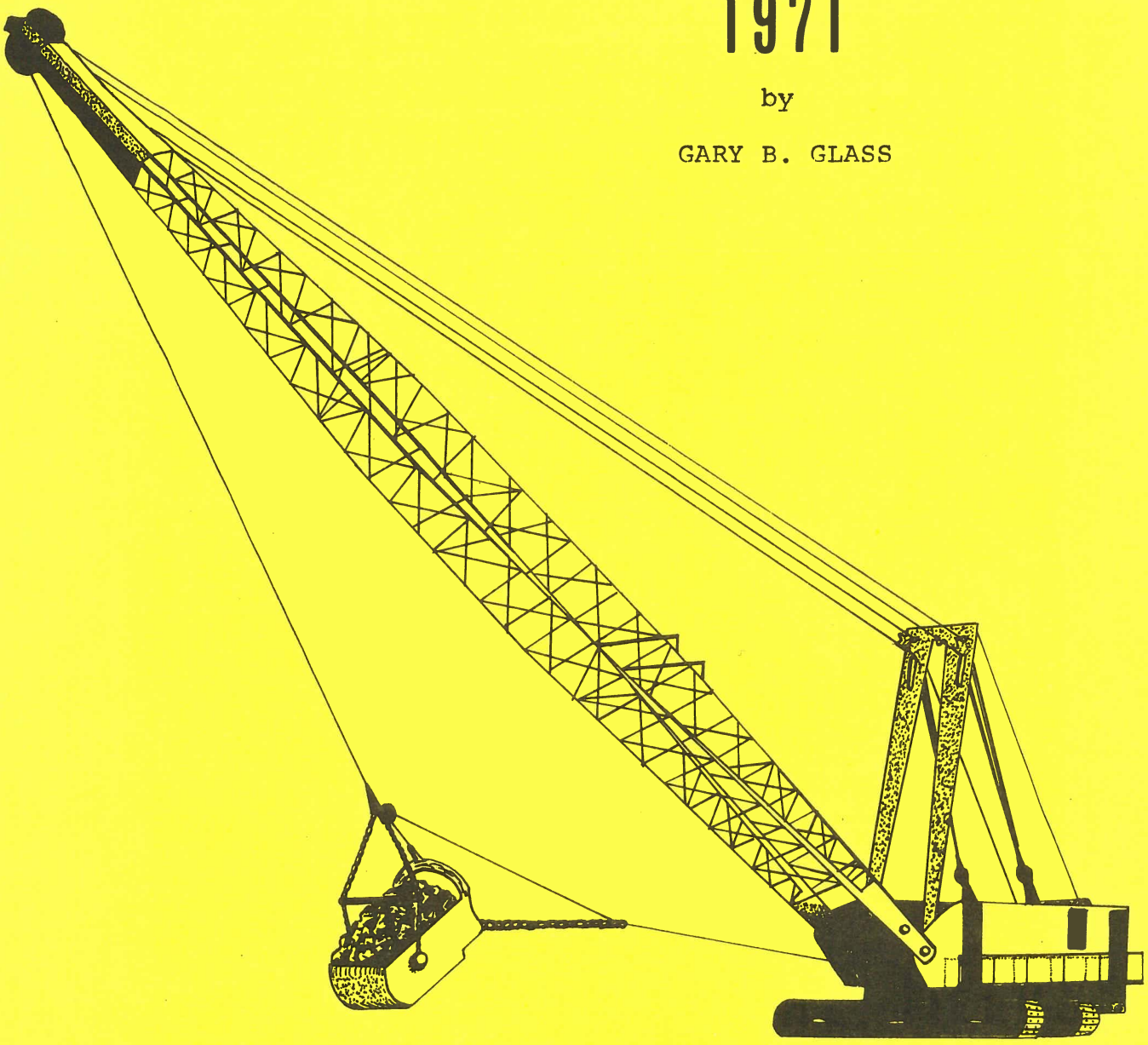
REVIEW OF WYOMING COAL FIELDS, 1971

by

GARY B. GLASS



THE GEOLOGICAL SURVEY OF WYOMING

DANIEL N. MILLER, State Geologist

May, 1972

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BOX 3008, UNIVERSITY STATION
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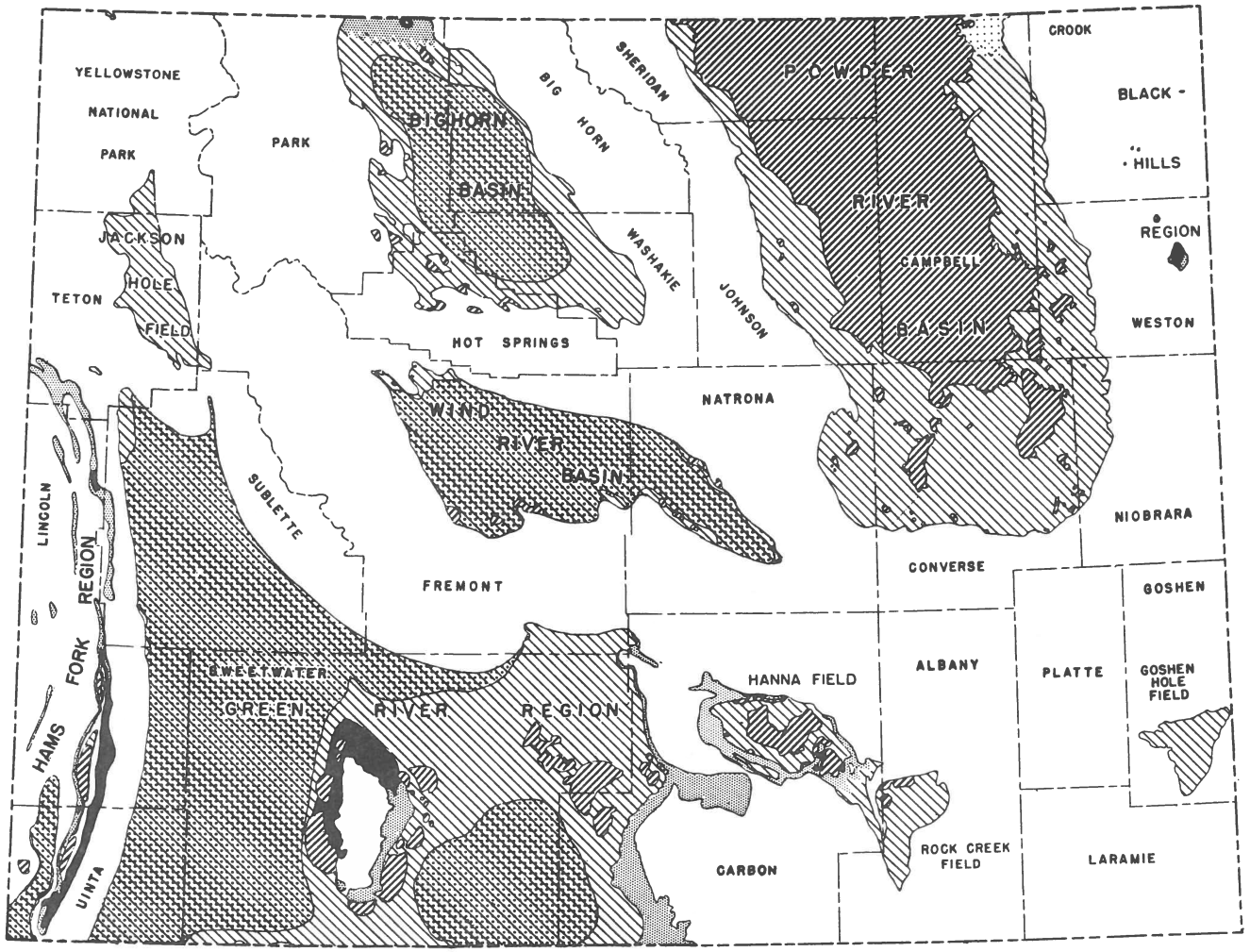
COAL-BEARING AREAS

As defined by the United States Geological Survey, Wyoming's coal fields fall into two coal-bearing provinces. The coals in northeastern Wyoming are within the Northern Great Plains Province while all other coal deposits of the State are in the Rocky Mountain Province. Additionally, the United States Bureau of Mines designates Wyoming as coal-producing District 19. Beyond these national designations, the State's coal-bearing areas are divided into the following 10 major regions, basins, or fields, which underlie more than 40,000 square miles or approximately 41% of the State and which collectively contain almost 17% of the nation's coal resources under less than 6000 feet of overburden (Figure 1):

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

These major regions are further subdivided into 42 individual coal fields (Figure 2). Twelve fields are in the Powder River Basin while 8 are

FIGURE 1: WYOMING COAL-BEARING AREAS



EXPLANATION

BITUMINOUS COAL AREA

Containing coal beds more than 14 inches thick

Containing coal beds less than 14 inches thick or of unknown thickness

SUB-BITUMINOUS COAL AREA

Containing coal beds more than 30 inches thick

Containing coal beds less than 30 inches thick or of unknown thickness

LIGNITE AREA

Containing lignite beds less than 30 inches thick

PROBABLE COAL-BEARING AREA

Containing coal-bearing formations at unknown depths

FROM BERRYHILL, 1950

in the Bighorn Basin. The Wind River Basin and the Green River Region each consist of 5 fields while the Hams Fork Region and the Black Hills Region each have 4 fields. The remaining four major regions are single coal fields. The exact boundaries of many of these fields are not specifically defined.

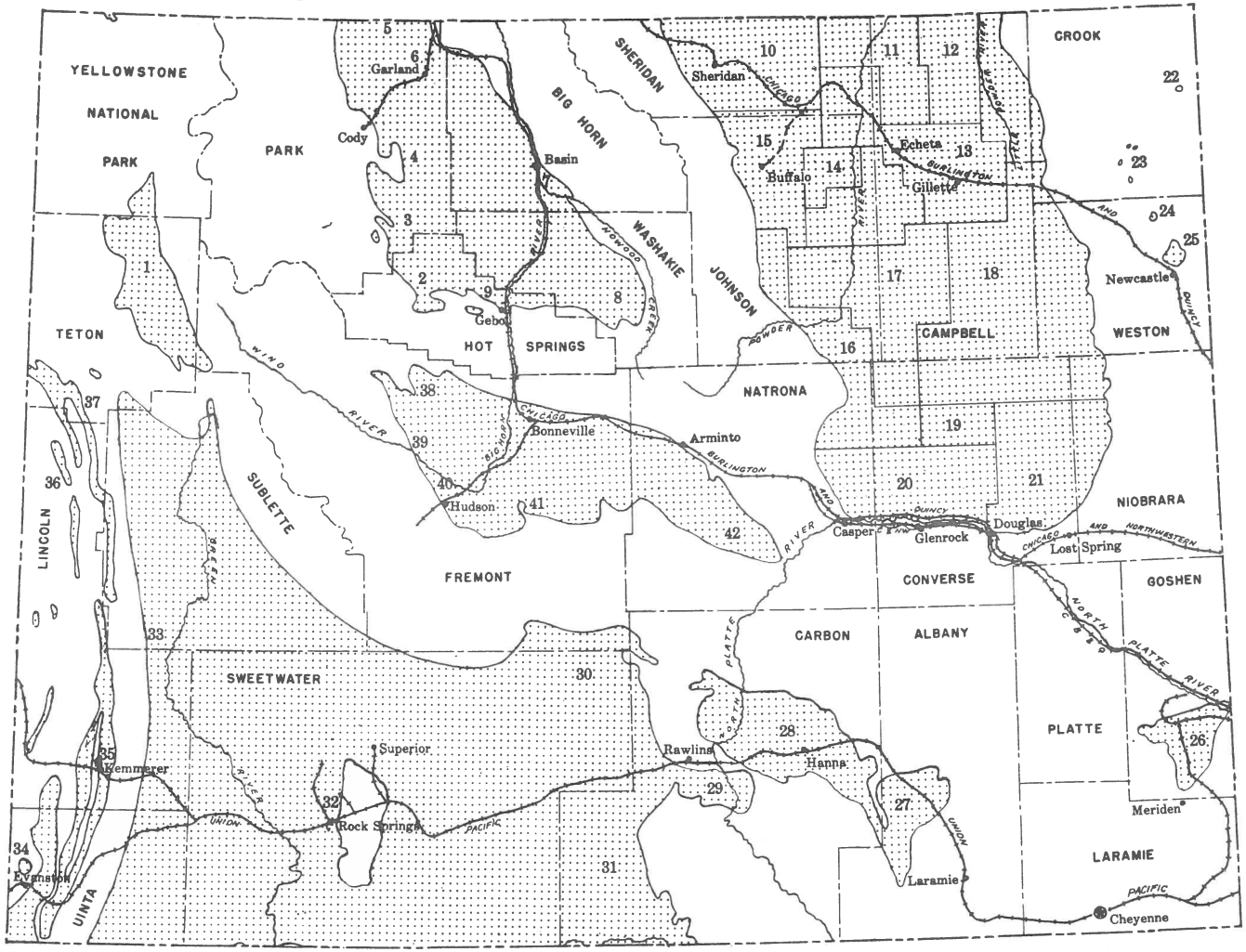
COAL-BEARING ROCKS

Coal-bearing rocks of Wyoming range in age from Lower Cretaceous to Eocene; however, Upper Cretaceous and younger rocks contain most of the calculated coal resources. Lower Cretaceous coals are restricted to the Black Hills Region. Upper Cretaceous coals are the most widespread and are found in all the major regions except the Black Hills Region. Paleocene coals are found in all but the Black Hills Region and the Goshen Hole Field. Eocene coals are the youngest and outcrop in the Powder River Basin, the Green River Region, the Hanna Field and the Rock Creek Field.

STRUCTURAL GEOLOGY OF COAL-BEARING AREAS

In general, Wyoming coal measures are situated in broad, asymmetrical, synclinal basins between various ranges of the Rocky Mountains. Except for seams that are tilted against the Rock Springs Uplift in the central portion of the Green River Region, most of the State's coal seams 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 Region and Hanna Field exhibit the greatest structural complexity, the Powder River

FIGURE 2: WYOMING COAL FIELDS



EXPLANATION

No. on map	Coal Field
1.	Jackson Hole
2.	Grass Creek
3.	Meeteetse
4.	Oregon Basin
5.	Silvertip
6.	Garland
7.	Basin
8.	Southeastern
9.	Gebo
10.	Sheridan
11.	Spotted Horse
12.	Little Powder River
13.	Powder River
14.	Barber
15.	Buffalo
16.	Sussex
17.	Pumpkin Buttes
18.	Gillette
19.	Dry Cheyenne
20.	Glenrock
21.	Lost Spring
22.	Aladdin
23.	Sundance
24.	Skull Creek
25.	Cambria
26.	Goshen Hole
27.	Rock Creek
28.	Hanna
29.	Kindt Basin
30.	Great Divide Basin
31.	Little Snake River
32.	Rock Springs
33.	Labarge Ridge
34.	Evanston
35.	Kemmerer
36.	Greys River
37.	McDougal
38.	Muddy Creek
39.	Pilot Butte
40.	Hudson
41.	Alkali Butte
42.	Powder River

FROM BERRYHILL, 1950

Basin shows the least. Faulting is most common in the southern and western coal regions, but it is not restricted to those areas.

RANK

The rank of Wyoming coal ranges from lignite to high volatile A bituminous. Lignite occupies a very small area in the northeastern part of the Powder River Basin. Bituminous coal is restricted to the Black Hills Region and portions of the Hanna Field, Green River Region, Hams Fork Region and Bighorn Basin. High volatile B and A bituminous coal is only reported in the Hams Fork Region. With few exceptions, the bituminous coals are all of Cretaceous age; however, the Cretaceous coals are not all of bituminous rank. Many Cretaceous coals are subbituminous rank.

Subbituminous coals are found in all the major coal regions of the State except the Black Hills Region. Figure 1 shows the geographic distribution of lignite, subbituminous and bituminous coals in Wyoming.

Like subbituminous coals, some Wyoming high volatile C bituminous coals are nonagglomerating. The weathering indices of these coals must be used to distinguish rank. Subbituminous A coal is a weathering type while Variety 3 of high volatile C bituminous is nonweathering.

While the older coal beds in any given field are generally higher in rank than the younger beds, the rank of individual beds in a field also seems to increase toward the troughs of the structural basins. Both of these variations in rank have been attributed to increases in depth of burial (Unfer, 1951).

COAL MOISTURE, ASH AND SULFUR CONTENT

On an as-received basis, moisture contents range between 1.7% and 32.8%. The average moisture content of Wyoming coals is reported as

14.2% (USBM, 1971). Moisture contents are generally correlative to a coal's rank although some subbituminous coals exhibit lower moisture contents than expected.

The average ash content of Wyoming coal is 5.2% (USBM, 1971). Reported as-received ash values normally range between 1.4% and 17.2%. Washability studies suggest that most if not all Wyoming coals can be readily washed to a desirable ash level with minimal loss of yield (Deurbrouck, 1971).

Sulfur content on an as-received basis averages 0.7%, but is occasionally reported as high as 5.0%. More than 99% of Wyoming coal contains less than 1% sulfur, and about one-half of that is less than 0.7%. Overall, bituminous coals appear to be slightly higher in sulfur than the lower rank coals.

In Wyoming coals the sulfate form of sulfur averages less than 0.03% (3-5% of the total sulfur); the pyritic form averages less than 0.2% (25-29% of the total sulfur); the organic form averages less than 0.47% (70-72% of the total sulfur) (Walker, 1966). Because most of the sulfur in Wyoming's coals is in the organic form, conventional mechanical cleaning or preparation processes are not going to 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%. In this case the average sulfur content of Wyoming coals could theoretically be reduced to 0.5%.

HEAT VALUE

Heat values of Wyoming coals are commensurate with their rank. On a dry, ash-free basis, the bituminous coals range between 14,440 Btu/lb. and 11,000 Btu/lb. while the subbituminous coals range between 8400 Btu/lb.

and 13,000 Btu/lb. Based on published coal analyses, the average heat value of the State's coal is 13,530 Btu/lb. On an as-received basis, the average heat value decreases to 10,850 Btu/lb. (USBM, 1971).

For at least the subbituminous coals, the heat values increase noticeably under greater increments of overburden. An increase of 300 Btu/lb. per 110 foot increase in overburden has been reported in the Hanna Field (Unfer, 1951).

CARBONIZING PROPERTIES

Most Wyoming coals are nonagglomerating but can be carbonized in fluidized systems. Chars produced at low temperatures contain about 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 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 (Landers, 1961).

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 range from 14 to 40 gallons/ton of raw coal processed (Landers, 1961).

COKING COAL

Coal with weak to moderate coking properties occurs in the Kemmerer Field of the Hams Fork Region, the Rock Springs Field of the Green River Region and the Cambria Field of the Black Hills Region. The Cambria coal in the Cambria Field possesses the best coking qualities. Unfortunately most

of the recoverable coal has already been removed. Reserves of this seam are believed to be very small (Berryhill, 1950). The Middle Main seam in the Kemmerer Field ranges between 3.1 feet and 6.5 feet thick and yields a weak coke. Recoverable reserves of this seam are estimated at 8,000,000 tons. Other seams in the Hams Fork Region also have coking potential. A pilot coke plant in the Kemmerer area presently uses local coal to manufacture "formed coke" for the phosphorus industry.

The Rock Springs No. 7 seam of the Rock Springs Field ranges between 2 feet and 10 feet in thickness. Although there are more than 200,000,000 tons of measured resources of this coal, it is of poor coking quality. The Rock Springs No. 7 seam, however, is presently used in a coke plant near Rock Springs to produce chemical coke for the phosphorus industry. Additional seams in the Rock Springs Field also have coking potential.

COAL MINING AND PRODUCTION

Since 1909, coal production in Wyoming has fluctuated between a low of 1,425,748 tons and a high of more than 9,000,000 tons (Figure 3). Peak production years were in 1920 and 1945. The record annual production of 9,836,798 tons was set in 1945. In 1959, however, production again began increasing, first slowly, and then nearly doubling between 1969 and 1970 to 7,380,930 tons. The tonnage for 1971 was 8,007,765 tons. Although somewhat below expectations because of a strike, it nevertheless exceeded the 1970 tonnage. The present upward trend in coal production will undoubtedly continue. In terms of dollar value, coal production in the last ten years has more than tripled to over $25,000,000 in 1970.

Coal production in Wyoming was dominated by deep mining until 1954. In that year strip mining tonnage barely exceeded that of the underground

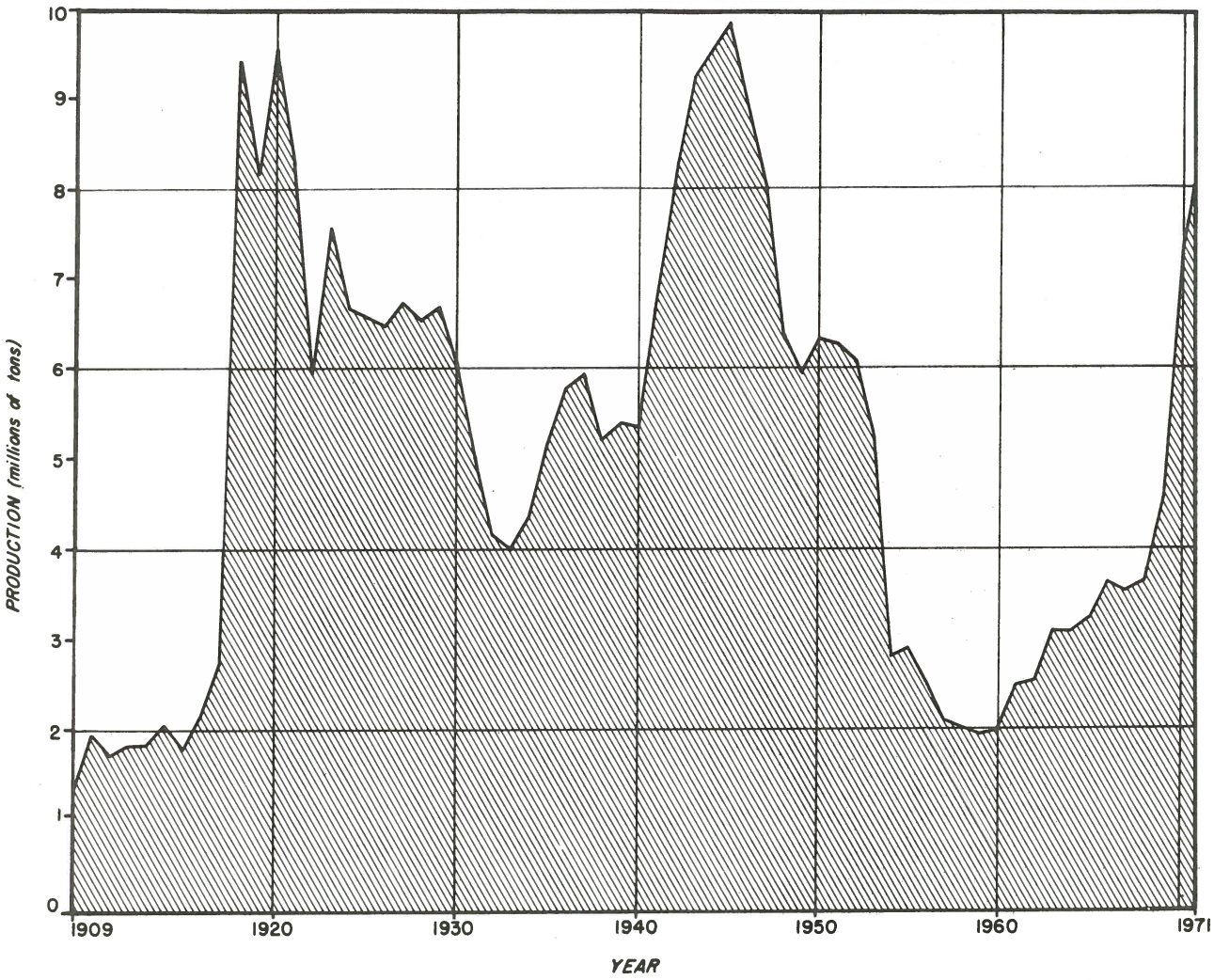


Figure 3: WYOMING COAL PRODUCTION 1909 TO 1971

mines. Since then, however, strip mining production has nearly quintupled to 7,146,112 tons in 1970 and accounted for more than 98% of Wyoming's production. At the same time, deep mining production decreased from 1,394,000 tons annually to 118,613 tons.

A preliminary estimate of the total coal production from Wyoming to January 1, 1971, is 440,001,000 tons of which 379,596,000 tons came from underground operations and 60,405,000 tons from strip mining.

In 1970, fifteen coal mining companies produced 7,380,930 tons of

coal. Ten of these operations were strip mines while only 5 were underground mines. Strip mine production accounted for 98.4% of the total production or 7,146,112 tons. Deep mines produced 118,613 tons. A single deep mine in Sweetwater County produced 92% of the underground tonnage in 1970. Four of the strip mining companies account for more than 88% of the stripped tonnage. Of these four mining companies, each produced more than 1,000,000 tons.

It is estimated that about 3.5 million tons of the coal mined in 1970 was used for the generation of electric power in Wyoming. Another 3 million tons were shipped out of the state for electric power generation. The remaining tonnage was used by the beet sugar industry, cement industry, coke industry, railroads, government, domestic and other miscellaneous users. Coal shipped out of Wyoming went to markets in Colorado, Iowa, Illinois, South Dakota, Wisconsin, Kansas, Minnesota, Nebraska, Idaho and Utah.

In 1971, one new underground mine went into operation and one older deep mine closed. Of the thirteen operating companies in 1971, four mined coal strictly from deep mines, one operated both a deep mining and a stripping operation, and eight were exclusively strip mines. Wyoming's 1971 coal production come from nine coal fields located in five of the major coal-bearing regions. The location of these mines by field, region, number and type are as follows:

Powder River Coal Basin

Powder River Field: 1 strip mine (Wyodak pits)

Gillette Field: 1 strip mine (East Antelope strip)

Sheridan Field: 2 strip mines (Big Horn No. 1 strip; Welch strip)

Glenrock Field: 1 strip mine (Dave Johnston Fuel Pit)

Green River Coal Region

Rock Springs Field: 1 strip mine (Reliance strip)

2 deep mines (Rainbow No. 7; Van Dyke)

Hanna Coal Field: 2 strip mines (Energy Development pits; Rosebud pits)

1 deep mine (Vanguard No. 1)

Hams Fork Coal Region

Kemmerer Field: 1 strip mine (Kemmerer Coal Co. pits)

Bighorn Coal Basin

Gebo Field: 1 deep mine (Roncco)

Grass Creek Field: 1 deep mine (Grass Creek)

The coal-producing counties in Wyoming were Campbell, Carbon, Converse, Hot Springs, Lincoln, Sheridan, and Sweetwater counties.

One new strip mining operation in the Hanna Field has already begun production in 1972. Another strip mine will probably begin production in the Gillette Field of the Powder River Basin in 1972. Several of the existing companies plan expansions of their operations also.

POWDER RIVER COAL BASIN

The Powder River Coal Basin covers more than 12,000 square miles in northeastern Wyoming. The basin forms a gentle, asymmetrical syncline between mountain ranges on the east and west. The axis of the syncline is west of the center of the basin. Dips which are usually less than 5° on the eastern side of the basin steepen against the Bighorn Mountains on the western side.

Most of the coal in the eastern part of the basin is subbituminous C rank. There is some lignite in the extreme northeastern corner. Coals in the western portion of the basin are subbituminous C and B ranks. In

general, coal beds are thickest in the northern part of the basin and thin southward. There are notable exceptions to this however. The eastern and northern sides of the basin contain the most persistent seams.

Although the Lance Formation (Upper Cretaceous) contains coals, they are generally conceded to be of little commercial value and they have not been included in coal resource calculations. The Tongue River Member of the Fort Union Formation (Paleocene) and the Wasatch Formation (Eocene) contain most of the coals of commercial importance. Important coal seams in the Powder River Basin are as follows:

BADGER SEAM: This is a subbituminous C rank coal best developed in the Glenrock Field. The coal occurs at the top of the Fort Union Formation and may be correlative with the Roland seam in other fields. The Badger seam ranges between 17 and 20 feet in thickness. The U. S. Bureau of Mines conservatively estimates that there is at least 7 million tons of strippable reserves of this seam.

As-received Basis	*Average*
Moisture (%)	*25.7*
Ash (%)	*7.2*
Btu/lb.	*8250*

CANYON SEAM: The Canyon seam is best developed in the Spotted Horse Field in portions of Campbell and Sheridan Counties. It is probably subbituminous C rank and is reported to average between 11 and 20 feet thick. This seam is in the Fort Union Formation and may be equivalent to one of the Dietz seams in the Sheridan Field. Strippable resources of this seam are estimated at 185 million tons (Smith, 1970). No analysis is available.

CARNEY SEAM: This seam is a subbituminous C coal well developed in the Sheridan Field. In thickness, it ranges between 7 and 20 feet.

Partings are not uncommon. The Carney seam occurs in the Fort Union Formation about 85 feet above the equally important Monarch seam. Although there are strippable reserves of this seam, no estimates have been made.

As-received Basis	*Range Analysis*
Moisture	*21.2 - 27.2*
Ash (%)	*2.6 - 9.5*
Sulfur (%)	*0.3 - 0.8*
Btu/lb.	*8320 - 9720*
Fusion Temp. (deg. F.)	*2040 - 2360*

D SEAM: This seam is important in the southern part of the Gillette Field. It is subbituminous and averages 8 to 16 feet in thickness. Maximum thickness of this seam is 65 feet. The D seam is found near the top of the Fort Union Formation and is believed to correlate with the Roland seam in other fields. According to U. S. Bureau of Mines' figures, strippable resources of this seam when combined with another seam 50 to 75 feet below it (E seam) total approximately 500 million tons. No analysis of this seam could be located.

E SEAM: This seam underlies the D seam in the southern portion of the Gillette Field. It occurs in the Fort Union Formation and averages 5 feet in thickness. Strippable resources of this subbituminous coal are combined with the D seam's to total about 500 million tons. No analysis of this seam is available.

F SEAM: This seam is well developed in portions of the Dry Cheyenne and Gillette Fields in Converse County. Bed F has a maximum thickness of 11.6 feet but averages only 7.5 feet. Strippable resources of this seam are estimated at 180 million tons (Smith, 1970). No analysis was found.

FELIX SEAM: The Felix seam is an important seam in the Spotted Horse Field in Campbell County. This seam, which is found in the Wasatch Formation,

ranges between 5 feet and 21 feet in thickness. The average thickness is 12.5 feet. Partings are common and fairly persistent in places. Strippable resources of this seam total 480 million tons (Smith, 1970). The seam is subbituminous in rank, but no analysis is available.

HEALY SEAM: The Healy seam in the Buffalo Field of Johnson County ranges between 5 feet and 25 feet at outcrop, but it is reportedly as much as 220 feet thick in some drill hole descriptions. Available data suggest the seam is subbituminous C in rank. Upper portions of the seam are frequently found to be burned. Its strippable resource of 2 billion tons is the second largest of any calculated in the State. The seam is in the Wasatch Formation (Smith, 1970).

As-received Basis	*Average*
Moisture (%)	*27.0*
Volatile Matter (%)	*30.1*
Fixed Carbon (%)	*34.0*
Ash (%)	*8.1*
Sulfur (%)	*0.7*
Btu/lb.	*7940*

MASTER NO. 1 AND NO. 2 SEAMS: These two seams are separated by approximately 60 feet of rock and are quite persistent in the Sheridan Field. They are both subbituminous coals and occur in the Lebo Shale member of the Fort Union Formation. They each average 6 feet in thickness. The maximum thickness for either seam is 16 feet. Combined range analysis for these seams is as follows:

As-received Basis	*Range Analysis*
Moisture (%)	*22.9 - 26.1*
Ash (%)	*3.9 - 7.4*
Sulfur (%)	*0.4 - 1.1*
Btu/lb.	*8980 - 9520*
Fusion Temp. (deg. F.)	*2130 - 2530*

MONARCH SEAM: The subbituminous Monarch seam is probably the most important seam in the Sheridan Field. It ranges from 18 feet to 57 feet

thick. In the past, there has been extensive underground mining of this seam. The coal occurs in the lower part of the Tongue River member of the Fort Union Formation. The U. S. Bureau of Mines estimates that there are 50 million tons of strippable resources of this seam.

As-received Basis	*Average*	*Range Analysis*
Moisture (%)	*23*	*17.0 - 26.0*
Ash (%)	*4.5*	*2.8 - 13.3*
Sulfur (%)	*0.5*	*0.3 - 1.0*
Btu/lb.	*9500*	*8490 - 10,400*
Fusion Temp. (deg. F.)		*1960 - 2490*

ROLAND-SMITH SEAM: See Wyodak seam.

SCHOOL SEAM: This seam, which is from 110 to 180 feet below the Badger seam, is an important seam in the Glenrock Field Converse County. The seam is subbituminous C rank and occurs near the top of the Fort Union Formation. It may be correlative with the Smith seam in other fields. The seam ranges between 22 feet and 38 feet in thickness but averages 35 feet. The quality of the seam deteriorates to the south due to shaley partings. Although its quality remains good to the north, the seam thins in that direction. The U. S. Bureau of Mines estimates that there are at least 38 million tons of strippable reserves of this seam.

As-received Basis	*Average*
Moisture (%)	*26*
Ash (%)	*9*
Btu/lb.	*8000*

SMITH SEAM: This seam is particularly well developed in the Spotted Horse Field and the western side of the Little Powder River Field. The seam ranges between 5 and 13 feet thick and is subbituminous. It is found in the Fort Union Formation. In the southern part of the area, a local seam, which ranges between 4.5 and 13 feet thick, underlies the Smith seam by about 30 feet. Taken collectively, the U. S. Bureau of Mines estimates there are 94 million tons of strippable reserves of these seams. No analysis is available.

WYODAK SEAM: The Wyodak seam is a subbituminous coal best developed in the Powder River and Gillette Fields. This seam averages 71 feet thick but ranges between 55 and 106 feet. It commonly has an 8-inch parting 38 feet above its base. The Wyodak seam splits into two separate seams to the west with the lower bench ranging between 22 and 35 feet in thickness. The interval between the two benches in this direction expands up to 100 feet. To the north the seam splits into 5 or more beds varying from 5 to 31 feet in thickness and separated by 4 to 33 feet of clay and shale. As the Wyodak seam is traced southward, it is represented by 60 to 80 feet of coal separated by partings up to 8 feet thick (Smith, 1970).

The Wyodak seam, which occurs at the top of the Fort Union Formation, has been correlated with the Roland and Smith seams. This correlation is questionable. Strippable resources of this seam exceed 16 billion tons and are the largest calculated for an individual seam in Wyoming.

As-received Basis	*Average*	*Range Analysis*
Moisture (%)	*28.1*	*22.3 - 32.8*
Ash (%)	*5.9*	*6.6 - 15.2*
Sulfur (%)		*0.4 - 1.4*
Btu/lb.	*8322*	*7640 - 8640*
Fusion Temp. (deg. F.)		*2110 - 2460*

GREEN RIVER COAL REGION

The Green River Coal Region covers about 15,400 square miles of southwestern Wyoming. It is divided into two major structural basins by the Rock Springs anticline; the Green River Basin to the west and the Great Divide Basin to the east. Dips in this region are small except around the Rock Springs Uplift and the western margin. Dips on the western side of the Rock Springs Uplift go up to 20°; and on the eastern side 10°. Along the western margin of the region, dips range between 20° and 50° in some areas.

Coal ranges in rank from subbituminous C to high volatile C bituminous. The higher rank coals occur on the eastern margins of the region as well as around the Rock Springs Uplift. The higher rank coals are of Cretaceous age.

Coal-bearing rocks in the Green River Region are largely concealed by younger rocks and very little is known about the total coal resources in the area. Coal beds in the region occur in the Mesaverde Group and the Lance Formation of Upper Cretaceous age, the Fort Union Formation of Paleocene age, and the Wasatch Formation of Eocene age. Coals of the Rock Springs Formation of the Mesaverde Group have historically been the most important. It may not be long, however, before their importance is surpassed by younger seams of the Fort Union and Wasatch Formations.

Rock Springs Formation coals are high volatile C bituminous and range up to 13.8 feet thick. Although they are designated by numbers, the numbers are not arranged consecutively. From the top down, some of the more important beds are No. 3, No. 1, No. 7½, No. 7, No. 9, No. 10, No. 11, and No. 15.

Wasatch coals in the southern part of the Great Divide Basin Field are designated from youngest to oldest: Battle No. 3, Battle No. 2, Monument No. 1, Sourdough-Monument-Tierney seams, Hadsell No. 2, Creston No. 3, Creston No. 2 and Latham No. 3. These coal beds are lenticular and grade into shale to the east and west. The average, as-received analysis of these seams shows a moisture content of 21%, an ash content of 16%, a sulfur content of 2.5% and a heat value of 7900 Btu/lb. (Smith, 1970). Analysis of drill core samples of these seams show that they yield from 7.8 to 25.2 gallons of oil per ton by the Fisher assay method. Additionally, the uranium content of these coals ranges between 0.001% and 0.009% U_3O_8.

These Wasatch coals are estimated to contain over 55 million pounds of uranium with U_3O_8 contents 0.003% or greater (Masursky, 1962).

Important coal seams in Green River Coal Region are as follows:

B AND C SEAMS: These two seams are subbituminous A coals of the Wasatch Formation and reach their maximum development in the northern part of the Little Snake River Field. The B seam ranges from 10 to 18 feet in thickness and normally has a 1 to 2 foot parting in it. The C seam, which is 40 - 70 feet below the B seam, ranges in thickness between 20 feet and 32 feet. It has a 1 to 1½ foot parting. In places these two seams coalesce into a single seam of 30 to 40 feet in thickness, which has a parting up to 4 feet thick. Strippable resources of these seams collectively reach 168 million tons (Smith, 1970).

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.	*5009 - 9000*

BATTLE NO. 1 AND BATTLE NO. 2 SEAMS: These two subbituminous B coals outcrop in the southeastern part of the Great Divide Basin Field. They are seams of the Wasatch Formation. They average between 6.4 and 8.6 feet in thickness. Strippable resources of these two seams are estimated to be 38.1 million tons (Smith, 1970). A typical analysis of the Battle No. 3 seam is as follows:

As-received Basis	*Typical Analysis*
Moisture (%)	*21.9*
Volatile Matter (%)	*29.9*
Fixed Carbon (%)	*37.0*
Ash (%)	*11.2*
Sulfur (%)	*1.9*
Btu/lb.	*8650*

CRESTON NO. 2 AND NO. 3 SEAMS: These seams are in the Wasatch Formation in the Great Divide Basin Field. They outcrop in the southeastern part of the field where they average about 18 feet in thickness. They are subbituminous B in rank. Strippable resources of these seams are 125.6 million tons (Smith, 1970). A typical analysis of the Creston No. 2 seam 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.	*8710*

HADSELL NO. 2 SEAM: This is another Wasatch seam outcropping in the southeastern part of the Great Divide Basin Field. It is subbituminous B in rank and averages 7.7 feet thick. There are 39.8 tons of strippable resources estimated from this seam (Smith, 1970).

As-received Basis	*Typical Analysis*
Moisture (%)	*23.0*
Volatile Matter (%)	*31.0*
Fixed Carbon (%)	*32.2*
Ash (%)	*13.8*
Sulfur (%)	*2.7*
Btu/lb.	*8250*

JIM BRIDGER SEAMS: Two coal seams of the Fort Union Formation are exceptionally well developed on the western edge of the Great Divide Basin Field. These seams have been referred to as the Jim Bridger deposits. Each seam averages 15 feet thick, and where the two seams coalesce into a single seam, it is 30 feet in thickness. The seams are probably subbituminous in rank. Strippable resources are approximately 250 million tons (Smith, 1970). No analysis is available.

LATHAM NO. 3 AND NO. 4 SEAMS: The Latham seams are best developed in the southeastern part of the Great Divide Basin Field. They occur in

the Wasatch Formation and are subbituminous B coals. Average thickness is 5.7 feet. Strippable resources of the two seams total 70.7 million tons (Smith, 1970). A typical analysis of the Latham No. 3 seam is as follows:

As-received Basis	*Typical Analysis*
Moisture (%)	*22.6*
Volatile Matter (%)	*30.9*
Fixed Carbon (%)	*31.2*
Ash (%)	*15.3*
Sulfur (%)	*5.4*
Btu/lb.	*7980*

ROCK SPRINGS NO. 7 SEAM: This seam averages 4 feet in thickness; is high volatile C bituminous in rank; and occurs in the Rock Springs Formation of the Mesaverde Group in the Rock Springs Field. This seam has some coking porperties:

As-received Basis	*Range Analysis*
Moisture (%)	*5.0 - 17.2*
Ash (%)	*1.4 - 8.2*
Sulfur (%)	*0.7 - 1.9*
Btu/lb.	*10240 - 13110*
Fusion Temp. (deg. F.)	*2030 - 2800*

ROCK SPRINGS NO. II SEAM: The No. II seam is high volatile C bituminous coal and averages 4 feet thick. It is an important seam in the Rock Springs Field. This seam is in the Rock Springs Formation. The No. II seam has some coking properties:

As-received Basis	*Range Analysis*
Moisture (%)	*7.5 - 16.1*
Ash (%)	*1.2 - 9.9*
Sulfur (%)	*0.7 - 1.3*
Btu/lb.	*10560 - 12500*
Fusion Temp. (Deg. F.)	*2020 - 2880*

SOURDOUGH-MONUMENT-TIERNEY SEAMS: This group of coals is actually five seams that occur at about the same horizon in the Wasatch Formation in the southeastern part of the Great Divide Basin Field. Because at times these seams coalesce with one another, separation of the coals into individual beds is not always possible. In places, each of these

subbituminous B coals exceeds 5 feet in thickness. Strippable resources for these seams are 184 million tons (Smith, 1970). Below, is a typical analysis of the Sourdough No. 2 seam:

As-received Basis	*Typical Analysis*
Moisture (%)	*23.2*
Volatile Matter (%)	*33.6*
Fixed Carbon (%)	*33.0*
Ash (%)	*10.2*
Sulfur (%)	*2.9*
Btu/lb.	*8680*

VAN DYKE SEAM: Van Dyke is a local name for the Rock Springs No. 15 seam. This seam is mined in the Rock Springs Field and is in the Rock Springs Formation. It is a high volatile C bituminous coal and probably does not average much over 4 feet in thickness.

As-received Basis	*Range Analysis*
Moisture (%)	*11.4 - 13.1*
Ash (%)	*6.2 - 7.6*
Sulfur (%)	*1.1 - 1.3*
Btu/lb.	*11060 - 11540*
Fusion Temp. (deg. F.)	*2170 - 2340*

HANNA COAL FIELD

Coal-bearing rocks of the Hanna Coal Field outcrop in a 750 square mile area of Carbon County in south-central Wyoming. 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 Field is bounded on the north, west and south by mountain ranges. Faulting is common in the field.

Coal seams occur in the Mesaverde Group and Medicine Bow Formations of Upper Cretaceous age, the Ferris Formation of Upper Cretaceous and Paleocene age, and the Hanna Formation of Paleocene and Eocene age. The rank of the coals in the Hanna Field ranges from subbituminous C to high volatile C

bituminous. The highest ranked coal, high volatile C bituminous, occurs in the Mesaverde Group. Collectively, coals of this Group and the Medicine Bow Formation range downward in rank to subbituminous B. The Hanna Formation and Ferris Formation coals are predominantly subbituminous although the Hanna No. 2 seam of the Hanna Formation has reportedly been ranked as high as high volatile C bituminous.

The U. S. Bureau of Mines has estimated that there is at least 10 million tons of strippable resources in just the Hanna Formation of the field. This figure was calculated on 8 seams of the formation. Total strippable resources in the Hanna Field very probably exceed 450 million tons.

The following seams are important in the Hanna Field:

BED NO. 50: This coal seam occurs near the middle of the Ferris Formation and is a subbituminous coal. The seam is best developed in the Hanna Basin portion of the field. It averages 15 feet in thickness. No analysis is available.

BED NO. 65: This Ferris Formation coal is of Paleocene age. It is subbituminous in rank and is the only seam currently being deep mined in the field. The seam is important in the Hanna Basin and ranges from 6 feet to 8 feet in thickness. Its average thickness is 7 feet. No analysis is available.

BED NO. 80: Bed No. 80 is a Paleocene coal of the Hanna Formation. The rank is subbituminous. This seam is well developed in the Hanna Basin where it ranges from 15.5 to 24 feet in thickness. The No. 80 bed generally has a 1 to 1½ foot parting 2 to 5 feet above its base.

As-received Basis	*Average*
Moisture (%)	*11.1*
Ash (%)	*6.3*
Sulfur (%)	*0.53*
Btu/lb.	*11300*

BED NO. 82: This seam is an Eocene coal in the Hanna Formation. It is a subbituminous coal and averages 9 feet thick. No analysis is available. This seam is best developed in the Hanna Basin.

BROOKS SEAM: This seam is a subbituminous Paleocene coal near the base of the Hanna Formation. It ranges between 8 feet and 15 feet in thickness. No analysis is available.

HANNA NO. 2 SEAM: Although this seam is not presently being mined, it has been extensively deep mined and strip mined in the Hanna Basin. This coal is normally of subbituminous A rank, but in places it is ranked as high volatile C bituminous. These higher ranked occurrences are where the seam is not weathering. The Hanna No. 2 seam ranges in thickness from 30 to 35 feet. The seam is usually divided into three benches by partings.

As-received Basis	*Range Analysis*
Moisture (%)	*7.5 - 12.7*
Ash (%)	*3.9 - 6.6*
Sulfur (%)	*0.2 - 0.6*
Btu/lb.	*10640 - 11660*
Fusion Temp. (deg. F.)	*2200 - 2450*

HAMS FORK COAL REGION

This region is the westernmost of the coal-bearing areas. Because it is highly folded and thrust faulted, the coal-bearing rocks outcrop in long narrow belts. The coal-bearing rocks of this region are the Bear River, Frontier and Adaville Formations of Upper Cretaceous age and the Evanston Formation of Paleocene age. Coals in this region range between high volatile A bituminous and subbituminous B. Coals up to 20 feet thick occur in the Frontier Formation and are the higher ranking seams.

The Adaville Formation coals are subbituminous B rank and attain thicknesses over 100 feet. The Adaville Formation coals are the most important seams in the region.

ADAVILLE SEAMS: These seams are the most important coals in the region and are best developed in the Kemmerer Field. At least eight seams in this formation exceed 8 feet in thickness. The Adaville No. 1 seam is the thickest and attains thicknesses in excess of 100 feet. All the seams have partings which range from 1 inch to 15 feet in thickness. These coals are all subbituminous B in rank. Strippable resources calculated on 13 of the Adaville seams are 1 billion tons (Smith, 1970).

The following analysis is a composite of the Adaville seams:

As-received Basis	*Range Analysis*
Moisture (%)	*16.6 - 22.7*
Ash (%)	*1.7 - 5.0*
Sulfur (%)	*0.6 - 1.0*
Btu/lb.	*9720 - 11020*
Fusion Temp. (deg. F.)	*2180 - 2910+*

BIGHORN COAL BASIN

The Bighorn Coal Basin is a broad structural basin bounded on the east, south and west by mountain ranges. Coal-bearing rocks underlie about 4,400 square miles of the basin. They are exposed in the folded rocks around the margin. In these folded edges of the Bighorn Basin, dips as steep as 50° are common.

Coal-bearing rocks are the Mesaverde, Meeteetse and Lance Formations of Upper Cretaceous age and the Fort Union Formation of Paleocene age. These rocks outcrop in a 3 to 5 mile wide zone around the basin. Coals in the more central portion of the basin are under deep cover and little is known about them. Most of the coals are lenticular and of limited extent, especially along the eastern side. Thicker and more extensive coal seams

occur on the southern and western sides.

Coal in the northernmost part of the Bighorn Basin is high volatile C bituminous in rank while the remaining part of the basin contains subbituminous A and B coals.

GEBO FIELD SEAMS: Range analysis of two uncorrelated seams in the field are as follows:

As-received Basis	*Range Analysis*
Moisture (%)	*11.2 - 17.6*
Ash (%)	*2.8 - 7.4*
Sulfur (%)	*0.4 - 1.1*
Btu/lb.	*10640 - 11650*
Fusion Temp. (deg. F.)	*1860 - 2260*

GRASS CREEK FIELD SEAMS: Range analysis of two uncorrelated seams in this field are as recorded below:

As-received Basis	*Range Analysis*
Moisture (%)	*9.5 - 17.2*
Ash (%)	*3.2 - 12.0*
Sulfur (%)	*0.4 - 0.8*
Btu/lb.	*10270 -11490*
Fusion Temp. (deg. F.)	*1990 - 2620*

WIND RIVER COAL BASIN

The Wind River Coal Basin is a large asymmetrical syncline in central Wyoming. Dips are steeper on the northern side than on the southern. Many minor folds and a number of faults complicate the basin. Coal-bearing rocks are the Cody Shale, Mesaverde and Meeteetsee Formations of Upper Cretaceous age and the Fort Union of Paleocene age. Coal-bearing rocks outcrop around the margins of the basin. Coals in the central part of the basin are under considerable cover. Coals are believed to be subbituminous.

JACKSON HOLE COAL FIELD

The Jackson Hole Coal Field in northwestern Wyoming is underlain by mineable seams over an area of 700 square miles. Mineable coals occur in

Upper Cretaceous, Paleocene and Eocene age rocks. The coal is probably subbituminous rank.

BLACK HILLS COAL REGION

The Black Hills Coal Region is in the extreme northeastern part of the State. Coal outcrops in a narrow, discontinuous belt through the region. Mineable coal is confined to the base of the Lakota Sandstone of Lower Cretaceous age. The field as a whole is usually considered to be "mined out". The coal in this field is high volatile C bituminous and is a moderately good coking coal.

ROCK CREEK COAL FIELD

The Rock Creek Coal Field is a small field southeast of the Hanna Field. Coal-bearing rocks occur in the Mesaverde Group of Upper Cretaceous age and the Hanna Formation of Paleocene and Eocene age. The thickest and best exposed coal seams are in the northwestern part of the field. Coal in the field is subbituminous B rank.

GOSHEN HOLE COAL FIELD

The Goshen Hole Coal Field is in the southeastern part of the State. Coals in the field occur in the Lance Formation of Upper Cretaceous age. No coal more than 2.5 feet thick is known to exist in this field. Much of the field is covered by younger rocks which do not contain coals. The coal is probably of subbituminous rank.

COAL RESOURCES, PRODUCTION, AND RESERVES

Wyoming's original in-place coal resources between 0 and 3000 feet of overburden are estimated to be 121,553,850,000 short tons (Berryhill, 1950). Approximately 2% of these resources are lignite, 4% bituminous

coal and 94% subbituminous coal. These resources, however, were based on only 46.54% of the known or probable coal-bearing land in Wyoming as they were limited to mapped and explored areas. When an estimate of the resources of the previously omitted 53.46% of the State's coal-bearing land is added to the mapped and explored estimate, the U. S. Geological Survey estimates that Wyoming's original resources under less than 3000 feet of overburden increase to 445,710,000,000 tons. Wyoming's original resource figure becomes 545,710,000,000 tons when the overburden category is extended to 6000 feet. In the 0 to 6000 feet overburden category, Wyoming has the largest in-place coal resources in the nation.

Estimates of Wyoming's original in-place coal resources by major coal-bearing region and by county are given in Tables 1 and 2. The original resources in these two tables include mapped and explored bituminous seams 14 inches or greater in thickness and subbituminous coals 2.5 feet and thicker. Measured, indicated, and inferred categories are combined; overburden limits for these figures are 0 to 3000 feet.

Table 3 shows the total original resources of the State, production and mining losses, and remaining resources. Coal reserves, which must be based on such factors as transportation and mining costs, are not tabulated. Wyoming's known strippable resources and recoverable resources of subbituminous coal are shown in Table 4. These strippable resources are limited to a few mapped and explored areas and are only a small portion of Wyoming's strippable coal potential.

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Table I: Estimated Original In-Place Coal Resources in Wyoming by Major Coal-Bearing Regions and Rank (Berryhill, 1950)

(millions of short tons)

Coal-Bearing Region	Bituminous	Subbituminous	Total
Powder River Coal Basin		94,881.37	94,881.37
Green River Coal Region	9,904.84	6,051.04	15,955.88
Hams Fork Coal Region	3,197.68	1,676.86	4,874.54
Hanna Coal Field	73.44	3,843.52	3,916.96
Wind River Coal Basin		875.66	875.66
Bighorn Coal Basin	17.90	563.78	581.68
Rock Creek Coal Field		305.18	305.18
Jackson Hole Coal Field		121.49	121.49
Black Hills Coal Region	41.09		41.09
Total	13,234.95	108,318.90	121,553.85

NOTE: There has never been an estimate of the resources of the Goshen Hole Coal Field.

Table 2: Estimated Original In-Place Coal Resources in Wyoming by Counties and Rank (Berryhill, 1950)

(millions of short tons)

County	Bituminous	Subbituminous	Total
Albany		293.59	293.59
Big Horn		17.90	17.90
Campbell		62,219.49	62,219.49
Carbon	100.24	4,843.28	4,943.52
Converse		4,153.97	4,153.97
Crook	1.15	8.64	9.79
Fremont		733.76	733.76
Hot Springs		261.08	261.08
Johnson		10,403.14	10,403.14
Lincoln	1,670.07	1,154.65	2,824.72
Natrona		192.88	192.88
Niobrara		14.31	14.31
Park	17.90	196.59	214.49
Sheridan		17,770.71	17,770.71
Sublette	1.60	5.21	6.81
Sweetwater	9,878.04	5,030.98	14,909.02
Teton	.26	121.91	122.17
Uinta	1,525.75	523.23	2,048.98
Washakie		88.21	88.21
Weston	39.94	285.37	325.31
Total	13,234.95	108,318.90	121,553.85

Table 3: Estimate of Remaining Coal Resources of Wyoming to January 1, 1971

(thousands of short tons)

Categories of Original Resources	Mapped and Explored Areas (0-3000 ft. of cover)	Mapped and Estimate of Unexplored Areas (0-6000 ft. of cover)
Original Resources[1]	121,553,850	545,710,000
Production from[2] strip mining	60,405	
Production from[2] deep mining	379,596	
Total production	440,001	440,001
Losses due to strip mining (20% lost)	12,081	
Losses due to deep mining (50% lost)	379,596	
Total production and mining losses	831,658	831,658
Remaining Resources	120,722,192	544,878,342

1 *Source: U. S. Geological Survey*

2 *Source: U. S. Bureau of Mines and Wyoming State Inspector of Mines*

Table 4: Strippable Subbituminous Coal Resources of Wyoming to January 1, 1968 by Coal-Bearing Region (Source: U. S. Bureau of Mines)

(millions of short tons)

Coal-Bearing Region	Remaining Strippable Resources	Recoverable Strippable Resource (80% recovery)
Powder River Coal Basin	19,867	15,894
Green River Coal Region	1,151	920
Hams Fork Coal Region	1,000	800
Hanna Coal Field	10	8
Total	22,028	17,622