Wyoming State Geological Survey
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Coal Geology of Wyoming

by

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Wyoming

The coalfields of Wyoming fall into two coal-bearing provinces: those in eastern Wyoming are within the Northern Great Plains Province, while all other coal deposits of the state are in the Rocky Mountain Province. Beyond these national designations, the state's coal-bearing areas are divided into 10 major coalfields (Fig. 1):[1,2]

1. Bighorn Coalfield
2. Black Hills Coalfield
3. Goshen Hole Coalfield
4. Green River Coalfield
5. Hams Fork Coalfield
6. Hanna Coalfield
7. Jackson Hole Coalfield
8. Powder River Coalfield
9. Rock Creek Coalfield
10. Wind River Coalfield

These coalfields underlie more than 53,000 square miles, approximately 54%, of the state, and collectively contain a remaining coal resource greater than 1.45 trillion tons.[90]

Coal Resources

Wyoming's original in-place coal resources were more than 1.46 trillion tons.[3] Table 1 provides a summary of Wyoming's coal resources by coalfield. This resource estimate is for coal in place, which is defined as "naturally occurring concentrations or deposits of coal at all depths in the Earth's crust, in all forms and amounts, regardless of whether economic extraction may be currently or potentially feasible."[3]

This new estimate of the coal resources in Wyoming differs from previous estimates in that coal beds of any thickness and to all depths are included. Previous estimates were restricted to coals that were less than 6,000 feet below the surface, to anthracite and bituminous coals that were more than 14 inches thick, and to subbituminous coals and lignites that were more than 30 inches thick.[21,81]

Wyomings's in-place coal resources are more than twice the in-place resources of any other state in the contiguous United States. Only Alaska has more in-place coal than Wyoming.

Table 1. Wyoming in-place coal resources (in millions of tons)*

Coalfields	Identified and Hypothetical	Onshore Speculative	Total
Bighorn	23,500	0	23,500
Black Hills	4,150	3,740	7,890
Goshen Hole	230	0	230
Green River	237,110	0	237,110
Hams Fork	22,080	27,530	49,610
Hanna	23,270	0	23,270
Jackson Hole	6,340	0	6,340
Powder River	1,030,340	255	1,030,595
Rock Creek	3,400	0	3,400
Wind River	81,010	0	81,010
Total	1,431,430	31,525	1,462,955

*Modified from Table 1 of Wood and Bour[3]

Of this resource, 68.1 billion tons are currently classified as demonstrated reserve base.[83, 90] This includes 25.6 billion tons of strippable reserve base and 42.5 billion tons of underground reserves. Because Wyoming's known strippable reserve base is limited to a few mapped and explored areas (Fig. 1), the current estimate of the strippable coal reserve base is significantly understated.

Fig. 1. Wyoming coalfields

Coal Production

Except for an 11-year interval after World War I, Wyoming's annual coal production for the years 1910 through 1945 remained above 6 million tons. After 1945, production fell, reaching a record low of 1.6 million tons in 1958. This decline marked the conversion of railroads from coal-fired, steam-driven locomotives to diesel engines.

Renewed interest in Wyoming's coal resources began in the late 1960s as power plant demands for inexpensive, low sulfur coals increased. Because of this demand, Wyoming's coal companies have set new production records almost every year since 1972 (Fig. 2). Production did decrease slightly in 1986 and in 1992.

Wyoming's 1995 tonnage set a new record at 263.9 million tons. Wyoming aslo remained the largest coal-producing state in the nation.

Coal production in Wyoming was dominated by underground mining until 1954. In that year surface mining tonnage barely exceeded that of the underground mines. Since then surface mining has become the dominant mining method and now accounts for 99.2% of Wyoming's annual production. Conversely, underground mining has slipped to 0.8% of the annual tonnage mined.

In 1995, about 98% of the coal mined in Wyoming was used to fuel power plants in 19 states and several other countries. In-state and out-of-state industrial users, including the beet sugar, cement, trona, bentonite, synthetic coke, and phosphate industries, used approximately 1.9% of the state's production. Residential/commercial users within and outside Wyoming accounted for less than 0.1%.[24]

Fig. 2. Wyoming coal production

General Geology of the Coalfields

In Wyoming, coals occur in rock sequences deposited during either the Cretaceous Period (66.4 to 135 million years ago) or during the Tertiary Period (38 to 66 million years ago) (Fig. 3). In both periods, depositional environments and climates were at least periodically well suited to the development of densely vegetated swamps. Peats that accumulated in these swamps have since been transformed into the numerous coal beds that underlie the state.

The geologic formations in which these coals occur are characteristically thick, each usually from 700 to 7,000 feet in thickness. While the Cretaceous formations normally exhibit gradual regional thickening or thinning across the state, the thicknesses of the various Tertiary formations vary from basin to basin. The thickness variations in the Tertiary are more related to the local tectonic and depositional events that affected each of the coalfields than to larger regional events.

The most widespread coal-bearing rocks in Wyoming are Cretaceous in age, but they usually crop out only as narrow bands of upturned rock around the margins of the larger structural basins and uplifted areas of the state. They also crop out as irregularly exposed, linear bands in the thrust belt of western Wyoming. Relatively flat-lying Tertiary rocks, on the other hand, occupy the central portions of most of the coalfields, where they overlie the older Cretaceous rocks. Even the Tertiary rocks often exhibit steeper dips as they approach the margins of the coalfields.

Cretaceous and Tertiary coal-bearing formations contain numerous coals that are separated from one another by as little as a few inches of shale or claystone to hundreds of feet of rock that may vary from coarse sandstone or conglomerate to siltstones, claystones, and shales. Although the Cretaceous coals interspersed in these rocks generally are less than 10 feet thick, a few Cretaceous coals are 30 to 100 feet thick in westernmost Wyoming.

The Tertiary coals, which were deposited during the Eocene and Paleocene Epochs, often exceed 10 feet in thickness, with 30- to 100-foot-thick coals common. Locally, some Tertiary coals exceed 200 feet in thickness.

Lower Cretaceous - The oldest coal-bearing formation in Wyoming is the Lower Cretaceous Lakota Formation (Fig. 3). This formation contains at least one minable coal in the Black Hills Coalfield and may be coal-bearing at depth on the eastern side of the Powder River Coalfield.

The Bear River Formation of Lower Cretaceous age is the next younger coal-bearing rock unit above the Lakota. The coals in the Bear River Formation are very local in extent and only have been reported in the Hams Fork Coalfield.[4] Most coals in the Bear River Formation are probably not economically minable.

Upper Cretaceous - Separated from the Bear River Formation by a marine shale, the overlying Frontier Formation (also mapped as the lower part of the Blind Bull Formation) contains numerous, fairly thick, persistent coals in western Wyoming.[4] Throughout the rest of the state, the coals in the Frontier Formation apparently are thin, shaly, and of very limited extent.

The oldest widespread coal deposits in Wyoming are found in the Mesaverde Group or its western equivalent, the Adaville Formation. These rocks contain numerous thick to moderately thick coals in the Hams Fork and Green River coalfields. North and east of these two coalfields, Mesaverde coals are less numerous, thinner, and not as persistent. Because the Mesaverde Group disappears northeastward across Wyoming, this group does not underlie the northeastern and northern portions of the Powder River Coalfield. The Mesaverde does, however, contain some thin coals on the southern flank of the Powder River field.[5]

The Meeteetse Formation is recognized in the Wind River and Bighorn coalfields, where it contains some minable coals. Most Meeteetse coals, however, are thin and discontinuous.

Lance Formation coals are the youngest Upper Cretaceous coals in Wyoming. Although the Lance and equivalent aged rocks (Fig. 3) contain coal throughout the state, Lance coals are best developed in southern Wyoming, where they are numerous, but seldom reach more than 10 feet in thickness. Lance coals in the Goshen Hole Coalfield are no more than 36 inches thick and are not economically minable.

Paleocene - Paleocene rocks (variously mapped as the Fort Union, Pinyon Conglomerate, Hanna, Ferris, or Evanston formations) crop out in all but the Black Hills and Goshen Hole coalfields. Paleocene rocks invariably contain coals,

although they are most prolific in the Powder River and Hanna coalfields. There are, in fact, more Paleocene coal beds in the Ferris and Hanna formations of the Hanna field than there are Fort Union coals in the Powder River field. The Paleocene coals in the Powder River field, however, are up to 200 feet thick. The thickest seam in the Hanna Coalfield, on the other hand, is only 60 feet thick.[62]

Eocene - The Eocene Wasatch Formation is the youngest coal-bearing rock unit of economic importance in Wyoming. At least in the Powder River Coalfield, the Wasatch rivals the older Paleocene rocks in both the number of coal seams it contains and in their thickness. (The Wasatch contains the thickest

Fig. 3. Principal coal-bearing formations in Wyoming

coal seam in Wyoming, the 250-foot-thick Lake De Smet bed[45]). Wasatch and equivalent age coals also are abundant and moderately thick in the northeastern corner of the Green River Coalfield and in the Hanna Coalfield. Elsewhere in the state, Wasatch coals are thinner and less persistent than many older coals.

In general, the coalfields of Wyoming are situated in broad, asymmetrical, synclinal basins between various ranges of the Rocky Mountains. Except for those coal beds that are tilted against the Rock Springs uplift in the central portion of the Green River Coalfield, most of the state's coals are relatively flat-lying in the more central portions of the basins. Steeper dips and significant folding are common at some basin margins, as well as on the flanks of mountain ranges. While the Hams Fork and Hanna coalfields exhibit the greatest structural complexity, the Powder River Coalfield shows the least. Faulting is most common in the southern and western coalfields, but is not restricted to those fields.

General Coal Characteristics

Rank - Except where deeply buried, the documented apparent rank of Wyoming coals ranges from subbituminous to high-volatile A bituminous. It is possible some untested coals in the state may be lignites.

Subbituminous coals, which are all either Tertiary or Late Cretaceous in age, are found in all the coalfields of the state except the Black Hills. Usually, the subbituminous coals occupy the more central parts of the coalfields, although in the case of the Hams Fork field subsequent erosion has relegated even the younger subbituminous coal-bearing rocks to narrow bands between faults and eroded folds.

Most of Wyoming's bituminous coals outcrop as narrow bands in the Hams Fork Coalfield, around the Rock Springs uplift, along the eastern edge of the Green River Coalfield and on the periphery and eastern half of the Hanna Coalfield. The Mesaverde coals in the north end of the Bighorn Coalfield and the Lower Cretaceous coal of the Black Hills Coalfield also are bituminous. Bituminous coals are much more widespread than these outcrops would suggest because many of them lie deeply buried. Although most bituminous coals are of Cretaceous age, some Paleocene coals also are of bituminous rank, i.e., in both the Hanna and Bighorn coalfields.

While older coal beds in any given coalfield generally are higher in rank than younger beds, the rank of individual beds in a coalfield also increases downdip. Both of these variations in rank have been attributed to increases in depth of burial.[6] A more recent report[7] shows a marked regional increase in rank eastward across the Hanna Coalfield. It is not known if this regional variation in rank is attributable to tectonic controls or to differences in depth of burial[7].

Moisture, Ash - Moisture, volatile matter, and fixed carbon contents of coals vary widely across the state in response to variations in rank. The bituminous and higher-ranked subbituminous coals of the Cretaceous and Tertiary are very similar on an as-received basis. Moisture contents are less than 15%, volatile matter contents are between 30 to 40%, and fixed carbon contents are greater than 40%. In contrast, the lower-ranked subbituminous Tertiary coals of the Green River and Powder River coalfields have as-received moisture contents between 20 and 30%, and volatile matter and fixed carbon contents both around 30%.

Ash and sulfur contents are characteristically low and are related to the depositional histories of the coals rather than to any differences in rank. Consequently, variations are quite irregular—ash contents, in particular. As-received ash contents range from a few percent to more than 50% in response to the volume of inorganic debris entering the original peat swamp. Published analyses of various coals sampled across the state, however, suggest that a typical, persistent Wyoming coal of minable thickness contains less than 10% ash (Table 2).

Washability studies suggest many Wyoming coals with higher than average ash contents are readily washed to a desirable ash level with minimum loss of yield.[8,9]

Sulfur - There are published estimates of the average sulfur content of Wyoming's coal resources and reserves,[10,82] but the basis for these estimates were statistically unsound. It is recommended they not be used.[11,12] On an as-received basis, published analyses of Wyoming's Cretaceous coals usually show 0.40 to 2.0% sulfur, compared to 0.3 to 0.9% sulfur in the state's Tertiary coals. Because of contract demands, sulfur contents of mined Wyoming coals seldom exceed 1.0% and average only 0.5% (Table 2).

In addition, a recent study for the U.S. Department of Energy indicated 15.8 billion tons (58.5%) of the strippable, demonstrated reserve base in Wyoming is compliant coal with less than 0.6 pounds of sulfur per million Btu. Another 20.6 billion tons (48.4%) of the underground reserve base is also compliant. All told, 36.4 billion tons, or 52% of the demonstrated reserve base in Wyoming, is compliant coal.[83]

Table 2. Characteristics of Wyoming coals that are currently mined

Coalfield	Apparent Rank	Bed Thickness (feet)	Moisture (%) (As-received)	Ash (%) (As-received)	Sulfur (%) (As-received)	Heat Value (Btu/lb) (As-received)	Hardgrove Grindability Index
Powder River Coalfield							
Northwestern portion	Subbituminous	Range: 10-57 Average: 40	Range: 14.5-26.0 Average: 21.5	Range: 3.1-8.2 Average: 4.9	Range: 0.3-1.0 Average: 0.48	Range: 9,000-10,410 Average: 9,410	Range: 39-50 Average:41
Eastern portion	Subbituminous	Range: 50-100 Average: 75	Range: 21.1-36.9 Average: 29.8	Range: 3.9-12.2 Average: 5.1	Range: 0.2-1.2 Average: 0.36	Range: 7,420-9,600 Average: 8,580	Range: 49-55 Average: 53
Southern portion	Subbituminous	Range: 17-38 Average: 35	Range: 19.5-29.3 Average: 22.2	Range: 6.6-15.7 Average: 10.3	Range: 0.4-0.7 Average: 0.47	Range: 7,610-8,870 Average: 7,710	Range: 30-35 Average: 35
Hanna Coalfield	Subbituminous and Bituminous	Range: 5-38 Average: 12	Range: 6.0-20.8 Average: 11.9	Range: 3.8-21.3 Average: 6.3	Range: 0.2-2.1 Average: 0.6	Range: 8,310-12,600 Average: 11,030	Range: 43-110 Average: 55
Green River Coalfield	Subbituminous*	Range: 5-30 Average: 15	Range: 17.0-20.5 Average: 20.5	Range: 5.9-10.0 Average: 8.8	Range: 0.4-0.8 Average: 0.5	Range: 9,270-10,000 Average: 9,480	Range: 79-82 Average: 80
Hams Fork Coalfield	Subbituminous	Range: 5-90 Average: 16.5	Range: 15.4-28.6 Average: 20.8	Range: 5.9-10.0 Average: 5.8	Range: 0.4-0.81 Average: 0.81	Range: 9,270-10,000 Average: 9,570	Range: 79-82 Average: 51
Bighorn Coalfield	Bituminous	Range: 8-36 Average: 20	Range: 10.7-12.8 Average: 12.3	Range: 5.0-9.4 Average: 7.4	Range: 0.3-0.6 Average: 0.4	Range: 10,730-11,246 Average: 10,970	Range: 50-55 Average: 51

*Note: Some bituminous coal is also mined, but it is not included in this summary.

High-sulfur coals do occur in the Green River and Hanna coalfields. Although the high-sulfur Wasatch coals of the Green River Coalfield are not mined, exploration has shown sulfur contents as high as 7%.[13] Some of the stratigraphically higher, unmined coals of the Carbon district of the Hanna Coalfield contain up to 8.7% sulfur.[14,15]

In Wyoming's lower sulfur coals, the sulfate form of sulfur averages less than 0.03% (3 to 5% of the total sulfur); the pyritic form averages less than 0.2% (25 to 29% of the total sulfur); and the organic form averages less than 0.47% (70 to 72% of the total sulfur).[16] Because most of the sulfur in Wyoming's coal is in the organic form, conventional mechanical cleaning or preparation processes cannot materially reduce the total sulfur content. Even if all the pyritic sulfur could be removed, total sulfur would only be reduced by a maximum of 30%. There are, however, indications that the combustion of some relatively high-calcium coals in Wyoming traps a portion of their sulfur contents in their ash, thereby reducing sulfur dioxide emissions when these coals are burned.[10]

In very-high-sulfur Wyoming coals, pyritic sulfur becomes the dominant form, although organic sulfur contents as high as 3% have been noted in some coals of the Carbon district of the Hanna Coalfield.[14] When the organic sulfur form in these high-sulfur coals is between 2 and 3%, the pyritic sulfur is always two to three times higher.

Heat Values - Heat values of currently mined coals, like moisture contents, vary widely across Wyoming (Table 2). In the southern half of the state, as-received heat values average about 10,000 Btu/lb. Heat values are typically between 9,480 and 11,030 Btu/lb. While heat values of coals mined in western Wyoming average 9,570 Btu/lb, they are much lower in northeastern Wyoming. Although the heat values for northeastern Wyoming vary from an average of 9,410 Btu/lb in the Sheridan area to 7,710 Btu/lb in Converse County, they average 8,580 Btu/lb.

Heat values of Wyoming coals are commensurate with their apparent rank.[17] On a moist, mineral-matter-free basis, the heat values of bituminous coals are between 11,500 and 14,000 Btu/lb, while the heat values of subbituminous coals are between 8,300 and 11,500 Btu/lb. For at least the subbituminous and bituminous coals, heat values increase noticeably under greater increments of overburden. While Unfer[6] reported an increase of 300 Btu/lb per 110-foot increase in overburden for relatively shallow coals in the Hanna Coalfield, an analysis of similar analytical data by Glass suggests that heat values increase about 140 Btu/lb per 100 feet for the Adaville coals in westernmost Wyoming.[4] More recently, a 6,000-foot exploration well for coalbed methane in the Hanna Coalfield indicates that heat values of coals between 1,500 and 6,000 feet deep increase between 50 to 60 Btu/lb per 100 feet. The apparent rank of the analyzed coals in this well is high-volatile B to high-volatile A bituminous. Where they crop out, their apparent rank is high-volatile C bituminous.

Major and Minor Elements - In Wyoming coals, major elements, which make up more than 0.1% of a coal, are silicon, calcium, aluminum, iron, and magnesium, usually in that order of abundance. Common minor elements, which account for less than 0.1% of a coal, are potassium, sodium, titanium, phosphorous, chlorine, and manganese, in that order (Table 3).

Silicon, aluminum, calcium, and iron all can be present in concentrations greater than 2%. Silicon concentrations have exceeded 5% in some samples. The minor elements in Wyoming coals rarely exceed 0.1% and are best described in parts per million (ppm).

Based on some recent analyses, Wyoming's Cretaceous and Tertiary coals show similar concentrations of all the major and minor elements, except calcium and sodium. The concentrations of calcium and sodium in the Tertiary coals are usually five to six times the concentrations normally reported in the Cretaceous coals of Wyoming.[18]

Trace Elements - Of the 30 trace elements recognized in 48 analyses of Wyoming coals, concentrations of the various elements vary from a high of 1,000 ppm to a low of 0.004 ppm. If grouped according to their average concentrations on a whole-coal basis, six elements average less than 1 ppm, 12 elements vary between 1 and 5 ppm, and 11 elements range between 5 to 100 ppm. Only barium averages more than 300 ppm (Table 4).

With the exception of zinc, which averages 17.9 ppm, the more common metals—copper, cobalt, nickel, and lead—all occur in concentrations between 1 to 5 ppm. While the potentially dangerous elements, arsenic and molybdenum, also average 1 to 5 ppm, selenium, cadmium, and mercury normally occur in concentrations of less than 1 ppm.

Based on these 48 published analyses, Tertiary coals in Wyoming contain higher concentrations of 26 of these trace elements than do the Cretaceous coals. Only boron, beryllium, and fluorine are higher in the Cretaceous coals.[18]

Carbonizing Properties - Although most Wyoming coals are nonagglomerating, they can be carbonized in fluidized systems. Chars produced at low temperatures contain 17 to 23% residual volatile matter and are easily ignited. On a moisture-free basis, char heating values lie between 10,500 and 14,200 Btu/lb and

Table 3. Major and minor elements in 48 Wyoming coal samples in percent on a whole-coal basis

	Wyoming Range	Wyoming Average[18]	U.S. Average[19]
Silicon	0.41-5.50	1.70	2.6
Calcium	0.13-2.10	0.75	0.54
Aluminum	0.17-2.50	0.72	1.4
Iron	0.15-2.100	0.51	1.6
Magnesium	0.026-0.340	0.17	0.12
Potassium	0.005-0.370	0.063	0.18
Sodium	0.003-0.190	0.044	0.06
Titanium	<0.001-0.130	0.038	0.08
Phosphorous	<0.0021-0.044	<0.0121	—
Chlorine	0.004<0.026	<0.010	—
Manganese	<0.0007-0.0492	0.004	0.01

Table 4. Average trace element concentrations in 48 coal samples (parts per million on a whole-coal basis)

Element	Wyoming Average[18]	U.S. Average[19]
Barium	300	150
Strontium	100	100
Boron	70	50
Fluorine	70	74
Cerium	<20	—
Zinc	17.9	39
Vanadium	15	20
Zirconium	15	30
Neodymium	<15	3
Copper	8	19
Chromium	7	15
Lanthanum	7	—
Nickel	5	15
Yttrium	5	10
Lithium	4.6	20
Gallium	3	7
Arsenic	<3	15
Lead	<3	16
Thorium	2.7	4.7
Cobalt	2	7
Germanium	<2	—
Niobium	1.5	—
Scandium	1.5	3
Molybdenum	1.0	3
Uranium	<0.9	1.8
Selenium	<0.8	4.1
Ytterbium	0.5	1
Antimony	<0.4	1.1
Cadmium	<0.15	1.3
Mercury	0.10	0.18

appear suitable as power plant fuel. Lump chars can be produced from most Wyoming coals, but they are relatively weak. These lump chars are a suitable substitute for coke breeze used in phosphate ore reduction.[20]

At low temperatures, the yield of tar generally increases with increase in rank, but the variation in yield within ranks may be large. Tar-plus-light oil yields vary from 14 to 40 gallons per ton of raw coal processed.[20]

Coking Coal

Coals with weak to moderate coking properties occur in the Kemmerer district of the Hams Fork Coalfield, the Rock Springs district of the Green River Coalfield, and the Cambria district of the Black Hills Coalfield. The Lower Cretaceous Cambria coal in the Cambria district possesses the best coking qualities, but there is little published information on the remaining resources of Cambria coal.[21,22]

The Willow Creek No. 5 or Middle Main bed in the Kemmerer district of the Hams Fork Coalfield is between 3.1 and 6.5 feet thick and yields a weak coke. Recoverable reserves of this Frontier Formation seam are 8 million tons. Other coals in the Hams Fork Coalfield also have coking potential.[21,23]

In the Green River Coalfield, the Rock Springs No. 7 bed in the Rock Springs Formation is 2 to 10 feet thick. Although there are more than 200 million tons of measured resources of this coal, it is of poor coking quality.[21] This coal crops out on the flanks of the Rock Springs uplift.

Commercial Coalbed Methane

Commercial accumulations of coalbed methane have been documented in several Wyoming coalfields. The more significant quantities apparently occur in the Green River[25,84,87] and the Powder River coalfields.[25,84,85,86] Typical gas yields from these fields are 150-375 Scf/ton and less than 100 Scf/ton, respectively.[84] In addition, coalbed methane accumulations have been identified in the Hanna Coalfield[25] and in the Wind River Indian Reservation in the Wind River Coalfield.[88,89]

Powder River Coalfield

This 12,000-square-mile coalfield, which areally is the second largest in the state, coincides with the topographic and structural basin of the same name. As defined, however, the coalfield is limited to that portion of the Powder River Basin underlain by the Mesaverde Formation or younger rocks. This definition was chosen because the Mesaverde is the oldest coal-bearing formation in the field.

Structurally, the coalfield is part of a broad asymmetric syncline bounded by the Bighorn Mountains to the west, the Black Hills to the east, and the Casper arch, Laramie Mountains, and the Hartville uplift to the south. The syncline continues into Montana where it is separated from the Williston Basin by the Cedar Ridge Anticline. Because the axis of this syncline is west of its geographic center, the rocks in the eastern and central portions of the coalfield have almost imperceptible dips compared to the steeper dips on the western side. Generally, the Cretaceous rocks around the margins of the coalfield dip more steeply than the Tertiary rocks, which lay nearly flat (2 to 3 degree dip), except on the west side where the Paleocene rocks steepen to 10 to 25 degrees.

Although some faulting occurs in many areas of the coalfield, faults are relatively rare, except on the western margin, particularly in southern Johnson County. Most of the faults trend northeast-southwest, with maximum vertical displacements of 300 to 400 feet in the Sussex area.

This coalfield has the largest in-place coal resources of any field in the contiguous United States; 1.03 trillion tons.[3] Although coals occur in the Upper Cretaceous Mesaverde and Lance formations, the thickest and most important coals occur in the Paleocene Fort Union Formation and the Eocene Wasatch Formation (Fig. 3). Denson and Crysdale mapped the aggregate thickness of coals in the Tertiary and Cretaceous coal-bearing rocks in the Powder River Coalfield.[95, 96] The maximum aggregate thickness, which occurs about 23 miles west and slightly south of Gillette, was 386 feet.[95]

The Fort Union Formation, which is between 2,000 and 3,000 feet thick, is perhaps the most prolific coal-bearing rock unit in Wyoming. Although the lower members of the formation contain coals, the most persistent and thickest coals occur in the 1,500- to 1,800-foot-thick upper member, the Tongue River Member. Coals in the Tongue River Member are best developed in the northern and eastern portions of the Powder River Coalfield and consist of eight to 12 persistent, subbituminous coals.

The most important of these Paleocene coals, the Wyodak bed, is persistently 50 to 100 feet thick.[26] The outcrop of this coal, though burned in many places, is mapped for more than 100 miles along the eastern side of the coalfield. Regionally, the Wyodak splits into two or more separate beds (Fig. 4). Several of these beds are correlative with coals in the Sheridan area, 60 miles across the field.[5] A portion of the Wyodak coal also is correlative with the Big George bed, which is another thick coal in the Fort Union Formation. This seam, which occurs in the west-central portion of the field, averages 113 feet in thickness and lies at depths greater than 1,000 feet.[27]

The Wasatch Formation, which is 1,000 to 2,000 feet thick, is another prolific coal-bearing formation, rivaled in importance only by the Fort Union Formation. The Wasatch Formation crops out over much of the central portion of the Powder River Coalfield, and usually exhibits shallow dips (less than 4 degrees).

The Wasatch Formation contains as many as eight thick, persistent coals (Fig. 4). While these Wasatch coals are mapped and correlated for tens of miles along their outcrop, they are thicker and more persistent in the western and central parts of the basin. The thickest Wasatch seam is the Lake De Smet bed on the west side of the field in northern Johnson County. The Lake De Smet coal bed locally exceeds 200 feet in thickness.[28]

Important Seams of the Powder River Coalfield

Anderson Bed - This Paleocene coal is well developed in most of the Powder River Basin. The Anderson coal coalesces with the Canyon coal in the Gillette area to form the 70- to 175-foot-thick Wyodak coal, which crops out on the eastern side of the field.[29,30,92] Northward, westward and southward, the Anderson splits off the Wyodak bed and thins to become 10 to 50 feet thick (Fig. 4). It may be a part of the Big George bed, discussed below.

In reports prior to the mid-1970s, the Anderson coal had been called the D coal bed south of Gillette. At one time it was also incorrectly correlated with the Roland coal bed, which is stratigraphically higher.

The strippable reserve base for the Anderson coal bed is included in the 17.9 billion tons of reserve base calculated for the Wyodak coal.[83] Currently the Anderson coal is mined only where it is combined with the Canyon coal to form the Wyodak bed.

The apparent rank of this coal is subbituminous C. Nine core analyses of the Anderson coal are summarized on the next page.[31,32]

As-received Basis	Range (9 analyses)	Average
Moisture (%)	24.9-34.1	29.5
Volatile matter (%)	26.5-34.5	30.1
Fixed carbon (%)	29.0-38.0	33.9
Ash (%)	3.5-12.2	6.5
Sulfur (%)	0.17-1.13	0.52
Btu/lb	7,130-8,740	7,900

Badger Bed - This coal is best developed in the Dave Johnston deposit in the southern part of the coalfield (Fig. 1). The coal occurs near the base of the Wasatch Formation, between the School and Felix coal seams.[29]

The Badger coal is 17 to 20 feet thick, and normally is 110 to 180 feet above the School bed. The U.S. Bureau of Mines conservatively estimated the original, in-place, strippable reserve base for this bed in Converse County was 9.5 million tons.[13]

The Badger coal is mined in Glenrock Coal Co.'s Dave Johnston surface mine north of Glenrock for use in the Dave Johnston power plant at Glenrock. Its apparent rank is subbituminous C. Five analyses from the mine show:

As-received Basis	Range (5 analyses)	Average
Moisture (%)	22.7-29.3	27.4
Volatile matter (%)	31.7-34.5	33.3
Fixed carbon (%)	28.5-32.6	31.4
Ash (%)	6.6-9.8	7.9
Sulfur (%)	0.4-0.5	0.45
Btu/lb	7,610-8,290	7,950

Big George Bed - The Big George coal is a relatively newly defined deposit of coalescing coal beds in the west-central Powder River Coalfield (Fig. 4). The coal reportedly is up to 200 feet thick, averaging 113 feet in thickness.[27] This thick coal does not crop out; it only occurs in the subsurface at depths between 1,000 and 2,000 feet.[33] For this reason, the bed is not currently mined.

Because the Anderson and Canyon coal beds merge to form the Big George seam, Big George is correlative with the upper portion of the thick Wyodak coal bed of the Fort Union Formation in the Gillette area.[34]

Fig. 4. Correlation of coal beds in the Powder River coalfield

In the intervening distance between these two thick deposits, the Anderson and Canyon coals thin.[27,34] The deposit contains an estimated resource of 113 billion tons.[35]

The apparent rank of this coal is subbituminous A. An average, unweighted analysis[27] derived from 30 incremental samples of a 200-foot-thick cored portion of the bed shows:

As-received Basis	Average
Moisture (%)	22.6
Volatile matter (%)	30.5
Fixed carbon (%)	43.3
Ash (%)	3.5
Sulfur (%)	0.25
Btu/lb	9,750

C Bed - See Wasatch Beds.

Canyon Bed - The Canyon coal is a persistent, 11- to 65-foot-thick coal bed in the Fort Union Formation over most, if not all, of the coalfield. In the Gillette area of Campbell County, the Canyon and other coals coalesce with the Anderson bed to form the thick Wyodak coal. North of Gillette, the Canyon also merges locally with the Cook coal to form a 54-foot-thick bed.[30] In western Campbell County and eastern Johnson County, the Canyon merges with the Anderson coal bed to form the thick Big George coal bed.[34]

The Canyon bed has been called the E coal bed south of Gillette. While the Canyon coal also is correlative with the Monarch bed in the Sheridan area, it is not correlative with the stratigraphically higher Smith bed, as previously noted.[36,92]

Except for an estimated 184.9 million tons of strippable reserve base along Clear Creek in northwestern Campbell County, the strippable reserve base of the Canyon seam is reported with the Wyodak bed or with the Monarch and Dietz beds in the Acme-Kleenburn district in the northwestern corner of the field (Fig. 1).[13]

The nine analyses of the Canyon coal summarized below are from Campbell County.[31,32] In this part of the field, the coal's apparent rank is subbituminous C. Analyses from Sheridan County are not averaged with these because the quality of the Canyon coal bed in the two counties is quite different. (See Monarch Bed.)

As-received Basis	Range (9 core analyses)	Average
Moisture (%)	26.5-31.5	29.6
Volatile matter (%)	28.7-33.3	30.7
Fixed carbon (%)	31.8-38.4	34.6
Ash (%)	3.1-7.4	5.1
Sulfur (%)	0.14-0.92	0.34
Btu/lb	7,540-8,610	8,290

D Bed - See Anderson Bed.

Daly Bed - See Wasatch Beds.

Dietz No. 2 Bed - This coal is locally important in the Acme-Kleenburn area in the northwestern corner of the Powder River Coalfield (Fig. 1). Big Horn Coal Co. mined it as a rider coal above the Monarch and Dietz No. 3 beds. This Fort Union Formation coal averages 12 feet in thickness and previously was identified as the Armstrong coal in Big Horn's surface mine.

Analytical data on the subbituminous Dietz No. 2 coal shows:

As-received Basis	Range or typical analysis (5 analyses)
Moisture (%)	21.7-23.8
Volatile matter (%)	33.6
Fixed carbon (%)	38.5
Ash (%)	5.6-6.6
Sulfur (%)	0.74-1.02
Btu/lb	9,220-9,390

Dietz No. 3 Bed - This coal is another important strippable bed in the northwestern corner of the coalfield, where it was once extensively deep mined. It averages 10 to 25 feet in thickness. Locally the Dietz No. 3 coalesces with the underlying Monarch (Canyon) coal bed to form a 40- to 45-foot-thick coal in the Acme-Kleenburn area of Sheridan County (Fig. 1). The Dietz No. 3 also locally coalesces with the Dietz Nos. 1 and 2 coals, reaching a cumulative thickness of 75 feet.[37]

The estimated original, in-place, strippable reserve base of this Fort Union Formation coal is included with the estimate for the Monarch coal, which underlies it by a few inches to 60 feet. Collectively, the original strippable reserve base for the two coals exceeded 12.5 million tons.[13]

The Dietz No. 3 was mined along with the Monarch coal in Big Horn Coal Co.'s surface mine north of Sheridan. A typical analysis of the Dietz No. 3 in this mine is provided below.[18] Based on this analysis and analyses of the underlying Monarch coal, the Dietz No. 3 has an apparent rank of subbituminous B.

As-received Basis	Typical analysis
Moisture (%)	19.1
Volatile matter (%)	34.8
Fixed carbon (%)	41.7
Ash (%)	4.4
Sulfur (%)	0.5
Btu/lb	9,710

E Bed - See Canyon Bed.

F Bed - This Wasatch coal occurs in the Dry Cheyenne deposit in the southern portion of the Powder River Coalfield in Converse County (Fig. 1). Bed F has a maximum thickness of 11.6 feet but averages only 7.5 feet.[13]

The strippable reserve base of this bed is estimated at 179.5 million tons.[13] There are no published analyses of this coal, and it is not presently mined.

Felix Bed - This is a persistent coal bed in the northern and central portions of the Powder River Coalfield. While this Wasatch Formation coal is 5 to 21 feet thick in the northwestern part of Campbell County, it is as thick as 50 feet in the central and southern parts of Campbell County. Partings are common and fairly persistent in places. In the Caballo Creek area south of Gillette (Fig. 1), a parting up to 79 feet thick separates the Felix coal bed into an upper bed, the $Felix_1$ (5.5 to 12 feet thick) and a lower bed, the $Felix_2$ (15.4 to 31 feet thick).[38-41]

Based on various reports,[13,38-42,27] the strippable reserve base of the Felix coal in the northern and central portions of the coalfield is at least 1.9 billion tons. The coal is not currently mined.

The Felix coal has an apparent rank of subbituminous C. Analyses of 42 core samples are:[31,32]

As-Received Basis	Range	Average
Moisture (%)	17.8-33.5	28.0
Volatile matter (%)	29.1-36.4	31.7
Fixed carbon (%)	28.4-39.4	32.5
Ash (%)	4.5-14.9	7.8
Sulfur (%)	0.32-3.26	0.89
Btu/lb	7,180-9,535	8,050

Lake De Smet Bed - The Lake DeSmet coal is the thickest known coal bed in the contiguous United States. The coal occurs in north-central Johnson County, where it is reportedly as much as 250 feet thick in some drill hole descriptions.[28,44,45] Upper portions of this Wasatch coal bed, however, frequently are burned over much of its area of occurrence. The Lake De Smet bed originally was correlated with the Healy coal to the north and east.[28,46] Other studies, however, reported that the thick Lake De Smet coal at Lake De Smet represents the coalescing of five major coal beds, possibly in response to basin-margin faulting active in Eocene time.[44,45] From oldest to youngest, these seams are the Ucross, Murray, Cameron, Healy, and Walters.

The strippable reserve base of the Lake De Smet coal is 790 million tons.[13] Most of these reserves are in the vicinity of Lake De Smet or southeast of there (Fig. 1). The coal is not currently mined.

The apparent rank of the Lake De Smet coal bed is subbituminous C. Fifteen analyses of the seam show the following range in quality (none of these analyses represent more than a portion of the total bed):

As-received Basis	Range (5-15 analyses)	Average (5 analyses)
Moisture (%)	22.6-30.7	28.5
Volatile matter (%)	28.6-31.9	30.0
Fixed carbon (%)	32.8-34.8	33.9
Ash (%)	5.1-22.1	7.6
Sulfur (%)	0.26-3.00	0.6
Btu/lb	6,480-8,270	7,880

Lower Ulm Bed - See PK, Ulm 2, and Ulm 1 Beds.

Monarch Bed - The Monarch coal is one of the most important Fort Union Formation coals in the Acme-Kleenburn area in the northwestern corner of the Powder River Coalfield (Fig. 1). Although it is reportedly up to 57 feet thick, the thicker occurrences apparently equate to areas where the Monarch and Dietz No. 3 coals merge into a single bed. The Monarch coal is correlative with the Canyon coal on the eastern side of the Powder River field (Fig. 4).[36, 92]

An estimate of the original, strippable reserve base for this coal was 125 million tons. This estimate included some Dietz No. 3 tonnage as well.

Big Horn Coal Co. had been mining the Monarch coal seam. The Monarch coal is merged with the Dietz No. 3 over a large portion of Big Horn Coal's surface mine, located near the former site of Acme. Collectively, the two coals were more than 44 feet thick at this mine.

The apparent rank of the Monarch coal is subbituminous B. Various coal analyses reported by federal and state agencies are summarized below. Some of these published analyses, like the reserve estimates, probably include the Dietz No. 3 coal.

As-received Basis	Range (203 analyses)	Average
Moisture (%)	14.5-26.0	21.5
Volatile matter (%)	30.3-38.4	34.5
Fixed carbon (%)	34.9-44.0	39.6
Ash (%)	3.1-8.2	4.4
Sulfur (%)	0.3-0.7	0.4
Btu/lb	9,000-10,410	9,600

Parnell Bed - See Wasatch Beds.

PK, Ulm 2, and Ulm 1 Beds - These three Wasatch Formation coals are persistent in the Wyarno-Verona deposit in the central part of Sheridan County, where they are 4 to 52 feet thick. The Ulm 2 is also locally persistent in the Caballo Creek area south of Gillette, where it is called the Lower Ulm (Fig. 1).[38-41]

In the central part of Sheridan County, the PK coal bed, which locally splits into at least three benches, is 4 to 18 feet thick and correlates with the Ucross bed in Johnson County.[46] The Ulm 2, which occurs about 300 feet above the PK coal zone, varies from 7 to 30 feet in thickness. This seam has been correlated to the Healy coal of the Lake De Smet deposit in Johnson County (Fig. 4).[46] The Ulm 1 bed lies 60 to 200 feet above the Ulm 2 and is believed to be correlative with the Walters coal bed of Johnson County.[46] The Ulm 1 in Johnson and Sheridan counties is 14 to 52 feet thick. It is thickest where it includes several thick shale partings. All three of these beds become part of the thick Lake De Smet bed in northern Johnson County.[44,45]

A strippable reserve base of 1.8 billion tons has been estimated for these three coals in the Wyarno-Verona deposit of central Sheridan County.[46] This strippable reserve base includes 200 million tons of the PK coal, 990 million tons of the Ulm 2 coal, 543 million tons of the Ulm 1 coal, and 67 million tons of other thinner and less persistent Wasatch coals. All the coal beds included in this estimate, however, were greater than 10 feet thick and under less than 200 feet of cover.

Grazis[38-41] estimates another 43.8 million tons of strippable reserve base for the Ulm 2 bed in the Caballo Creek area of Campbell County. All the coals included in this estimate were 5 feet or greater in thickness and under less than 200 feet of cover. None of these Wasatch coal beds, in either area, currently are mined.

Analyses of these coals are few, and many were performed on badly weathered samples. Excluding all analyses where the heat values were less than 6,500 Btu/lb, analyses of the Ulm 1, Ulm 2, and PK beds are averaged below. The apparent rank is subbituminous C.

As-received Basis	Range (5 analyses)	Average
Moisture (%)	30.7-27.4	30.2
Volatile matter (%)	28.9-33.2	31.2
Fixed carbon (%)	31.0-38.4	34.3
Ash (%)	2.3-8.8	4.3
Sulfur (%)	0.3-3.2	1.5
Btu/lb	7,640-8,320	8,000

School Bed - In the southern portion of the coalfield, the School bed is a thick, persistent coal in the Dave Johnston deposit north of Glenrock (Fig. 1). The coal occurs near the base of the Wasatch, between the Anderson coal of the underlying Fort Union Formation and the Badger coal of the Wasatch Formation.[29] The School bed, which lies 110 to 180 feet below the Badger coal bed, is 22 to 38 feet thick, averaging 35 feet. The quality of the coal deteriorates to the south due to shaly partings. Northward its quality remains good.

The original strippable reserve base of this coal in Converse County was 126.2 million tons.[13] Since 1958, Glenrock Coal Co. has been mining this coal at its Dave Johnston surface mine north of Glenrock. Three analyses from this mine are given below. The apparent rank of the School bed is subbituminous C.

As-received Basis	Range (3 analyses)	Average
Moisture (%)	19.5-26.4	22.2
Volatile matter (%)	34.4-38.1	35.9
Fixed carbon (%)	28.3-33.6	30.5
Ash (%)	8.8-15.7	11.4
Sulfur (%)	0.5-0.7	0.6
Btu/lb	7,830-8,870	8,180

Scott Bed - See Wasatch Beds.

Smith Bed - The Smith bed is best developed in northwestern Campbell County (Fig. 1).[48] The bed occurs near the top of the Fort Union Formation when it has not been cut out by the Wasatch-Fort Union unconformity (Fig. 4). The Smith is not correlative with the stratigraphically lower Canyon coal bed of the Gillette area.[49]

Where it is best developed, the Smith bed is 5 to 20 feet thick.[13,48,49] In the vicinity of Spotted Horse, a local 4.5- to 13-foot-thick unnamed coal (possibly the Swartz coal bed) underlies the Smith coal seam by 30 feet. In that area, there are an estimated 178 million strippable tons of the Smith coal and another 58.3 million strippable tons of the local coal.[13] Neither of the coal seams is mined at the present time.

A single core analysis of the Smith coal bed is provided below.[32] Based on this analysis, the coal has an apparent rank of subbituminous C.

As-Received Basis	Core Analysis
Moisture (%)	31.8
Volatile matter (%)	28.7
Fixed carbon (%)	34.8
Ash (%)	4.7
Sulfur (%)	0.63
Btu/lb	7,990

Sussex District lower coal bed - A number of Fort Union Formation coals crop out in the southeastern corner of Johnson County (Fig. 1). The outcrops occur in what has been called Sussex Basin No. 4. The lower coal bed in Basin No. 4 of the Sussex district averages 11.8 feet thick, but reaches a maximum of 50 feet in places. A preliminary estimate of the strippable reserve base of this Fort Union Formation coal is 13.6 million tons.[13] This coal currently is not mined.

Based on the one analysis of the lower coal bed given below, this coal has an apparent rank of subbituminous B.[13]

As-received Basis	One analysis
Moisture (%)	23.5
Volatile matter (%)	35.6
Fixed carbon (%)	35.7
Ash (%)	5.2
Sulfur (%)	0.49
Btu/lb	9,160

Truman Bed - See Wasatch Beds.

Ulm Bed - See PK Bed.

Walters Bed - See PK Bed and Lake De Smet Bed.

Wasatch Beds - In the northwestern and central areas of Campbell County, there are a number of less well known but persistent Wasatch Formation coals. In northwestern Campbell County, these coals are, in descending order, the Truman, Parnell, Scott, and Daly beds. These coals all overlie the Felix coal bed. In the Caballo Creek area south of Gillette, the C bed is another persistent Wasatch coal, which lies 330 feet above the Felix coal bed.

All of these coals are locally 5 to 10 feet thick. At least the Truman coal bed exceeds 10 feet in thickness in the northwestern corner of the county. The thickness of the C bed also is greater than 10 feet in the Caballo Creek area.

Estimates place the strippable reserve base at 74.5 million tons for the Truman bed, 30.6 million tons for the Parnell bed, 17.9 million tons for the Scott bed, and 11.2 million tons for the Daly bed.[42,50] Another 4.8 million tons of strippable reserve base has been estimated for a local coal seam below the Felix bed. The strippable reserve base for the C coal bed is estimated at 41.8 million tons.[38-41] This coal bed commonly is 6 to 10 feet thick. None of these Wasatch Formation coals presently are being mined.

There are no analyses of these coals available, but analyses of comparable coals indicate they are probably subbituminous.

Wyodak Bed - Outcrops show this thick Fort Union Formation coal is persistent, though extensively burned, on the eastern side of Campbell County, especially in the Gillette area (Fig. 1). The coal has been called variously the Roland-Smith, Wyodak-Anderson, and Anderson-Canyon coal. Recent geologic mapping by the U.S. Geological Survey, however, shows that this coal bed does not directly correlate with the stratigraphically higher Roland coal, as previously reported.[27,30, 91-94]

The coal is 25 to 190 feet thick, and averages 100 feet.[51, 94] In the central part of the coalfield, the Wyodak coal splits westward into an Upper Wyodak, comprised of the Anderson and Canyon coal beds, and a lower and less persistent Lower Wyodak. In this area, the Upper and Lower Wyodak are each 10 to 65 feet thick. Farther west in the vicinity of the Campbell and Sheridan county line, the Upper Wyodak (Anderson and Canyon coals merged) become the Big George coal bed.[34]

To the north of Gillette, the Wyodak splits into an Upper Wyodak and Lower Wyodak.[49] The Upper Wyodak then splits into the Smith, Swartz, and Anderson coal beds, while the Lower Wyodak splits into the Canyon and Cook coals.[30] When the Wyodak splits into five or more beds, the individual coals are 3 to 38 feet thick and separated by a few feet to 200 feet of claystone, shale, or sandstone. The Wyodak also splits into the Anderson coal (D bed) and the Canyon coal (E bed) in southern Campbell County (Fig. 4).

The strippable reserve base of this Fort Union Formation coal is the largest for any single coal bed in Wyoming. Using a 200-foot cutoff depth for overburden, it is estimated that the remaining strippable reserves are 17.9 billion tons.[83] The strippable reserve base of the Wyodak in just the Caballo Creek area of Campbell County are estimated at 1.4 billion tons.[38-41]

This is the only coal bed mined in the Gillette area. Its apparent rank is subbituminous C. Fifty-nine analyses of the Wyodak coal in the Gillette area are summarized as:

As-received Basis	Range (59 analyses)	Average
Moisture (%)	21.1-36.9	29.8
Volatile matter (%)	26.5-35.5	30.7
Fixed carbon (%)	29.6-41.4	33.5
Ash (%)	3.9-12.2	6.0
Sulfur (%)	0.2-1.2	0.5
Btu/lb	7,420-9,600	8,220

Green River Coalfield

The Green River Coalfield, which is the state's largest coalfield, covers about 15,400 square miles of southwestern Wyoming (Fig. 1). The field coincides with the Greater Green River Basin. The more important coals crop out on the flanks of the Rock Springs uplift in the central part of the field, on the eastern margin of the field, and in the Red Desert Basin in the northeastern corner of the field. Dips in this coalfield are small except around the Rock Springs uplift and along the field's eastern margin. Dips on the western side of the Rock Springs uplift are up to 20 degrees, and on the eastern side of the uplift, 10 degrees. Along the eastern margin of the coalfield, dips are 20 to 50 degrees in some areas.

The apparent rank of outcropping coals are subbituminous B to high-volatile C bituminous. The higher rank coals, which are Cretaceous in age, crop out on the eastern margins of the coalfield, as well as around the Rock Springs uplift.

The field's in-place coal resources have been estimated at 237.11 billion tons.[3] Coal beds in the field occur in the Frontier Formation, Mesaverde Group, and Lance Formation of Upper Cretaceous age, the Fort Union Formation of Paleocene age, and the Wasatch of Eocene age (Fig. 3). While coals of the Mesaverde Group (Rock Springs Formation) were once the most important, that importance has waned with the more recent mining of younger beds in the Lance, Fort Union, and Wasatch formations. Coal-bearing strata in the Green River Coalfield are largely concealed by younger rocks.

Fig. 5 shows the bed designations for the coals in the Rock Springs Formation on the flanks of the Rock Springs uplift. Coals in that formation are bituminous and up to 13.8 feet thick.

Except on the southwestern side of the Rock Springs uplift, coals occur in the Almond Formation of the Mesaverde Group where it crops out around the uplift. These bituminous coals have not been mined extensively, but they are reportedly up to 13.1 feet thick on the east side of the uplift.[52]

Fig. 5. Coal nomenclature for the Rock Springs Formation of the Green River Coalfield

Although coals in the Fort Union Formation are some of the thicker and more persistent coals in the field, they were not mined extensively until 1974, when the Jim Bridger surface mine opened on the Deadman coal. The seam is up to 30 feet thick in that area. South of the Bridger mine, up to five Fort Union coals have been identified and mapped.[52-55] In descending order, these beds are the Leaf, Big Burn (Nuttal), Hail, Washout, and Little Valley (Deadman). Each of these coals is locally greater than 5 feet thick. The Big Burn and Little Valley beds are up to 9 feet and 15 feet thick, respectively. All these coals apparently are subbituminous.

Wasatch coals of the Red Desert deposit (Fig. 1) in the northwestern corner of the Green River Coalfield are designated, from youngest to oldest: Battle No. 3, Battle No. 2, Monument No. 1, Sourdough-Monument-Teirney seams, Hadsell No. 2, Creston No. 3, Creston No. 2, and Latham No. 3.[56,57] These coal beds are lenticular and grade into shale to the east and west. An average, as-received analysis of these subbituminous coals shows a moisture content of 21%, an ash content of 16%, a sulfur content of 2.5%, and a heat value of 7,900 Btu/lb.[13] Analyses of drill core samples of these beds by the Fischer assay method show that they yield from 7.8 to 25.2 gallons of oil per ton. Also, the uranium content of these coals is between 0.001 and 0.009% U_3O_8. These coals contain more than 55 million pounds of uranium with U_3O_8 content equal to or greater than 0.003%.[56,57]

Two Wasatch coals in the Cherokee deposit just south of the Red Desert deposit also reach minable thicknesses. These coals, called the Upper and Lower Cherokee coal beds, average 11 feet and 25 feet in thickness, respectively.

Important Seams of the Green River Coalfield

Almond Formation Beds - Recent mapping shows as many as 18 relatively persistent, mappable coals in the Almond Formation on the southeastern flank of the Rock Springs uplift.[52,54]

It has been estimated[52-55] there is 5.56 billion tons of coal in the Almond Formation along the flanks of the Rock Springs uplift. This coal resource only includes coals greater than 2.5 feet thick and under less than 3,000 feet of cover. It is further estimated that 5 to 10% of that resource may be strippable. Detailed resource estimates for more than 828 million tons of Almond Formation coal, of which almost 54 million tons are within strippable limits (under less than 200 feet of cover), have been published.[52,54] These reports, however, represent a very small portion of the total resource area.

The Black Butte and Salt Wells areas in Fig. 1 indicate where most of the potentially strippable reserves of these Almond coals occur. A report published in 1983 provides the results of a nine-hole drilling project in this area.[58]

Based on the analyses given below, the Almond Formation coals on the southeastern flank of the Rock Springs uplift have an apparent rank of high-volatile C bituminous.

As-received Basis	Range (29 analyses)	Average
Moisture (%)	9.6-18.0	12.6
Volatile matter (%)	26.4-33.3	30.6
Fixed carbon (%)	35.8-53.6	47.4
Ash (%)	2.1-27.9	9.5
Sulfur (%)	0.44-2.82	0.8
Btu/lb	8,510-12,070	10,770

In the Leucite Hills deposit, three of five Almond Formation coals are mined. These coals, designated A2, A3, and A4, average 6.5 feet, 3.7 feet, and 4 feet thick, respectively. The original, in-place strippable reserves on the mine property were 168 million tons. The apparent rank of these Almond coals is subbituminous A to high-volatile C bituminous.

As-received Basis	Range of all three beds	Average of all three beds
Moisture (%)	15.5-28.0	18.5
Volatile matter (%)	28.7-32.5	30.8
Fixed carbon (%)	39.4-46.7	44.4
Ash (%)	3.27-13.4	6.4
Sulfur (%)	0.28-1.18	0.51
Btu/lb	7,210-10,670	9,970

B and C Beds - See Upper and Lower Cherokee Beds.

Battle No. 1 and Battle No. 2 Beds - These two subbituminous B coals crop out in the Red Desert deposit in the northwestern corner of the coalfield (Fig. 1). They occur in the Wasatch Formation and average between 6.4 and 8.6 feet in thickness, respectively. The strippable reserve base of these two beds is 38.1 million tons.[13] A typical analysis of the Battle No. 1 bed is:

As-received Basis	Typical Analysis
Moisture (%)	21.9
Volatile matter (%)	29.9
Fixed carbon (%)	37.0
Ash (%)	11.2
Sulfur (%)	1.9
Btu/lb	8,650

Creston No. 2 and No. 3 Beds - These coals are in the Wasatch Formation. They crop out in the Red Desert deposit in the east-central part of the field, where they average about 18 feet in thickness. They are subbituminous B in apparent rank. The strippable reserve base of these beds is 125.6 million tons.[13] A typical analysis of the Creston No. 2 bed is:

As-received Basis	Typical Analysis
Moisture (%)	20.7
Volatile matter (%)	32.2
Fixed carbon (%)	34.4
Ash (%)	12.7
Sulfur (%)	1.8
Btu/lb	8,710

Deadman Bed - The Deadman coal of the Fort Union Formation is exceptionally well developed in the Jim Bridger deposit on the northeastern flank of the Rock Springs uplift. There, the Deadman coal is 30 feet thick, except where it splits into as many as five thinner beds, designated the D-5 through D-1 in descending order. The Deadman coal can be traced southward into the Black Butte area of the uplift (Fig. 1), and is equivalent to the Little Valley bed.[53,55,57,59] In this area the Little Valley bed reportedly is as thick as 15 feet. It is yet unclear if the Little Valley bed is correlative with all five splits of the Deadman coal bed in the Jim Bridger deposit.

The remaining strippable reserve base of the Deadman coal bed is approximately 151.2 million tons.[13] The seam now is being surface mined. Analyses of the Deadman coal bed, which has an apparent rank of subbituminous B, show:

As-received Basis	Range (4 analyses)	Typical Analysis
Moisture (%)	17.0-20.5	20.5
Volatile matter (%)	29.1-32.6	29.1
Fixed carbon (%)	40.7-42.0	40.7
Ash (%)	5.9-10.0	9.7
Sulfur (%)	0.36-0.77	0.47
Btu/lb	9,270-10,000	9,350
HGI	79-82	

Fort Union Formation Beds - As many as five relatively persistent Fort Union coals crop out on the southeastern side of the Rock Springs uplift.[53,55,57,59] These coals occur in an interval that has been termed the Black Rock Coal Group. In descending order, the coals are named the Leaf, Big Burn, Hail, Washout, and Little Valley beds. At least locally, all these beds exceed five feet in thickness. The Big Burn coal reaches 9 feet in thickness, while the Little Valley is up to 15 feet thick. Northward, the Little Valley bed correlates with the Deadman bed of the Black Butte and Bridger deposits (Fig. 1). The Big Burn coal tentatively is correlated with the Nuttal bed of the Black Butte deposit.[52]

Detailed resource estimates have been made for about 885 million tons of coal in the Fort Union Formation in a small area on the southeast side of the Rock Springs uplift. Again, the resource is comprised of coals greater than 2.5 feet in thickness and under less than 3,000 feet of cover. It is estimated that more than 40 million tons of that resource is under less than 200 feet of cover and would therefore qualify as a strippable resource.[52-54]

Analyses of four 5- to 10-foot-thick Fort Union Formation coals in this area are summarized below[58] (the apparent rank of these coals is high-volatile C bituminous):

As-received Basis	Range (4 analyses)	Average
Moisture (%)	10.9-15.9	13.4
Volatile matter (%)	28.0-31.2	30.3
Fixed carbon (%)	44.7-47.8	46.6
Ash (%)	8.0-12.1	9.7
Sulfur (%)	0.70-1.07	0.8
Btu/lb	10,210-10,860	10,380

Hadsell No. 2 Bed - Another Wasatch coal that crops out in the Red Desert deposit in the northeastern part of the Green River Coalfield (Fig. 1), this coal is subbituminous B in rank and averages 7.7 feet thick. There are 39.8 million tons of strippable reserve base estimated for this bed.[13]

As-received Basis	Typical Analysis
Moisture (%)	21.0
Volatile matter (%)	31.0
Fixed carbon (%)	32.2
Ash (%)	13.8
Sulfur (%)	2.7
Btu/lb	8,250

Lance Formation Beds - Subbituminous coals of the Lance Formation are known as the Black Butte Coal Group. Where they crop out on the northeastern and eastern sides of the Rock Springs uplift, several small underground mines worked 4- to 9.6-foot-thick coals in the early 1900s (Fig. 1). Mining has resumed on some Lance coals in the Black Butte strippable deposit.[60] In that deposit, the minable coals, in decending order, are the Overland, Gibraltar, Black Butte, Maxwell, and Hall beds. All five of these coals are 4 to 10 feet thick. Farther south, the French and Bluff beds reach 6.5 and 8.4 feet in thickness, respectively. These two beds are correlative with the Maxwell and Hall beds.

In the Black Butte area, the Overland coal is the highest minable coal in the Lance Formation. However, it is seldom more than 4 feet thick. Locally the Overland bed contains shaly partings that raise its ash content to as high as 31%, and lower its heat value to less than 6,900 Btu/lb. More typically, the ash is in the 5 to 7% range and its heat value nearer 9,650 Btu/lb. The Gibraltar bed usually is only 4 to 5 feet beneath the Overland bed, with a maximum reported thickness of 8 feet.

The next lower bed is the Black Butte bed, which averages 5 to 6 feet thick, except where it coalesces with the underlying Maxwell bed to form a coal that is 16 to 22 feet thick. The normal interval between these two beds is 25 feet. The Maxwell coal bed averages 5.5 feet in thickness when it isn't merged with the overlying Black Butte seam.

The Hall bed is the lowest minable seam in the Lance Formation in the Black Butte deposit. It is up to 10 feet thick.

The Black Butte deposit contains an estimated 88.5 million tons of strippable reserve base when tonnages for the coal beds in the Almond, Lance, Fort Union and Wasatch formations are combined. Roehler[53,54] delimits almost 268 million tons of in-place coal resources for the French and Bluff beds south of the Black Butte area. These resources only include coals under less than 3,000 feet of cover and more than 2.5 feet thick. Almost 7 million tons of that resource is strippable.

The Lance Formation coals on the southeast flank of the Rock Springs uplift have an apparent rank of subbituminous B. Analyses of these coals show:

As-received Basis	Range	Average
Moisture (%)	17.5-21.0	20.1
Ash (%)	4.1-6.0	4.9
Sulfur (%)	0.40-1.08	0.69
Btu/lb	9,650-10,110	9,850

Latham No. 3 and No. 4 Beds - The Latham beds are best developed in the Red Desert deposit in the northeastern part of the coalfield (Fig. 1). These beds occur in the Wasatch Formation and are subbituminous B in apparent rank. Average thicknesses are 5.7 feet. The strippable reserve base of the two coals totals 70.7 million tons.[13] A typical analysis of the Latham No. 3 coal is:

As-received Basis	Typical Analysis
Moisture (%)	22.6
Volatile matter (%)	30.9
Fixed carbon (%)	31.2
Ash (%)	15.3
Sulfur (%)	5.4
Btu/lb	7,980

Lebar Bed- This Almond Formation coal crops out in the Black Butte area on the southeastern flank of the Rock Springs uplift, where it averages 8 to 12 feet in thickness. There are plans to mine the Lebar bed, along with the overlying C and D beds. The apparent rank of these coals is subbituminous A to high-volatile C bituminous. The Lebar bed correlates with the Mourning Dove coal,[52,55] which is discussed in the above section on Almond Formation coals. A typical analysis of the Lebar bed is:

As-received Basis	Typical Analysis
Moisture (%)	17.5
Ash (%)	7.6
Sulfur (%)	0.57
Btu/lb	10,000

Little Valley Bed - See Deadman Bed.

Rock Springs No. 1 Bed - This coal crops out on the west and north flanks of the Rock Springs uplift where it is still periodically mined underground (Figs. 1,5). Analyses of this Rock Springs Formation coal, to include some recent analyses,[61] are summarized below. The apparent rank of this coal is high-volatile C bituminous.

As-received Basis	Range Analysis
Moisture (%)	8.5-17.6
Volatile matter (%)	34.5-36.5
Fixed carbon (%)	43.9-50.4
Ash (%)	4.0-6.0
Sulfur (%)	0.8-1.0
Btu/lb	10,480-11,830

Rock Springs No. 3 Bed - This coal in the Upper Cretaceous Rock Springs Formation was deep mined near Rock Springs (Figs. 1,5). The bed, at least locally, exceeds 11 feet in thickness, and has an apparent rank of high-volatile C bituminous. An analysis of this coal shows:[61]

As-received Basis	One Analysis
Moisture (%)	16.7
Volatile matter (%)	35.7
Fixed carbon (%)	45.4
Ash (%)	2.2
Sulfur (%)	0.9
Btu/lb	10,520
HGI	52

Rock Springs No. 7 Bed - This coal averages 4.5 feet in thickness, is high-volatile C bituminous in apparent rank[61], and occurs in the Rock Springs Formation of the Mesaverde Group on the west and north flanks of the Rock Springs uplift (Figs. 1,5). This bed also has some coking properties. The No. 7 bed is still deep mined intermittently in Sweetwater County.

As-received Basis	Range (17 samples)	Average
Moisture (%)	5.0-16.5	10.1
Volatile matter (%)	33.8-40.3	37.2
Fixed carbon (%)	44.3-52.6	48.1
Ash (%)	2.4-6.4	4.5
Sulfur (%)	0.6-1.1	0.8
Btu/lb	10,640-13,110	11,660
HGI	48-54	51

Rock Springs No. 11 Bed - The apparent rank of the No. 11 coal is high-volatile C bituminous. The bed is 44 to 54 inches thick, and averages 48 inches. It is an important coal on the west and north flanks of the Rock Springs uplift (Figs. 1,5). This bed, which is in the Rock Springs Formation, also has some coking properties.

As-received Basis	Range Analysis
Moisture (%)	6.56-8.46
Volatile matter (%)	38.42-39.74
Fixed carbon (%)	47.69-48.55
Ash (%)	4.57-6.69
Sulfur (%)	0.7
Btu/lb	12,380-12,570

Sourdough-Monument-Tierney Beds - This coal zone in the Red Desert deposit in the northeastern corner of the field (Fig. 1) is comprised of up to five coals that all occur at about the same horizon in the Wasatch Formation. Because these beds sometimes coalesce with one another, separation of the coals into individual beds is not always possible. In places, each of these coals exceeds 5 feet in thickness. The strippable reserve base of these unmined seams is 458.9 million tons.[13] A typical analysis of the Sourdough No. 2 bed is:

As-received Basis	Typical Analysis
Moisture (%)	23.2
Volatile matter (%)	33.6
Fixed carbon (%)	33.0
Ash (%)	10.2
Sulfur (%)	2.9
Btu/lb	8,680

Upper and Lower Cherokee Beds - These two unmined coals occur in the Wasatch Formation. They reach their maximum development in the Cherokee deposit in the east-central part of the coalfield (Fig. 1). The Upper Cherokee, or B bed, is 10 to 18 feet thick and normally has a 1- to 2-foot parting. The Lower Cherokee, or C bed, which is 40 to 70 feet below the upper bed, is 20 to 32 feet thick. It has a 1- to 1.5-foot parting. In places these two coals coalesce into a single 30- to 40-foot-thick bed, with a parting up to 4 feet thick. The apparent rank of these coals is subbituminous A. Collectively, the strippable reserve base of these coals is 200.9 million tons.[13]

As-received Basis	Range Analysis
Moisture (%)	15-25
Volatile matter (%)	28-36
Fixed carbon (%)	27-40
Ash (%)	10-25
Sulfur (%)	0.5-5.0
Btu/lb	5,010-9,000

Ute Bed - The Ute bed is a Fort Union Formation coal that occurs about 55 feet below the Deadman bed in the Black Butte area of the Rock Springs uplift (Fig. 1). It is up to 7 feet thick and may be mined in the near future. The coal is subbituminous in rank.

Wasatch Formation Beds (exclusive of the Red Desert and Cherokee deposits) - Wasatch coals in the Black Butte area of Sweetwater County (Fig. 1) reportedly average 6 to 8 feet thick.[60] The reserve base for these Wasatch Formation coals is included with the estimate given in the above discussion of Lance Formation coals.

Analyses of the Wasatch coals that crop out on the flanks of the Rock Springs uplift show:

As-received Basis	Average or Range
Moisture (%)	19.3-19.6
Volatile matter (%)	33.0
Fixed carbon (%)	40.4
Ash (%)	7.2-8.1
Sulfur (%)	0.74-1.5
Btu/lb	8,770-9,610

Hanna Coalfield

Coal-bearing rocks of the Hanna Coalfield crop out in a 750-square mile area of Carbon County in south-central Wyoming (Fig. 1). Most simply, the Hanna field occupies a structural trough that is divided into two separate basins by a northeast-southwest trending anticline. The Hanna Basin lies to the northwest of the anticline, while the Carbon Basin lies to the southeast. The Hanna Coalfield is bounded on the north, west, and south by mountain ranges. Faulting is common in the field.

The in-place coal resources in the Hanna Coalfield are an estimated 23.27 billion tons.[3] Coal beds occur in the Mesaverde Group and Medicine Bow Formation of Upper Cretaceous age, the Ferris Formation of Upper Cretaceous and Paleocene age, and the Hanna Formation of Paleocene and Eocene age (Fig. 3). Fig. 6 provides the coal bed names for the Hanna and Ferris formations.

The apparent rank of outcropping coals in the Mesaverde Group and the Medicine Bow Formation is subbituminous C to high-volatile C bituminous. While Ferris Formation coals are subbituminous A to high-volatile C bituminous, outcropping coals of the Hanna Formation have apparent ranks as high as high-volatile C bituminous.[7,15,62,63]

The remaining strippable reserve base is an estimated 566.1 million tons in the Hanna field.[83] Of that reserve base, Hanna coals account for 352.7 million tons; Ferris coals, 196.3 million tons; and Mesaverde and Medicine Bow coals, 17.08 million tons.

Important Seams of the Hanna Coalfield

Bed No. 25 - This Ferris Formation coal is 5 to 12 feet thick (Fig. 6). It was strip mined on the west side of the coalfield, where it was called Bed No. 21 by the mining company. Of Paleocene age, the bed has an apparent rank of subbituminous A to high-volatile C bituminous.

As-received Basis	Range (10 samples)	Average
Moisture (%)	11.05-16.77	14.1
Volatile matter (%)	31.50-34.39	32.8
Fixed carbon (%)	43.88-45.58	44.6
Ash (%)	6.07-13.09	8.5
Sulfur (%)	0.21-0.74	0.4
Btu/lb	9,095-10,290	9,750

Bed No. 28 - This Paleocene Ferris Formation coal is 4.5 to 18 feet thick (Fig. 6). Where it was mined in the western part of the field, it was called Bed No. 24. The bed has an apparent rank of subbituminous A to high-volatile C bituminous.

As-received Basis	Range (9 samples)	Average
Moisture (%)	9.52-16.00	11.53
Volatile matter (%)	33.82-36.54	34.95
Fixed carbon (%)	45.80-49.59	47.57
Ash (%)	3.90-17.85	5.95
Sulfur (%)	0.21-0.74	0.31
Btu/lb	8,570-11,480	10,080
HGI	47 (1 sample)	

30 Series Beds - Beds 30, 31, and 32 are Paleocene in age. These coals occur in the lower third of the Ferris Formation and were mined together on the west side of the coalfield (Fig. 6). Locally they coalesce with one another. Bed No. 30, the lowermost bed, is 5 to 8 feet thick; Bed No. 31, the middle bed, is 5 to 18 feet thick; and Bed No. 32, the uppermost bed, usually is less than 4 feet thick. These coals were called benches of Bed No. 25 by one mining company. The apparent rank of these coals is subbituminous A to high-volatile C bituminous.

As-received Basis	Range (17 samples)	Average
Moisture (%)	10.92-18.90	14.03
Volatile matter (%)	31.99-37.69	34.53
Fixed carbon (%)	40.65-50.31	45.48
Ash (%)	3.95-15.68	5.96
Sulfur (%)	0.22-0.58	0.45
Btu/lb	8,340-10,650	10,180
HGI	50-66 (2 samples)	

Bed No. 50 - This Paleocene coal occurs near the middle of the Ferris Formation (Fig. 6). The bed was mined west of Hanna, where it is 5 to 22 feet thick. The apparent rank of Bed No. 50 is subbituminous A to high-volatile C bituminous.

As-received Basis	Range (4 samples)	Average
Moisture (%)	11.30-15.73	12.50
Volatile matter (%)	31.72-35.75	33.93
Fixed carbon (%)	41.97-48.45	44.29
Ash (%)	6.74-15.20	9.29
Sulfur (%)	0.30-0.63	0.42
Btu/lb	8,460-10,540	9,640
HGI	45 (1 sample)	

50 Series Beds (exclusive of Bed No. 50) - Bed Nos. 51 and 54 were mined in the western part of the field, where they are 5 to 10 feet thick and 5 to 15 feet thick, respectively (Fig. 6). Bed No. 51 is called Bed No. 53 by the mining company. The apparent ranks of these Paleocene-age coals is subbituminous A to high-volatile C bituminous.

As-received Basis	Range (14 samples)	Average
Moisture (%)	9.38-17.84	12.06
Volatile matter (%)	31.10-36.67	34.40
Fixed carbon (%)	39.20-48.14	45.89
Ash (%)	5.60-17.20	7.67
Sulfur (%)	0.47-1.30	0.52
Btu/lb	8,310-10,930	10,230

60 Series Beds - Beds 60, 61, 62, 63 and 64 all are mined in the western portion of the field. These Paleocene coals are 4 to 11 feet thick. Beds 62, 63, and 64 were usually called Beds 63, 64, and 65,by the mining company in this area. These Ferris Formation coals are high-volatile C bituminous in apparent rank.

As-received Basis	Range (16 samples)	Average
Moisture (%)	8.2-12.9	10.8
Volatile matter (%)	33.5-39.3	35.4
Fixed carbon (%)	37.5-46.9	44.2
Ash (%)	6.5-20.8	9.6
Sulfur (%)	0.28-0.73	0.57
Btu/lb	9,140-11,750	10,400

Fig. 6. Coal nomenclature: Hanna and Ferris formations of the Hanna Coalfield

Bed No. 65 - This Paleocene bed is subbituminous A to high-volatile C bituminous in apparent rank. It was mined in the western part of the Hanna Coalfield where it is 5 to 12 feet thick. One mining company referred to it as Bed No. 66. It occurs in the Ferris Formation (Fig. 6).

As-received Basis	Range (11 samples)	Average
Moisture (%)	8.96-15.44	11.98
Volatile matter (%)	33.58-39.69	35.55
Fixed carbon (%)	36.86-49.04	46.29
Ash (%)	4.55-10.69	6.18
Sulfur (%)	0.29-0.79	0.55
Btu/lb	9,770-11,280	10,670

70 Series Beds - Beds 74, 76, and 79 are mined in the central part of the field. These Paleocene coals occur in the Hanna Formation (Fig. 6), where they are 5 to 11 feet, 7 to 28 feet, and 5 to 23 feet thick, respectively. The apparent rank of the 70 Series beds is high-volatile C bituminous.

As-received Basis	Range (7 samples)	Average
Moisture (%)	8.14-16.51	10.73
Volatile matter (%)	34.29-39.70	36.74
Fixed carbon (%)	26.24-47.30	41.79
Ash (%)	5.73-21.33	10.74
Sulfur (%)	0.60-2.29	1.18
Btu/lb	9,680-11,105	10,500

Bed No. 80 - Bed No. 80, a Paleocene coal of the Hanna Formation (Fig. 6), has an apparent rank of high-volatile C bituminous. This bed is 5 to 26 feet thick and generally has a 1- to 1.5-foot parting 2 to 5 feet above its base. It is both stripped and deep mined in this coalfield.

As-received Basis	Range (17 samples)	Average
Moisture (%)	5.97-15.44	10.83
Volatile matter (%)	35.03-47.34	39.23
Fixed carbon (%)	35.65-50.92	43.68
Ash (%)	4.40-15.83	6.27
Sulfur (%)	0.48-1.24	0.98
Btu/lb	9,940-12,600	11,000
HGI	47-50	

Bed No. 82 - This bed, presently being mined, is possibly an Eocene coal in the Hanna Formation. Its apparent rank is high-volatile C bituminous, and it averages 9 feet in thickness.

As-received Basis	Range (15 samples)	Average
Moisture (%)	6.51-20.75	11.90
Volatile matter (%)	31.28-43.78	37.08
Fixed carbon (%)	36.56-48.08	42.46
Ash (%)	4.29-13.20	8.56
Sulfur (%)	0.35-1.94	1.35
Btu/lb	9,105-12,150	10,620
HGI	50	

Brooks Bed - The Brooks bed is a Paleocene coal lying near the base of the Hanna Formation. Between 5 and 8 feet in thickness, this seam has been strip mined. Its apparent rank is high-volatile C bituminous.

As-received Basis	Range (7 samples)	Average
Moisture (%)	8.89-13.67	12.34
Volatile matter (%)	32.45-36.74	34.02
Fixed carbon (%)	46.46-49.92	48.10
Ash (%)	4.29-7.00	5.54
Sulfur (%)	0.25-0.70	0.60
Btu/lb	10,395-11,180	10,860
HGI	48-51	49

Hanna No. 1 Bed - Although this Hanna Formation coal is not now mined, it has been deep mined extensively in the past (Fig. 6). The bed is 4 to 27 feet thick and has an apparent rank of high-volatile C bituminous. It was converted into a low-Btu gas at a now defunct in-situ gasification site south of Hanna.

As-received Basis	Range (20 samples)	Average
Moisture (%)	6.30-15.65	12.05
Volatile matter (%)	32.65-43.39	39.33
Fixed carbon (%)	34.09-45.26	41.71
Ash (%)	4.17-23.76	6.90
Sulfur (%)	0.29-1.02	0.50
Btu/lb	8,660-11,480	10,740

Hanna No. 2 Bed - This Paleocene coal has an apparent rank of high-volatile C bituminous. Although it was deep mined extensively in the past, it also was surface mined near Hanna. The Hanna seam, 5 to 38 feet thick, occurs in the Hanna Formation.

As-received Basis	Range (20 samples)	Average
Moisture (%)	9.10-17.20	11.58
Volatile matter (%)	33.20-42.58	39.26
Fixed carbon (%)	39.33-44.90	42.61
Ash (%)	3.80-16.33	6.65
Sulfur (%)	0.21-0.80	0.48
Btu/lb	9,990-11,390	10,910
HGI	48	

Hanna No. 5 Bed - This bed, which was strip mined in the central part of the coalfield, is a Paleocene-age coal in the Hanna Formation. It is 5 to 31 feet thick but splits into a number of benches. It has an apparent rank of subbituminous A to high-volatile C bituminous.

As-received Basis	Range (4 samples)	Average
Moisture (%)	10.30-20.56	13.82
Volatile matter (%)	36.30-38.90	37.45
Fixed carbon (%)	37.20-47.30	42.70
Ash (%)	5.60-6.70	6.04
Sulfur (%)	0.34-0.60	0.47
Btu/lb	8,880-11,190	10,540

Hams Fork Coalfield

The Hams Fork Coalfield of western Wyoming includes portions of Lincoln, Teton, and Uinta counties, and is the fifth largest coalfield in the state. As defined, the Hams Fork Coalfield is limited to those portions of the Thrust Belt underlain by coal-bearing rocks of the Bear River, Frontier, Adaville, Blind Bull, and Evanston formations. Fig. 1 shows the approximate location of these coal-bearing rocks.

Structurally, the Hams Fork Coalfield is very complex. Folded Paleozoic and Mesozoic rocks are thrust eastward over folded Cretaceous rocks, with the younger Cretaceous and Tertiary rocks of the area resting unconformably on top of these older rocks. The coal-bearing strata of the Hams Fork field now crop out in long, narrow belts bounded by major thrust faults or eroded limbs of folds. These same faults and folds form the Salt River and Wyoming ranges of western Wyoming.

For the most part, coal-bearing rocks crop out between the north-south-trending ranges common to this field. The coal strata usually dip westward at 16 to 80 degrees. The southwestern portion of the field occurs within the Fossil Basin, which is bounded by the Absaroka Thrust to the east and the Medicine Butte Thrust on the west. Coal-bearing rocks in this part of the field generally are buried beneath younger rocks that are barren of coals. In the vicinity of Almy, minable coals crop out with easterly dips of 10 to 20 degrees.

Faults are common in the Hams Fork Coalfield, particularly thrust faults. These faults are thrust eastward and usually strike north-south, although they do locally change direction. The Absaroka and Darby Thrusts are the largest. These thrust faults each extend nearly the entire 170-mile length of the coalfield. In the southern third of the Hams Fork Coalfield, these two faults often are covered by younger, unfaulted rocks. Stratigraphic throw on the thrust faults in the Thrust Belt generally is 10,000 to 20,000 feet.

High-angle faults also are common, particularly in the western part of the field. Both normal and reverse faults occur with stratigraphic throws between a few hundred feet to several thousand feet.[64]

Collectively, coal-bearing strata account for more than 9,000 feet of the estimated 20,000 feet of post-Jurassic rocks in the Hams Fork Coalfield. In-place coal resources within these strata have been estimated at 49.61 billion tons.[3] The most important coals occur in the Frontier and Adaville formations of Upper Cretaceous age. In a few places, minable coals also occur in the Paleocene-age Evanston Formation and the Lower Cretaceous-age Bear River Formation (Fig. 3).

In Uinta and southern Lincoln County, Bear River coals locally reach minable thicknesses; they were prospected and mined on a very small scale in the late 1800s.

The economic value of coals in the Bear River Formation cannot be evaluated from the sparse data that are available. No coal analyses are reported in published references, and the coal outcrops have not been mapped. Additionally, the existence of Bear River coals in northern Lincoln County and southernmost Teton County is not documented.

The 2,000- to 2,200-foot-thick Frontier Formation is the oldest significant coal-bearing unit in the Hams Fork Coalfield. The formation consists of alternating shales, sandstones, clays and coals. The apparent rank of Frontier Formation coals is high-volatile C bituminous to high-volatile A bituminous.

Although coal thicknesses do not compare with some of the thicker coals in the Adaville Formation, Frontier coals in southern Lincoln and Uinta counties are persistent and higher in rank. Although the Main Kemmerer coal bed is up to 20 feet thick, most Frontier coal seams are less than 6 feet thick. Minable coals occur throughout most of the Frontier Formation.[21,65]

In the southeastern portion of the coalfield, the Kemmerer, Willow Creek and Spring Valley groups are traceable along outcrop for more than 60 miles. Correlation of individual coal beds within these zones, however, is somewhat questionable. Collectively, these coal groups contain as many as nine minable beds (Fig. 7). A fourth coal group, the Lower Carter Group, occurs near the base of the Frontier Formation and is locally important at least several miles south and east of Kemmerer. This lowermost zone apparently is characterized by a single coal bed.

To date, most coal production from the Frontier Formation has come from the east-central part of the coalfield near Kemmerer. Although Frontier coals have been deep mined extensively in this field, there are no active mines on Frontier coal beds. The last coal mine in the Frontier Formation was Kemmerer Coal Co.'s Brilliant No. 8 deep mine on the Main Kemmerer coal bed. This mine closed in 1964.

In the northern part of the Hams Fork Coalfield, minable coals occur in the Upper Cretaceous Blind Bull Formation.[66] In the northern half of the field, the basal portion of this formation is equivalent in age to the Frontier Formation. The Vail coal bed in the Blind Bull Formation is more than 10 feet thick and has an apparent rank of high-volatile B bituminous.

The Upper Cretaceous Adaville Formation is unquestionably the most important coal-bearing formation in the Hams Fork field. Ranging from 2,900 to 4,500 feet thick, the basal 1,200 feet of interbedded shales, claystones, and sandstones of this formation contain up to 32 subbituminous coals, many of which are much thicker than other Upper Cretaceous coals in Wyoming.[4]

Adaville Formation coals crop out in three elongate basins in the southeastern and east-central portions of the field over a combined distance of more than 60 miles. Dips in these three basins generally are westward at 17 to 45 degrees. Because all the Adaville coals in this area thicken, thin, split, and coalesce over very short distances, correlation of individual beds within the formation is extremely difficult.[4] The apparent rank of Adaville Formation coals is subbituminous C to subbituminous A.

The thickest and greatest number of Adaville coal beds occur in the central basin west of Kemmerer (Fig. 1). In that basin, at least eight coals exceed 10 feet in thickness, while another seven beds range between 4 and 8 feet thick (Fig. 8). The thickest bed, the Adaville No. 1, is locally 118 feet thick.[67]

In the northernmost basin, the Adaville coals evidently are thin and decrease in number. Little information is available for that area or for the southernmost basin, which apparently also has fewer coals than the central basin. Coals in the southern basin reportedly are 7 to 30 feet thick in places.[65,68]

To date, most Adaville coal production has come from the central basin west of Kemmerer. Although the Adaville coals have been deep mined in the past, most of Adaville production came from Kemmerer Coal Co.'s open pit mine, which opened on the Adaville No. 1 bed in 1950, and on stratigraphically higher Adaville coals in 1963. Presently, there are two active open pit coal mines on the Adaville coals: Pittsburg & Midway's Kemmerer mine and FMC Corp.'s Skull Point mine. These two mines are the only active coal mines in the Hams Fork Coalfield.

Although Veatch[65] states that the Evanston Formation underlies most of the Fossil Basin, Evanston coals reportedly only crop out in fault blocks near Almy, north of Evanston. The upper few hundred feet of the Evanston Formation in that area contains at least five subbituminous coals that are 6 to 18 feet thick. According to Veatch,[65] all but the Almy coal bed contained too many rock partings for efficient mining. Portions of the thick Almy coal bed were clean enough that at least 2.7 million tons were deep mined between 1869 and 1905, when the last mine closed.

The apparent rank of the Almy coal bed is subbituminous A to high-volatile C bituminous.

Important Seams of the Hams Fork Coalfield

Adaville No. 1 Coal - This coal is the lowermost Adaville Formation coal and generally sits almost on top of the Lazeart Sandstone (Fig. 8). Although it varies in thickness and is locally split, the Adaville No. 1 apparently is the most persistent and thickest of the Adaville coals. The seam reportedly reaches 118 feet in thickness in some areas.[67] Commonly, it averages 74 to 84 feet thick in the central basin, where it is best developed. If the Adaville No. 1 is correlative with the lowest Adaville coal in the southern basin, it is still 30 feet thick in that area.[68] Presently, Pittsburg & Midway's Kemmerer mine and FMC Corp.'s Skull Point mine are producing from this coal bed.

Twenty-five published analyses of the Adaville No. 1 coal bed are summarized below. Six of these analyses were performed on channel samples (only one channel represents the entire bed thickness); the other 19 were made on tipple samples. While the apparent rank of the overlying Adaville coals varies between subbituminous C and B, the apparent rank of this basal Adaville coal is subbituminous A. None of the analyzed channel samples show any agglomerating properties.

As-received Basis	Range Analysis	Average Proximate[1] (25 analyses)	Average Ultimate[2] (7 analyses)
Moisture (%)	16.7-22.7	20.4	
Volatile matter (%)	33.0-36.6	34.5	
Fixed carbon (%)	38.8-44.7	42.1	
Ash (%)	1.5-5.3	3.0	3.7
Sulfur (%)	0.5-1.3	0.6	0.7
Hydrogen (%)	6.1-1.1		6.3
Carbon (%)	56.0-60.1		58.1
Nitrogen (%)	0.9-1.0		0.9
Oxygen (%)	27.5-33.6		30.2
Btu/lb	9,720-10,530	10,190	
Ash soft. temp. (°F)	2,150-2,660	2,370	

[1]Includes six deep mine samples
[2]Includes three deep mine samples

Adaville Coals (undifferentiated) - At least in the Kemmerer area of the coalfield, Adaville coals are numbered consecutively from the lowermost bed upward (Fig. 8). These numerical designations, however, have little meaning beyond the boundaries of Pittsburg & Midway Coal Mining Co.'s mine. For this reason, all Adaville coal beds above the Adaville No. 1 bed are discussed collectively. Glass provides a description of each numbered bed in the Kemmerer mine.[4,18]

The coal beds above the Adaville No. 1 seam vary from a few inches to as much as 50 feet in thickness. In the central basin (Kemmerer area), at least seven of these coals are more than 10 feet thick. Another seven are between 4 and 8 feet thick.[18] The rock intervals between these coals change considerably over short distances.[4] Correlation of these beds is extremely difficult without very close control or continuous exposures.

The strippable reserve base of Adaville coals to include the Adaville No. 1 bed is estimated at more than 1 billion tons.[13] Pittsburg & Midway's Kemmerer mine currently is mining as many as 21 of these coals above the Adaville No. 1 as well as the Adaville No. 1 itself. Production from this mine is about 3.6 million tons per year.

Twenty analyses of various Adaville coals that occur above the Adaville No. 1 are summarized below. The apparent rank of these coals increases down section, going from subbituminous C for the uppermost coals to subbituminous B for the lower coals. All but two of these analyses were performed on channel samples of the Adaville No. 2 through No. 11 coal beds, which were collected in the Kemmerer mine.[18] The other two analyses were made on tipple samples, one of which came from an underground mine.

As-received Basis	Range Analysis	Average Proximate (20 analyses)	Average Ultimate (18 analyses)
Moisture (%)	15.4-28.6	21.2	
Volatile matter (%)	31.1-36.1	33.9	
Fixed carbon (%)	36.1-44.7	41.3	
Ash (%)	3.2-8.9	3.8	4.9
Sulfur (%)	0.2-1.8	0.6	0.6
Hydrogen (%)	5.9-6.5		6.1
Carbon (%)	47.2-60.0		55.1
Nitrogen (%)	0.8-1.5		1.4
Oxygen (%)	28.2-39.4		31.8
Btu/lb	7,920-10,510	9,520	
Ash soft. temp. (°F)	1,980-2,340	2,100	

Almy Bed - This is the only named bed in the Evanston Formation. Between 1869 and 1905, more than 2.7 million tons of the Almy bed were mined near Almy, just north of Evanston. Where it was mined, the Almy coal bed reached 28 feet in thickness, but it was characterized by numerous thin partings near the top and middle.[65] An upper 8-foot-thick bench, which splits off the main mined bed in places, evidently never was mined; possibly because of poor quality or because it aided roof support.

The two published analyses of this bed only represent a 43-inch cut and the lower 8 feet of a 24-foot expression of the coal.[69] Based on these analyses, the apparent rank of the Almy coal bed is subbituminous A to high-volatile C bituminous.

As-Received basis	Range (2 analyses)	Average (2 analyses)
Moisture (%)	14.1-14.4	14.3
Volatile matter (%)	35.3-36.8	36.1
Fixed carbon (%)	34.4-41.6	38.0
Ash (%)	7.2-16.2	11.7
Sulfur (%)	0.2-4.5	2.35
Hydrogen (%)	5.3-5.4	5.35
Carbon (%)	48.9-60.0	54.5
Nitrogen (%)	0.8-1.2	1.0
Oxygen (%)	24.4-26.0	25.2
Btu/lb	8,820-10,450	9,635

A Seam - This coal lies 15 to 40 feet below the Main Kemmerer bed (Fig. 7). Also called the Lower Kemmerer bed, the A Seam was mined in the central basin near Kemmerer, where the bed reached a maximum thickness of 6.5 feet.[70] All mining on this Frontier Formation coal bed has been underground.

Based on the single analysis below, the apparent rank of this coal is high-volatile C bituminous.[65]

As-received Basis	Average
Moisture (%)	5.9
Volatile matter (%)	39.5
Fixed carbon (%)	51.0
Ash (%)	3.6
Sulfur (%)	1.1
Hydrogen (%)	5.6
Carbon (%)	73.0
Nitrogen (%)	1.1
Oxygen (%)	15.7
Btu/lb	12,780

Blind Bull Bed - See Vail Bed.

Frontier No. 1 Bed - See Kemmerer Bed.

Kemmerer No. 1 Bed - See Main Kemmerer Bed.

Kemmerer No. 5 Bed - See Willow Creek No. 5 Bed.

Lower Kemmerer Bed - See A Seam.

Lower Spring Valley Bed - The Lower Spring Valley coal bed is another Frontier Formation coal best developed in the south-central portion of Lincoln County (Fig. 7). In that area, this coal locally exceeded five feet in thickness and was deep mined in the past. The Lower Spring Valley coal may be equivalent to one or more coals of the Spring Valley Group to the south in Uinta County.

Two analyses of the Lower Spring Valley coal bed are provided below.[71] The apparent rank of this coal is high-volatile B bituminous.

As-received Basis	Typical Sample	Tipple Analysis
Moisture (%)	5.9	4.9
Volatile matter (%)	34.4	37.1
Fixed carbon (%)	48.1	52.6
Ash (%)	11.6	5.4
Sulfur (%)	0.4	0.4
Btu/lb	11,890	12,340
Ash softening temp. (°F)	2,590	2,330

Lower Willow Creek Bed - In the south-central part of Lincoln County, this Frontier coal often underlies the Willow Creek No. 5 bed north of Kemmerer (Fig. 7). The interval between the two beds is 5 to 20 feet. Frequently, the Lower Willow Creek coal is less than 2 feet thick, but locally it reaches 4 feet in thickness.

Although the Lower Willow Creek bed has not been mined, the coal is weakly coking and has an apparent rank of high-volatile A bituminous. A summary of 20 core analyses[23] shows:

As-received Basis	Range (20 analyses)	Average (20 analyses)
Moisture (%)	2.0-7.9	3.0
Volatile matter (%)	35.0-41.5	38.6
Fixed carbon (%)	45.8-52.7	49.7
Ash (%)	5.4-14.3	8.7
Sulfur (%)	0.9-1.4	1.1
Hydrogen (%)	5.2-5.7	5.4
Carbon (%)	65.3-74.8	71.7
Nitrogen (%)	1.0-1.4	1.3
Oxygen (%)	11.0-15.6	11.8
Btu/lb	11,650-13,410	12,820
Ash softening temp. (°F)	2,340-2,720	2,480

Main Kemmerer Bed - This coal, variously called Kemmerer No. 1 or Frontier No. 1, is the thickest and most persistent coal in the Kemmerer Coal Group. Stratigraphically, the Main Kemmerer bed lies 200 to 250 feet below the top of the Frontier Formation, at least in the south-central portion of the coalfield (Fig. 7).

This bed, which is reportedly up to 20 feet thick in the southern part of Lincoln County, typically is split into two benches by a 6-inch-thick rock parting. While the top bench usually is 10 to 16 feet thick, the lower bench is closer to 4 or 5 feet. The rock parting reportedly thickens to 30 feet north and south of Kemmerer, and the two benches thin to 5 and 3 feet, respectively.[70] Occasionally, the Main Kemmerer bed exceeds 7 feet in thickness, even in northern Uinta County.

Most deep mining in the Hams Fork Coalfield has been in this coal bed, with extensive mining near Kemmerer and Diamondville in the east-central part of the field. This coal was mined in the Brilliant No. 8 deep mine, which was the last operating deep mine in the field (closed in 1964).

The apparent rank of the Main Kemmerer coal bed varies from high-volatile B to high-volatile C bituminous, possibly due to different depths of burial. Twenty-three analyses of this bed are summarized below. Of these analyses, nine were made on channel samples, 11 on tipple samples, one on a delivered sample, and two on unspecified sample types.

As-received Basis	Range Analysis	Average Proximate (23 analyses)	Average Ultimate (10 analyses)
Moisture (%)	3.9-6.8	5.9	
Volatile matter (%)	35.0-42.0	39.6	
Fixed carbon (%)	44.3-51.3	47.6	
Ash (%)	3.5-10.5	6.9	5.9
Sulfur (%)	0.4-2.7	0.9	1.1
Hydrogen (%)	5.3-5.7		5.5
Carbon (%)	68.1-75.9		70.5
Nitrogen (%)	1.0-1.3		1.1
Oxygen (%)	13.5-17.9		16.0
Btu/lb	11,980-12,690	12,380	
Ash soft. temp. (°F)	2,060-2,270	2,170	

Middle Main Coal Bed - See Willow Creek No. 5 Bed.

Upper Spring Valley Bed - The Upper Spring Valley coal bed is a persistent Frontier coal in the southern part of Lincoln County, where it has been deep mined on a small scale. In this area, the Upper Spring Valley coal locally exceeds 6 feet in thickness, although it averages less. This bed may be correlative with one or more coals at about the same stratigraphic position in the Spring Valley area of Uinta County (Fig. 7). Correlation of individual beds between these two areas, however, is not documented. It has been reported that some Spring Valley coals in the Ragan Quadrangle north of Spring Valley are 3 to 6.5 feet thick.[68]

Based upon the following typical analysis of the Upper Spring Valley coal from the Kemmerer area, the coal's apparent rank is high-volatile B bituminous.[71]

As-received Basis	Typical Analysis
Moisture (%)	5.2
Volatile matter (%)	37.6
Fixed carbon (%)	48.5
Ash (%)	8.8
Sulfur (%)	0.4
Hydrogen (%)	5.3
Carbon (%)	69.6
Nitrogen (%)	1.2
Oxygen (%)	14.8
Btu/lb	12,340
Ash softening temp. (°F)	2,560

Vail Bed - In the northeastern portion of the Hams Fork Coalfield, this coal bed, which occurs in the Blind Bull Formation, reportedly is up to 10.2 feet thick. Most mines on the Vail or Blind Bull coal bed, however, mined only 6 to 7.5 feet of low ash, low sulfur coal.[65] The outcrop of the Vail bed apparently is traceable for more than 10 miles in this area of the coalfield.

Analyses of nine coals, presumably all correlative with the Vail coal bed, are summarized below. All these analyses were performed on tipple samples. The apparent rank of the Vail coal bed is high-volatile B bituminous.

As-received Basis	Range Analysis	Average Proximate (9 analyses)	Average Ultimate (3 analyses)
Moisture (%)	5.5-10.0	7.4	
Volatile matter (%)	36.8-43.9	39.4	
Fixed carbon (%)	44.5-50.3	47.5	
Ash (%)	2.2-9.7	5.7	4.6
Sulfur (%)	0.3-1.0	0.6	0.4
Hydrogen (%)	5.7-5.9		5.8
Carbon (%)	68.0-72.8		69.9
Nitrogen (%)	1.3-1.6		1.5
Oxygen (%)	16.2-19.8		17.8
Btu/lb	11,640-12,800	12,210	
Ash soft. temp. (°F)	2,180-2,370	2,250	

Willow Creek Bed - See Willow Creek No. 5 Bed.

Willow Creek No. 5 Bed - The Willow Creek No. 5 coal, which has also been called the Willow Creek, Middle Main, or Kemmerer No. 5 coal bed, is the thickest and most persistent of the Frontier coals in the Willow Creek Group (Fig. 7).[4] Although the Willow Creek No. 5 coal was 3 to 11.2 feet thick where it was mined, it thins to less than 2 feet in places and is not even recognized in the southern portion of the coalfield.[68]

About 50 years ago, it was found that the Willow Creek No. 5 coal exhibited weak coking properties that improved if the coal was cleaned before coking. It was concluded, however, that it was not useful for metallurgical grade coke unless it was blended with high quality coking coal.[23] Of the three Willow Creek Group coals tested, the Willow Creek No. 5 bed did offer the most promise for development.

It has been estimated[21] that in five townships where the Willow Creek No. 5 bed is 28 to 42 inches thick, the measured and indicated original resources of the bed total 96.64 million tons to a depth of 2,000 feet. An additional 47.98 million tons were estimated between 2,000 and 3,000 feet of cover. Because of steep dips and depth of cover, most if not all of this 144.62 million tons of coal are underground reserve base rather than strippable reserve base.

Most mining on the Willow Creek No. 5 coal was in the southern part of Lincoln County, although the coal bed crops out for more than 50 miles along strike. To date, all mining has been underground.

Both the ash and sulfur contents of this coal are the lowest of any analyzed Willow Creek

Fig. 7. Coal nomenclature for the Frontier Formation of the Hams Fork Coalfield

Fig. 8. Nomenclature for the Adaville formation

Group coal. Thirty-five published analyses of the Willow Creek No. 5 bed are summarized below. These analyses indicated an apparent rank of high-volatile A bituminous.

As-received Basis	Range Analysis	Average Proximate (35 analyses[1])	Average Ultimate (24 analyses[2])
Moisture (%)	2.0-7.7	3.4	
Volatile matter (%)	34.7-42.7	37.2	
Fixed carbon (%)	46.0-55.1	51.8	
Ash (%)	4.3-15.3	7.7	8.0
Sulfur (%)	0.4-2.1	0.9	0.9
Hydrogen (%)	4.9-5.6		5.3
Carbon (%)	66.3-76.4		72.8
Nitrogen (%)	1.0-1.3		1.2
Oxygen (%)	10.5-17.3		11.8
Btu/lb	11,850-13,610	12,930	
Ash soft. temp. (°F)	2,150-2,520	2,300	

[1]19 core samples; 10 channel samples; 4 tipple samples; 1 delivered sample; 1 unspecified sample
[2]19 core samples; 4 channel samples; 1 unspecified sample

Bighorn Coalfield

The Bighorn Coalfield of northwestern Wyoming includes portions of Park, Hot Springs, Washakie, and Big Horn counties (Fig. 1). This coalfield, which is the third largest in the state, coincides with the topographic and structural basin of the same name. As defined, however, the coalfield is limited to that portion of the Bighorn Basin underlain by Mesaverde or younger rocks.[72] This definition was chosen because the Mesaverde Formation is the oldest important coal-bearing formation in the field.[73]

Structurally, this coalfield coincides with a broad syncline bounded on the east by the Bighorn Mountains, on the south by the Owl Creek Mountains, and on the west by the Absaroka Plateau and Beartooth Mountains. To the north, the Bighorn Coalfield continues into Montana and narrows where it is flanked by the Beartooth and Pryor mountains. Local folding characterizes the marginal areas of the field where the coal crops out. These small anticlines and synclines create local dips at various angles to the overall synclinal structure of the Bighorn Basin. Dips from 15 to 50 degrees are common in these border areas. There also are numerous normal faults on the margins of the coalfield, especially in the northern half of the field. Most of these faults trend northeast-southwest with some vertical displacements up to 250 feet.

Although coals occur in the Cloverly, Frontier, Lance, Willwood, and Tatman formations, the thicker and more important beds are limited to the Upper Cretaceous Mesaverde and Meeteetse formations and the Paleocene Fort Union Formation (Fig. 3). These latter formations crop out around the margins of the coalfield, but are deeply buried in the central portions of the field. In-place coal resources are estimated at 23.5 billion tons.[3]

Coaly shale and coal are sometimes found associated with the basal sandstones of the Lower Cretaceous Cloverly Formation. Just outside the boundary of the defined coalfield, eight feet of Cloverly Formation coal was mined.

Only thin coals have been found in the Upper Cretaceous Frontier Formation of the Bighorn Coalfield. Thicknesses over a few inches are seldom mentioned.

Although Mesaverde coals occur throughout the field, they are thin in the southeastern corner, where they seldom exceed 14 inches in thickness. The thickest and most persistent Mesaverde coals are in the south-central and southwestern portions of the field, where bed thicknesses are up to 12 feet. More commonly, Mesaverde coals are only 4 to 6 feet thick. The coals in the Mesaverde Formation historically have been the most important coals in the field, and they have been mined in all but the central and southeastern portions of the field. The minable coals of the Mesaverde normally are found in the basal portion of the formation. Taucher et al. provide some recent analytical data on Mesaverde Formation coals.[74] The apparent rank of Mesaverde coals is subbituminous A to high-volatile C bituminous.

Apparently, coals are distributed throughout the Upper Cretaceous Meeteetse Formation everywhere in the field, but they are not as thick nor as persistent as the older Mesaverde coals. The thicker Meeteetse coal beds coincide with areas where numerous thin coals coalesce into interbedded shale and coal units. These thicker coals commonly are 4 to 6 feet thick, although 8- to 11-foot-thick beds have been reported. Meeteetse coals have been mined in all but the central, northern, and southwestern portions of the field. Because the Meeteetse and Lance formations in the Bighorn Coalfield are not always mapped separately, the distinction between upper Meeteetse coals and basal Lance coals is often not possible. Of the two formations, however, the Meeteetse Formation normally contains the thicker and more persistent beds of coal. The apparent rank of Meeteetse coals is subbituminous A to high-volatile C bituminous.

Where the Upper Cretaceous Lance Formation is separable from the Meeteetse, it contains only thin coals. These thin coals, usually found near the top of the formation, are less than 6 inches thick. Because separation of the Lance from the overlying Fort Union Formation also is difficult, some of these uppermost Lance coals may be in fact Fort Union coals.

Fort Union Formation coals are found in all but the northern end of the coalfield. These Paleocene coals reach their maximum reported thickness in the southern end of the coalfield, where they are as thick as 38 feet. Elsewhere, Fort Union coals are up to 8.8 feet thick. In all cases the thicker and more important coals occur in the lower part of the formation. The shallower dips exhibited by these younger Paleocene coals complement their greater thicknesses. Coals in the Fort Union Formation have apparent ranks between subbituminous A and high-volatile C bituminous.

The Eocene Willwood Formation reportedly contains a few low quality coals. One report cites thicknesses up to 2 feet and gives an analysis of one Willwood coal with a heat value of only 4,119 Btu/lb, suggesting the sample might have been extremely weathered or a coaly shale rather than a coal.[75] A 19-inch-thick coal seam has been reported in the Eocene Tatman Formation, but the coals in the Tatman typically are less than 8 inches in thickness and are very low in quality.[75]

Important Coals of the Bighorn Coalfield

Gebo Bed - In the south-central portion of the field, the Gebo coal seam of the Mesaverde Formation is 6 to 11 feet thick, but averages only 7 feet. The bed was mined by conventional underground methods.[73] Where mined, the bed dipped 17 to 45 degrees. The coal's apparent rank is high-volatile C bituminous.

As-received Basis	Range (69 analyses)	Average
Moisture (%)	12.4-17.8	15.5
Volatile matter (%)	31.3-40.3	34.2
Fixed carbon (%)	43.0-49.7	46.0
Ash (%)	2.3-9.1	4.3
Sulfur (%)	0.4-0.8	0.6
Btu/lb	10,080-11,780	10,970

Mayfield Bed - This Fort Union Formation coal occurs in the southwestern corner of the field, where currently it is strip mined near Grass Creek. The bed, 8 to 38 feet thick, has been deep mined in the past. A preliminary estimate of the strippable reserve base for this bed is in excess of 15 million tons.[76] The apparent rank of this coal is high-volatile C bituminous.

As-received Basis	Range (6 samples)	Average
Moisture (%)	10.7-12.8	12.3
Volatile matter (%)	34.0-38.0	35.6
Fixed carbon (%)	42.2-48.1	44.7
Ash (%)	5.0-9.4	7.4
Sulfur (%)	0.3-0.6	0.4
Btu/lb	10,730-11,250	10,970

Meeteetse Formation Beds (undifferentiated) - The apparent rank of these coals is subbituminous A to high-volatile C bituminous.

As-received Basis	Range (10 samples)	Average
Moisture (%)	12.8-15.2	13.8
Volatile matter (%)	32.1-49.7	38.0
Fixed carbon (%)	23.7-45.4	37.3
Ash (%)	6.5-16.6	10.9
Sulfur (%)	0.3-0.7	0.5
Btu/lb	7,770-10,965	9,800

Wind River Coalfield

The Wind River Coalfield coincides with a large asymmetrical syncline in central Wyoming (Fig. 1). Dips are steeper on the northern side than on the southern. Many minor fields and a number of faults also occur in the field.

Although coals occur in the Frontier, Cody, Mesaverde, Meeteetse, Lance, Fort Union, and Wind River formations, the thicker and more important coals are in the Upper Cretaceous Mesaverde and Meeteetse formations (Fig. 3). Coals in the Mesaverde and Meeteetse formations are deeply buried in the central part of the Wind River Coalfield and only crop out around the margins of the field.

Summaries of this field are available.[77-79] Estimated in-place coal resources for this field have been put at 81.01 billion tons.[3]

The apparent rank of minable Mesaverde Formation coals in the Wind River Coalfield is subbituminous C to high-volatile C bituminous. Available analyses of Meeteetse coals indicate an apparent rank of subbituminous A.

Jackson Hole Coalfield

The Jackson Hole Coalfield in northwestern Wyoming is underlain by minable beds over an area of 700 square miles (Fig. 1).[80] In-place coal resources are estimated to be 6.34 billion tons.[3] Minable coals occur in Upper Cretaceous, Paleocene, and Eocene-age rocks (Fig. 3). The coals probably are subbituminous.

Black Hills Coalfield

The Black Hills Coalfield is in the extreme northeastern part of the state (Fig. 1). Coals crop out in a narrow, discontinuous belt through the field. Minable coal beds apparently are confined to the base of the Lakota Sandstone of Lower Cretaceous age (Fig. 3). The coals in this field are moderately good coking coals and have an apparent rank of high-volatile C bituminous. The field contains an in-place coal resource of 7.89 billion tons.[3]

Rock Creek Coalfield

The Rock Creek Coalfield is a small field southeast of the Hanna Coalfield (Fig. 1). Coal-bearing rocks occur in the Mesaverde and Medicine Bow formations of Upper Cretaceous age and the Hanna Formation of Paleocene age (Fig. 3). The thickest and best exposed coals are in the northwestern part of the field. At least some of the coals in the field are subbituminous. In-place coal resources in this field have been estimated at 3.4 billion tons.[3]

Goshen Hole Coalfield

Much of the Goshen Hole Coalfield, which is in the southeastern part of the state, is covered by relatively young rocks that do not contain coals (Fig. 1). In this field, coals occur only in the Lance Formation of Upper Cretaceous age (Fig. 3). These coals probably are subbituminous. The field contains an estimated in-place coal resource of 230 million tons.[3]

Although Lance coals are relatively thick to the south in Colorado, no coals over 3 feet thick are documented in Wyoming. For this reason, it is very unlikely that any economically minable coals occur in this field.

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COAL GEOLOGY OF WYOMING

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R 63