Review of Wyoming Coalfields, 1975

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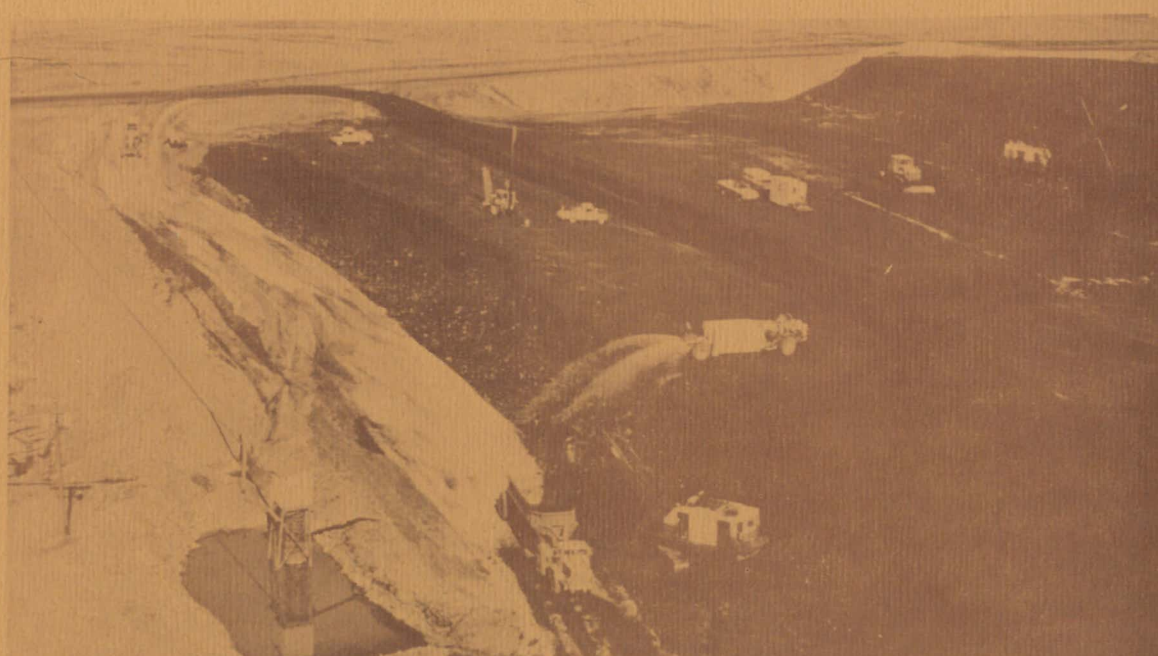

March 1975

THE GEOLOGICAL SURVEY OF WYOMING
Daniel N. Miller Jr., State Geologist

REVIEW OF WYOMING COALFIELDS, 1975

BY

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TABLE OF CONTENTS

ILLUSTRATIONS

Photo on cover: Big Horn No. 1 strip mine in Sheridan County, Wyoming. The Monarch and Dietz No. 3 seams coalesce into a 44 foot coal in this mine.

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COAL-BEARING REGIONS OF WYOMING

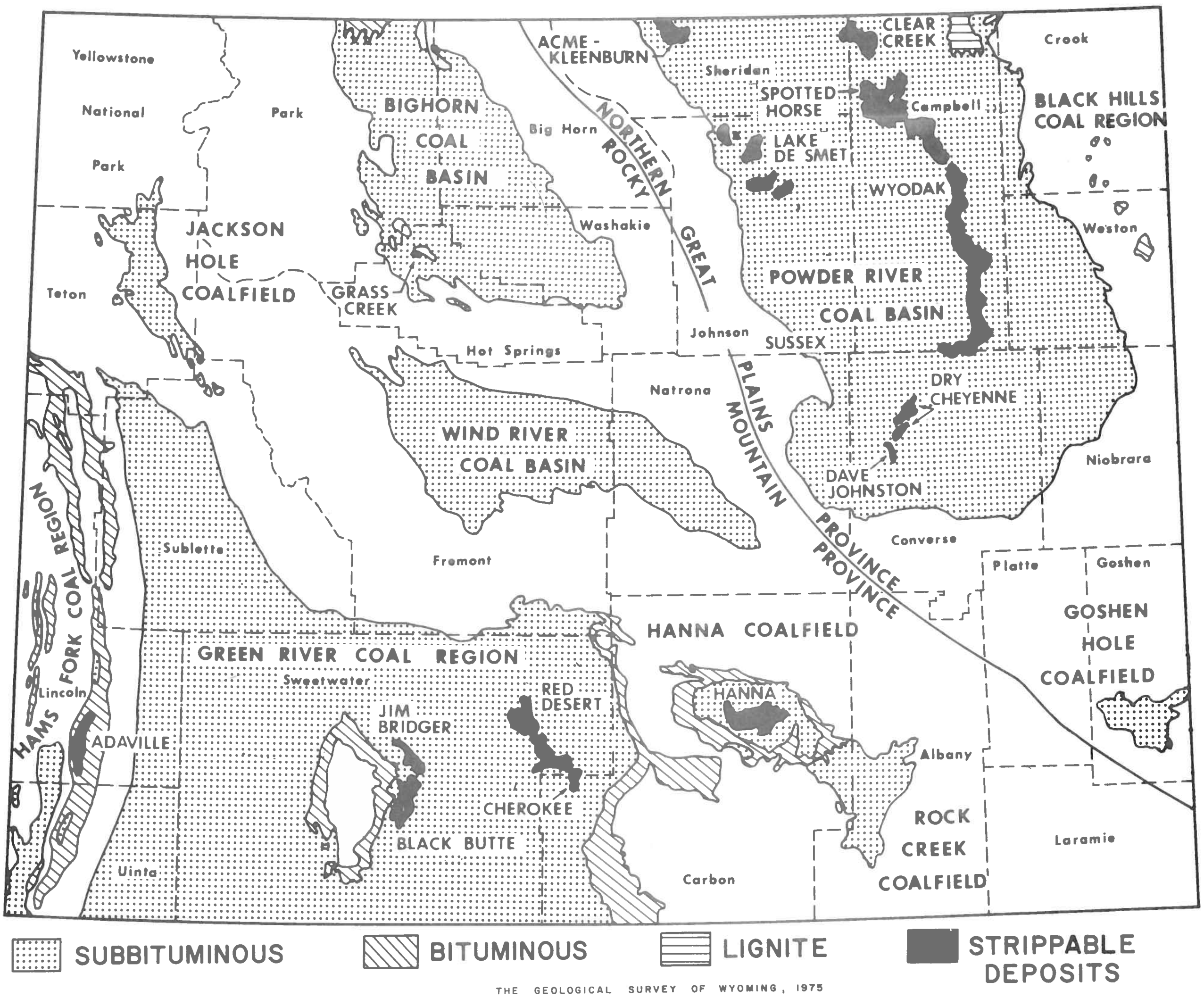

Figure 1.

COAL-BEARING AREAS

As defined by the United States Geological Survey, Wyoming's coalfields 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

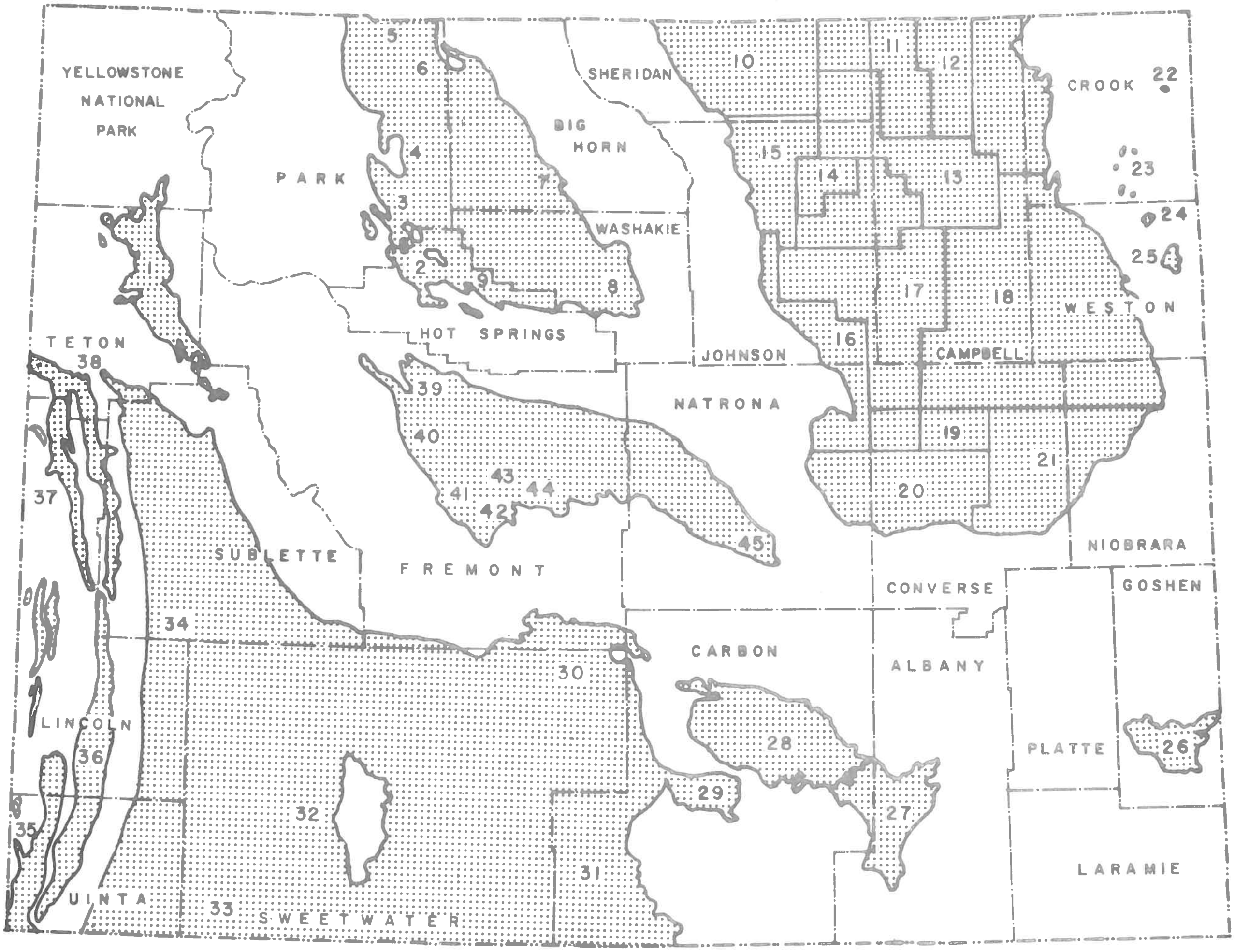

Figure 2. List of the coalfields in Wyoming, marked by number on map:

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. Henry's Fork
34. La Barge Ridge
35. Evanston
36. Kemmerer
37. Greys River
38. McDougal
39. Muddy Creek
40. Pilot Butte
41. Hudson
42. Beaver Creek
43. Big Sand Draw
44. Alkali Butte
45. Powder River

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 Fork Coal Region
4. Hanna Coalfield
5. Wind River Coal Basin
6. Bighorn Coal Basin
7. Rock Creek Coalfield
8. Jackson Hole Coalfield
9. Black Hills Coal Region
10. Goshen Hole Coalfield

These major regions are further subdivided into 45 individual coalfields (Figure 2). Twelve fields are in the Powder River Basin while 8 are in the Bighorn Basin. The Wind River and Green River Regions consist of 7 and 6 fields respectively, while the Hams Fork Region and the Black Hills Region each have 4 fields. The remaining four major regions are single coalfields. 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 crop out 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 those 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 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.

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

With one exception, the as-received moisture contents of currently mined coals average 12.5% in the southern half of the state and in the Bighorn Basin (Table 1). The exception is the Jim Bridger strip mine in southwestern Wyoming. The younger coals mined there average 20.5% moisture. Coals in the western and northeastern portions of the state average 21% and 26% moisture (as-received), respectively.

Table 1: Wyoming coal characteristics

Geographic Area	*Rank*	*Bed Thicknesses (Feet)*	*Moisture[1] (%) (AR)*	*Ash[1] (%) (AR)*	*Sulfur[1] (%) (AR)*	*Heat Value[1] (Btu/lb.) (AR)*	*Hardgrove[1] Grindability Index*
Northeastern Wyoming	Lignite Subbituminous Bituminous	Max.: 220 Range[1]: 12-125 Aver.[1]: 70	Range 20.3-29.8 Average 26.3	Range 4.4-11.4 Average 7.9	Range 0.45-0.6 Average 0.54	Range 7550-9700 Average 8300	Range 35-53 Average 45
Southern Wyoming	Subbituminous Bituminous	Max.: 50 Range[1]: 4-35 Aver.[1]: 20	Range 10.2-20.5 Average 12.4	Range 4.2-12.2 Average 7.1	Range 0.4-0.9 Average 0.52	Range 9350-11,700 Average 10,500	Range 45-80 Average 49
Western Wyoming	Subbituminous Bituminous	Max.: 110 Range[1]: 5-110 Aver.[1]: 16.5	Range 20.4-20.9 Average 20.8	Range 3.0-4.8 Average 4.5	Range 0.6-0.7 Average 0.6	Range 9500-10,200 Average 9600	Range 53-57 Average 54
Northcentral Wyoming	Subbituminous Bituminous	Max.: 50 Range[1]: 7-20 Aver.[1]: 13	Range 12.1-12.8 Average 12.5	Range 3.7-9.0 Average 6.3	Range 0.4-0.55 Average 0.48	Range 10,800-11,400 Average 11,100	

[1]Beds currently mined.   (Table compiled by Geological Survey of Wyoming, February 1975.)

Currently, the average as-received ash content of Wyoming coals is 7.2%. Reported as-received ash values normally range between 4 and 10% (Table 1). 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 contents on an as-received basis now average 0.55% and rarely exceed 0.9% (Table 1). The highest known sulfur contents occur in some Wasatch coals in the Green River Coal Region. Although these coals are not being mined, exploration has shown sulfur contents as high as 5%. More than 99% of Wyoming's total known coal resources, however, contain less than 1% sulfur, and about one-half of that is less than 0.7%. Ninety-six percent of Wyoming's known strippable resources contain less than 2% sulfur (USBM, 1971).

The sulfate form of sulfur in Wyoming coals 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 coal 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%.

HEAT VALUE

Heat values of presently mined coals, like moisture contents, vary widely across Wyoming (Table 1). In the southern half of the state and in the Bighorn Basin, as-received heat values average between 10,800 and 11,100 Btu/lb. They typically range between 10,000 and 11,500 Btu/lb. Again, the younger coals, mined at the Jim Bridger strip mine in southwestern Wyoming, are a notable exception. Those coals average only 9350 Btu/lb. While heat values of coals mined in western Wyoming average 9600 Btu/lb., the heat values in northeastern Wyoming are generally lower. They range from 9300 Btu/lb. in the Sheridan area to 8000 Btu/lb. in Converse County, but average only 8300 Btu/lb. In summary, the heat values of mined Wyoming coals average only 9400 Btu/lb.

Heat values of Wyoming coals are commensurate with their rank. On a moist mineral-matter-free basis, the bituminous coals range between 14,400 Btu/lb. and 11,000 Btu/lb. while the subbituminous coals range between 8400 Btu/lb. and 13,000 Btu/lb.

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).

GRINDABILITY AND FRIABILITY

Wyoming coals have low Hardgrove Grindability Indices, averaging only 50 (Table 1). This means they will be harder to grind or crush than coals with higher indices. Additionally, Wyoming coals tend to cake during pulverization. This caking tendency, which is a result of high moisture contents, retards pulverization.

The friability of Wyoming coals, on the other hand, equates with their rank. The higher rank coals shatter during handling while the lower rank coals slack readily upon exposure to air.

FUSIBILITY OF ASH

The ash in Wyoming coals softens and fuses at comparatively low temperatures, averaging 2140° for its softening temperature. Because of this, they can be very troublesome in many types of burning equipment. Clinker and slag formation as well as a tendency to stick in ash hoppers are common problems. However, burning equipment designed for low-fusing ash minimizes or eliminates these problems.

CARBONIZING PROPERTIES

Most Wyoming coals are nonagglomerating and may 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 Cambria 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.

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.

COKING OPERATIONS IN WYOMING

Currently there are two coking facilities in Wyoming. The FMC Corporation's pilot coke plant near Kemmerer was built in the early 1960's and utilizes the Adaville No. 1 coal from the Kemmerer Coalfield. The Adaville No. 1 is subbituminous in rank and noncoking by normal processes. The patented FMC process dries, carbonizes, and calcines raw noncoking coal into a uniform carbon product called calcinate. The calcinate is then combined with a liquid binder and formed into small pillow-shaped briquets. A typical composition for FMC coke in 1963 was as follows (Farr, 1966):

Moisture	1.9%
Moisture-free ash	4.5%
Moisture-free volatile matter	1.6%
Moisture-free fixed carbon	93.9%
Moisture-free sulfur	0.6%

Char produced in an early stage of the FMC process is suitable as a fuel to produce power and steam and can also be used for injection into blast furnaces. The calcinate is a suitable fuel for sintering iron ore.

FMC now makes two grades of coke, chemical and metallurgical. Chemical coke, which is the lower grade, is used for reducing phosphate rock in electric furnaces at FMC's plant in Pocatello, Idaho. Another use for this coke is in the production of calcium-carbide. FMC's metallurgical grade coke is a much higher temperature coke that is suitable for blast furnace use.

Kemmerer Coal Company's subsidiary Gunn-Quealy Coal Company, operates a new commercial-sized coke plant near Rock Springs. This plant is approximately three times larger than its prototype built in 1963. Gunn-Quealy's process uses poorly coking to noncoking bituminous coals to produce a chemical coke suitable for reducing phosphate in electric furnaces. The Rock Springs No. 7 coal of the Rock Springs Coalfield is currently used in the plant, which employs a rabble-type rotary oven. Gunn-Quealy's process can also use subbituminous coal. An average analysis of the coke produced from this plant in 1966 was as follows (Fagnant, 1966):

Moisture	0.5%
Moisture-free volatile matter	1.17%
Moisture-free fixed carbon	91.6%

Currently Gunn-Quealy ships all its coke to Monsanto's phosphate plant in Idaho.

IN SITU GASIFICATION

For 2½ years, the U. S. Bureau of Mines' Laramie Energy Research Center (now under ERDA) has conducted research on in situ production of gas from coal at Hanna, Wyoming. The site in southern Wyoming was provided by Rocky Mountain Energy Company. In the fall of 1972, the Bureau drilled numerous 400-foot holes into a 30-foot thick subbituminous coal underlying the site. Since the coal's ignition in 1973, the combustion and gasification has been controlled by regulation of air fed through the boreholes. According to Bureau researchers, although gas volumes and heat values have ranged from 75,000 to 2 million cubic feet per day and from 30 to 475

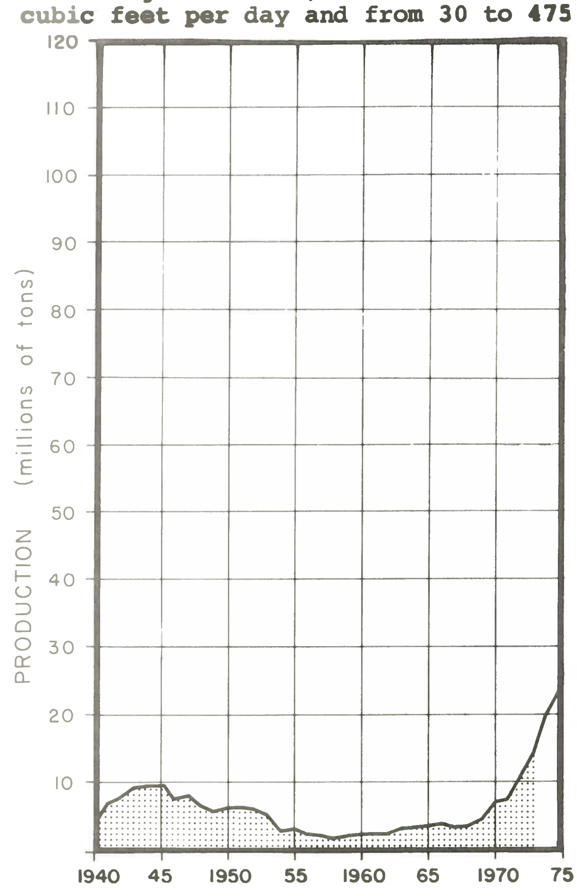

Figure 3. Wyoming coal production 1940-1973 with projections to 1975.

Table 2: Wyoming Coal Production 1973[1]

Amax Coal Co.	strip (Belle Ayr)	867,544
Arch Mineral Corp.	strip (Seminoe #1)	2,865,100
	strip (Seminoe #2)	1,497,675
Best Coal Co.	strip (East Antelope)	1,195
Big Horn Coal Co.	strip (Big Horn #1)	444,545
Dusky Diamond Coal Co.	deep (Dusky Diamond)	2,000
Energy Development Co.	deep (Vanguard #1)	331,855
Muddy Creek Mines Corp.	strip (Muddy Creek)	85
Gunn-Quealy Coal Co.	deep (Rainbow #7 - closed)	7,946
	deep (Rainbow #8)	95,524
Kemmerer Coal Co.	strip (Elkol)	400,241
	strip (Sorensen)	2,546,435
Pacific Power & Light Co.	strip (Dave Johnston)	2,897,383
Resource Exploration (strips for Energy Development)	strip (Rimrock)	624,996
Roncco Coal Co.	deep (Roncco)	2,870
Rosebud Coal Sales Co.	strips (Rosebud Pits)	1,509,736
Welch Coal Co.	strip (Welch)	18,708
Wyodak Resources	strip (Wyodak)	727,019
	Total Strip Mined	14,400,662
	Total Deep Mined	440,195
	Total Mined	14,840,857

[1]Wyoming State Inspector of Mines, Rock Springs, Wyoming.

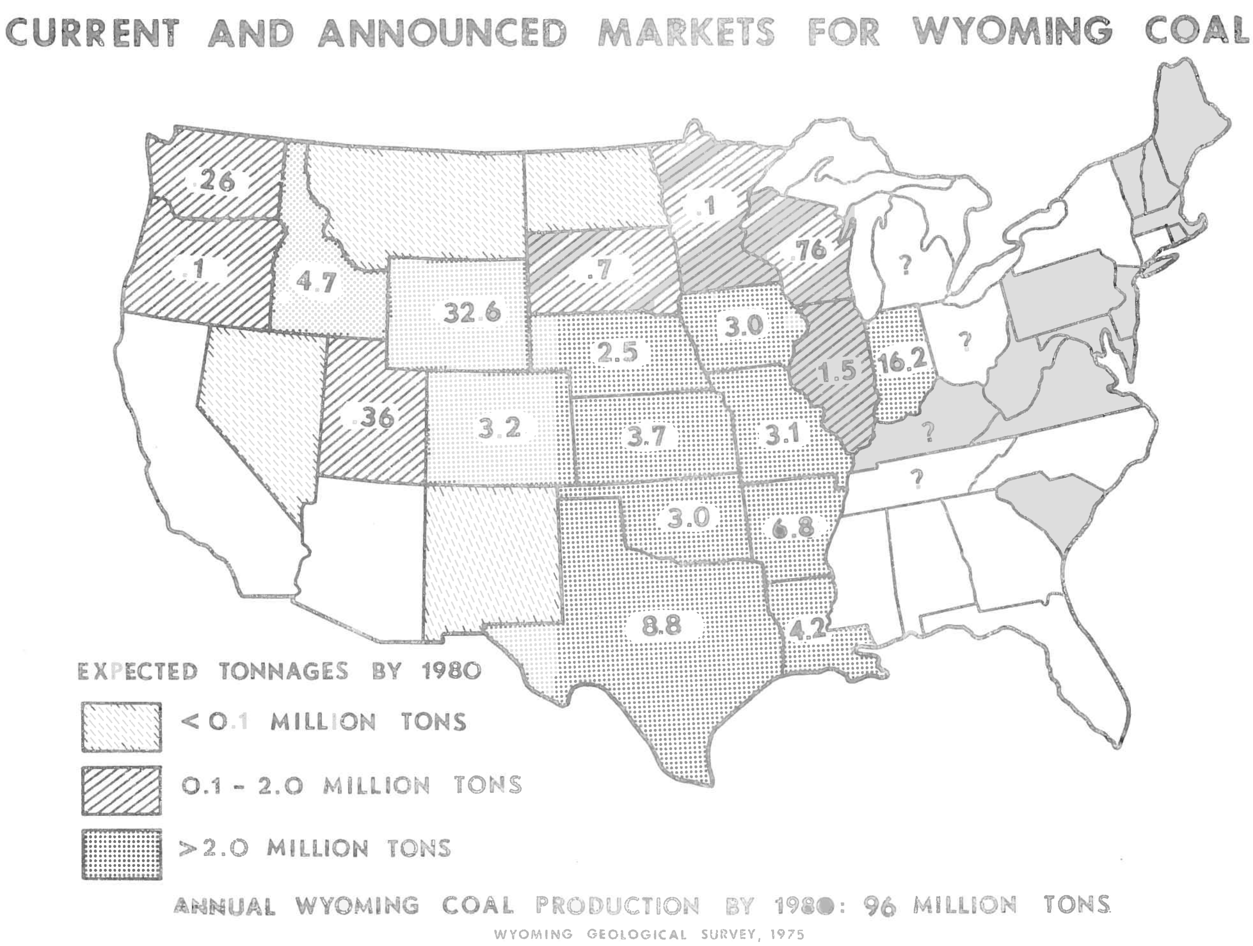

Figure 4.

Btu per cubic foot, both are now remaining on the high side of those ranges. Currently, the main fuel constituent of the gas is carbon monoxide, accounting for the low heat values. Future plans call for oxygen injection and the drilling of directional horizontal holes.

COAL MINING AND PRODUCTION

Except for an eleven-year interval after World War I, Wyoming's coal production for the years 1910 through 1945 remained above 6 million tons annually. After 1945, production plummeted to a record low of 1.6 million tons by 1958. This decline followed World War II, and, more importantly, the railroad's change from steam locomotives to diesel engines. Low-sulfur fuel demands revived the state's coal industry in the 1960's. Production increased, first slowly, and then more than doubled between 1969 and 1972 to a record 10,920,468 tons (Figure 3).

Wyoming's 1973 tonnage set yet another record at 14,840,857 tons. This tonnage ranked Wyoming as the largest coal producing state in the Rocky Mountains and the 10th largest in the nation. In 1974, production probably exceeded 20 million tons.

Coal production in Wyoming was dominated by underground mining until 1954. In that year strip mining tonnage barely exceeded that of the underground mines. Since then, however, strip mining has become the dominant mining method and accounts for more than 94% of Wyoming's annual production. Conversely, underground mining has slipped to less than 6% of the annual tonnage mined.

During 1974, there were 5 underground mines and 15 strip mines operational. Although the 15 companies that operated these mines produced an estimated 20 million tons in 1974, not all those companies remained open by the year's end. The Dusky Diamond mine closed in 1974.

The locations of mines operational in 1974 are summarized below:

<u>Powder River Coal Basin</u>
- Powder River Field: Wyodak Resources and Development (Wyodak strip - T50N, R71W)
- Gillette Field: Amax Coal Company (Belle Ayr strip - T48N, R71W), Best Coal Company (East Antelope strip - T41N, R71W)
- Sheridan Field: Big Horn Coal Company (Big Horn No. 1 strip - T57N, R84W), Welch Coal Company (Welch strip - T57N, R85W)
- Glenrock Field: Pacific Power and Light (Dave Johnston strip - T36N, R75W)

<u>Green River Coal Region</u>
- Rock Springs Field: Bridger Coal Company (Jim Bridger strip - T21N, R100W), Gunn-Quealy Coal Company (Rainbow No. 8 deep mine - T18N, R105W)

<u>Hanna Coalfield</u>
- Hanna Field: Energy Development (Vanguard No. 1 deep mine - T22N, R82W, Vanguard No. 2 deep mine - T22N, R82W) Resource Exploration and Mining, Inc. (Rimrock strip - T22N, R82W), Rosebud Coal Sales Company (Pit No. 4 - T22N, R82W, Pit No. 5 - T23N, R81W, Pit No. 8 - T23N, R81W), Arch Mineral Corporation (Seminoe No. 1 strip - T22N, R83W, Seminoe No. 2 strip - T22N, R81W)

<u>Hams Fork Coal Region</u>
- Kemmerer Field: Kemmerer Coal Company (Sorensen strip - T21N, R116W, Elkol strip - T21N, R116W)

<u>Bighorn Coal Basin</u>
- Gebo Field: Roncco Coal Company (Roncco deep mine - T44N, R95W)
- Grass Creek Field: Dusky Diamond Coal Company (Dusky Diamond deep mine - T46N, R99W)

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

An estimate of the total coal production from Wyoming to January 1, 1974, is 477,027,590 tons of which 80.5% or 383,870,381 tons came from underground mines and 19.5% or 93,157,209 tons from strip mines.

In 1975, an estimated 89.2% or 21.8 million tons of Wyoming's production will be used in coal-fired power plants with approximately 31.6% or 7.7 million tons of that used in-state. The remaining 10.8% of Wyoming's annual tonnage will be used by the beet sugar industry, cement industry, trona industry, synthetic coke industry, railroads, governments, domestic, and other miscellaneous users. Power plant coal is currently shipped out of Wyoming to Colorado, Illinois, Indiana, Iowa, Missouri, Nebraska, South Dakota, and Wisconsin. Smaller volumes now go to other users in Idaho, Kansas, Minnesota, Montana, Nevada, North Dakota, Oregon, Utah, and Washington as well. By 1980, coal will also be shipped to Arkansas, Louisiana, New Mexico, Oklahoma, and Texas (Figure 4).

Wyoming's coal production is expected to increase 5.5 to 18.0 million tons per year throughout this decade. This is an average annual increase of 12.9 million tons. At these rates, annual tonnage will be 96-110 million tons by 1980; 140-240 million tons by 1985 (Figure 5). These projected increases are principally to satisfy the electric power market and include the requirements of only one to perhaps 4 coal gasification plants.

If only the most probable forecast

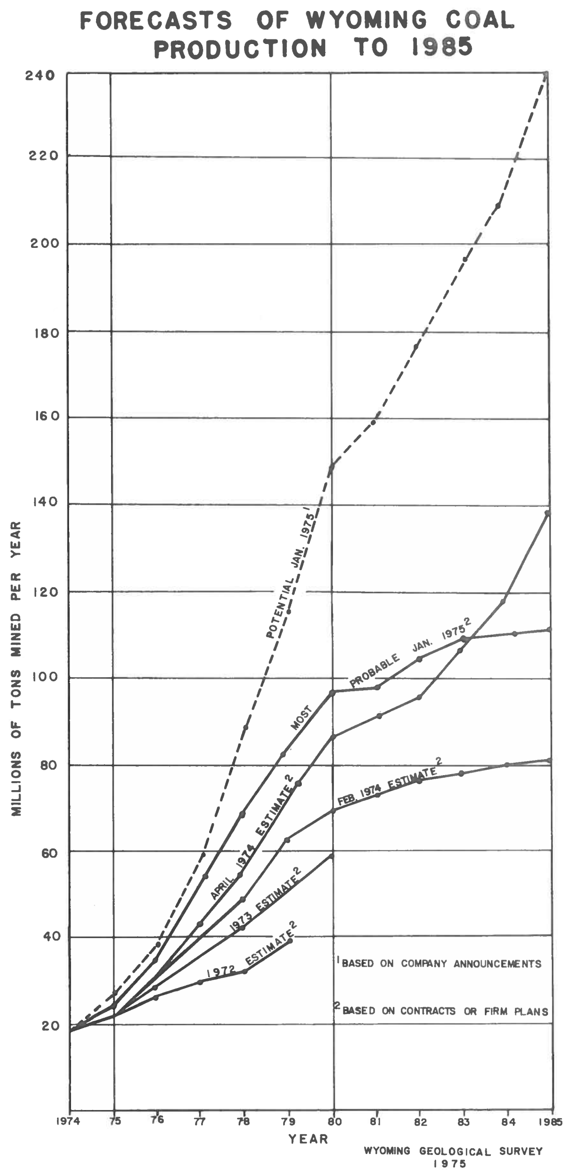

Figure 5.

materializes, Wyoming coal companies will have to mine twice as much coal in the 13 years between 1973 and 1985 as their predecessors produced in the previous 108 years of recorded coal mining in the state.

In regard to mine size, most Wyoming strip mines are slated to be very large -- in excess of 5 million tons per year and several as high as 20 million tons. For examples, Amax, Carter Oil, Kerr-McGee, Atlantic Richfield, Pacific Power & Light, Kemmerer, and Peabody each expect to have one or more strip mines producing between 5 and 20 million tons per year by 1980. For comparison, Utah International's Navajo mine in New Mexico, which is currently the largest surface mine in the nation, produces about 7.5 million tons per year.

BED THICKNESSES

Currently, mined coals range from 4-110 feet thick, but average 13-70 feet thick (Table 1). The thickest beds are restricted to the Powder River Basin in northeastern Wyoming and the Hams Fork Coal Region in westernmost Wyoming. The thickest coal in the state occurs on the western side of the Powder River Coal Basin. There, the Healy Seam is reportedly 220 feet thick, but it is not presently mined.

The maximum coal thicknesses in the southern, northwestern, and central portions of Wyoming are 50 feet although the mined average is currently less than 20 feet. The thinnest coal mined in the state is 4 feet (southern Wyoming). This seam, incidentally, is the only bituminous coal mined in Wyoming. All other mined seams are subbituminous in rank.

POWDER RIVER COAL BASIN

The Powder River 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 2° on the eastern side of the basin steepen against the Bighorn Mountains on the western side.

Although some lignitic to subbituminous coals occur in the Cretaceous Lance Formation, the most persistent and thickest coals occur in the Tertiary Fort Union and Wasatch Formations. In fact these two formations are probably the most prolific coal-bearing formations in Wyoming. The Fort Union Formation coals, which are best developed on the north and east sides of the basin, consist of 8 to 12 thick, subbituminous coals. One, the Wyodak-Anderson seam, frequently ranges between 70 and 125 feet thick. The Wasatch Formation, on the other hand, contains as many as 8 persistent coals. The thickest Wasatch coal occurs at Lake De Smet on the west side of the basin. There, the Healy Seam locally exceeds 220 feet in thickness.

Important coal seams in the Powder River Coal Basin are as follows:

Anderson Seam: This Fort Union Formation seam is a subbituminous coal well developed in all but the western portion of the basin. The Anderson seam merges with the Canyon seam in the Gillette area to form the 70-125 foot thick Wyodak-Anderson seam, which crops out on the eastern side of the basin (Denson, 1974). Northward, eastward, and southward the Anderson splits off the Wyodak-Anderson bed and thins to 10-50 feet thick. The D seam of the southern part of the Gillette Coalfield is correlative with the Anderson seam, but the Roland seam, which is stratigraphically higher, does not correlate with it as previously reported (Breckenridge, 1974). Although most of the strippable resources calculated for this seam are included in the Wyodak-Anderson estimate, approximately 250 million tons of strippable Anderson or D seam are reported in the southern part of the Gillette Coalfield (Smith, 1972). The Anderson seam is currently only mined where it is combined with the Canyon coal to form the Wyodak-Anderson seam.

As-received Basis	*Range-9 Cores (USGS, 1973, 1974)*	*Ave.*
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.	7,128-8,737	7,979

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 Anderson 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 are at least 9.5 million tons of strippable reserves of this seam (Smith, 1972). This seam is strip mined in Converse County.

As-received Basis	*Range-5 Samples*	*Ave.*
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.	7,606-8,290	7,951
HGI	29-30	29.5

Canyon Seam: The subbituminous Canyon seam is well developed over all but the western side of the basin. In the Gillette area of Campbell County, the Canyon coalesces with the Anderson seam to form the thick Wyodak-Anderson bed (70-125 feet), which crops out on the eastern side of the basin. North, west, and south of Gillette, the Canyon splits off the bottom of the Wyodak-Anderson bed (Denson, 1974). Where it is not joined with the Anderson seam, the Canyon ranges between 11 and 65 feet thick. The Canyon bed of the Fort Union Formation is correlated with the E seam of the southern part of the Gillette Coalfield (Breckenridge, 1974). It is not correlative with the stratigraphically higher Smith seam as previously reported. It may, however, be correlative with a Dietz seam of the Sheridan Coalfield. Except for an estimated 250 million tons of strippable resources in the southern Gillette Coalfield (E seam) and another 184.9 million tons along Clear Creek in the Spotted Horse Coalfield (Smith, 1972), strippable resources of the Canyon bed are reported with the Wyodak-Anderson estimates. Currently the Canyon seam is only mined at two sites near Gillette, where it is merged with the Anderson seam.

As-received Basis	*Range-9 Cores (USGS, 1973, 1974)*	*Ave.*
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.	7,537-8,609	8,286

D Seam: See Anderson Seam

Dietz No. 2 Seam: This coal is locally important in Sheridan County where it is currently strip mined as a rider coal above the Monarch and Dietz No. 3 coals. This subbituminous Fort Union Formation coal averages 12 feet in thickness. It was previously mistaken for the Armstrong bed in the strip mine.

As-received Basis	*Range or typical-5 samples*
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.	9,220-9,387
HGI	40

Dietz No. 3 Seam: This subbituminous seam is an important strippable coal in the Sheridan Field, where it was once extensively deep mined. It averages 10-25 feet in thickness. Locally the Dietz No. 3 coalesces with the underlying Monarch seam to form a 40-45 foot thick bed. It is strip mined with the Monarch seam in Sheridan County. The strippable resource estimate of this Fort Union Formation coal is included with the estimate for the Monarch seam, which underlies it by a few inches to 60 feet (Smith, 1972). Although this seam is usually analyzed with the Monarch coal, a typical analysis is:

As-received Basis	*Typical*
Moisture (%)	19.1
Volatile Matter (%)	34.8
Fixed Carbon (%)	41.7
Ash (%)	4.4
Sulfur (%)	0.5
Btu/lb.	9,710
HGI	39

E Seam: See Canyon Seam

F Seam: Although this seam is well developed in portions of the Dry Cheyenne and Gillette Fields in Converse County, it is not presently mined. Bed F has a maximum thickness of 11.6 feet but averages only 7.5 feet. Strippable resources of this seam are estimated at 179.5 million tons (Smith, 1972). This seam has not been correlated beyond Converse County.

Felix Seam: This is an important seam in the northern and eastern portions of the Powder River Coal Basin. This Wasatch Formation coal ranges from 5-21 feet in thickness in the Spotted Horse Coalfield in the north to as thick as 50 feet in the southern part of the Gillette Coalfield. Partings are common and fairly persistent in places. Known strippable resources of this seam total 480.7 million tons in the Spotted Horse Coalfield (Smith, 1972). The seam is subbituminous in rank, and is not being mined.

As-received Basis	*Range-42 Cores (USGS, 1973, 1974)*	*Ave.*
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	8,053

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 analyses suggest the seam is subbituminous C in rank. Upper portions of the seam are frequently burned. Its strippable resource is approximately one billion tons and is centered around Lake De Smet (Smith, 1972). The seam is in the Wasatch Formation. It is not currently mined.

As-received Basis	*Range-5 Samples*	*Ave.*
Moisture (%)	23.6-30.7	28.5
Volatile Matter (%)	28.6-31.9	30.0
Fixed Carbon (%)	32.8-34.8	33.9
Ash (%)	5.1-9.7	7.6
Sulfur (%)	0.4-1.0	0.6
Btu/lb.	7,515-8,270	7,884

Monarch Seam: The subbituminous Monarch seam is one of the most important coals in the Sheridan Field. Although it reportedly ranges up to 57 feet in thickness, the thicker occurrences are where the Monarch and Dietz No. 3 seams are merged into a single seam. The Monarch's normal thickness probably ranges between 5 and 25 feet. In the past, there has been extensive underground mining of this seam. This mining suggests that the Monarch seam splits into 3 or more benches westward from the Acme-Kleeburn area. The Monarch 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 32 million tons of strippable resources of this seam, but these resources include some Dietz No. 3 tonnage as well (Smith, 1972). The Monarch is strip mined in Sheridan County. Some of the published analyses of the Monarch, like the resource estimates, probably include the Dietz No. 3 coal.

As-received Basis	*Range-203 Analyses*	*Ave.*
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
HGI	38-45	42

School Seam: This seam, which is from 110 to 180 feet below the Badger seam, is an important seam in the Glenrock Field of Converse County. The seam is subbituminous C in rank and occurs near the top of the Fort Union Formation. It may be correlative with the Canyon seam in other fields. The coal 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 126.2 million tons of strippable resource in this seam. The School seam is strip mined in Converse County.

As-received Basis	*Range-3 Samples*	*Ave.*
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	8,183
HGI	35-35.5	35

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 near the top of the Fort Union Formation. In the southern part of the Spotted Horse Field, a local coal, which ranges between 4.5 and 13 feet thick, underlies the Smith seam by 30 feet. There are an estimated 178 million strippable tons of the Smith seam and another 58.3 million tons of the local coal (Smith, 1972). Neither seam is mined at this time. The "Smith" seam of the Gillette area is now called the Canyon seam rather than this stratigraphically higher seam to which it is not correlative.

As-received Basis	*Core Analysis (USGS, 1974)*
Moisture (%)	31.8
Volatile Matter (%)	28.7
Fixed Carbon (%)	34.8
Ash (%)	4.7
Sulfur (%)	0.63
Btu/lb.	7,991

Sussex Field (Lower Bed): This "lower bed" in "Basin No. 4" of the Sussex Field averages 11.8 feet thick but reaches a maximum of 50 feet. A preliminary estimate of strippable resources of this Wasatch Formation seam is 13.6 million tons (Smith, 1972). Currently, the seam is not mined.

As-received Basis	*Ave.*
Moisture (%)	23.5
Volatile Matter (%)	35.6
Fixed Carbon (%)	35.7
Ash (%)	5.2
Sulfur (%)	0.49
Btu/lb.	9,160

Wyodak-Anderson Seam: Outcrops show this thick seam is well developed, though extensively burned, on the eastern side of the basin, especially in the Gillette area (Breckenridge, 1974). Recent geologic mapping by the U. S. Geologic Survey now shows that this seam, formerly misnamed the Roland-Smith seam, is actually the Anderson and Canyon seams coalesced into one (Denson, 1974). The seam is subbituminous, ranges between 25 and 125 feet thick, and probably averages 70 feet in thickness. It commonly has an 8 inch parting 38 feet above its base, which probably marks the contact between the Anderson and Canyon seams. The bed separates into the Anderson and Canyon seams to the west with the two seams each ranging between 10 and 65 feet in thickness. To the north, the Wyodak-Anderson seam splits into 5 or more benches varying from 5 to 31 feet in thickness and separated by 4 to 33 feet of claystone and shale. The seam also splits into the D seam (Anderson) and E seam (Canyon) southward from Gillette. Strippable resources of this Fort Union Formation coal are estimated at 19 billion tons, and are the largest calculated for an individual seam in Wyoming. The Wyodak-Anderson seam is strip mined in Campbell County.

As-received Basis	*Range-59 Samples*	*Ave.*
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	8,224
HGI	49-56	53

(to next column)

GREEN RIVER COAL REGION

The Green River 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 Lance, 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.

Almond Formation coals encircle all but the southwestern side of the Rock Springs Uplift area. These subbituminous coals of the Mesaverde Group have not been extensively mined, but they reportedly average up to 12 feet thick on the east side of the uplift (VTN, 1974).

Lance Formation coals reportedly average 5-10 feet thick at least on the east flank of the uplift (VTN, 1974).

Although Fort Union Formation coals are some of the thicker and more persistent coals in the region, they were not extensively mined until 1974 when the Jim Bridger strip mine officially opened. Up to 30 feet of coal is exposed in that area. South of the Bridger mine, Fort Union Formation coals average

10 to 26 feet thick in the Black Buttes area (VTN, 1974). In both cases the coal is subbituminous in rank.

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, 1972). Analyses 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 the Green River Region are as follows:

Almond Seams (Undifferentiated): Although there are no formal names for these coals, at least one Almond coal averages 10-12 feet thick in the Black Buttes area east of Rock Springs (VTN, 1974).

As-received Basis	*Ave. (Root, 1973)*
Moisture (%)	16.4
Volatile Matter (%)	31.0
Fixed Carbon (%)	47.7
Ash (%)	5.0
Sulfur (%)	0.6
Btu/lb.	9,727

B and C Seams: These two unmined 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 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 200.9 million tons (Smith, 1972).

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.	5,009-9,000

Battle No. 1 and Battle No. 2 Seams: These two subbituminous B coals crop out 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, 1972). 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.	8,650

Creston No. 2 and Creston No. 3 Seams: These seams are in the Wasatch Formation in the Great Divide Basin Field. They crop out 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, 1972). 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.	8,710

Deadman Seam: The Deadman seam of the Fort Union Formation is exceptionally well developed on the western edge of the Great Divide Basin Field. There, the seam has been referred to as the Jim Bridger deposit. The Deadman seam is 30 feet thick except where it splits into two 15 foot beds. It is subbituminous in rank. Strippable resources are approximately 250 million tons (Smith, 1972). The seam is now strip mined.

As-received Basis	*Range-4 Analyses*	*Typical*
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 Seams (Undifferentiated): Subbituminous Fort Union coals are locally known as the Black Rock Coal Group (Root, 1973). Although they crop out on both sides of the Rock Springs Uplift, they are best developed on the east side where they were occasionally mined underground in the early 1900's. In the Black Buttes area, these unnamed Fort Union Formation coals average 10-26 feet thick (VTN, 1974). They are not currently mined.

As-received Basis	*Ave. (VTN, 1974)*
Moisture (%)	17.69
Volatile Matter (%)	30.93
Fixed Carbon (%)	43.85
Ash (%)	8.48
Sulfur (%)	0.41
Btu/lb.	9,728

Hadsell No. 2 Seam: This is another Wasatch seam cropping out 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 million tons of strippable resources estimated from this seam (Smith, 1972).

As-received Basis	*Typical Analysis*
Moisture (%)	23.0
Volatile Matter (%)	31.0
Fixed Carbon (%)	32.2
Ash (%)	13.8
Sulfur (%)	2.7
Btu/lb.	8,250

Lance Formation Seams: (Undifferentiated): Subbituminous coals of the Lance Formation are known as the Black Buttes Coal Group (Root, 1973). Where they crop out on the northeastern and eastern sides of the Rock Springs Uplift, several small underground mines worked 4-9.6 foot thick coals in the early 1900's. Lance coals averaging 5-10 feet thick are reported in the Black Buttes area by VTN, 1974 and may be strip mined in the near future.

As-received Basis	*Ave. (Root, 1973)*
Moisture (%)	17.5
Volatile Matter (%)	29.8
Fixed Carbon (%)	48.6
Ash (%)	4.1
Sulfur (%)	0.4
Btu/lb.	10,110

Latham No. 3 and Latham 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, 1972). 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.	7,980

Rock Springs No. 1 Seam: Although this bituminous seam was extensively deep mined in the past it is not presently mined. Plans to reopen the Stansbury No. 1 underground mine on this seam are nearing completion, however. A run-of-the-mine analysis of this Rock Springs Formation coal, taken at Stansbury in 1952, showed:

As-received Basis	*Tipple Analysis*
Moisture (%)	17.6
Volatile Matter (%)	34.5
Fixed Carbon (%)	43.9
Ash (%)	4.0
Sulfur (%)	0.99
Btu/lb.	10,480

Rock Springs No. 7 Seam: This seam averages 4.5 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 properties. The No. 7 seam is deep mined in Sweetwater County and used for making chemical grade coke suitable for reducing phosphate in electric furnaces.

As-received Basis	*Range-14 Samples*	*Ave.*
Moisture (%)	5.0-16.5	11.4
Volatile Matter (%)	33.8-40.3	37.7
Fixed Carbon (%)	44.3-52.6	46.7
Ash (%)	2.4-5.4	4.2
Sulfur (%)	0.6-1.1	0.9
Btu/lb.	10,640-13,110	11,695
HGI		48

Rock Springs No. 11 Seam: The No. 11 seam is volatile C bituminous coal, ranges from 44 to 54 inches in thickness, and averages 4 feet thick. It is an important seam in the Rock Springs Field. This seam is in the Rock Springs Formation, and 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.	12,379-12,572

This seam is not currently mined.

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 unmined seams are 458.9 million tons (Smith, 1972).

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.	8,680

Wasatch Formation Seams (Undifferentiated): Unnamed Wasatch coals in the Black Buttes area of Sweetwater County reportedly average 6-8 feet thick (VTN, 1974). These coals are subbituminous in rank, but are not presently mined. Analyses of the Wasatch coals that crop out on the flanks of the Rock Springs Uplift are as follows:

As-received Basis	*Ave. 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 Field crop out 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 volatile C bituminous (Glass, 1972).

The U. S. Bureau of Mines has estimated that there are 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 are approximately 313 million tons (Glass, 1972).

The following seams are important in the Hanna Field:

Bed No. 24: This subbituminous Ferris Formation coal averages 18-20 feet thick. It is presently strip mined on the west side of the Hanna Field. A typical analysis is:

As-received Basis	*Range or Typical*
Moisture (%)	14.0-16.0
Volatile Matter (%)	34.3
Fixed Carbon (%)	45.8
Ash (%)	3.9-8.4
Sulfur (%)	0.3-0.4
Btu/lb.	10,050-10,180
HGI	47

Bed No. 25: Bed No. 25 is a subbituminous coal in the lower third of the Ferris Formation and is best developed on the west side of the Hanna Field. This coal averages up to 22 feet thick except where it splits into as many as three thinner benches, designated Seam 1, 2, and 3 from the top down. Seam 1, or the upper bench, averages 4 feet thick; seam 2 averages 5.5 feet; seam 3, or the lower bench, averages 7.2-8.3 feet thick. The coal is currently strip mined.

As-received Basis	*Range-4 Samples*	*Ave.*
Moisture (%)	11.5-18.9	14.6
Volatile Matter (%)	32.5-34.5	33.6
Fixed Carbon (%)	39.3-44.3	42.0
Ash (%)	6.6-16.7	9.8
Sulfur (%)	0.3-0.7	0.5
Btu/lb.	8,340-9,940	9,327
HGI	41-66	51

Bed No. 50: This coal occurs near the middle of the Ferris Formation and is subbituminous in rank. The seam is best developed west of the town of Hanna where it is presently mined. It varies between 15 and 19 feet in thickness.

As-received Basis	*Range or Typical*
Moisture (%)	11.3-14.3
Volatile Matter (%)	34.1
Fixed Carbon (%)	43.7
Ash (%)	10.9-13.6
Sulfur (%)	0.4-0.43
Btu/lb.	9,410-10,070
HGI	45

Bed No. 65: This Ferris Formation coal is of Paleocene age. It is subbituminous in rank, and is now deep mined in the field. The seam is important west of the town of Hanna where it ranges from 6 feet to 8 feet thick.

(Analysis is on next page.)

As-received Basis	*Range-3 Samples*	*Ave.*
Moisture (%)	9.0-11.6	9.6
Volatile Matter (%)	36.8-37.2	37.0
Fixed Carbon (%)	46.4-49.0	47.7
Ash (%)	5.2-7.1	5.7
Sulfur (%)	0.60-0.7	0.65
Btu/lb.	11,020-11,277	11,213
HGI	50-54	52

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. It is strip mined in Carbon County.

As-received Basis	*Range-10 Samples*	*Ave.*
Moisture (%)	10.6-14.5	11.5
Volatile Matter (%)	37.4-39.2	38.3
Fixed Carbon (%)	39.6-47.6	43.6
Ash (%)	4.4-9.3	6.6
Sulfur (%)	0.6-1.2	0.9
Btu/lb.	10,307-11,510	10,665
HGI	47-49	48

Bed. No. 82: This seam is an Eocene coal in the Hanna Formation. It is a subbituminous coal averaging 9 feet thick and is best developed in the Hanna Basin. It is stripped in Carbon County.

As-received Basis	*Range-8 Samples*
Moisture (%)	11.2-13.5
Volatile Matter (%)	40.9
Fixed Carbon (%)	40.6
Ash (%)	6.9-10.7
Sulfur (%)	0.73-1.0
Btu/lb.	10,140-10,870
HGI	50

Brooks Seam: This seam is a subbituminous Paleocene coal near the base of the Hanna Formation. It ranges between 7.5 feet and 15 feet in thickness and is strip mined in Carbon County.

As-received Basis	*Range-3 Samples*	*Ave.*
Moisture (%)	8.9-13.7	10.6
Volatile Matter (%)	33.5-36.7	35.1
Fixed Carbon (%)	47.2-47.5	47.4
Ash (%)	6.5-7.0	6.9
Sulfur (%)	0.45-0.7	0.55
Btu/lb.	10,806-11,179	10,935
HGI	48-51	49

Hanna No. 1 Seam: Although this Hanna Formation coal is not now mined, it has been extensively deep mined in the past. The seam ranges between 15 and 30 feet in thickness, and is presently being converted into a low-Btu gas at a Bureau of Mines in situ gasification site south of Hanna. The coal is subbituminous in rank.

As-received Basis	*Range-3 Samples*	*Ave.*
Moisture (%)	6.3-11.7	10.6
Volatile Matter (%)	32.6-41.1	36.9
Fixed Carbon (%)	34.1-41.7	37.9
Ash (%)	5.6-23.8	14.7
Sulfur (%)	0.26-0.68	0.47
Btu/lb.	8,660-9,633	9,831

Hanna No. 2 Seam: This coal is normally of subbituminous A rank, but in places it is ranked as high volatile C bituminous. Although it was extensively deep mined in the past, it is now strip mined near Hanna, Wyoming. The Hanna No. 2 seam ranges between 30 and 36 feet thick.

As-received Basis	*Range-6 Samples*	*Ave.*
Moisture (%)	7.5-11.7	10.2
Volatile Matter (%)	38.4-40.5	39.6
Fixed Carbon (%)	42.9-46.7	44.4
Ash (%)	5.0-7.3	5.8
Sulfur (%)	0.26-0.45	0.37
Btu/lb.	11,180-11,660	11,350
HGI		48

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 crop out 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 in rank and attain thicknesses over 100 feet.

Adaville Seams: These seams are the most important coals in the region and are best developed in the Kemmerer Field. At least seventeen seams in this formation exceed 6 feet in thickness. The Adaville No. 1 seam is the thickest and attains thicknesses in excess of 100 feet. Some production of the No. 1 seam is used to make chemical coke for the phosphorous industry as well as experimental metallurgical grade coke. 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 greater than 1 billion tons (Smith, 1972). All the current mining on these seams is by surface methods.

Adaville No. 1 Seam

As-received Basis	*Range-9 Samples*	*Ave.*
Moisture (%)	16.7-22.7	20.4
Volatile Matter (%)	33.0-36.5	34.5
Foxed Carbon (%)	40.8-42.8	42.1
Ash (%)	1.5-4.0	3.0
Sulfur (%)	0.5-1.3	0.7
Btu/lb.	9,720-10,530	10,193
HGI	55-59	57

Adaville Seams
(Exclusive of Adaville No. 1)

As-received Basis	*Range-19 Samples*	*Ave.*
Moisture (%)	15.4-28.6	20.9
Volatile Matter (%)	31.1-36.1	33.8
Fixed Carbon (%)	33.5-44.7	40.4
Ash (%)	3.2-6.9	4.8
Sulfur (%)	0.2-1.8	0.6
Btu/lb.	7,920-10,400	9,472
HGI	41-87	53

BIGHORN COAL BASIN

The Bighorn 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 crop out 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 lenticluar 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 (Uncorrelated): One uncorrelated coal seam is currently mined in the Gebo Field. The seam ranges between 7 and 9 feet in thickness, but averages only 7 feet. The seam is mined underground by conventional methods.

As-received Basis	*Range-4 Samples*	*Ave.*
Moisture (%)	12.5-13.1	12.8
Volatile Matter (%)	35.1-38.4	36.6
Fixed Carbon (%)	44.8-48.6	46.9
Ash (%)	3.4-3.8	3.7
Sulfur (%)	0.5-0.7	0.55
Btu/lb.	11,290-11,440	11,372

Mayfield Seam: This seam in the Grass Creek Field is currently strip mined. The seam ranges from 20 to 50 feet in thickness and has been deep mined in the past. A preliminary and very conservative strippable resource estimate for this seam is 3 million tons (Travis, 1951).

As-received Basis	*Range-3 Samples*	*Ave.*
Moisture (%)	11.7-12.4	12.1
Volatile Matter (%)	34.4-37.1	35.6
Fixed Carbon (%)	42.2-44.3	43.4
Ash (%)	8.3-9.4	9.0
Sulfur (%)	0.3-0.5	0.4
Btu/lb.	10,730-10,850	10,807

WIND RIVER COAL BASIN

The Wind River 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 Meeteetse Formations of Upper Cretaceous age and the Fort Union of Paleocene age. Coal-bearing rocks crop out around the margins of the basin. Coals in the central part of the basin are under considerable cover and are believed to be subbituminous.

JACKSON HOLE COALFIELD

The Jackson Hole Field in northwestern Wyoming is underlain by coal-bearing rocks over an area of 700 square miles. Mineable coals occur in Upper Cretaceous, Paleocene and Eocene age rocks. The coal is probably subbituminous in rank.

BLACK HILLS COAL REGION

The Black Hills Region is in the extreme northeastern part of the state. Coals crop out 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 COALFIELD

The Rock Creek 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 in rank.

Table 3: Estimated original in-place coal resources in Wyoming by counties and rank (modified after Berryhill, 1950)
(millions of short tons)

County	*Bituminous*	*Subbituminous*	*Total*
Albany		293.59	293.59
Big Horn		17.90	17.90
Campbell*		69,033.84	69,033.84
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*		12,235.66	12,235.66
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*		24,461.42	24,461.42
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	123,656.48	136,891.43

*This figure has been changed to reflect resources delimited after Berryhill's 1950 calculations (Doss White, U. S. Bureau of Mines, personal communication).

Table 4: Estimated original in-place coal resources in Wyoming by major coal-bearing regions and rank (modified after Berryhill, 1950)
(millions of short tons)

Coal-Bearing Region	*Bituminous*	*Subbituminous*	*Total*
Powder River Coal Basin*		110,218.95	110,218.95
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 Coalfield	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 Coalfield		305.18	305.18
Jackson Hole Coalfield		121.49	121.49
Black Hills Coal Region	41.09		41.09
Total	13,234.95	123,656.48	136,891.43

NOTE: There has never been an estimate of the resources of the Goshen Hole Coalfield.
*This figure has been changed to reflect resources delimited after Berryhill's 1950 calculations (Doss White, U. S. Bureau of Mines, personal communication).

Table 5: Estimate of remaining coal resources of Wyoming to January 1, 1974

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]	136,891,430,000	545,710,000,000
Production from strip mining[2]	93,157,209	
Production from deep mining[2]	383,870,381	
Total Production	477,027,590	477,027,590
Losses due to strip mining (20% lost)	18,631,442	
Losses due to deep mining (equals prod.)	383,870,381	
Total production and mining losses	879,529,413	879,529,413
Remaining Resource	136,001,900,587	544,830,470,587

[1]Source: U. S. Geological Survey and U. S. Bureau of Mines
[2]Source: U. S. Geological Survey, U. S. Bureau of Mines and Wyoming State Inspector of Mines

Table 6: Reported coal production by county to January 1, 1974 (short tons)[1]

Albany	5,711	Natrona	30,131
Big Horn	382,683	Niobrara	0
Campbell	15,163,708	Park	36,404
Carbon	62,819,074	Sheridan	58,843,467
Converse	22,494,806	Sublette	16,828
Crook	60,815	Sweetwater	201,479,992
Fremont	3,809,045	Teton	11,140
Hot Springs	11,852,377	Uinta	22,416,900
Johnson	387,818	Washakie	200
Lincoln	63,736,908	Weston	12,427,948

County Total	475,975,954
Total Miscellaneous Reported Tonnage[2]	1,051,636
Grand Total	477,027,590

[1]Sources: U. S. Geological Survey, U. S. Bureau of Mines, and Wyoming State Mine Inspectors
[2]Most of this tonnage was reported during the 1800's and early 1900's, but was not recorded by county. Since the grand total is a summation of the reported annual tonnages and not a summation of the county totals, some small measure of this tonnage may result from reporting errors or discrepancies in figures by the three sources above.

Table 7: Remaining strippable subbituminous coal resources of Wyoming to January 1, 1974 (modified from Smith, 1972)

Coal-Bearing Region	*Strippable Deposit*	*Coal Bed(s) (Average thickness in feet)*	*Acreage Estimate*	*Original Estimated Resources to Jan. 1, 1968*	*Production and Mining Losses Since Jan. 1, 1968*	*Remaining Strippable Resources to Jan. 1, 1974*
Powder River Coal Basin	Acme-Kleenburn	Monarch and Dietz No. 3 (23')	786.0	32,000,000		
	Clear Creek	Canyon (11.2')	9,337.6	184,900,000		
	Dave Johnston	School (38')	2,418.0	126,200,000		
		Badger (16')	390.0	9,500,000		
	Dry Cheyenne	F (7.6')	13,260.8	179,500,000		
	Lake De Smet	Healy (163')	3,520.0	1,000,000,000		
	Spotted Horse	Felix (12.5')		480,700,000		
		Smith (10.0')	36,736.0	178,000,000		
		Local (10.0')		58,300,000		
	Sussex	Wasatch Fm. coal (11.8')	651.0	13,600,000		
	Wyodak	Wyodak-Anderson (71'); Anderson (D) and Canyon (E)	155,282.0	19,000,000,000		
		Subtotal	222,381.4	21,262,700,000	26,239,813	21,236,460,187
Green River Coal Region	Black Buttes	Almond, Lance, Ft. Union, and Wasatch Fm. coals (12')	3,889.0	82,600,000[3]		
	Cherokee	B (10') C (17')	4,204.0	200,900,000		
	Jim Bridger	Deadman (30')	4,708.0	250,000,000		
	Red Desert	Battle 2 & 3 (7')	2,938.0	38,100,000		
		Sourdough, Monument and Tierney (6.8')	27,469.0	458,900,000		
		Hadsell 2 (7.7')	2,874.0	39,800,000		
		Creston 2 & 3 (14')	3,846.0	125,600,000		
		Latham 3 & 4 (5.7')	6,893.0	70,700,000		
		Subtotal	56,821.0	1,266,600,000	34,483	1,266,565,517
Ham's Fork Coal Region	Adaville	Adaville Fm. coals (44')	12,800.0	1,000,000,000		
		Subtotal	12,800.0	1,000,000,000	13,977,597	986,022,403
Hanna Coalfield	Hanna	Hanna, Ferris, and Medicine Bow Fm. coals (21')	8,400.0	313,000,000[1]		
		Subtotal	8,400.0	313,000,000	30,963,626[2]	282,036,374
Bighorn Coal Basin	Grass Creek	Mayfield (35')	97.0	3,000,000[4]		
		Subtotal	97.0	3,000,000	0	3,000,000
		GRAND TOTAL	301,372.4	27,845,300,000	71,215,519	23,768,684,472

[1]This approximation is based on Berryhill's 1950 original resources estimate (Glass, 1972).
[2]This is strip mine production and mining losses since 1950.
[3]This is based on a report by (VTN, 1974).
[4]This is based on a report by (Travis, 1951).

GOSHEN HOLE COALFIELD

The Goshen Hole Coalfield is in the southeastern part of the state. There are coals in the Lance Formation of Upper Cretaceous age, but little is known about their quality or thicknesses. While published reports only mention 2.5 foot thick subbituminous coals, oil and gas well logs suggest there may be some thicker coals. Additionally, much of this field is covered by younger noncoal-bearing rocks.

COAL RESOURCES, PRODUCTION, AND RESERVES

Wyoming's original in-place coal resources between 0 and 3000 feet of overburden are estimated to be 136,891,430,000 short tons (modified 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 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 3 and 4. 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 5 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. County production is shown in Table 6.

DISTURBED SURFACE LAND AND RECLAMATION

In 1969, it was estimated that a total of 3078 acres of surface land in Wyoming was disturbed by surface coal mining in five counties: Campbell, Converse, Carbon, Lincoln, and Sheridan (Kovats, 1969). Disturbed lands in this estimate not only included the open pit acreage but also the spoil (waste) piles, roads and building acreages. A conservative estimate, which adds acreage not included in the 1969 estimate as well as acreage disturbed since 1969, would be 6000 acres to January 1, 1975. This area is about 9 square miles or ¼ of a township. It is also estimated that surface land disturbed by coal strip mining is currently increasing at a rate of 500-1000 acres per year.

Between August 1969 and June 31, 1973, strip mined land was reclaimed under Wyoming's Open Cut Land Reclamation Act. In July, 1973, this law was rescinded and replaced by Wyoming's new Environmental Quality Act. The Act established a Division of Land Quality, which regulates and enforces reclamation of all mined lands within the state excepting Indian lands (Dept. of Environmental Quality, 1973).

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