad escarpment which stands about 250 feet above the surrounding lowlands in the western part of the township. Bed J is probably unburned beneath a very small portion of sec. 18 and is about 3 feet 6 inches thick.

T. 40 N., R. 67 W.

The surface of T. 40 N., R. 67 W., is a rolling upland, dissected into badlands in its northeastern part along tributaries of North Fork of Cheyenne River. Beds P, P', and Q, which crop out in the northeastern part, were the only coal beds observed within the

township. Bed P is 20 feet above bed P' in this township, but the interval between them decreases to 2 feet in T. 41 N., R. 67 W. Bed P is thin, impure, and broken by several thin shale partings, as may be seen by referring to sections 59, 62, and 63, Plate 6. Bed P' is 2 feet 4 inches thick at location 62 but is much thinner south of this location. The following sections also show the character of beds P and P' in this township:

Section at location 60, in the NW. $\frac{1}{4}$ sec. 24, T. 40 N., R. 67 W. (bed P)

	Ft. in.
Shale, carbonaceous.....	8
Coal, fair quality.....	1 1
Shale, carbonaceous.....	1
Total coal.....	1 1

Section at location 61, in the NE. $\frac{1}{4}$ sec. 10, T. 40 N., R. 67 W. (beds P and P')

	Ft. in.	
Sandstone.....		
Clay.....	5	
Shale.....	1 6	
Bed P {	Coal, impure.....	8
	Shale.....	8
	Coal, impure.....	1 2
	Sandstone.....	1 6
	Coal.....	4
Clay.....	20	
Shale.....	1	
Bed P', coal, impure.....	1 7	
Total coal.....	3 9	

Bed Q is about 65 feet below bed P'. At location 65, in sec. 13, it contains 1 foot 10 inches of bone, and at location 67, in sec. 3, 3 feet 7 inches of coal. Less than half a mile south of location 67 it is much thinner, as shown in the following section:

Section at location 66, in the SE. $\frac{1}{4}$ sec. 3, T. 40 N., R. 67 W. (bed Q)

	Ft. in.
Sandstone.....	20
Shale.....	8
Coal.....	1 3
Shale.....	3½
Coal.....	4
Shale, sandy.....	-----
Total coal.....	1 7

T. 41 N., R. 67 W.

Beds L, L', P, P', and Q and some local lenses were mapped in T. 41 N., R. 67 W. (See pl. 9.) The outcrop of bed L barely enters the township in sec. 18 and contains 2 feet 1 inch of coal at

location 145. Bed L' crops out in sec. 6 and averages about 3 feet 6 inches in thickness at locations 141 and 142 (pl. 6). Bed P crops out in a north-south direction across the central portion of the township and averages about 2 feet in thickness, as shown by the graphic sections in Plate 6. In the southern part of the township, where beds P and P' are 17 to 20 feet apart, they are mapped separately (pl. 9), but in the northern part of the township, where they are only 2 feet apart, they are mapped and classed as benches of bed P. At locations 124 and 125 bed P' is 20 feet below bed P and is about 3 feet thick. At location 126, however, the sandy shale separating the two beds thins from 18 feet to 2 feet within a horizontal distance of about 75 feet and the bed is 2 feet 7 inches thick.

The following measured sections of beds P and P' are not shown graphically in Plate 6:

Sections of coal beds in T. 41 N., R. 67 W.

Location 128, NE. $\frac{1}{4}$ sec. 32		Ft. in.
Clay-----		4
Shale-----		4
Coal, good quality (bed P)-----		1 4
Shale, carbonaceous, base unexposed.		-----
Total coal-----		1 4
Location 131, SW. $\frac{1}{4}$ sec. 9		Ft. in.
Sandstone-----		15
Shale-----		6
Coal (bed P)-----		2 1
Shale, gray-----		2 4
Coal (bed P')-----		2 6
Total coal-----		4 7
Location 133, NW. $\frac{1}{4}$ sec. 15		Ft. in.
Sandstone, friable, gray-----		4
Shale, sandy-----		3
Coal (bed P)-----		1 3
Sandstone-----		4
Total coal-----		1 3
Location 135, NW. $\frac{1}{4}$ sec. 15		Ft. in.
Sandstone, yellow-white-----		60
Shale, sandy-----		20
Coal-----		4½
Sandstone, friable, with bands of sandy shale 2 to 5 inches thick-----		23
Coal (bed P)-----		1 8
Shale, sandy-----		11 8
Coal (bed P')-----		1
Total coal-----		2 8

Location 137, NE. $\frac{1}{4}$ sec. 10		Ft. in.
Sandstone, gray	-----	10
Shale, brown, carbonaceous	-----	7 1
Coal (bed P)	-----	7
Shale, brown, carbonaceous	-----	10
Sandstone, gray, lenticular	-----	2
Coal (bed P')	-----	1 4
Shale, brown, carbonaceous	-----	2
Total coal	-----	2 1

Bed Q lies about 65 feet below bed P' and is 2 feet 4 inches thick at location 122, in sec. 28, its only definitely known outcrop in the township. An isolated outcrop of coal 2 feet 8 inches thick at location 123, in sec. 15, may be bed Q, but precise correlation was made impossible by the lack of continuous exposures. At location 140, in sec. 19, an isolated exposure contains 2 feet 7 inches of coal. Another coal bed less than 2 feet thick occurs at location 143, in sec. 6.

T. 42 N., R. 67 W.

Beds L, L', and P and five lenses of short horizontal extent crop out in T. 42 N., R. 67 W., as shown on Plate 9. The lenses are distributed through a vertical interval of about 100 feet and lie near the top of the Lance formation. The following section of the lowest of these lenses is exposed in the bank of Little Thunder Creek:

Section at location 189, in the SW. $\frac{1}{4}$ sec. 3, T. 42 N., R. 67 W. (lens)

	Ft. in.
Sandstone.	
Coal, impure	6
Sandstone	10
Clay	4
Coal	1
Shale	1
Coal	1
Shale	1
Sandstone	7
Coal	7
Sandstone.	-----
Total coal	2 2

At location 188, in sec. 21, 2 feet 5 inches of impure coal is exposed. At the unnumbered outcrop in sec. 27 there is 1 foot 7 inches of coal, and at location 190, in sec. 32, there is a lens 1 foot thick. Bed P is 2 feet 4 inches thick at location 187, in sec. 34, as shown on Plate 6. Beds L and L' are about 25 feet apart in this township and crop out in its southwestern corner. Bed L' is 3 feet 6 inches thick at location 191, in sec. 32. At locations 192 and 193 (pl. 6) bed L is 5 feet and 4 feet 6 inches thick, respectively.

T. 43 N., R. 67 W.

Three coal beds occur in the Tullock member of the Lance formation in T. 43 N., R. 67 W. Bed O, the most valuable of these three beds, averages about 3 feet in thickness and extends over a considerable area; the other two beds are lenses of less extent. Bed O contains 1 foot 11 inches of coal at location 222, in sec. 30, and 1 foot 6 inches at location 223, in sec. 19. Other measurements of the bed are shown graphically in Plate 6. The section at location 227, in sec. 9, is almost identical with that at location 226. The bed measured at locations 229 and 230 is 10 feet below bed O, but the interval varies somewhat at other places. At location 230 this lens is only 10 inches thick, and at location 229, 2 feet. At location 226 it is 7 feet below bed O and is 3 feet 3 inches thick (226-A, pl. 6). At location 231, in sec. 31, a bed probably equivalent to bed M crops out as an outlier and is 1 foot 10 inches thick. Local lenses containing about 1 foot of coal were measured at locations 232 and 233.

The following stratigraphic section measured at location 217, in sec. 28, shows the normal composition of the Tullock as developed in the central and eastern parts of the township below the beds just discussed:

Section at location 217, in sec. 28, T. 43 N., R. 67 W.

	Ft. in.
Sandstone, drab, massive-----	10
Coal, fair-----	11
Shale, brown, carbonaceous-----	1
Coal, with shale partings-----	7
Shale, drab, sandy, carbonaceous-----	1
Coal, impure, bony-----	1 8
Shale, drab, carbonaceous-----	1 3
Coal, fair, but with several thin bone partings-----	1 6
Shale, sandy-----	2
Coal-----	1
Sandstone, massive, hard-----	3
Shale, sandy, with thin coal lenses-----	10
Coal, good, hard-----	9
Sandstone, blue, massive, hard, shaly at base; has thin lenses of coal locally-----	3 10
Coal-----	4
Sandstone, blue, hard-----	2 5
Clay, blue-----	2 10
Sandstone, friable-----	4
Coal, fair-----	6
Sandstone, hard-----	5
Shale, friable-----	3
	41 11

T. 44 N., R. 67 W.

The most extensive coal bed that crops out in T. 44 N., R. 67 W., is bed O, measurements of which are shown graphically in Plate 6. At location 268 bed O contains 3 feet 7 inches of coal; at locations 272 and 274, 1 foot 3 inches and 1 foot 4 inches, respectively. There are at least three other coal beds, more or less lenticular, exposed in the township. One of these is 2 feet thick at location 263, 1 foot 1 inch thick at location 264, and 1 foot 8 inches thick at location 262. Another lens is 2 feet thick at locations 278 and 279 and 1 foot 10 inches at location 277. Another lens of impure coal about 2 feet thick crops out at location 276, in sec. 7.

T. 45 N., R. 67 W.

Coal bed O and several lenses crop out in T. 45 N., R. 67 W. The outcrop of bed O traverses the western part of the township in a north-south direction, as shown on Plate 9. It ranges in thickness from 1 foot 4 inches at location 315, in sec. 30, to 7 feet at location 322, in sec. 4. Other measurements of bed O in the township are represented in Plate 6. This bed has been mined by the open-cut method to supply coal for local consumption at location 316, which is on Lodgepole Creek in sec. 19. The rocks below bed O in this township are for the most part barren of coal, but some local lenses were noted. At locations 323, 324, and 325 about 2 feet of impure coal is exposed, and at location 326 a lens contains 1 foot 6 inches of coal. Another impure coal bed about 2 feet thick was noted at locations 327 and 328, in secs. 6 and 7.

T. 46 N., R. 67 W.

About 400 feet of strata belonging to the Tullock member of the Lance formation and the Lebo shale member of the Fort Union formation crop out in T. 46 N., R. 67 W., and contain two thin coal beds of considerable extent. The lower of these, bed O, is exposed in secs. 28, 32, and 33 and is not more than 3 feet thick, as shown by graphic sections 393, 394, and 395, Plate 6. A local lens about 2 feet thick, shown graphically in Plate 6 by sections 394-A and 395-A, occurs about 20 feet below bed O at locations 394 and 395, the intervening beds being shale.

At location 393, in sec. 34, there are six other thin coal beds, as shown in the following detailed section:

Stratigraphic section at location 393, in the NW. ¼ sec. 34, T. 46 N., R. W.

	Ft.	in.
Sandstone, yellowish, friable-----	15±	
Shale, brown, carbonaceous-----	2	
Coal (bed O)-----	3	

	Ft.	in.
Clay-----	4	
Shale, brown, carbonaceous-----		8
Coal-----	1	
Shale, brown, carbonaceous-----	2	6
Clay, sandy-----	6	
Shale, black, carbonaceous-----		7
Coal, very impure-----	1	8
Shale, sandy-----	20	
Shale, carbonaceous-----	1	4
Coal-----		4
Shale, clay, and friable sandstone-----	30	
Sandstone, concretionary, hard-----	3	
Shale, sandy-----	10	
Coal-----		3
Clay, sandy-----	5	
Shale-----		3
Coal-----	1	4
Shale, brown, carbonaceous-----	1	
Bone and shale-----		8
Shale, clay, and sandstone-----	17	
Shale, brown, carbonaceous-----	6	
Coal, fair-----	1	2
Shale, carbonaceous-----		5
	134	2

Bed N crops out in secs. 30 and 31, and, as may be seen by reference to sections 396, 397, 399, 400, and 401, Plate 6, its average thickness is about 2 feet, though at location 398, in sec. 30, it is only 1 foot 6 inches thick.

TPS. 47 TO 50 N., R. 67 W.

The surface formations in T. 47 N., R. 67 W., belong to the Hell Creek and Tullock members of the Lance formation and contain thin carbonaceous layers but no coal beds of economic value, as the following representative section will show.

Stratigraphic section at location 461, in the NW. $\frac{1}{4}$ sec. 19, T. 47 N., R. 67 W.

	Ft.	in.
Sandstone-----	4	
Clay-----	10	
Sandstone-----	1	6
Clay, ferruginous-----	9	6
Coal-----		7
Shale, carbonaceous-----	8	
Clay-----	11	
Sandstone-----	5	
Clay, shaly-----	11	6
Sandstone-----	4	6
Clay-----	8	
Shale, carbonaceous-----	2	4

	Ft.	in.
Coal-----	3	
Shale, carbonaceous-----	4	3
Clay-----	3	6
Coal-----	1	
Shale, carbonaceous-----	1	
Clay-----	16	
Coal-----	9	
Shale, carbonaceous-----	4	6
Clay-----	9	
Shale-----	6	4
Clay, ferruginous-----	12	
Shale, carbonaceous-----	10	6
Coal-----	8	
Clay, sandy-----	20	
Sandstone-----	4	
Clay-----	40	
Shale, carbonaceous.	208	9

The Fox Hills sandstone and older rocks crop out in the northeast corner of T. 48 N., R. 67 W., and dip 29° SW. The remainder of the township is occupied by the Hell Creek member of the Lance formation, which dips 5° and 2° SW. in its central and western portions, respectively. Bed S and one lens of coal crop out in this township. Bed S averages about 2 feet in thickness and is represented graphically in Plate 6. Its southern limit occurs at location 554-A, where it is only 6 inches thick. At location 545 bed S is composed of two benches of coal, each 1 foot thick, separated by 3 inches of shale. At location 546 it is impure and occurs in two benches each about 1 foot thick, separated by 1 foot of shale. At location 547 two benches 10 inches and 1 foot 4 inches thick are separated by 2 feet of shale. An analysis of a sample from a small prospect on bed S at location 551 may be found on page 17. A lens of coal 1 foot thick crops out at location 543, in sec. 6.

The Fox Hills sandstone and older rocks and the lower part of the Hell Creek member of the Lance formation are exposed over the whole of Tps. 49 and 50 N., R. 67 W., and are barren of coal.

TPS. 39 AND 40 N., R. 68 W.

Beds I, J, and K are the most valuable coals in Tps. 39 and 40 N., R. 68 W. Measurements of bed K at locations 10, 27, and 28, in T. 39 N., show that its average thickness in this township is about 5 feet, but the upper 1 foot is impure. (See pl. 6.) One other measurement of bed K in this township not represented on Plate 6 is given on page 30.

Section at location 29, in the SE. ¼ sec. 3, T. 39 N., R. 68 W. (bed K)

	Ft. in.
Clay	4
Sandstone	11
Coal, impure	1 6
Shale, carbonaceous	2
Coal, somewhat dirty	3 3
Shale, carbonaceous	—
Total coal	4 9

The graphic sections of bed J in Plate 6 show an average thickness of about 5 feet, although at location 13, in sec. 24, it is only 2 feet 4 inches thick.

Bed I is extensively burned along its outcrop in T. 39 N., as shown on Plate 9. The clinker thus produced caps an irregular table-like ridge covered with a dense growth of pine trees. The measured sections represented in Plate 6 show that bed I increases rapidly in thickness northward, attaining a maximum thickness for the township of 13 feet 6 inches at location 24, in sec. 18. In 1911 it was burning near its outcrop in the NE. ¼ sec. 21. (See pl. 3, B.)

Bed K crops out in the extreme southeastern part of T. 40 N., R. 68 W., and probably also north of the North Fork of Cheyenne River. Lack of exposures, however, prevents the precise correlation of these outcrops. The only measurement of bed K in this township south of the North Fork of Cheyenne River was made at location 68, in sec. 32, where it contains 4 feet 8 inches of impure coal, bone, and sandstone. North of the river, in T. 40 N., a bed supposed to be bed K was measured at locations 69, 70, 71, 72, 73, and 74, and all but the last two sections are represented graphically in Plate 6. The average thickness of the bed at these locations is about 3 feet.

Sections of supposed coal bed K in T. 40 N., R. 68 W.

Location 73, in the SW. ¼ sec. 3		Location 74, in the NE. ¼ sec. 4	
Clay.	Ft. in.	Clay.	Ft. in.
Shale	3	Shale, carbonaceous	5
Coal	9	Coal, impure	7
Bone	1	Shale, carbonaceous	3
Coal	1	Coal, fair quality	2
Total coal	1 9	Total coal	2 7

TPS. 41 AND 42 N., R. 68 W.

The summit of the Rochelle Hills escarpment, in the northwestern and southwestern portions of Tps. 41 and 42 N., R. 68 W., respectively, stands about 400 feet above the surrounding lowlands and is capped by a thick pine-covered bed of slag formed by the burning of coal bed D, the Roland coal. Beds I, J, K, L, and L' and several smaller lenses crop out in these townships, and beds P and Q probably underlie them.

The lowest coals exposed in these townships are beds L and L', which crop out in the easternmost tier of sections and underlie a large part of the townships. In T. 41 N., at location 144, bed L contains 1 foot 7 inches of impure coal; at location 145, 2 feet of coal; and at location 146, 4 feet 2 inches. (See pl. 6.) At location 146 bed L', which is 25 feet below bed L, contains 3 feet 9 inches of coal (No. 146-A, pl. 6). Section 146-B (pl. 6) was measured 27 feet above bed L at location 146 and appeared to be a local lens.

Bed K is 1 foot 7 inches thick at location 147 and 1 foot 4 inches thick at location 148, in sec. 33. For about 3 miles north of location 148 bed K is concealed in grass-covered slopes and could not be traced. At locations 149, in sec. 16, and 150, in sec. 4, 1 foot 8 inches of coal is exposed. At location 151, in sec. 4, two beds are exposed, each about 2 feet thick and separated by 14 feet of shale and clay. One of these is probably bed K and the other a local lens.

Bed J averages about 5 feet in thickness at locations 152, 153, and 154. (See pl. 6.) Bed I crops out in the slopes of the Rochelle Hills escarpment and ranges in thickness from 3 feet 8 inches at location 158 to 5 feet 2 inches at location 159, both in sec. 5. Other measurements of bed I in this township are shown in Plate 6. At locations 155, 156, 157, 159, and 160 a lens of coal about 3 feet thick occurs 9 to 20 feet below bed I. It is represented in Plate 6 by sections 155-A, 156-A, 157-B, 159-A, and 160-A. In T. 42 N., R. 68 W., at locations 197 and 198, in secs. 1 and 2, respectively, 5 inches and 1 foot 7 inches of coal belonging to unidentified beds were measured. Locations 199, 200, and 201, in secs. 22 and 23, show sections of a coal lens 10 inches thick.

Bed L' ranges in thickness and character from 2 feet 2 inches of impure coal at location 196 to 3 feet 5 inches and 3 feet 3 inches of coal at locations 194 and 195, respectively. (See pl. 6.) Bed K is 2 inches thick at location 202, in sec. 33, its only outcrop in the township, and is believed to be entirely replaced by shale north of this location. Bed I crops out at the base of the Rochelle Hills escarpment in the southwestern part of the township and ranges in thickness from 4 feet 7 inches to over 6 feet, as shown by the sections in Plate 6.

TPS. 43 AND 44 N., R. 68 W.

Bed M, the only economically important coal bed exposed in T. 43 N., R. 68 W., was measured at locations 236 to 244 and has a maximum local thickness of 3 feet 4 inches of coal at location 244. At location 240 it contains 2 feet of impure coal; at 241, 4 feet of carbonaceous shale, bone, and coal. Sections at the other locations are represented graphically in Plate 6.

A lens about 30 feet below bed G was measured at location 245, near the west line of T. 43 N., and is 1 foot 3 inches thick. Several other coal beds measured in the township to the east also presumably underlie this township.

No coal beds of economic importance were observed in T. 44 N., R. 68 W. Lenses of local extent are exposed at locations 275, in sec. 13; 280, in sec. 22; and 281, in sec. 6 (see pls. 6 and 9), but none of these beds are over 2 feet 6 inches thick.

T. 45 N., R. 68 W.

Bed G is the most valuable coal exposed in T. 45 N., R. 68 W., and its average thickness is slightly over 3 feet, as shown by the sections given in Plate 7. At location 340, in sec. 17, bed G contains 3 feet 7 inches of coal; at 344, in sec. 21, 3 feet 1 inch; at 348, in sec. 16, 2 feet 8 inches; at 349, in sec. 16, 2 feet 6 inches; at 350, in sec. 16, 1 foot 9 inches; and at 351, in sec. 9, 1 foot 7 inches. At location 339, in sec. 31, two beds separated by 15 feet of shale are exposed. It was impossible to determine which of these is bed G, hence the complete section is shown on Plate 9.

Below bed G there are several isolated exposures of coal. At location 329, in sec. 24, 1 foot 7 inches of very impure coal crops out. A lens which at location 330, in sec. 14, is 5 feet 3 inches thick is apparently of very local extent, as no other exposures of it could be found, although its horizon is exposed near by. At location 331, in sec. 12, a total of 4 feet 3 inches of coal was measured, as shown on Plate 7. The coal bed that crops out in sec. 1 is 4 feet 8 inches thick at location 332, but at locations 333, 334, and 336 it is less than 3 feet thick and decidedly impure. (See pl. 7.) At location 335, in sec. 1, there are two thin coal beds, each 1 foot 6 inches thick, separated by 8 feet of clay. At location 337, in sec. 32, 1 foot 1 inch of impure coal is exposed along the side of a butte. At location 338, in sec. 22, there is an isolated exposure of coal 1 foot 6 inches thick.

In addition to the coal beds measured in T. 45 N., beds N and O, which crop out in the township to the east, probably also underlie this township.

T. 46 N., R. 68 W.

Coal beds N and N' and a number of local lenses crop out at the base of a pine-clad ridge that crosses the east-central part of T. 46 N., R. 68 W., from north to south. Beds N and N' average between 2 and 3 feet in thickness and are 25 feet apart; bed N is the lower. Variations in thickness of bed N are shown graphically in Plate 7. At location 405 bed N is 1 foot 9 inches thick. Sections of bed N' were measured at locations 410 to 420. This bed is 1 foot 11 inches

thick at location 411, 2 feet 2 inches at location 414, and 3 feet at locations 416 and 417; the remaining measurements are shown in Plate 7. One of the lenses referred to above averages about 2 feet in thickness and lies about 50 feet above bed N. It is exposed at locations 421 to 428, and the corresponding sections, except those at locations 421 and 426, are shown in Plate 7. At location 421 this lens is 1 foot 9 inches thick, and at location 426, 2 feet 1 inch. Another local lens below bed N and much more impure is exposed in sec. 4. It is 2 feet 2 inches thick at location 430, and 2 feet at 431. At location 429, in sec. 3, another local lens contains 10 inches of coal.

T. 47 N., R. 68 W.

No valuable beds of coal crop out in T. 47 N., R. 68 W., though local lenses are numerous. The outcrops of these lenses, so far as they could be traced, are shown on Plate 9, and the coal sections, except as otherwise indicated, are shown graphically in Plate 7.

Two beds about 30 feet apart exposed along Fourhorse Creek in secs. 7, 18, and 19 are the lowest coals in the township. The lower bed is represented by the exposure at location 462 and probably by those at locations 463, 464, and 465, although the bed could not be traced between these places. Its average thickness at these locations is a little over 2 feet. (See pl. 7.) The upper bed is 2 feet 2 inches thick at location 469, 10 inches at 470, 1 foot 2 inches at 467 and 468, and only 6 inches at 466. Section 469, the only one on this bed which is shown graphically in Plate 7, contains 2 feet 2 inches of coal. The average thickness for the bed is about 1 foot 2 inches.

Several local lenses of coal crop out near the top of the ridge in the central part of the township. Sections on one of these lenses, at locations 471, 472, 473, and 474, average nearly 4 feet in thickness over a small area. About 60 feet higher occurs another lens which averages about 2 feet in thickness. Sections 475 and 477 to 482, Plate 7, represent this bed. At location 476 the bed is divided by 3 feet of shale into two benches, each about 1 foot thick. At locations 483 and 484, in sec. 28, outliers of coal cap buttes. At location 483 the coal is 2 feet 3 inches thick, but at 484, where it is divided into three benches by shale partings, it is much thicker. (See pl. 7.) In secs. 16, 21, and 28 there is an outcrop of coal ranging in thickness from 2 feet 4 inches at location 485 to 1 foot 3 inches at 487-A and averaging 1 foot 7 inches in thickness. This bed also crops out at locations 486 and 487, where 1 foot 3 inches and 1 foot 8 inches of coal, respectively, were measured. These sections are not shown graphically, but the detailed stratigraphic section measured at location 485, where three different lenses occur, is given below:

Section at location 485, in the NE. ¼ sec. 28, T. 47 N., R. 68 W.

Sandstone.	Ft. in.
Coal (sec. 485)-----	2 4
Shale, carbonaceous-----	14
Coal-----	1 1
Sandstone-----	8
Coal-----	1 5
Sandstone.	-----
	26 10

A coal lens exposed at location 488, in sec. 15, contains 3 feet 2 inches of coal. This bed was noted again at location 489, where two other beds, represented by sections 489-A and 489-B, lie, respectively, 17 and 35 feet below it. A coal bed that crops out in the top of a butte is 11 inches thick at location 490, in sec. 23, 8 inches at 491, and 2 feet 1 inch at 492. Section 492 is shown in Plate 7. At locations 493, 494, 502, and 503, in sec. 27, is found another lens that averages about 2 feet in thickness. The section at location 502, which includes several other thin coal beds, is given below:

Section at location 502, sec. 27, T. 47 N., R. 68 W.

	Ft. in.
Clay, carbonaceous-----	12
Coal, poor-----	6
Clay-----	2
Coal, fair-----	11
Clay-----	10
Coal, fair-----	8
Clay-----	2
Coal, fair-----	1 5
Clay-----	6
Coal, good (sec. 502)-----	2

	37 6

A coal lens 2 feet 4 inches and 3 feet thick at locations 495 and 496, respectively, was noted. At location 497, in sec. 15, an isolated lens is 1 foot 5 inches thick. Bed N crops out in the southern part of the township and ranges in thickness from 1 foot 7 inches at location 498 to 3 feet 2 inches at location 501. These sections, except 498, are shown in Plate 7.

TPS. 48 TO 50 N., R. 68 W.

A few thin and lenticular coal beds were found in Tps. 48, 49, and 50 N., R. 68 W., chiefly near Belle Fourche River in T. 49 N. Several isolated outcrops of lenticular coal beds were observed in T. 48 N., as follows: A lens contained 1 foot 4 inches of coal at location 555, in sec. 1; another, 3 feet 6 inches thick, occurs at location 588, in sec. 2; a third, 9 inches thick, at location 556, in sec. 11;

and a fourth, 10 inches thick, at location 557, in sec. 18. A lens exposed in secs. 20 and 29 ranges in thickness from 1 foot 7 inches at location 558 to 2 feet 4 inches at location 559. At location 560, in sec. 8, a lens 1 foot 4 inches thick crops out in the top of a hill; at location 561, in sec. 33, a coal bed 1 foot 4 inches thick is likewise exposed in a hill; and in the southeastern part of the same section there are three outliers of a higher coal which at location 562 is 1 foot 8 inches thick and at location 563 2 feet thick. None of these isolated outcrops could be correlated with others, and it is doubtful if any two, except those at locations 562 and 563, have the same stratigraphic position. An analysis of a sample of coal taken at location 559 is given on page 17.

Bed R is the lowest coal that crops out in T. 49 N., R. 68 W., and was once exploited by a local mine, now abandoned, at location 575. It averages about 2 feet in thickness at locations 574, 575, 576, 578, and 579. (See pl. 7.) At location 577 it contains 2 feet 9 inches of coal. Locations 580 and 581, in sec. 31, are on a coal bed about 2 feet thick. These exposures probably represent a single horizon. In the southeastern part of the township several coal beds crop out. The lowest contains about 2 feet 6 inches of coal, as shown by graphic sections 582, 583, 584, 585, 588, and 589, Plate 7. At location 586 it is 3 feet 9 inches thick, and at 587, 3 feet 6 inches thick. A coal bed 60 feet higher than the one just described is exposed near the top of the buttes in secs. 34 and 35 and is 2 feet thick at locations 593 and 593-A. Three isolated outcrops occur at locations 590, 591, and 592, in sec. 26, which could not be correlated with others on account of lack of exposures. Their thicknesses are 1 foot 3 inches at 590, 6 inches at 591, and 2 feet at 592. As there are several other thin beds of coal exposed at location 592, a detailed stratigraphic section at this locality is given below:

*Stratigraphic section at location 592, in the SE. ¼ sec. 26, T. 49 N.,
R. 68 W.*

Sandstone and shale.	Ft. in.
Shale, carbonaceous, sandy-----	2
Coal, fair-----	3
Bone, shaly-----	10
Shale, carbonaceous-----	6
Coal, very bony, impure-----	7
Sandstone and clay shale-----	3
Shale, carbonaceous-----	6
Coal-----	5
Shale and shaly sandstone-----	16
Coal-----	2
Shale, carbonaceous-----	4
Coal-----	6
Shale, carbonaceous.	<hr/>
	30 7

At location 594, in sec. 9, there are two thin beds of coal, 6 and 8 inches thick, separated by 6 feet of shale. A stratigraphic section measured at location 595, in sec. 7, from the bottom of a draw to the top of a small butte, contains three thin coal beds, each of which is less than 1 foot 6 inches thick. The thickest of these is exposed near the top of the butte and is 1 foot 3 inches thick. The section in detail follows:

*Stratigraphic section at location 595, in the NW. $\frac{1}{4}$ sec. 7, T. 49 N.,
R. 68 W.*

Roof, shale.	Ft. in.
Coal.....	1 3
Shale, carbonaceous.....	8
Shale, sandstone and clay.....	20
Shale, with two 4-inch coal bands.....	2 6
Shale and clay.....	6
Coal, fair.....	8
Sandstone, friable, and clay shale.....	40
Shale, blackish, carbonaceous.....	3
Sandstone, friable.....	15
Shale, carbonaceous, sandy, grading into friable sandstone..	6
Coal, fair.....	10
Clay, sandy base.....	2
	92 5

A few thin coal lenses are present in the Hell Creek member of the Lance formation in T. 50 N., R. 68 W., but most of them are too thin to be of economic importance. At location 597, in sec. 29, 1 foot 1 inch of coal was measured, and the sections given below are representative of the township.

Sections of coal beds in T. 50 N., R. 68 W.

Location 596, in the NW. $\frac{1}{4}$ sec. 32	Ft. in.	Location 598, in the SW. $\frac{1}{4}$ sec. 27	Ft. in.
Clay and carbonaceous clay in alternating bands.....	18	Sandstone.	
Shale, carbonaceous.....	1 2	Clay and shale, in alternating bands, carbonaceous.....	30
Shale, soft.....	4 6	Coal, poor.....	8
Coal, black but poor.....	7	Shale, carbonaceous.....	1
Shale, soft.....	3 5	Clay.....	8
Shale, carbonaceous.....	4	Shale, carbonaceous.....	6
Shale, soft.....	4	Coal.....	1 1
Coal.....	8		41 3
Shale, carbonaceous.	32 8		

TPS. 39 AND 40 N., R. 69 W.

Beds I and J are the principal coal beds that crop out in Tps. 39 and 40 N., R. 69 W., which are probably also underlain by thin coal

beds exposed in townships to the east. Bed I crops out on both sides of Cheyenne River and was measured at locations 30 to 41 and 86 to 90. It ranges in thickness from 1 foot 10 inches to 8 feet 2 inches south of the river and averages about 3 feet in thickness north of the river. All the sections of the bed measured are shown graphically in Plate 7, except those at locations 35 and 39, where the bed is 2 feet 5 inches and 1 foot 7 inches thick, respectively.

Bed J was measured at location 42, in sec. 1, T. 39 N., where it consists of 2 feet of coal underlain by 4 feet of carbonaceous shale and dirty coal, and it was also measured at locations 75 to 81, in T. 40 N., and found to have a maximum observed thickness of about 8 feet of coal at location 76. (See pl. 7.) Half a mile east of location 76, at location 75, the upper 2 feet of bed J is impure, and the remainder is badly broken by partings. The irregularity of the bed is further illustrated by the following section:

Section at location 80, in the NW. ¼ sec. 2, T. 39 N., R. 69 W.

Sandstone.	Ft. in.
Coal, fair quality-----	1 3
Shale, carbonaceous-----	1 9
Coal, fair quality-----	10
Total coal-----	<hr/> 2 1

At location 84, in sec. 16, a coal bed 1 foot 6 inches thick crops out. This is an isolated exposure and represents a local lens between beds I and J. Another local lens was measured at locations 82 and 83, in sec. 15, where it contains 11 inches and 1 foot 6 inches of coal, respectively.

TPS. 41 AND 42 N., R. 69 W.

Beds D, I, and J are exposed in Tps. 41 and 42 N., R. 69 W., and other thin coal beds which crop out farther east probably underlie them. The clinker-covered surface of the plateau lying west of the Rochelle Hills escarpment occupies more than half of Tps. 41 and 42 N., R. 69 W., the remainder lying within the rugged slopes on or below the escarpment. (See pl. 9.)

Bed J crops out in the southeast corner of T. 41 N., R. 69 W., but is nowhere well enough exposed to be measured in detail. Measurements made in T. 41 N., R. 68 W., indicate that bed J is probably 3 feet thick in this township.

Bed I also crops out in the southern portion of T. 41 N. but is of little value, as is shown by the following sections, which include the only measurements of the bed made in the township:

*Sections in T. 41 N., R. 69 W.***Location 161, in the SE. $\frac{1}{4}$ sec. 24**

	Ft. in.
Shale and clay.....	1
Shale and bone, with thin coal bands interbedded.....	6
Coal.....	22
Shale and sandstone, friable.....	6
Coal.....	11
Sandstone, brown, massive, friable.....	1
Shale, carbonaceous, roof.....	6
Coal.....	11
Bone.....	3
Coal.....	5
Parting, bone.....	2
Coal, impure.....	10
Shale, carbonaceous.....	1
Bone and carbonaceous shale, with local coal lenses.....	2
Shale, sandstone, and clay.....	35
Shale, brown, carbonaceous, with three 4-inch bands of coal interbedded, one near middle, one at top, and one 2 feet from top.....	6
Coal, impure, bony.....	1
Coal, bone, and black carbonaceous shale.....	7
Shale, brown, carbonaceous.....	4
Total coal.....	2

Location 162, in the NE. $\frac{1}{4}$ sec. 27

	Ft. in.
Sandstone, white, friable.....	2
Shale, gray, sandy.....	6
Bone.....	4
Coal, poor quality, with bony streaks (bed I).....	1
Shale, sandy.....	2
Total coal.....	1
	8

In T. 42 N., R. 69 W., at locations 207 and 208, in secs. 2 and 12, respectively, bed I is between 3 and 4 feet thick. (See pl. 7.) Elsewhere in the township it is concealed. Although its burning has formed the extensive clinker bed already referred to, unburned coal belonging to the Roland bed (bed D) crops out at several places in T. 41 N. At location 165, in sec. 6, a number of thin benches of coal at the horizon of this bed are exposed, but it is very likely that the main part of the bed is concealed. The Roland bed is also exposed in a hill southwest of location 164, in sec. 4, but is partly burned. At location 166, in sec. 7, an isolated lens of coal 2 feet thick crops out, and a similar lens of impure coal is exposed in the bottom of a coulee at location 164. Though extensively burned in T. 42 N., the presence of some tracts within the township containing unburned coal at the horizon of bed D is indicated by the absence of baking in areas shown as underlain by that bed on

Plate 9. No outcrop of bed D was, however, found within the township.

A small lens containing 1 foot 8 inches of impure coal is exposed at location 163, in sec. 22.

TPS. 43 AND 44 N., R. 69 W.

Clinker formed by the burning of bed D caps high ridges in Tps. 43 and 44 N., R. 69 W., and small tracts of unburned coal belonging to it are believed to underlie the higher hilltops in T. 43 N. Beds G and F and some local lenses of coal also crop out in these townships, and other thin coal beds that crop out farther east probably underlie them.

Bed G is 2 feet thick at location 251, in T. 43 N.; in T. 44 N. it has a maximum observed thickness of 8 feet 9 inches at location 299, and a minimum thickness of 1 foot 11 inches at locations 282 and 288. Measured sections of the bed are shown graphically in Plate 7, except that at location 293, where it contains 2 feet of impure coal.

Bed F crops out in the northwest corner of T. 44 N. but is of little importance, as indicated by sections shown in Plate 7 and those given below.

Sections of coal bed F in T. 44 N., R. 69 W.

Location 304, in the NE. $\frac{1}{4}$ sec. 7		Location 302, in the NW. $\frac{1}{4}$ sec. 33	
	Ft. in.		Ft. in.
Shale, yellowish brown, carbonaceous-----	18	Shale -----	5
Coal -----	1 2	Bone -----	2
Coal, very poor quality, bony -----	4	Coal -----	1 4
Shale, carbonaceous -----	5	Bone -----	3
Coal -----	11	Coal -----	4
Shale, carbonaceous. -----		Shale, carbonaceous -----	5
Total coal -----	2 5	Total coal -----	1 8

Less extensive beds of coal are also present in both townships. In T. 43 N. two coal beds, separated by 20 feet of shale and sandstone, crop out at location 246, in sec. 12, where the thickness of each is about 2 feet, as shown in Plate 7. A lens of coal extending across sec. 12 nearly to the center of sec. 2 averages about 2 feet in thickness and is represented in Plate 7 by sections 247, 249, and 250. Another coal bed 30 feet lower in the section is 2 feet 3 inches thick at location 250 (section 250-A, pl. 7). At location 252, in sec. 12, an isolated lens of coal 1 foot 2 inches thick crops out. Another coal bed 20 feet above bed G contains on the average 2 feet 6 inches of coal at locations 284, 300, 301, and 301-A, all of which except 300 are shown in Plate 7.

T. 45 N., R. 69 W.

No less than five coal beds are exposed in T. 45 N., R. 69 W., chiefly in the western part of the township, along the Rochelle Hills escarpment. Several other thin coal beds that crop out farther east probably underlie the township. Bed G, the lowest of the beds exposed, contains 5 feet 4 inches of coal at location 353, in sec. 36, its only outcrop in the township.

Bed F crops out in the southwestern part of the township and commonly consists of about 2 feet of coal interbedded with carbonaceous shale and bone. The details of the sections of bed F are given graphically in Plate 7.

Bed D is the most valuable coal in the township and has a maximum observed thickness of 15 feet at location 373, in sec. 9. Sections of bed D in this township are shown graphically in Plate 7. At location 366, in sec. 19, a total of about 33 feet of coal is exposed within a stratigraphic interval of 70 feet. Section 366 is 8 feet higher and section 366-B 20 feet lower than section 366-A, which was mapped as bed D. At location 381, in sec. 4, two coal beds occur 75 feet apart; the higher of these two, represented by sections 379, 380, and 381, probably corresponds with the bed on which section 366 was measured, and the lower, 381-A, with bed D.

The top of the ridge in the northwestern part of the township is occupied by two coal beds a little higher than bed D. The lower of these is about 3 feet thick and is represented in Plate 7 by sections 375, 376, and 378-A. The other bed, which lies 30 feet higher, is about 6 feet thick, as shown by graphic sections 377 and 378, Plate 7. In secs. 29, 30, 31, and 32 a coal bed crops out which averages nearly 4 feet in thickness, as may be seen by reference to graphic sections 382, 383, and 384, Plate 7. This coal is probably considerably weathered, owing to the small amount of cover above it. Two other isolated exposures of coal occur in the township; one of these, at location 354, in sec. 1, is 2 feet 3 inches thick, and the other, at location 355, in sec. 17, is 2 feet thick.

T. 46 N., R. 69 W.

The Rochelle Hills escarpment crosses the western part of T. 46 N., R. 69 W., and stands 250 to 400 feet above the eastern part of the area. A pine-clad ridge extends from the escarpment in sec. 7 eastward to sec. 2. There are also timbered hills in the southern portion of the township.

Bed D, the most extensive coal bed exposed in the township, crops out along the Rochelle Hills and has an average thickness probably not less than 7 feet. The minimum observed thickness of this bed is 5 feet 6 inches, at location 437, in sec. 33, and the maximum is 16

feet 6 inches, at location 448, in sec. 18. Other measurements of bed in this township are shown graphically in Plate 7.

Below bed D there are several thin and lenticular coal beds exposed in the township. A lens exposed in sec. 2 ranges from 1 foot 8 inches in thickness at location 432 to about 2 feet at either end of its mapped outcrop line shown in Plate 9. At location 433, in sec. 25, about 1 foot of coal is exposed. At location 443, in sec. 7, about 40 feet below bed D, there is an exposure of coal 2 feet thick. A coal bed about 80 feet above bed D crops out near the top of a number of hills in secs. 7, 31, and 32. Measurements of this bed, shown graphically in Plate 7 by sections 434, 435, and 444, indicate that the coal is not less than 6 feet in thickness. In addition, several thin coal beds that crop out east of T. 46 N., R. 69 W., probably underlie this township.

TPS. 47 AND 48 N., R. 69 W.

Coal beds D and H and thin, irregular beds in the upper part of the Tullock member of the Lance formation are exposed in Tps. 47 and 48 N., R. 69 W. In T. 48 N., R. 69 W., a local coal bed that crops out in the bank of Belle Fourche River is 4 feet 10 inches and 4 feet 5 inches thick at locations 564 and 565, respectively, and has been mined in a small way for 40 years or more. In secs. 24 and 25, T. 48 N., two thin coal beds separated by 12 feet of sandstone and shale crop out on the east side of Fourhorse Creek. The upper bed averages about 1 foot 9 inches in thickness and the lower somewhat less. The lower bed is exposed at location 566, where it contains 1 foot 4 inches of impure coal; at 569, where it is 1 foot 7 inches thick; and at 570, where it is 1 foot 10 inches thick. The upper bed is 1 foot 10 inches thick at location 569 and 1 foot 8 inches thick at locations 567 and 568. It is probable that one of these beds is the same as the bed exposed in sec. 22, but a correlation is impossible on account of lack of exposures. At location 571, in sec. 13, a bed containing 2 feet of impure coal crops out in the top of a ridge. At location 572 this bed contains 1 foot 9 inches of coal and 4 inches of shale, and at 573, 7 inches of coal. Two lenses are exposed along Fourhorse Creek in T 47 N. and are about 25 feet apart. The lower of these is 1 foot 11 inches thick at location 507 and 2 feet 5 inches at 504. The upper bed is 2 feet 10 inches thick at location 505, 1 foot at 506, and 1 foot 5 inches at 508. These beds appear to be equivalent to those exposed at locations 463 to 470, in the township to the east, but definite correlation was impossible on account of poor exposures.

Bed H is about 100 feet above those just described and averages about 3 feet in thickness, as shown by sections in Plate 7. At locations 510 and 513 this bed is 1 foot 4 inches thick, and at 514, 1 foot 8 inches. At location 515 it consists of three benches, as follows:

Section at location 515, in the SW. ¼ sec. 20, T. 47 N., R. 69 W.

	Ft. in.
Clay, bluish gray, sandy-----	4
Shale, carbonaceous-----	1
Coal-----	7
Shale-----	2
Coal-----	5
Shale, carbonaceous-----	6
Coal-----	8
Shale, carbonaceous-----	2
Total coal-----	1 8

TPS. 49 AND 50 N., R. 69 W.

The lower slopes of the Rochelle Hills escarpment cross the southwestern part of T. 49 N., R. 69 W., and the remainder of this township and all of T. 50 N. lie within the featureless plain bordering Donkey Creek. These townships are probably underlain by one or more thin coal beds belonging to the Tullock member of the Lance formation, but owing to the lack of good exposures no coal beds over 1 foot thick were found in T. 49 N., and only two isolated outcrops were found in T. 50 N. At location 599, in sec. 3, 1 foot of impure coal crops out, and at location 600, in sec. 10, an exposure shows 1 foot 6 inches of dirty coal.

TPS. 39 AND 40 N., R. 70 W.

The extensive level tracts covered with sagebrush and grass along Dry Fork of Cheyenne River in T. 39 N., R. 70 W., merge northward into rough and broken slopes which lead up to the clinker-capped plateau that forms a large part of the surface of T. 40 N., R. 70 W., and is locally broken by buttes of light-gray sandstone. Deep ravines dissect the eastern and northern margins of this plateau, and steep slopes descend abruptly to the valley of Antelope Creek. The central portion of the township is crossed by the divide between Antelope Creek and Dry Fork of Cheyenne River.

Bed E is the lowest and most valuable coal bed in the township, but complete sections of it could be obtained in only a few places, owing to the burned condition of its outcrop. At location 91, in sec. 32, it contains about 2 feet of coal, but it thickens northward, attaining a maximum thickness for this township of over 15 feet at location 98, in sec. 22. Measurements of bed E in the township are represented graphically in Plate 8.

Bed D underlies a small area in T. 40 N., largely in secs. 29 and 30, and its thickness at locations 106 and 107 is about 12 feet. (See pl. 8.) Isolated exposures of other beds showing 5 feet 3 inches and

2 feet 7 inches of coal were found at locations 104 and 105, respectively, in sec. 22.

Beds I and J are believed to underlie Tps. 39 and 40 N., R. 70 W., at depths of 50 to 500 feet, and coal beds in the upper part of the Lance formation may underlie it at proportionately greater depths.

TPS. 41 TO 44 N., R. 70 W.

Tps. 41, 42, 43, and 44 N., R. 70 W., lie on or just west of the Rochelle Hills escarpment, and their surface features consist of the rugged slopes that form the face of this escarpment and the massive "clinker" beds that form the escarpment rim and merge westward into a featureless prairie upland.

Bed F, the lowest coal bed exposed in these townships, crops out in T. 44 N. and is shown graphically in Plate 8 by sections ranging in thickness from 1 foot 10 inches at location 308 to 4 feet at location 309.

Bed E is over 20 feet thick, as exposed at locations 167 and 168, in secs. 32 and 31, T. 41 N., R. 70 W. (See pl. 8.) North of sec. 31, however, it is either absent or concealed by slag.

Heavy clinker beds commonly mark the outcrop of bed D in these townships, and complete exposures of the bed are rare. It is only partly exposed in T. 41 N. at locations 169 and 170, which show, respectively, a few inches and 8 feet 4 inches of coal. On the basis of measurements made in adjoining townships it is thought that bed D where unburned is not less than 12 feet thick in this township, and it may be considerably thicker.

In T. 42 N. bed D is the only coal bed mapped, and its thickness ranges from 4 feet 2 inches of coal at location 210 to about 27 feet of coal, clay, and carbonaceous shale at location 209. (See pl. 8.) Both of these measurements may, however, represent only a part of the bed.

In T. 43 N. the outcrop of bed D is everywhere so concealed by slag and grass-covered slopes that the thickness of the bed could not be determined. The broken line shown on Plate 10 represents the contact of baked and unbaked rock and probably indicates very closely the position of the unburned coal. Measurements at locations 310, in sec. 9, T. 44 N., R. 70 W., and 210, in sec. 11, T. 42 N., R. 70 W., where bed D is, respectively, at least 16 feet and 4 feet 2 inches thick, indicates that it is probably not less than 7 feet thick in this township. The bed was on fire in the SE. $\frac{1}{4}$ sec. 14 when visited in 1910, and the locality had been known to the ranchmen for many years as the "Fire Hole."

In T. 44 N. bed D is exposed at locations 310, 311, 312, and 313 (see pl. 10), though its outcrop is usually concealed by soil or by

clinker beds. The maximum thickness within the township was found at location 310, in sec. 9, where a partial measurement of this bed showed 16 feet of coal. The remaining sections of bed D in this township, shown in Plate 8, undoubtedly represent measurements of only part of the bed.

The outcrop of a local lens of coal 10 inches thick was traced for a short distance in and near sec. 21, T. 44 N., as shown on Plate 10, but no attempt was made to correlate it with any of the beds previously mapped.

In addition to the coals exposed within these townships, beds I to Q may underlie them, although no data as to their thickness or quality within the townships are available.

TPS. 45 AND 46 N., R. 70 W.

The most valuable coal in Tps. 45 and 46 N., R. 70 W., is bed D, which crops out in the southeastern part of T. 45 N. and is also brought to the surface in secs. 2, 3, and 11 by a small uplift. Sections were measured on bed D at locations 385 and 386, where partial exposures showed 8 feet 4 inches and 5 feet of coal.

At location 387, in sec. 3, a coal bed nearly 7 feet thick crops out. Of this amount, however, only the basal 2 feet 7 inches is good coal. (See pl. 8.) West of location 387 the outcrop of this bed is concealed by slag, and its crop line, as shown on Plate 10, is inferred.

The coal outcrop in secs. 30 and 31 indicated on Plate 10 occurs on the crest of a hill and is under very little cover. One measurement of 3 feet 7 inches was obtained at location 388. Bed F, which crops out in T. 45 N., R. 69 W., underlies the southeastern part of this township, probably not over 100 feet below the surface, with an average thickness of 2 feet.

In T. 46 N. the lowest coal is a lens of local extent which crops out 15 feet below bed D in sec. 23 and is not quite 3 feet thick at locations 445 and 446. (See pl. 8.) Bed D is exposed in the northern and eastern parts of the township and on the flanks of a small dome in the southern part. At location 447, in sec. 1, less than 4 feet of the bed crops out, but this is not thought to represent its entire thickness, as at location 448, in sec. 18, T. 46 N., R. 69 W., its total thickness is 16 feet 6 inches, and at location 449, in sec. 26, T. 46 N., where the bed is partly exposed in a draw, 10 feet of coal was measured.

A higher coal than bed D crops out near the crest of several of the ridges. It averages slightly over 4 feet in thickness and is very impure, as shown by sections 450, 451, 452, and 453, Plate 8.

T. 47 N., R. 70 W.

Bed H, the lowest coal mapped in T. 47 N., R. 70 W., crops out in secs. 2, 11, and 12, where its average thickness is about 3 feet 6 inches, as shown by Plate 8. It is not exposed north of Belle Fourche River, but the broken line on Plate 10 indicates its approximate position. A coal bed about 175 feet above bed H is exposed in secs. 22, 23, 26, and 27 and has an average thickness of about 2 feet 6 inches, as shown by sections 526 to 531, Plate 8. At location 531 this bed is divided by shale partings into four benches, one of which contains 6 feet of impure coal. The outcrop of this bed may be more extensive than is indicated on Plate 10, but it is so concealed by slag produced by the burning of bed D that it could not be traced beyond the limits shown. A coal lens 10 inches thick crops out at location 525, in sec. 4, and is probably the bed just described.

Bed D is exposed in secs. 31 and 36. At location 532, in sec. 36, it is 17 feet 2 inches thick in a small outlier. At location 533, in the same section, 4 feet 2 inches of coal is exposed, and at location 536, in sec. 31, 5 feet 6 inches. The broken lines on the map indicate the approximate location of areas in secs. 32, 33, 35, and 36, beneath which bed D is unburned. At location 536, in sec. 31, a 1-foot coal bed 47 feet above bed D crops out.

TPS. 39 TO 41 N., R. 71 W.

Featureless plains form the surface of most of Tps. 39, 40, and 41 N., R. 71 W., and are locally terminated eastward by badland slopes and areas of clinker-capped buttes.

Coal bed D and local lenses of coal, one of which probably represents bed C, crop out in these townships, and beds G to Q presumably underlie them. Because of the low relief and general heavy mantle of soil the coal beds are poorly exposed, and although bed D is a thick bed, its outcrop is rarely marked by more than a few inches of exposed coal. Incomplete measurements of bed D were made in these townships at locations 43, 109, 110, 171, and 172, and a single complete section was measured at location 108, where the bed is 12 feet 8 inches thick. Sections at locations 109 and 110 are also shown in Plate 8, and the partial measurements at locations 171 and 172 revealed, respectively, 20 feet and 4 feet of coal. It is reported that in times of freshet at least 40 feet of coal shows in the bluff at location 171.

A lenticular coal bed about 3 feet thick and 150 feet below bed D was measured at locations 112, 113, and 114, in T. 40 N. (see pl. 8),

and two beds of coal, 6 feet apart and each less than 2 feet thick, were measured at location 111, in sec. 7.

Local exposures in T. 41 N., probably representative of bed C, revealed 2 feet 11 inches and 4 feet of coal at locations 173 and 174, respectively. What is probably bed D is reported to be over 38 feet thick in the bottom of a well 175 feet deep on the Lindsay farm, in the southeastern part of this township.

TPS. 42 TO 47 N., R. 71 W.

For the most part the surface of Tps. 42 to 47 N., R. 71 W., consists of a grass-covered prairie dotted with numerous intermittent lakes. Extensive clinker-capped ridges and hills are, however, present on the divide between Cheyenne and Belle Fourche Rivers, especially in T. 44 N., as shown by Plate 9. Coal beds B, C, and D and some minor local beds crop out in these townships, and beds E to Q, presumably underlie them.

Bed D is exposed only in Tps. 46 and 47 N., a partial measurement at location 454, in T. 46 N., showing 3 feet 5 inches of coal, and a measurement at location 534, in T. 47 N., showing 18 feet of coal broken by partings. (See pls. 4 and 8.) The bed was on fire near location 534 when visited in 1911, and the effect of the fire is shown by Plate 3, A. A coal bed 1 foot 9 inches thick lying 50 feet above bed D was measured at location 535, in T. 47 N., and other thin beds, 1 foot 10 inches, 3 feet 2 inches, and 1 foot 6 inches thick were found at locations 455, 456, and 456-A, respectively, in T. 46 N. Bed C, which probably underlies large parts of Tps. 42 to 47 N., is exposed only near the Bishop ranch, in Tps. 45 and 46 N., and the measurements of it made at locations 457 and 389 showed, respectively, 10 feet 6 inches and 9 feet 6 inches of coal. Three 1-foot coal beds 40 to 60 feet above bed C were found at location 390, in T. 45 N., and at 211, in T. 42 N., about 7 feet of coal was measured, believed to represent bed B. Bed B has been burned over large areas in Tps. 44 and 45 N., and some tracts containing unburned coal may lie within the margins of these clinker-covered areas, as shown by Plate 9.

TPS. 39 TO 41 N., R. 72 W.

The surface of Tps. 39 to 41 N., R. 72 W., is a rolling upland, considerably dissected along the larger streams but without any conspicuous topographic features. Bedrock exposures are very poor in these townships, and the only outcrops of coal found were isolated. In T. 39 N. what appears to be bed D contains 4+ feet and 3 feet of coal at locations 44 and 46, respectively. (See pl. 8.) At loca-

tion 45 what appears to be the same bed, or the upper part of it, consists chiefly of carbonaceous shale, as the following section shows:

Section at location 45, in the SW. $\frac{1}{4}$ sec. 2, T. 39 N., R. 72 W.

	Ft.	in.
Sandstone, yellow, friable.....	4	
Shale, sandy.....	6	
Shale, brown, carbonaceous.....	1	
Coal with carbonaceous shale lines in upper 5 inches.....	1	6
Shale, carbonaceous.....	12	
Total coal.....	1	6

In T. 40 N. a coal bed questionably correlated with bed D crops out on Sand Creek in sec. 33 and was measured at locations 115 and 116, where it is 5 feet 7 inches and 2 feet 4 inches thick, respectively. (See pl. 8.) Further tracing and more definite correlation of this bed were impossible because the exposures are disconnected. The only other measured coal section in the township is at location 117, in sec. 13, where a coal bed 4 feet thick is exposed in Sand Creek.

In T. 41 N. the isolated exposures of coal observed range in thickness from 2 feet 7 inches at location 177, in sec. 27, to over 11 feet at location 178, in sec. 4, all probably representing bed C. Other measurements of this bed in this township are shown graphically in Plate 8.

Coal beds E to Q may underlie these townships at depths which can be roughly computed by reference to Plate 5.

TPS. 42 AND 43 N., R. 72 W.

The surface of Tps. 42 and 43 N., R. 72 W., is a featureless plain rising northwestward to the Cheyenne-Belle Fourche divide. Bed B was measured at locations 212 and 213, in T. 42 N., where it is not less than 8 feet thick, and at locations 253, 254, 255, and 256, in T. 43 N. (See pl. 8.) Of these, the section at location 256 is the only complete one and shows 15 feet of coal. Coal for local consumption has been mined from this bed by the open-cut method at locations 253 and 256. (See pl. 10.) Bed A is exposed at a few places in T. 43 N. and was measured at locations 257 (257-A), 258, 259, and 260. It ranges in thickness from 3 feet at location 260 to over 8 feet at location 258. At location 257, in sec. 16, a local lens of coal 20 feet above bed A is 6 feet 6 inches thick.

Numerous lower coal beds shown on Plates 5, 9, and 10 probably underlie these townships. Bed D, the most valuable of these lower beds, lies about 600 feet below bed B, and other beds still lower in the section would lie at proportionately greater depths.

TPS. 44 TO 47 N., R. 72 W.

The portions of Tps. 44 to 47 N., R. 72 W., indicated by hachures on Plate 10, are slag-covered areas surmounted by a number of small buttes. The remaining portions of these townships are rolling uplands.

In T. 44 N. the outcrops of coal beds A and B are either concealed in grass-covered slopes or burned, and no detailed sections of the beds could be made. However, the position of the unburned coals, as shown on Plate 10, was pretty accurately determined by mapping the contact of baked and unbaked rock. In T. 45 N. bed B is at least 13 feet thick, and hence it is assumed to be of about the same thickness in T. 44 N., where it is unburned.

In T. 45 N., at location 391, in sec. 6, a partial measurement of bed B shows 13 feet 3 inches of coal. (See pls. 4, A, and 8.) Elsewhere in the township the outcrop of bed B is either burned or concealed in grass-covered slopes, and no sections of it could be procured. The dotted line on Plate 10 indicates approximately the eastern limit of the unburned coal in this township.

In T. 46 N. beds B and C, which are about 150 feet apart, are the only coal beds mapped. Bed C ranges in thickness from 3 feet 2 inches at location 458 to 10 feet 6 inches at location 457. Partial measurements of bed B at locations 459 (see 459-A, pl. 8) and 460 showed 5 feet and 5 feet 6 inches of coal, respectively. As shown on Plate 10, bed B is extensively clinkered along its outcrop in this township, and no complete section of it could be obtained. However, on the basis of measurements made at locations 391, in T. 45 N., and 538, in T. 47 N., where it is, respectively, 13 feet 6 inches and 21 feet thick, it is probably not less than 10 feet thick where unburned in T. 46 N. A local lens of coal above bed B is 2 feet 6 inches thick at location 459.

In T. 47 N. bed B crops out extensively and averages about 14 feet in thickness, as shown by the sections in Plate 8. Its maximum thickness of 21 feet occurs at location 538 (538-A) and its minimum of 6 feet 6 inches at 540. At location 537, in sec. 2, what is probably bed C crops out about 100 feet below bed B and contains two benches of coal 1 foot 6 inches and 6 feet thick, separated by 4 feet of carbonaceous shale. A detailed stratigraphic section at this location is given below:

Stratigraphic section at location 537, in the NE. ¼ sec. 2, T. 47 N., R. 72 W.

	Ft. in.
Sandstone, yellowish, friable, containing quartz pebbles half an inch in diameter.....	40
Sandstone, coarse grained, rusty, with quartz pebbles half an inch in diameter.....	3

	Ft. in.
Shale, carbonaceous-----	10
Sandstone, bluish gray, friable-----	15
Shale, carbonaceous, and clay-----	2 6
Coal-----	1 2
Shale and sandstone, carbonaceous-----	45
Shale, brown to blackish, carbonaceous, with a 2-inch coal near the base and a 2-inch bony coal toward the top----	15
Shale, dark bluish gray to brown, carbonaceous and sandy-----	20
Coal, bright-----	1 6
Shale, brown, carbonaceous, with thin coaly lenses--	4
Coal, fair quality-----	3
Sandstone, bluish gray, friable, with small pyrite con- cretions-----	3 8
Shale, dark, soft, sandy-----	1
Coal, bright-----	9
Shale, bluish gray, soft, sandy-----	4
Sandstone, bluish gray, friable, massive, with some small pyrite concretions at top-----	12
	184 7

In secs. 26, 27, and 34 a coal bed crops out about 25 feet above bed B and averages 4 feet 6 inches in thickness at locations 538 and 542. (See pl. 8.) This bed is probably equivalent to bed A of areas farther south.

Bed D, the most valuable coal bed in the Gillette field, probably lies from 400 to 500 feet below bed B in Tps. 44 to 47 N., R. 72 W., and other coal beds that crop out in townships farther east may be present at proportionately greater depths. (See pl. 5.)

TPS. 39 AND 40 N., R. 73 W.

Bed C is the only coal bed mapped in the featureless uplands covering Tps. 39 and 40 N., R. 73 W. In T. 39 N., at location 47, in sec. 10, its minimum thickness of 1 foot 6 inches of coal occurs, and at location 53, in sec. 6, its maximum thickness of 8 feet. Other measurements of bed C in the township are represented in Plate 8.

In T. 40 N. three isolated coal outcrops occur which are questionably correlated with bed C. At locations 118 and 119 the bed contains 8 feet of coal (pl. 8), and at location 120, in sec. 1, a partial exposure of what appeared to be the same bed showed 4 feet 5 inches of coal split by shale partings. No other coal outcrops were observed in the township.

These townships are probably underlain by beds D to Q, but no information as to their quality and thickness within the townships is available.

TPS. 41 AND 42 N., R. 73 W.

In Tps. 41 and 42 N., R. 73 W., beds B and C, the only coal beds recognized, are poorly exposed owing to the slight relief and heavy

soil. Bed B is about 4 feet thick at location 181, in T. 41 N., and is about 8 feet thick at locations 214, 215, and 216, in T. 42 N. Bed C is 3 feet thick at location 180, in T. 41 N. Numerous lower coal beds shown on Plates 9 and 10 probably underlie these townships. Bed D, the best of these, lies at depths of 1,000 feet, and the others at corresponding depths. (See pl. 5.)

TPS. 39 AND 40 N., R. 74 W.

The surface of Tps. 39 and 40 N., R. 74 W., consists of a grass-covered prairie devoid of conspicuous topographic features. Rock exposures are confined almost entirely to the few isolated hills or to stream bottoms. In T. 39 N. the only coal section measured was at location 54, in sec. 24, where bed C crops out in the bank of Stinking Water Creek and has a thickness of 8 feet 8 inches.

In T. 40 N. the only coal outcrop observed was an 8-inch lens in sec. 22.

Bed D probably underlies these townships at a depth of 1,000 feet or less, and other beds shown on Plates 9 and 10 at corresponding depths.

TPS. 41 AND 42 N., R. 74 W.

Exposures are very few in Tps. 41 and 42 N., R. 74 W., because of the low relief of the surface and the mantle of soil and sod. Location 182 marks the only outcrop of a carbonaceous bed found in T. 41 N., which revealed 7 feet of carbonaceous shale believed to represent coal bed B.

No coal outcrops were observed in the grass-covered prairie in T. 42 N., R. 74 W. The outcrop of bed B in this township, as shown in Plate 10, is inferred.

These townships are presumably underlain by bed D, about 700 feet below bed B, and by thinner beds shown in Plate 5.

THE MINTURN DISTRICT AND THE NORTHWESTERN PART OF THE GILLETTE FIELD

By W. T. THOM, Jr.

INTRODUCTION

Purpose of investigation and location of district.—The value of lignite and of subbituminous coal as fuel and as potential sources of oil and other by-products is a matter of increasing public interest, and inquiries are being made as to the quality and extent of the reserves of these fuels, their geographic location, and the most efficient and profitable methods of utilization.

This chapter presents the results of a field study of the northwestern part of the Gillette coal field, including the Minturn dis-

trict, which embraces the part of the Gillette field that is of principal present interest and importance, as the scene of mining operations. As here defined, the northwestern part of the Gillette coal field includes the northern third of T. 49 N. and the southern two-thirds of T. 50 N., Rs. 70, 71, and 72 W., shown in Plate 12, and the Minturn district includes the northern third of T. 49 N. and the southern two-thirds of T. 50 N., R. 71 W. The northwestern part of the Gillette field lies almost wholly within the drainage basin of Donkey Creek and forms a part of the Powder River coal field, which was examined in a reconnaissance way by Stone and Lupton⁹ during 1908. (See index map, fig. 1.)

Acknowledgments.—The topographic mapping of the part of the Minturn district shown on Plate 13 was done by J. M. Whitman, of the Geological Survey, during September and October, 1923, in spite of handicaps imposed by inclement weather. Much information concerning diamond-drill exploration and surface prospecting of coal near the Peerless mine was given to the writer by Messrs. Samuel Ditto, Claude Lawrence, C. V. Mapel, and H. P. Hensley. The results of spirit leveling near Minturn by the Wyodak Coal & Manufacturing Co. were furnished by Mr. E. G. Ross, superintendent of the company, and vertebrate fossils obtained from the Wyodak strip pit were loaned to the Geological Survey for study. Mr. J. E. Spielman, county surveyor of Campbell County, guided the writer to set stones marking section corners and pointed out other landmarks accepted as marking land-survey corners. Thanks are also due to Mr. Ernest Spaeth and other residents of Gillette and vicinity for many courtesies and material aid rendered during the course of the work.

Field work.—The field work upon which this report is based was done in August, 1923, and was primarily intended to afford geologic information needed by the Geological Survey and the Bureau of Mines in fixing leasing terms to control the exploitation of Government-owned coal lying between Gillette and Minturn. The positions of coal outcrops, coal mines, and borings penetrating the Roland and Smith coal beds were located as accurately as possible by plane-table triangulation from section corners, and altitudes at such points were also determined by plane table.

GEOGRAPHY

LAND FORMS

Rugged uplands covered with slag or clinker produced by burning of the Roland coal bed are conspicuously developed east of

⁹ Stone, R. W., and Lupton, C. T., The Powder River coal field, Wyo., adjacent to the Burlington Railroad: U. S. Geol. Survey Bull. 381, pp. 115-136, 1908.

Minturn, and a steep eastward-facing escarpment marks the western limit of the main burned-out area north and south of Minturn. (See pl. 13.) Several extensive depressions, some of them containing natural lakes, are present in the district and probably are due to the burning out or weathering of the thick Roland coal bed. One such depression just northeast of Gillette is used as a reservoir by the Chicago, Burlington & Quincy Railroad.

West of Minturn moderately steep slopes, 100 to 150 feet high, separate bottom lands along Donkey Creek from ridge tops capped by sandstone (pls. 11, *D*, and 13), or from an upland plain (pl. 11, *B*) that is well developed along the railroad in R. 72 W. Near Gillette this plain is dotted by buttes capped by clinker from burning of the Felix coal bed, and similar clinker is present at many places along the escarpment west and southwest of Gillette, which follows the outcrop of the Felix bed. The surface relief between the valley near Minturn and the hilltops near Gillette is about 350 feet. Local differences of altitude near Minturn are also shown by the contours in Plate 13.

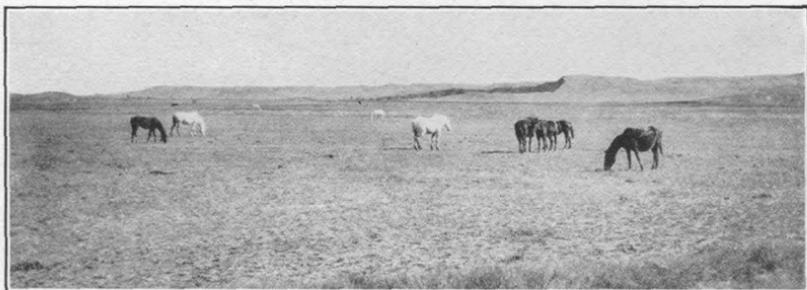
WATER AND TIMBER SUPPLY

Donkey Creek, though not a perennial stream, contains flowing water during most of the year, and the railroad company impounds part of its flow in a reservoir near Gillette. Lakes near Minturn are also a potential source of a considerable water supply, and dug and drilled wells yield water for the municipal supply of Gillette and for domestic use in its vicinity. Water from all these sources is mineralized to at least a moderate degree.

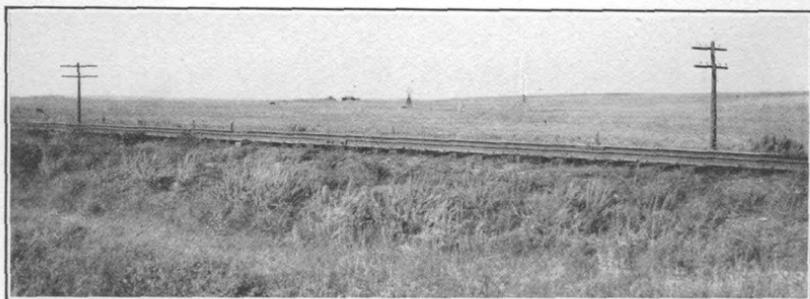
Near Gillette the country is almost devoid of timber, but considerable numbers of pine trees of moderate size grow on the clinker-covered ridges between Minturn and Rozet and along the plateau lying west of the Rochelle Hills escarpment described on page 4.

COMMERCIAL RELATIONS

The Chicago, Burlington & Quincy Railroad traverses the northern part of the Gillette coal field and is the key to the development of the coal within the Minturn district and within the field as a whole, affording at once a large part of the potential market for such coal as may be produced near Gillette and an outlet to markets toward the east in which Gillette coal may be expected to enter into active competition with coal now being shipped from the Sheridan field. Inasmuch as the demand for coal in territory naturally tributary to the Gillette field is not now and probably will not soon be developed to great proportions, it is believed that at least for some years it will



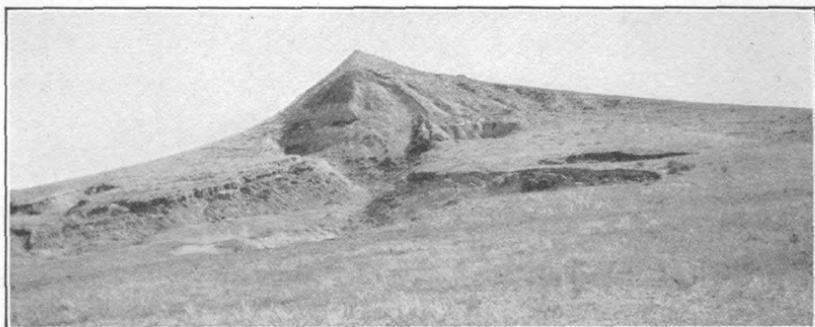
A. VALLEY OF DONKEY CREEK, LOOKING SOUTHEASTWARD TOWARD MINTURN, WYO.



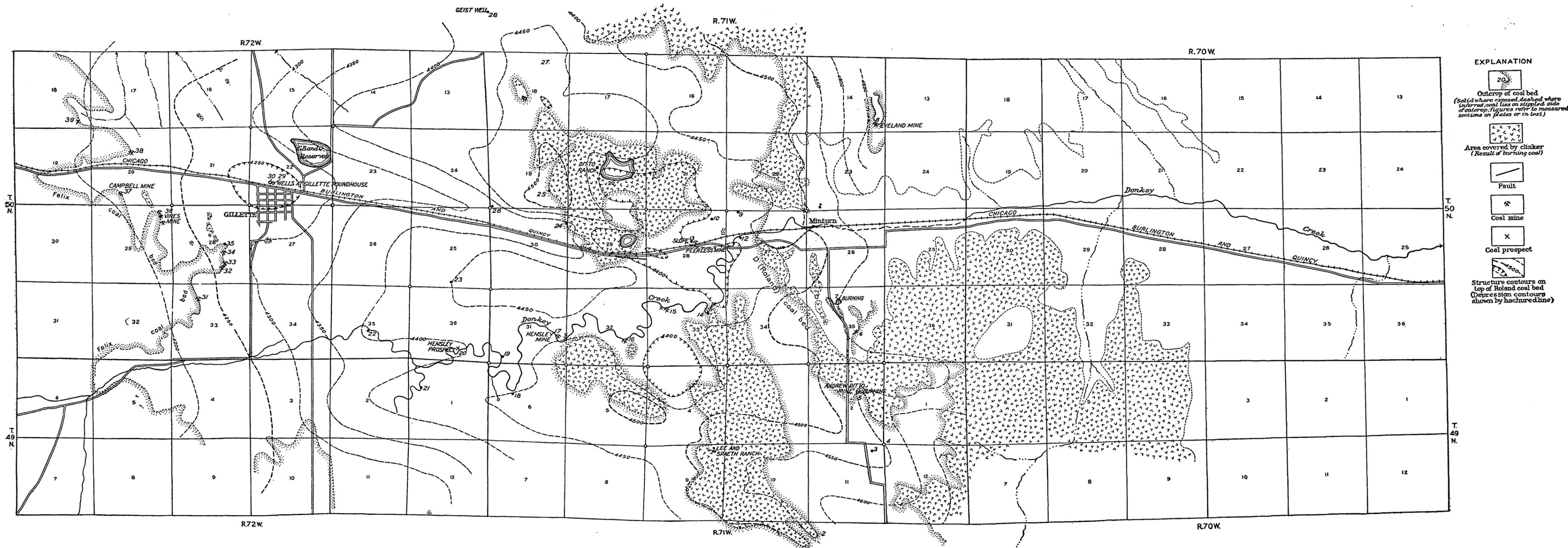
B. VIEW OF UPLAND PLAIN, LOOKING NORTHWESTWARD TOWARD WINDMILL NEAR SOUTHWEST CORNER OF SEC. 19, T. 50 N., R. 71 W., WYOMING



C. PEERLESS MINE OF KIRBY MUTUAL COAL CO., MINTURN DISTRICT, WYOMING

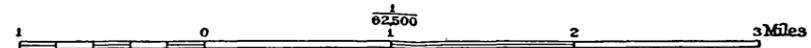


D. HILL ABOVE OLD ANDREW DITTO MINE, MINTURN DISTRICT, WYOMING

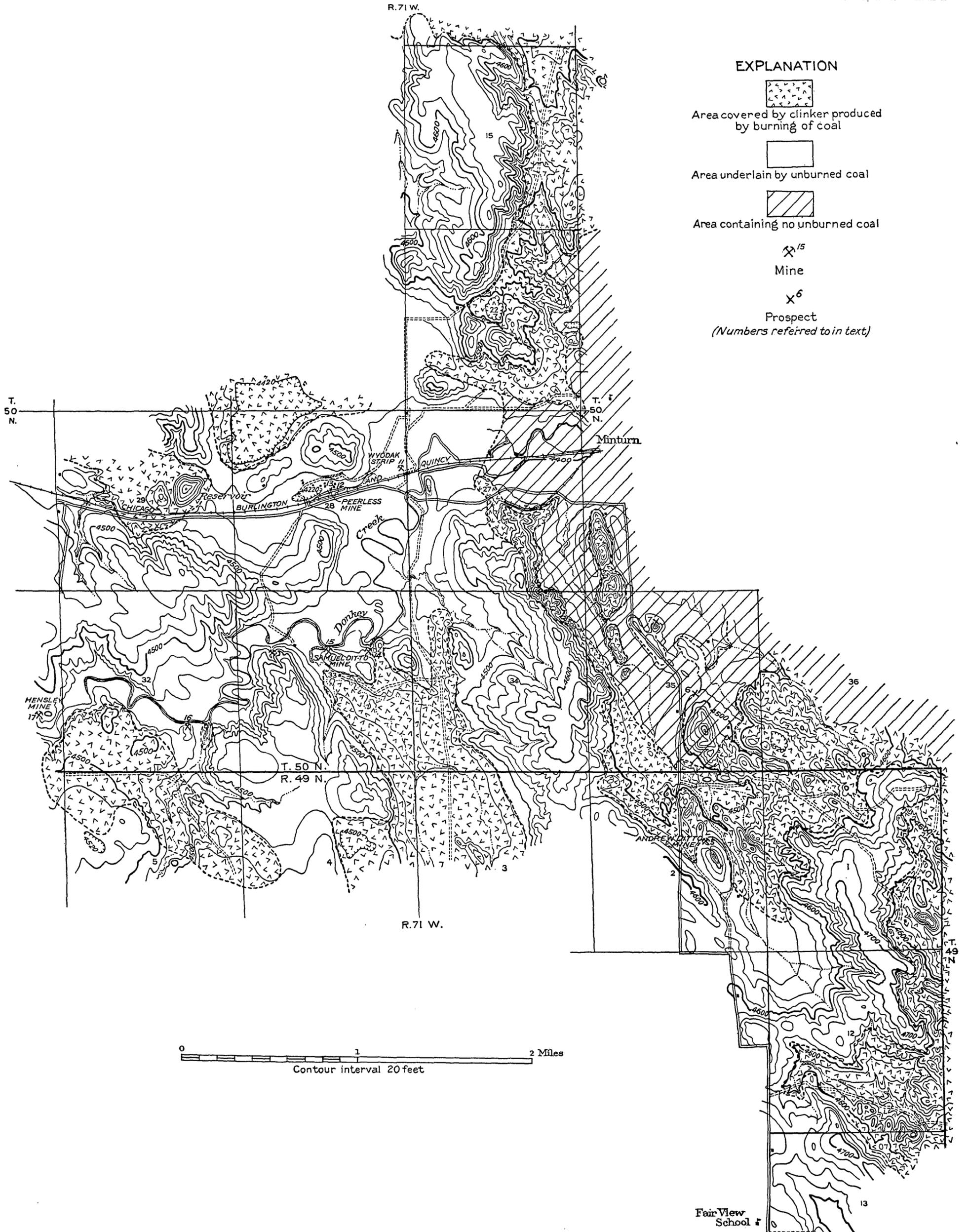


EXPLANATION

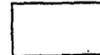
- Outcrop of coal bed
(Solid where exposed, dashed where inferred; coal lies on stippled side of outcrop; figures refer to measured sections on plates or in text)
- Area covered by clinker
(Result of burning coal)
- Fault
- Coal mine
- Coal prospect
- Structure contours on top of Roland coal bed
(Depression contours shown by hachured line)



GEOLOGIC MAP OF THE NORTHWESTERN PART OF THE GILLETTE COAL FIELD, WYOMING



EXPLANATION

-  Area covered by clinker produced by burning of coal
-  Area underlain by unburned coal
-  Area containing no unburned coal
-  Mine
-  Prospect
(Numbers referred to in text)

0 1 2 Miles
 Contour interval 20 feet

Fair View School

GEOLOGIC AND TOPOGRAPHIC MAP OF THE MINTURN DISTRICT, GILLETTE COAL FIELD, WYOMING

not be profitable to open large-scale mines within the Gillette coal field except near the existing railroad line and close to the eastern outcrop of the Roland coal bed, which passes just west of Minturn. At the present time much of the land near Gillette and Minturn is used for grazing, though there are a number of well-kept farms on the more level upland areas, and the State of Wyoming maintains an agricultural experiment station about 2 miles east of Gillette.

GEOLOGY

STRATIGRAPHY

General section.—The composition, sequence, and general areal relations of the formations exposed within the northwestern part of the Gillette field or lying at moderate depths below its surface are discussed in detail on pages 6–11 of this report, and it is probably sufficient here to say that the Fort Union and Wasatch formations, which are exposed around and west of Minturn, alone contain coals of present commercial importance near Gillette and Minturn.

Fort Union formation.—Gray shaly sandstone and sandy clay belonging to the Fort Union formation crop out along Donkey Creek and its tributaries east of Minturn and in the high escarpments in Tps. 49 and 50 N., R. 70 W. Except for the Smith coal bed, which lies near the top of the formation and is irregularly developed, and the Roland coal, which forms the top bed of the Fort Union in this region, no coals of any value are known to be present in the Fort Union within the Gillette area.

Wasatch formation.—Rocks of Wasatch age, corresponding to the lower part of the Intermediate coal group of the Sheridan¹⁰ and Powder River¹¹ fields, crop out west of the base of the Roland coal (the top bed of the Fort Union formation) or of the clinker formed by its burning.

In view of the fact that the coal of the Minturn district will probably be extensively exploited by strip mining, the stratigraphy of the rocks overlying the Roland coal bed will be described in considerable detail, although even a detailed description will give only an imperfect conception of the situation, because of the variability of the individual sandstone and shale beds. In general, however, the Roland coal is overlain by about 35 feet of clay or soft sandstone surmounted by a hard ledge-making sandstone 2 or 3 feet thick. Sandy shale predominates for about 35 feet above the sandstone "cap rock" just mentioned, though numerous sandstone "log concretions,"

¹⁰ Taff, J. A., The Sheridan coal field, Wyo.: U. S. Geol. Survey Bull. 341, pp. 130–142, 1909.

¹¹ Stone, R. W., and Lupton, C. T., The Powder River coal field, Wyo., adjacent to the Burlington Railroad: U. S. Geol. Survey Bull. 331, pp. 115–136, 1908.

2 to 4 feet thick, are locally developed in this interval, in places in sufficient number to form ledges or to cap dip slopes. Between 70 and 80 feet above the Roland bed there is commonly a bed of carbonaceous shale, locally containing coal that is apparently representative of the lower bench of the Arvada coal bed. This bed is underlain by numerous petrified tree stumps, such as are also found less abundantly in higher carbonaceous beds. Coal found at the Cates place, in sec. 26, T. 50 N., R. 72 W., and along Donkey Creek near the Hensley prospect, in sec. 36 of the same township, is believed to belong to this bench of the Arvada bed. Above it is a thin concretionary sandstone with which there are usually associated numerous fragments of fossil *Union* and snail shells, and this in turn is overlain by a bed of carbonaceous shale with local lenses of coal, probably representing the upper bench of the Arvada bed. Between 106 and 110 feet above the Roland coal there is a fairly persistent concretionary sandstone bed, overlain in succession by 60 feet of soft sandy strata and 20 feet of carbonaceous shale and sandstone. In sec. 15, T. 49 N., R. 71 W., carbonaceous beds extend 100 feet higher in the section, but as a rule the interval from 185 to 420 feet above the Roland coal is filled by slightly consolidated sand and gravel, surmounted by the Felix coal zone, which has an average thickness of about 30 feet of interbedded coal and carbonaceous shale.

All the sandy beds probably have local enlargements corresponding to those in the old drainage lines in which they were deposited, and channeling at the base of these sandstones and beneath some of the carbonaceous beds is apparent in places. A "want" or barren area at the Roland coal horizon is apparently visible at the Eveland mine, in sec. 14, T. 50 N., R. 71 W. The Smith coal is there about 30 feet below the base of the Roland clinker, but south of the mine a ridge composed largely of soft sandstone rises 50 feet above the base of the Roland slag, which laps against the east side of the hill. Apparently this ridge represents an old sand-filled channel in the Roland coal swamp, and similar barren channels of uncertain width and linear extent may be discovered in the course of development of the Roland and associated minor coal beds.

Pleistocene valley fill.—Some 20 feet more or less of stratified silt, gravel, and quicksand, which underlie and compose the flood plain of Donkey Creek in the vicinity of Minturn, are of Pleistocene age, according to Dr. J. W. Gidley, who studied fossil remains found in the lower part of these strata. The fossils were obtained by Mr. E. G. Ross, of the Wyodak Coal & Manufacturing Co., from the company's strip pit near Minturn and were recognized by Doctor Gidley as belonging to an extinct species of bison, of Pleistocene age.

STRUCTURE

The regional monoclinial dip from the Black Hills uplift toward the Powder River geosyncline is the most pronounced structural feature of the region near Gillette and causes the eastward termination of the coal-bearing area. The regional slope of the rocks is modified near Minturn, however, by a complex system of small folds and domes, whose general size and slope are probably fairly well indicated by the structure contours on the accompanying map (pl. 12), which show the variation in altitude of the top of the Roland coal. In some places the character of the folds is clearly apparent, but elsewhere the absence of drill records or the irregularity of key horizons introduces uncertainties into the interpretation made. These structural features may have been superficially accentuated by the compacting, weathering, or underground burning of the thick Roland coal, which may also have caused the numerous undrained depressions that are characteristic of the area, but it is believed that irregularities of the structure of the district are shown with fair accuracy by the structure contours.

ECONOMIC GEOLOGY

CLINKER

The existence in this field of extensive beds of clinker, or rock baked by the burning of coal beds near their outcrop, has been referred to on page 12, and the quarrying of clinker for ballast by the Chicago, Burlington & Quincy Railroad has also been mentioned. The railroad quarry is located along the spur track extending west from Minturn (see pl. 13), and the clinker is dug by steam shovel, crushed, and loaded onto cars. The clinker bed is about 50 feet thick and affords a great reserve of material well suited for track ballast and available at small cost.

COAL

CHARACTER, TONNAGE, AND USE

The general chemical and physical character of the coal of the Gillette field is described on pages 15-16 and analyses of coal from this and other fields are compared on pages 17-19. As shown by the facts so summarized, the coal of the Minturn district and the Gillette field, as a whole, is of subbituminous rank; is intermediate in heating value between Sheridan coal and lignite from Wilton, N. Dak.; and is somewhat lower in heating value than the coal mined in strip pits for railroad fuel south of Forsyth, Mont. In the Minturn district, as elsewhere in the Gillette field, spontaneous burning of the coal beds seems to have taken place at nearly every point where the

coal has been exposed by erosion or where it has lain under thin cover and somewhat above ground-water level. However, where the coal bed was split by a clay parting, the upper bench may have burned without the destruction of the lower bench. The total absence of coal in an area of apparent burning can not therefore safely be assumed unless corroborative evidence is obtained.

Owing partly to the possibility that coal is present beneath areas that show at least superficial burning, the quantity of coal present within the Minturn district can not be estimated except in a very rough way without the drilling of a great number of prospect holes. Some idea as to the general magnitude of the reserve of coal within the district is of interest, however, and to make a rough estimate it has been arbitrarily assumed that the Roland and Smith beds maintain an average aggregate thickness of 75 feet beneath the part of the district where burning of the beds has not taken place. As a horizontal bed of coal 75 feet thick contains approximately 135,000 short tons to the acre, or 85,000,000 short tons to the square mile, the estimates of reserves of coal in the combined Roland and Smith beds within the area mapped west of Minturn are as follows:

Estimated reserves of coal in Roland and Smith beds in area west of Minturn

	Short tons
T. 49 N., R. 71 W. (north third)-----	700, 000, 000
T. 50 N., R. 71 W. (south two-thirds)-----	1, 050, 000, 000
T. 49 N., R. 72 W. (north third)-----	1, 000, 000, 000
T. 50 N., R. 72 W. (south two-thirds)-----	2, 000, 000, 000
	4, 750, 000, 000

Only a relatively small part of these reserves can be won by underground mining, but a very large part can be recovered by stripping. Coal of a slightly superior rank and heating value is now being mined on a large scale south of Forsyth, Mont., for use as locomotive fuel, and it is reported that stripping operations are soon to be begun near the Peerless mine.

Owing to the rapidity with which coal such as that of the Minturn district loses moisture and disintegrates when exposed to the air, it does not ship well, and as water composes nearly one-third of the weight of the coal as mined, much freight is paid on this moisture when the coal is shipped without processing. It is therefore evident that any process that can be applied cheaply and on a large scale to remove the moisture and valuable oils and other by-products from the coal before shipment will at once effect a saving in freight on the coal shipped and possibly open a profitable field in by-product recovery. Moreover, processed coal should stand shipment much better, increasing the radius within which it might be marketed, and should be much less subject to spontaneous combustion when stored

in bulk. Without such processing Gillette coal must look for its market to the railroad, to the domestic and small steam trade within a rather small shipping radius eastward from the district, or to such plants at a greater distance as burn powdered fuel or are equipped with automatic stokers.

DISTRIBUTION

From the work of Stone and Lupton¹² and of Davis¹³ and from work done by Dobbin and Barnett in preparing this report it is evident that the Roland coal bed of the Sheridan field is the principal coal bed (bed D) of the Minturn district and of the Gillette field as a whole. The Smith bed of the Sheridan field is apparently absent at many places in the Donkey Creek valley near Minturn and lies at an irregular interval below the Roland coal bed. Apparently it forms the lower bench of the thick bed at the Peerless mine, in sec. 28, T. 50 N., R. 71 W., and diverges from the Roland bed both westward and eastward, probably corresponding to beds E and F of the central and southern parts of the Gillette field (see pls. 9 and 10) and to the lower thick coal penetrated by the wells at the Gillette roundhouse.

Carbonaceous shale and thin lenses of coal about 100 feet above the Roland bed apparently correspond to the Arvada bed of Stone and Lupton and possibly to bed B of the main part of the Gillette coal field.

The Felix coal bed of the Wasatch formation, probably to be correlated with bed B of Dobbin and Barnett, lies about 420 feet above the Roland bed and is extensively exposed in the hills west and south of Gillette. This bed has been mined in a small way at many points along its outcrop near Gillette, and much of the domestic fuel supply of the town has been obtained from these mines during past years.

DETAILS BY COAL BEDS

The information available concerning each coal bed found in the Minturn district is here summarized to facilitate reference by anyone interested in a particular tract of land. To each location at which a natural or artificial exposure or drill hole yielded information as to the thickness or depth of the coal beds is given a serial number, which appears at the appropriate position on Figure 2 and is used in text references to the locality.

Smith coal bed.—Coal considered as belonging to the Smith bed was found at locations 6, 7, and 8, in T. 50 N., R. 70 W. At location

¹² Stone, R. W., and Lupton, C. T., The Powder River coal field, Wyo., adjacent to the Burlington Railroad: U. S. Geol. Survey Bull. 381, pp. 115-136, 1908.

¹³ Davis, J. A., The Little Powder River coal field, Campbell County, Wyo.: U. S. Geol. Survey Bull. 471, pp. 423-440, 1912.

6 an incomplete measurement of the coal bed revealed more than 7 feet of weathered coal at an old prospect pit, and at location 7, also in sec. 35, the following section was measured:

Partial section of Smith coal bed at location 7, in sec. 35, T. 50 N., R. 70 W.

	Ft.	in.
Shale, sandy, and thin-bedded sandstone to top of ridge----	41	
Shale, carbonaceous, interbedded with coal-----	16	
Coal, base concealed (Smith bed)-----	2	6+

A small prospect at this location is said to have been abandoned because of the heat and gases produced by near-by burning of the bed.

At the Eveland mine, in sec. 14 (location 8), the following section was measured:

Section of exposed part of Smith coal bed at Eveland mine, in the SE. $\frac{1}{4}$ sec. 14, T. 50 N., R. 71 W.

	Ft.	in.
Base of Roland clinker.		
Sandstone -----	30	
Coal -----	2	4
Shale, carbonaceous-----		3
Coal -----		6
Shale, carbonaceous, fissile-----	16	
Coal -----		6
Shale, carbonaceous-----		6
Coal -----	1	3
Shale, carbonaceous-----	1	3
Coal, irregular-----	1	6
Shale, carbonaceous-----	1	
Coal, base concealed-----	15+	

In the slope a few hundred feet east of the Eveland mine the Smith coal bed is seen to lie about 30 feet below the base of the Roland clinker, but south of the mine a ridge composed largely of soft sandstone rises some 80 feet above the Smith bed, apparently indicating the existence of an old sand-filled drainage channel in the Roland coal swamp at this locality. The Smith coal bed is burned around the south base of this ridge but extends under slight cover for an unknown distance north and northwest of the Eveland mine.

As pointed out in the discussion of the Roland bed on pages 59-61, the lower bench of the thick bed at the Peerless mine is believed to represent the Smith bed at that place, and the lower thick coal bed penetrated by drill holes at locations 26, 29, and 30 is also correlated with the Smith bed.

Roland coal bed.—Data on the Roland coal bed were obtained at locations 1 to 5, in T. 49 N., R. 71 W. At location 1, in sec. 12,

the top of the bed was exposed in a low bluff, and at location 2, in sec. 14, coal dust mingled with the soil marked the position of the bed. Wells at locations 3 and 4, in sec. 11, are reported to have found the top of the coal at depths of 40 and 20 feet, respectively, and it is reported that at least 38 feet of coal was disclosed by former operations at the old Andrew Ditto mine, at location 5, in sec. 2. This mine is reported to have had an entry about 25 feet high and 400 to 500 feet long, but it was on fire when visited in 1923 and consequently was caved shut. (See pl. 11, *D*.)

In T. 50 N., R. 71 W., locations 9 and 10, in secs. 27 and 28, mark the position of prospect shafts sunk by the Wyodak Coal & Manufacturing Co. to test the thickness and quality of the Roland bed, and location 11 is at the pit at which stripping of the coal was begun by the company in 1923. About 1,000 feet southeast of location 11 the top of the Roland bed is exposed in the south creek bluff and dips westward about 8°. At this exposure the top of the coal is somewhat eroded and overlain by massive carbonaceous sandstone. Locations 12 and 13, in sec. 28, are, respectively, at the shaft and slope of the Kirby Mutual Coal Co.'s Peerless mine, in which the upper bench of coal (Roland bed) lies about 25 feet below the surface and is reported to be between 52 and 66 feet thick and to be separated by 8 inches or more of carbonaceous clay from a lower bench of coal about 38 feet thick, believed to correspond to the Smith coal bed.

The upper part of the Roland bed is exposed in the bluffs of Donkey Creek at locations 14 and 15, in sec. 33, where the following sections were measured:

Section of coal exposed in bank of Donkey Creek at location 14, in the NE. ¼ sec. 33, T. 50 N., R. 71 W.

	Ft.	in.
Sandstone -----	4	
Shale, sandy-----	26	
Sandstone, carbonaceous-----	6	
Coal-----	2	
Shale, carbonaceous, sandy-----	1	1
Coal, impure-----	1	1
Shale, carbonaceous, sandy-----		11
Coal-----	1	8
Coal, impure-----	1	4
Shale, brown, carbonaceous-----		4
Coal, base concealed-----	6+	

Section of coal exposed at Samuel Ditto prospect, at location 15, in the NW. ¼ sec. 33, T. 50 N., R. 71 W.

	Ft.	in.
Clay, gray-----	3	
Clay, massive, carbonaceous-----	3	
Coal-----	3	

	Ft.	in.
Clay, brown-----		10
Coal-----	1	1
Clay-----		6
Coal-----	2	10
Clay-----		2
Coal-----	1	2
Clay-----		1
Coal, to 9 inches below water level-----	3	10+

The top of the Roland bed is approximately at water level near the large bend of the creek northwest of location 15 and also in the west-central part of sec. 32. At location 16 the upper 11 feet of the bed is exposed in the creek bank. Workings at the Hensley mine, in sec. 31, have revealed at least 30 feet of coal, of which 2 to 4 feet lying above a thin clay parting is left for a mine roof. Laboratory sample A2641, the analysis of which is given on page 18, was taken from this mine, which has been operated principally as a source of supply for the Gillette trade. Several old drifts just east of the Hensley mine have been abandoned for some time and have burned and caved in. At location 25, in sec. 19, 13 feet of weathered coal believed to belong to an upper bench of the Roland bed was dug out by the writer on a hillside, and dark soil near the reservoir in the south-central part of sec. 18 presumably indicates the exposure of the top of the Roland bed at that locality. A drill hole at location 26, in sec. 19, showed the Roland bed to be 60 feet thick and to lie 76 feet above the top of the Smith bed, 14 feet of which was penetrated. The log of this prospect hole is as follows:

Log of drill hole at location 26, in the southwest corner of sec. 19, T. 50 N., R. 71 W.

	Feet
Soil-----	0-4
Sand, soft, with pebbles near base-----	4-29
Clay and sandy shale-----	29-40
Sand, with water-----	40-45
Clay, sandy-----	45-53
Sandstone, medium to fine grained-----	53-118
Clay, gray, sandy-----	118-120
Coal-----	120-122
Clay, gray, sandy-----	122-147
Clay, carbonaceous-----	147-150
Coal (Roland bed)-----	150-210
Clay, blue and gray-----	210-218
Sandstone-----	218-223
Clay-----	223-286
Coal (Smith bed), bottom not reached-----	286-300

Twenty feet of coal belonging to the upper part of the Roland bed is also reported to have been penetrated between 115 and 135 feet in

a well drilled at the Geist homestead, at location 28, in the SW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 7, T. 50 N., R 71 W.

In T. 50 N., R. 72 W., the Roland and Smith coal beds have been penetrated in wells drilled at the Gillette roundhouse (locations 29 and 30) by the Chicago, Burlington & Quincy Railroad Co., of which the following logs were obtained by Stone and Lupton.¹⁴

Logs of water wells at Gillette

Location 30		Location 29	
	Feet		Feet
Sandstone and shale.....	345	Soil, shale, and sandstone.....	335
Coal (Roland bed).....	55	Shale, dark with coal streaks (Roland bed).....	65
Shale, white, black, and blue.....	85	Clay, shale, and sandstone.....	90
Coal (Smith bed).....	35	Coal (Smith bed).....	22
Shale and sandstone.....	345	Shale, sandstone, and limestone.....	1,048
	<u>865</u>		<u>1,560</u>

It is uncertain whether the Roland bed consists principally of carbonaceous shale at location 29, or whether the report is merely the result of inaccurate determination of the nature of the drill cuttings obtained from the well. These two wells are so close together that the discrepancies between their records would appear to indicate that little attention was paid to precise classification and measurement of the strata penetrated.

A well in the northeastern part of sec. 26 is reported to have found the Roland bed to be 70 feet thick and its top from 140 to 170 feet below the surface, but no definite record of the occurrence was obtainable.

Arvada (?) coal bed.—Thin lenses of coal of no apparent economic value are found along Donkey Creek west of the Hensley mine, at locations 18, 19, 20, and 21, and apparently belong to the lower bench of the Arvada coal bed. Operations at the Hensley strip pit, in sec. 36, T. 50 N., R. 72 W., showed that the bed was too much broken by partings to be of value at that place. Weathered coal $2\frac{1}{2}$ feet thick, apparently at the same geologic horizon, was also found on a hillside at location 24, in sec. 30, T. 50 N., R. 71 W.

An incomplete section of an upper bench of the Arvada (?) bed contained more than 4 feet of coal dust in the creek bank at location 22, in sec. 35, T. 50 N., R. 72 W., and the same bench contained about 5 feet of weathered coal near the top of a ridge at location 26, in sec. 18, T. 50 N., R. 71 W. A thick bed of carbonaceous shale found at location 23, in sec. 25, T. 50 N., R. 72 W., is probably also at this horizon.

¹⁴ Stone, R. W., and Lupton, C. T., op. cit., p. 130.

Felix bed.—The Felix coal bed was studied in only an incidental way during the recent investigation of the Minturn district, but such facts as are available concerning its quality and thickness within the area mapped in 1923 will be presented. Locations 31, 32, 33, and 34, southwest of Gillette, mark the position of small mines that have been operated at different times to supply coal for the Gillette market. A section of the bed measured at location 35 is as follows:

Section of Felix coal bed at location 35, in the SE. ¼ sec. 28, T. 50 N., R. 72 W.

Sandstone, carbonaceous, cross-bedded.	Ft. in.
Coal.....	4
Shale, black.....	1
Coal, impure.....	4 11
Shale carbonaceous and coal streaks.....	10
Coal.....	6
<hr/>	
Total section.....	25 11
Total coal.....	14 11

At the Vines and Barker mines (locations 36 and 39) the Felix bed shows the following section, according to Stone and Lupton:¹⁵

Section of Felix coal bed at Vines mine (location 36), in the NE. ¼ sec. 29, T. 50 N., R. 72 W.

	Ft. in.
Coal, with clay bands up to 1 foot thick.....	9 10
Shale and clay.....	1 6
Coal.....	1
Clay, drab.....	5
Shale, carbonaceous.....	8
Coal, clear, solid.....	7 6

Section of Felix coal bed at Barker mine (location 39), in the SE. ¼ sec. 18, T. 50 N., R. 72 W.

	Feet
Coal.....	13
Clay, carbonaceous.....	4
Coal.....	9

At the Campbell mine (location 37), it is reported, about 6½ feet of an 8 or 9 foot bench of the Felix bed is being mined, and another mine in the north-central part of sec. 20 was operated in 1923 but was not visited.

DEVELOPMENT IN THE MINTURN DISTRICT

Early development.—For many years small quantities of coal for domestic use have been obtained from country mines and prospects within the Minturn district, of which the Hensley, Andrew Ditto,

¹⁵ Stone, R. W., and Lupton, C. T., op. cit., p. 124.

Eveland, and Samuel Ditto mines have made the largest output. Since the discovery of the presence of the thick Roland and Smith coal beds in the vicinity of the Peerless mine, west of Minturn, interest in the exploitation of the coal on a larger scale has been aroused, and numerous inquiries have been received as to the distribution and quality of this coal. Exploration to date has shown that so great a tonnage of coal can be mined by stripping west of Minturn that demand for coal is the factor limiting the number of mines which can be profitably opened and operated in the district and that until there is a great increase in the use of coal within the region naturally tributary to the Gillette field competition will be excessive if more than a few large-scale mines are opened.

Peerless mine.—The Peerless mine, operated by the Kirby Mutual Coal Co., of Gillette, in the NE. $\frac{1}{4}$ sec. 28, T. 50 N., R. 71 W., was in 1923 the only mine in the Minturn district provided with railroad shipping facilities or designed to yield a considerable output of coal. The shaft and slope of this mine, marked, respectively, by locations 12 and 13 on Plate 13, were partly filled with water when visited, but it is reported that only 9 or 10 feet of the lower (Smith) bench, or about one-tenth of the total coal penetrated by the shaft, was being mined during previous development work. No estimate of the productive capacity of the mine was possible, but the general scale of the operation may be gaged from the photograph reproduced in Plate 11, *C*. The relation and approximate thickness of the Roland and Smith coal beds and the parts represented by analyses given on pages 17–18 are shown by Figure 3.

Stripping of the overburden from the Roland coal in the W. $\frac{1}{2}$ SE. $\frac{1}{4}$ sec. 28, just south of the Peerless mine, is reported to have been begun in 1924, the relative thinness of the cover upon the coal being indicated by the exposure of the top of the Roland bed in the creek banks in sec. 33 and by the Peerless mine shaft, which found the top of the Roland bed about 25 feet below the surface. The shaft and slope at this mine revealed about 90 feet of coal belonging to the Roland and Smith beds, which are here separated by a parting from 8 inches to 1 foot thick.

Andrew Ditto mine.—The Andrew Ditto mine (location 5, pl. 13) had caved in and was on fire when visited but is reported to have consisted of a drift 500 or 600 feet long from which a thickness of 20 to 25 feet of coal had been removed. It is reported that borings in the roof and floor had indicated that the Roland bed was more than 38 feet thick at this mine.

Eveland mine.—At the Eveland mine, in the SE. $\frac{1}{4}$ sec. 14, T. 50 N., R. 71 W., the Smith coal bed contains more than 15 feet of coal, as shown by the section given on page 58. Two small drifts have been opened, and a small quantity of coal has been extracted, the

general character of which is indicated by laboratory analysis No. A2643. The coal presumably underlies a relatively small area south and west of the mine, as shown by Plate 12, and extends northward and eastward beneath thin cover for an indefinite distance.

Samuel Ditto mine.—The Samuel Ditto mine, in the NW. $\frac{1}{4}$ sec. 33, T. 50 N., R. 71 W., has been operated in a small way but had been abandoned when visited in 1923. A section of part of the Roland bed exposed at this mine is given on pages 59–60.

Hensley mine.—The Hensley mine, in the SE. $\frac{1}{4}$ sec. 31, T. 50 N., R. 71 W., was in active operation when visited in 1923 and was equipped with a tippie for screening and loading a small output of coal, which was at that time being sold for domestic use in Gillette. The workings of the mine, which were reached by a slope, are reported to have revealed the upper 35 to 40 feet of the Roland coal bed. A thin clay parting 2 to 4 feet from the top of the bed was utilized in mining, the coal above this parting being left for a roof. Laboratory sample No. A2641 was taken in this mine and shows the coal to be of the same general composition as that of the remainder of the Minturn district.

Other prospects.—A small amount of prospecting has been done at the Hensley strip pit, in sec. 36, T. 50 N., R. 72 W., and at locations 6, 7, and 14, in T. 50 N., R. 71 W., but the results obtained were not such as to lend encouragement to exploitation of the beds opened at those points.

Prospects for future development.—As strip mining will make possible more complete extraction of the coal from the thick Roland and Smith beds, at a minimum cost of mining, the three factors which will chiefly limit the acreage that can be profitably exploited in the Minturn district will be the size of the market demand for the coal, the relative cost of railroad construction from mine sites to the Chicago, Burlington & Quincy Railroad, and the thickness and nature of the overburden lying upon the Roland coal bed. As shown by Plate 13, mines that are opened in the lowlands bordering Donkey Creek, south and west of the center of sec. 15, T. 50 N., R. 71 W., will be relatively near the existing railroad and will have only a slight thickness of overburden to remove from coal mined by stripping as compared to that at possible mining operations under the higher divides and ridges.