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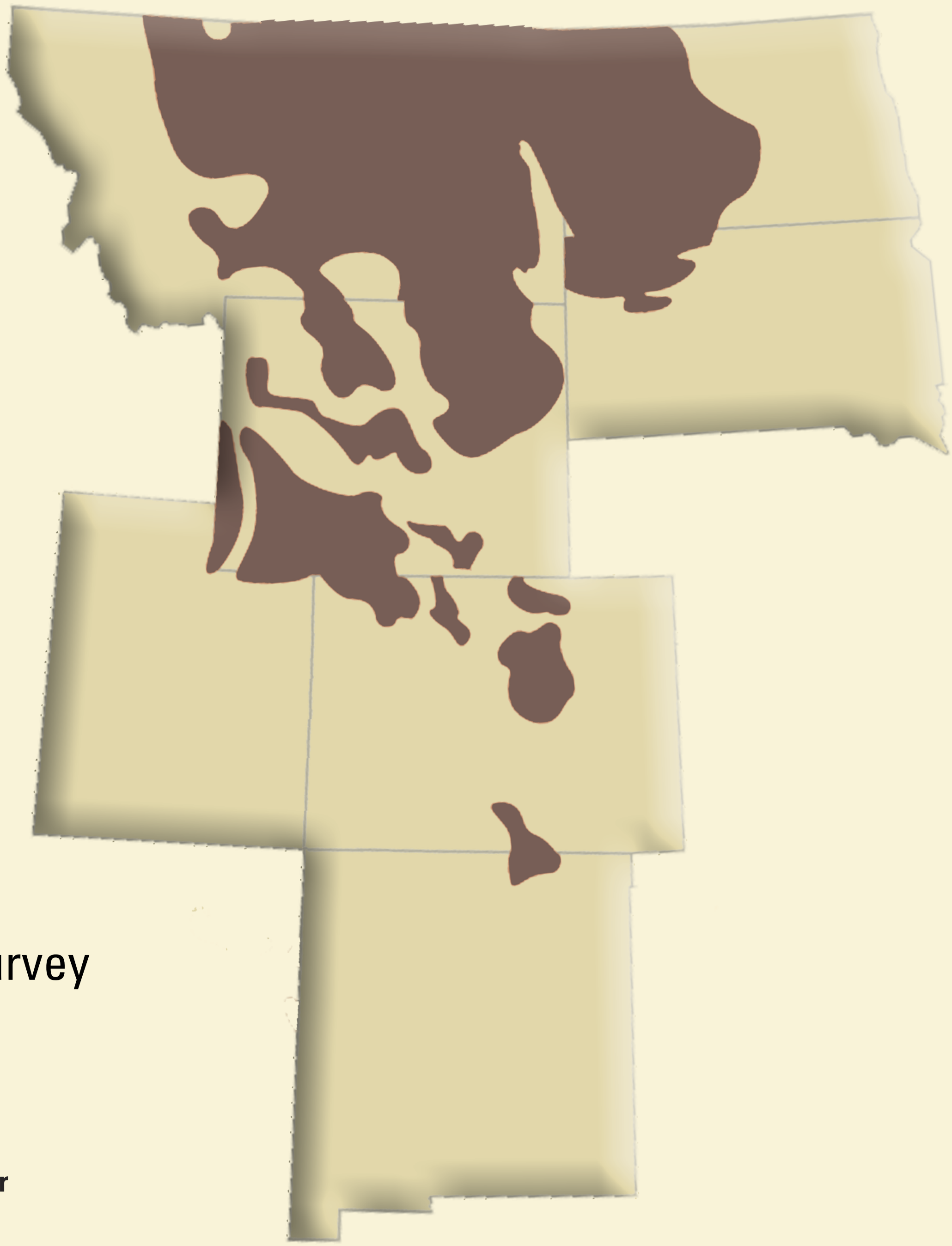
A Summary of the U.S. Geological Survey 1999 Resource Assessment of Selected Coal Zones in the Northern Rocky Mountains and Great Plains Region, Wyoming, Montana, and North Dakota



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A Summary of the U.S. Geological Survey 1999 Resource Assessment of Selected Coal Zones in the Northern Rocky Mountains and Great Plains Region, Wyoming, Montana, and North Dakota

By M.S. Ellis and D.J. Nichols

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Contents

Figures

Tables

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Abstract

In 1999, 1,100 million short tons of coal were produced in the United States, 38 percent from the Northern Rocky Mountains and Great Plains region. This coal has low ash content, and sulfur content is in compliance with Clean Air Act standards (U.S. Statutes at Large, 1990).

The National Coal Resource Assessment for this region includes geologic, stratigraphic, palynologic, and geochemical studies and resource calculations for 18 major coal zones in the Powder River, Williston, Green River, Hanna, and Carbon Basins. Calculated resources are 660,000 million short tons. Results of the study are available in U.S. Geological Survey Professional Paper 1625–A (Fort Union Coal Assessment Team, 1999) and Open-File Report 99-376 (Flores and others, 1999) in CD-ROM format.

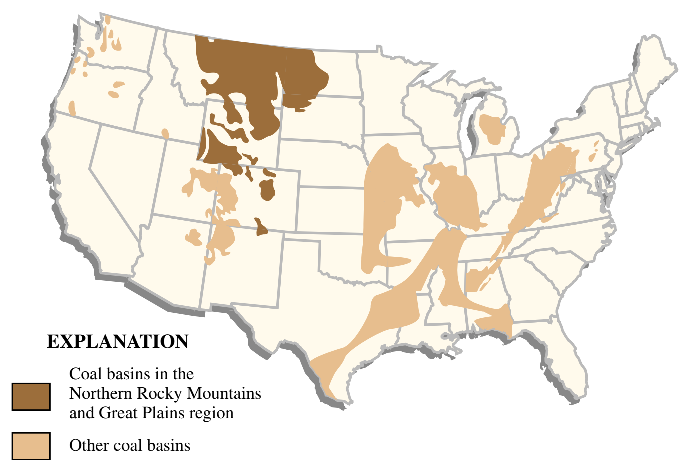

Figure 1. Major coal basins in conterminous United States.

Introduction

The U.S. Geological Survey (USGS) assessed coal resources in the conterminous United States to determine the quantity, quality, and minability of coal that is likely to be produced within the next 20-30 years. The National Coal Resource Assessment (NCRA) included studies of coal in five regions—the Northern Rocky Mountains and Great Plains (fig. 1), the Colorado Plateau, the Illinois Basin, the Gulf Coast, and the Appalachian Basin.

The Northern Rocky Mountains and Great Plains region contains an abundance of coal with a high potential for development. In 1999 more than 38 percent of national coal production was from Wyoming, Montana, and North Dakota (table 1). Coal in the region is generally low in total sulfur and ash content and compliant with Clean Air Act standards for use in coal-fired power plants. Current standards require that no more than the equivalent of 1.24 lb of SO_2 per million Btu be released in flue emissions (U.S. Statutes at Large, 1990).

The coal assessment in the Northern Rocky Mountains and Great Plains region covered 18 priority coal assessment units in five coal basins (fig. 2). In addition to the resource calculations, the project included local and regional geologic, stratigraphic, palynologic, and coal-geochemical studies. Objectives of the NCRA in this region were to compile all pertinent information on the selected coal beds, identify clean and compliant coal in the region, compile a publicly available digital database, and publish spatial digital products in a variety of interpretive and interactive forms.

Final products for the assessment include two CD-ROMs that present the results of the study in a variety of formats. These CD-ROMs contain resident software for viewing, printing, querying, and downloading text, graphics, spatial layers, and raw data (Fort Union Coal Assessment Team, 1999; Flores and others, 1999).

Coal Assessed

Coal assessment units in the Northern Rocky Mountains and Great Plains region included the Wyodak-Anderson, Anderson-Canyon, Rosebud-Robinson, and Knobloch coal in the Powder River Basin of Wyoming and Montana; the Harmon, Hansen, Beulah-Zap, and Hagel coal in the Williston Basin; the Deadman coal in the Greater Green River Basin, and the Ferris, Hanna, and Johnson-107 coal in the Hanna and Carbon Basins (fig. 2). The assessment units and the coal beds within the assessment units are shown in table 2. Coal in the Bighorn, Bull Mountain, Denver, North Park, Raton, and Wind River Basins was not assessed in detail for this study, because it has a lower potential for development. These basins are discussed in a general manner in the final report (Chapters SB, SM, SD, SN, SR, and SW in Fort Union Coal Assessment Team, 1999).

Geologic Setting

Coal assessed for this study occurs in basins of Tertiary age. The coal developed from peat that was deposited in swamps adjacent to fluvial drainages during middle to late Paleocene time. Palynologic time zones have been identified, based on palynostratigraphy, for the coal assessed (Nichols, 1994, 1999; Fort Union Coal Assessment Team, 1999) (figs. 3, 4). Biozones were identified using fossil pollen and spores that occur only in certain intervals in lower Eocene, Paleocene, and Upper Cretaceous rocks. The palynologic biozones were used to define the age of individual coal beds and other lithologic units for stratigraphic correlation and to aid in determining which beds were to be included in the priority assessment units.

The environments of deposition of peat in the Northern Rocky Mountains and Great Plains region differed in detail in the four basins, although the primary environment of deposition in the basins was fluvial, with drainage generally flowing to the northeast or the east. The thickness of peat accumulation, amount and type of detritus in the peat, lateral variability of the beds, and apparent rank (as defined by American Society for Testing and Materials, 1999) of the coal were dependent on the environment of deposition of the peat and subsequent factors affecting the coalification. Some of the factors affecting the coal characteristics were the rate of subsidence of the basin, the dynamics of the drainage system, the proximity of the swamp to the origin or the terminus of the drainage, the susceptibility of the peat swamp to flooding, and the location of sediment source areas.

Thick peat accumulated in deep portions of the Powder River Basin where the basin was rapidly subsiding. During middle to late Paleocene time much of the peat accumulated in raised bogs, which led to the formation of coal that was thick and contained little clastic detritus. Although the coal beds in the Wyodak-Anderson coal zone are relatively thick, they are not laterally continuous because braided, meandering, and anastomosed rivers cut through and eroded away portions of the peat swamps. The assessed coal in the basin is subbituminous in apparent rank.

The Williston Basin was subsiding slowly, and therefore was shallower than the Powder River Basin during Paleocene time. Because the peat was not deeply buried, it has lower apparent rank than coal in the other basins. All of the assessed coal in the Williston Basin is lignite. Peat swamps were adjacent to slow-moving fluvial drainages that emptied into the Cannonball Sea. The beds are relatively thin, cut by channels, and contain large quantities of clastic detritus.

The Hanna and Carbon Basins were surrounded by uplifts consisting of rocks of marine origin. These basins rapidly subsided subsequent to peat accumulation. Deep burial of the peat led to the formation of coal that is of higher apparent rank than coal in the other basins, subbituminous to bituminous. Coal that has been deeply buried has undergone a higher level of coalification caused by high temperature and high pressure. Higher level of coalification translates to higher calorific value and lower moisture content. The higher content of sulfur

Table 1. Coal production from Wyoming, Montana, and North Dakota in 1999.
[Modified from Freme and Hong (2000)]

Area of production	Coal production (In millions of short tons)
Wyoming	335
Montana	41
North Dakota	30
Total from these States	416
Total from all of conterminous United States	1,094

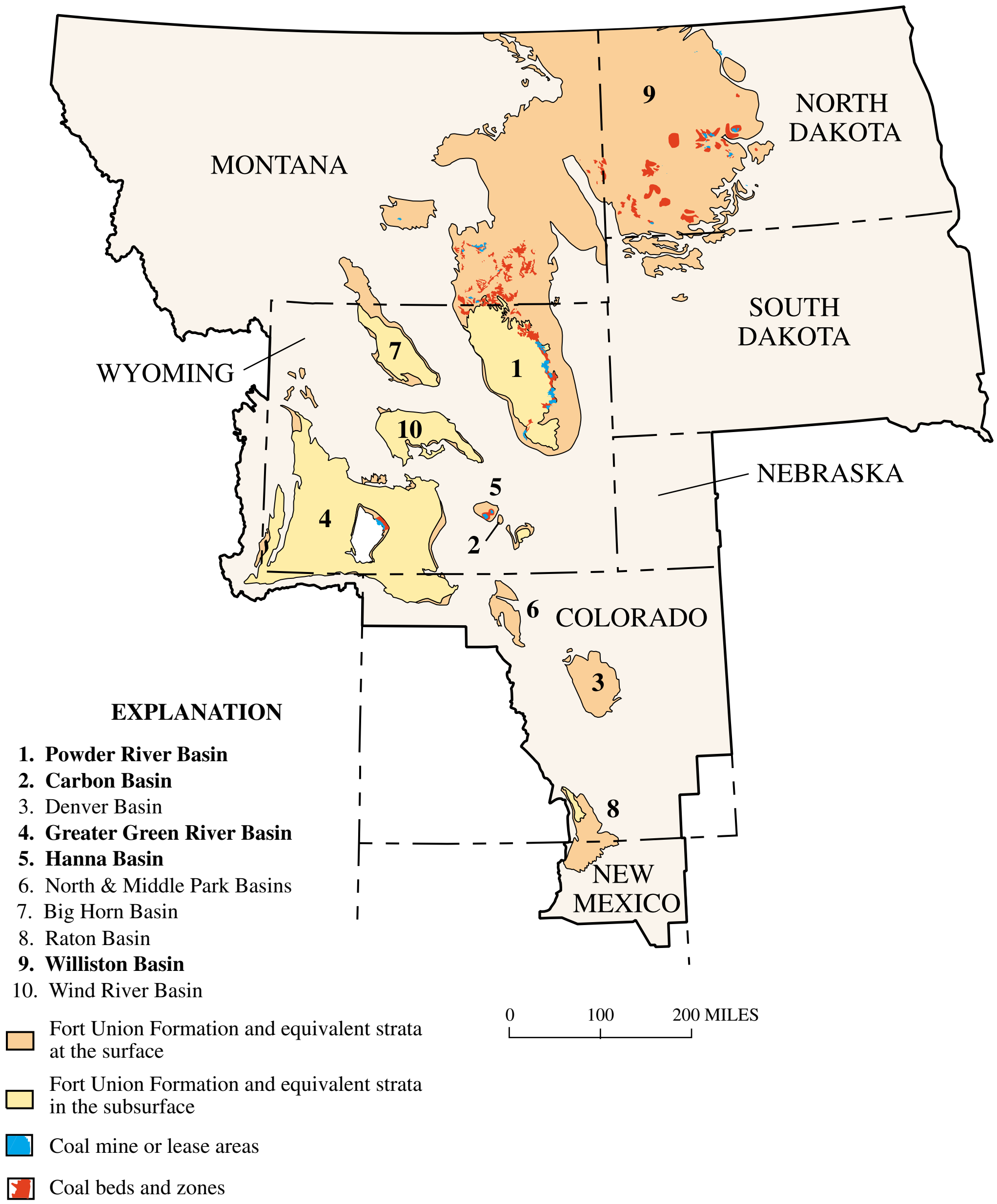

Figure 2. Coal basins in Northern Rocky Mountains and Great Plains region. Basins indicated in bold type contain priority assessment units studied in detail for USGS coal assessment.

Table 2. Coal basins, coal fields, assessment units, and coal beds included in the Northern Rocky Mountains and Great Plains region coal resource assessment.

Coal field / Assessment unit	Coal beds in assessment unit
Powder River Basin, Wyoming and Montana	
Wyodak-Anderson / Wyodak-Anderson	Anderson, Dietz, Canyon, Monarch, Werner, Wyodak, Smith, Swartz, Sussex, School, and Badger
Powder River Basin, Montana	
Decker/ Anderson-Canyon	Anderson, Kirby, Dietz 1, 2, and 3, Cox, and Canyon
Ashland/Knobloch	Knobloch
Colstrip/Rosebud-Robinson	Rosebud, McKay, and Robinson
Williston Basin, North Dakota	
Bowman-Dickinson / Harmon-Hansen	Harmon and Hansen
Beulah/Beulah-Zap	Beulah-Zap
Center-Falkirk/ Hagel	Hagel
Greater Green River Basin, Wyoming	
Black Butte–Point of Rocks/ Deadman	Deadman 1-5 and A-C
Hanna and Carbon Basins, Wyoming	
Ferris/Ferris	Ferris 23, 25, 31, 50, and 65
Hanna/Hanna	Hanna 77, 78, 79, and 81
South Carbon/ Johnson-107	Johnson, Finch, C106, and C107

(table 3) in the coal is most likely caused by the influx of detritus derived from the marine rocks into peat swamps.

The Deadman coal in the Greater Green River Basin formed in swamps that were probably low-lying and prone to floods by the braided and anastomosed rivers that meandered through them. The coal is of subbituminous apparent rank, contains moderately high ash content (table 3), and is laterally discontinuous.

Coal Quality

Coal in the Northern Rocky Mountains and Great Plains region is considered to be clean, low in contaminants, and compliant with 1990 Clean Air Act emission standards for acceptable levels of pounds of sulfur per million Btu from coal-fired power plants (U.S. Statutes at Large, 1990). Wyodak-Anderson coal from the Powder River Basin has the lowest mean content of pounds of SO_2 per million Btu of any of the coal assessed for the NCRA (table 3).

The apparent coal rank ranges from bituminous in the Hanna Basin, where it has been mined underground, to lignite in the Williston Basin, where it is surface mined. A more detailed description of coal quality for beds assessed for the NCRA is provided in Stricker and Ellis (1999a, b, c, and d).

Coal Resources

Data for this study were acquired through cooperation with the U.S. Bureau of Land Management, State geological surveys, U.S. Office of Surface Mining, and coal companies. The USGS National Coal Resource Data System (NCRDS) database was also a source of digital data. This database includes proprietary and public stratigraphic and lithologic information from coal and oil and gas exploratory drill holes, and measured sections at over 18,900 locations. Coal quality and coal geochemistry data were from the U.S. Geological Survey COALQUAL database (Bragg and others, 1994) and

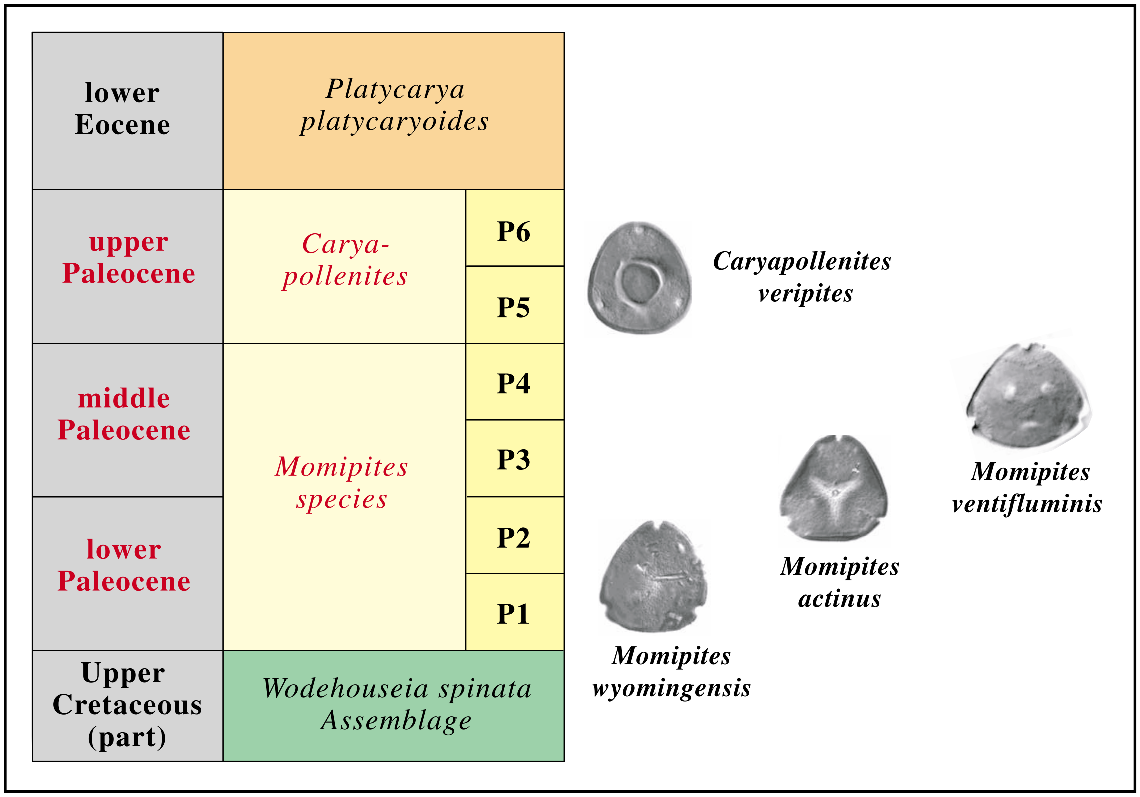

Figure 3. Biostratigraphic (palynostratigraphic) zonation of the Paleocene and adjacent rocks in Rocky Mountain region. Biozones are defined by occurrences of fossil pollen and spores (palynostratigraphy). "P" biozones of the Paleocene are defined by species of the related fossil pollen genera *Momipites* and *Caryapollenites*.

from proprietary sources. The coal quality and coal geochemistry information consists of sample analyses from about 1,000 data point locations.

In the Northern Rocky Mountains and Great Plains region, most coal is discontinuous. Within short distances the beds are quite variable in thickness. Because of the lack of continuity of individual coal beds in this region, beds were grouped and correlated in zones. For coal resource calculations and categories, the thickness of the coal was represented by the net coal thickness in the zone (fig. 5).

Coal beds, coal zones, and related rocks were correlated in a relational database. The assessment was organized by study areas or coal fields (fig. 6). The pertinent data were downloaded from the relational database and run through a custom program that uses the definition of partings and splits of Wood and others (1983) to determine the thickness of coal beds and calculate net coal thickness at each data point location (fig. 5). Net coal thickness does not include coal beds that are less than 2.5 ft thick.

The net coal and overburden thickness was gridded and modeled using geologic modeling software, and the isopach maps were exported into geographic information system (GIS) software to generate polygon coverages. The layers of information (coverages) were then combined. The layers of information include not only the coal and overburden thicknesses but also land status, coal ownership, 7.5-minute quadrangle map areas, counties, clinker areas, and mine and lease areas. The union coverage, containing all attributes from each of the coverages, was used to calculate coal resources within each of the coverage polygons. Coal resource tables were produced from the final ASCII data output. The total coal resource numbers reported do not include areas extrapolated to contain net coal less than 2.5 feet thick, or coal in mine, lease, or clinker areas (Heffern and others, 1993; E.L. Heffern, Bureau of Land Management, oral and written commun., 1998, 1999). This resource calculation does not take into consideration many of the economic, technological, cultural, and environmental restrictions to coal development.

Coal resources were reported in tables using a variety of different parameters, including State, county, surface management, coal ownership, net coal thickness, overburden, reliability of the data (distance from a data point), and 7.5-minute quadrangle map area (Fort Union Coal Assessment Team, 1999). Categories for coal thickness and overburden followed reporting standards for subbituminous or lignite apparent rank coal (Wood and others, 1983). Coal resources reported by coal field (fig. 6) and by surface management (fig. 7) are shown in table 4 and figure 8. The total resources (in millions of

Table 3. Average total sulfur content and ash yield, pounds of SO_2 per million Btu, and calorific value of assessed coal.

[Values for the Powder River Basin include only coal analyses from the Wyodak-Anderson coal zone]

Coal basin	Total sulfur content (percent)	Ash yield (percent)	SO_2 per million Btu (lb)	Calorific value (Btu)
Powder River	0.48	6.44	1.24	8,220
Williston	0.84	7.96	2.54	6,510
Greater Green River	0.56	11.18	1.27	9,000
Hanna and Carbon	0.96	12.48	2.07	10,090

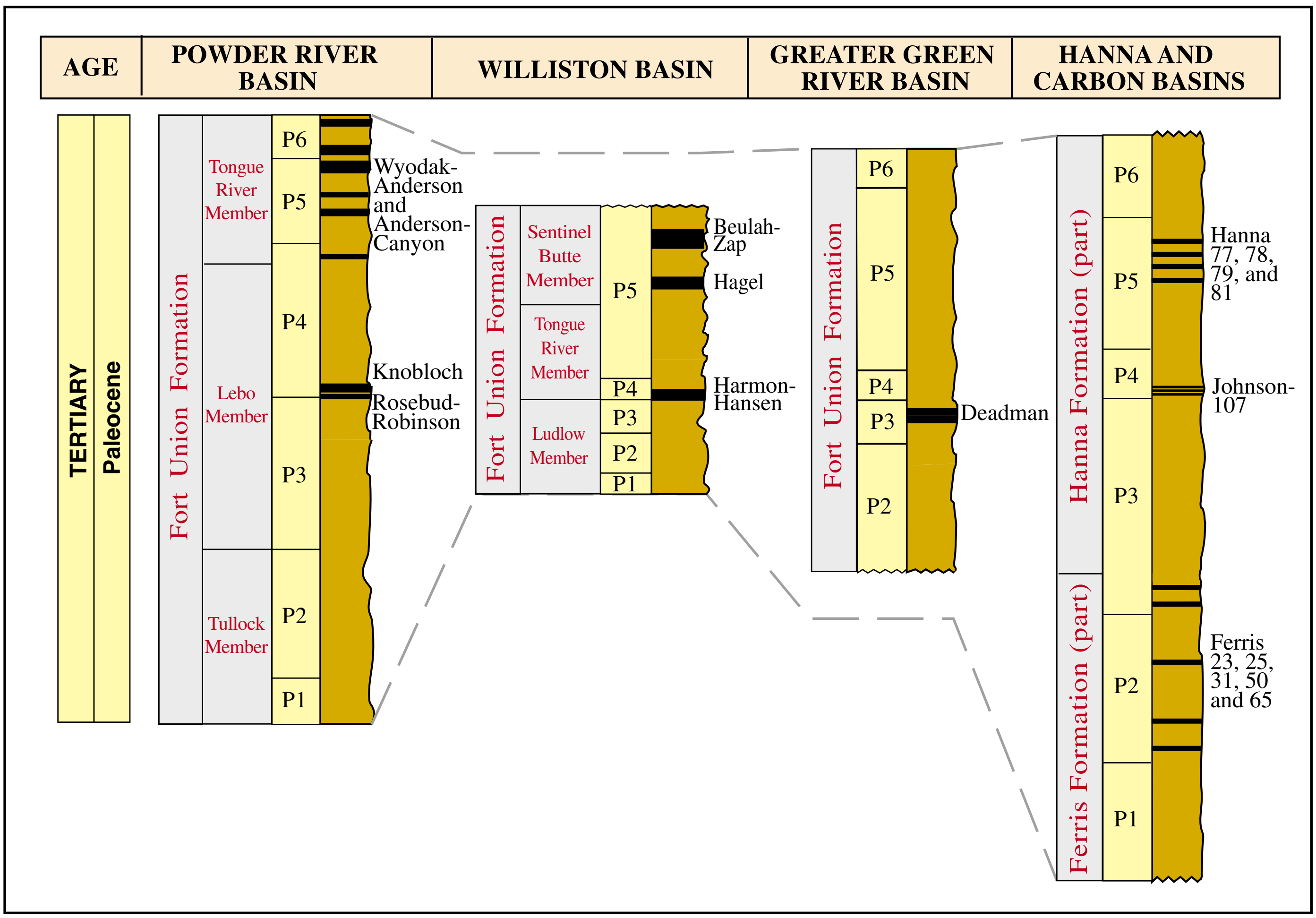

Figure 4. Generalized sections showing relative age, thickness, and stratigraphic relationship of coal assessed for the National Coal Resource Assessment in Northern Rocky Mountains and Great Plains region. All coal assessed is Paleocene in age. Age of the coal is based on palynological biozones; "P" biozones 5 and 6 are late Paleocene; 3 and 4 are middle Paleocene; and 1 and 2 are early Paleocene (Nichols, 1994). (Modified from Fort Union Coal Assessment Team, 1999.)

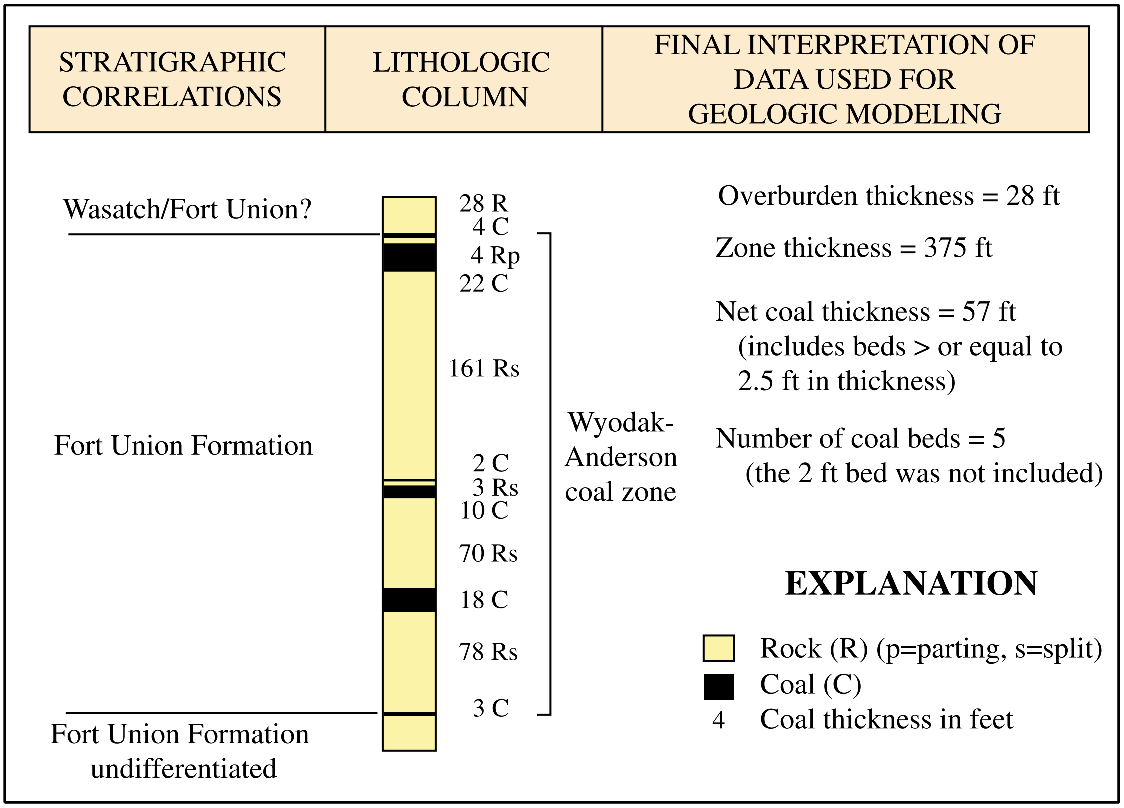

Figure 5. Diagram showing how lithologic data are interpreted to determine net coal thickness at each data point location.

Table 4. Coal resources reported by coal field.

[Resources are reported in millions of short tons (mst) rounded to two significant figures. Resources do not include coal in mine or lease areas, coal less than 2.5 ft thick, or coal in clinker areas]

Basin	State	Coal field	Coal resources (mst)
Powder River	Wyoming	Wyodak-Anderson (WA)	550,000
	Montana	Decker (also included in WA total)	45,000
		Ashland	6,000
		Colstrip	13,000
Williston	North Dakota	Bowman-Dickinson	66,000
		Beulah	4,800
		Center-Falkirk	4,400
Greater Green River	Wyoming	Black Butte–Point of Rocks	2,700
Hanna and Carbon	Wyoming	Ferris	2,900
		Hanna	4,400
		South Carbon	1,100

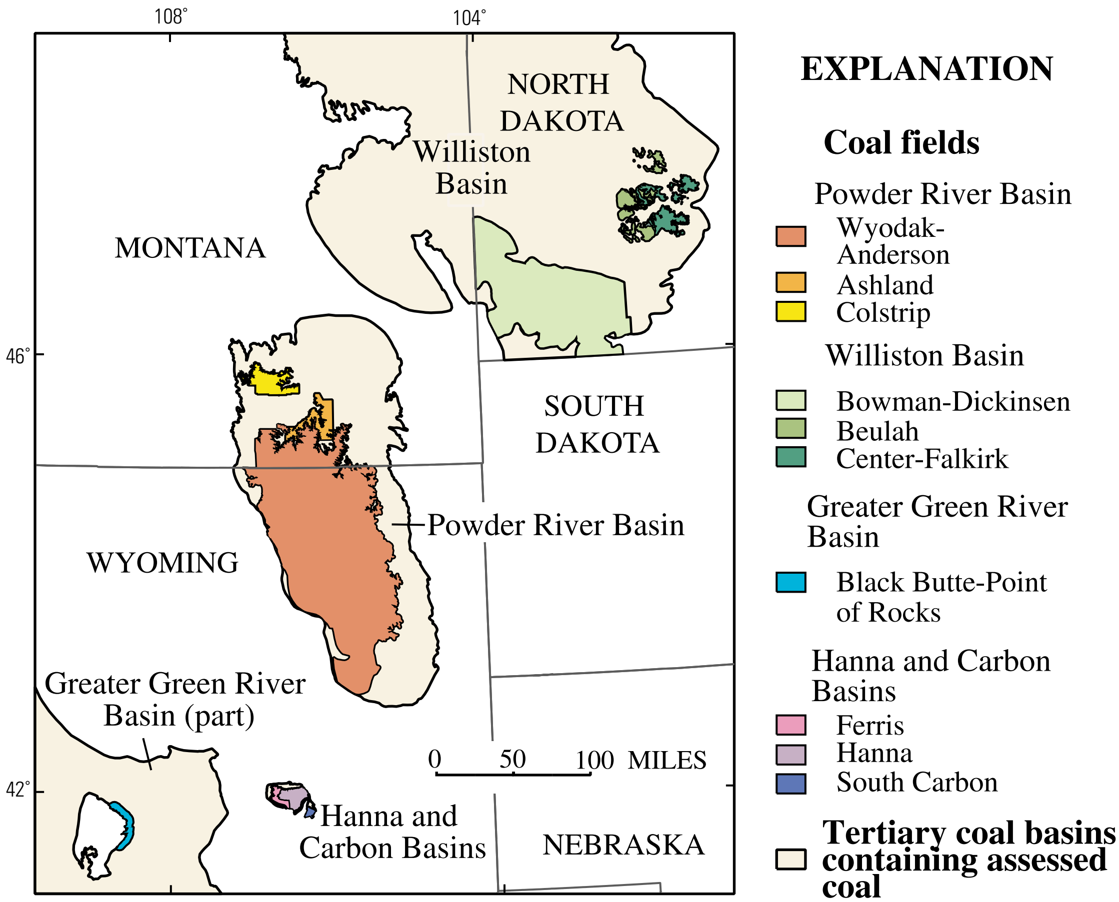

Figure 6. Index map showing coal fields studied for National Coal Resource Assessment in Northern Rocky Mountains and Great Plains region.

short tons (mst) and rounded to two significant figures) for the coal assessed in each of the basin areas is 570,000 mst in the Powder River Basin; 76,000 mst in the Williston Basin, 2,700 mst in the Greater Green River Basin, and 7,300 mst in the Hanna and Carbon Basins.

Conclusions

The National Coal Resource Assessment in the Northern Rocky Mountains and Great Plains region included detailed studies of selected coal beds. The total number of resources calculated for these coal beds and zones was about 660,000 million short tons, 80 percent of which is Federally owned. The coal is generally low in contaminants and compliant with Clean Air Act emissions standards. Given the quantity and quality of coal in this region, the potential for continued development of coal that was assessed by this study, particularly in the Powder River Basin, is very high.

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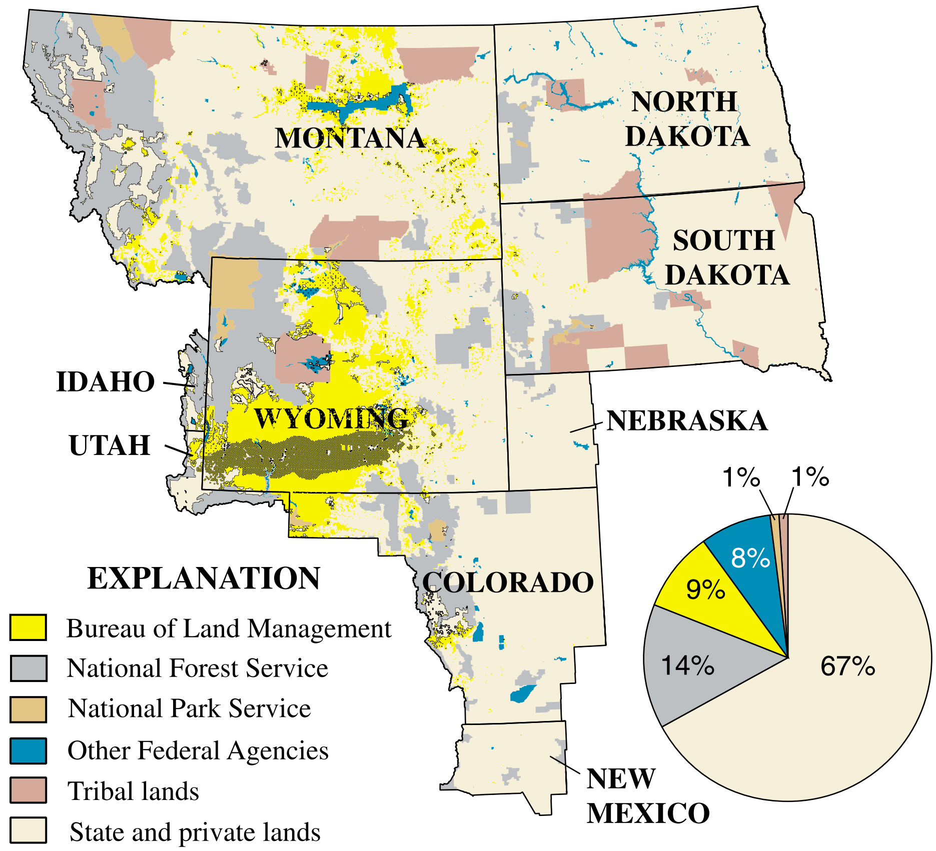

Figure 7. Surface management of land in Northern Rocky Mountains and Great Plains region.

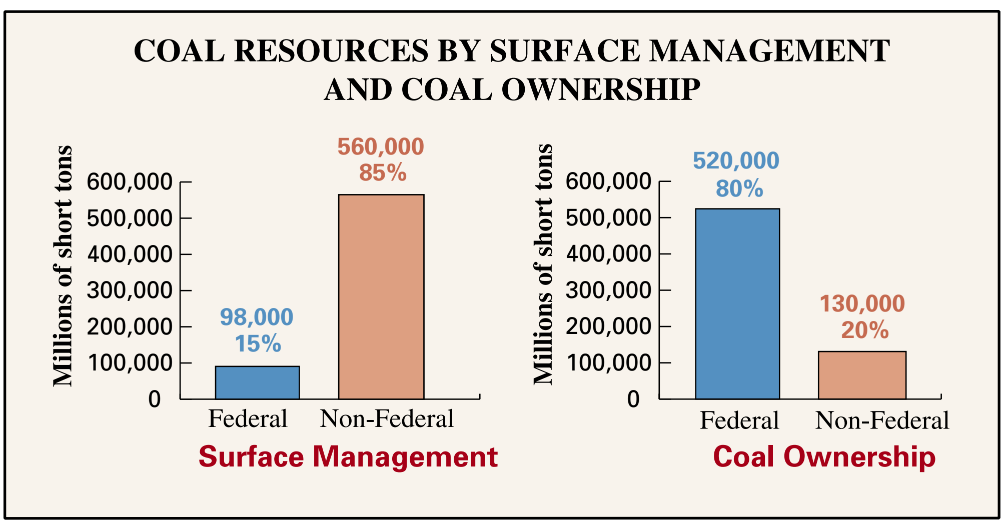

Figure 8. Coal resources for assessed coal in Northern Rocky Mountains and Great Plains region reported by Federal and non-Federal surface management and coal ownership. Coal resources are rounded to two significant figures. Totals do not sum because of independent rounding of coal resources in each category. (Modified from U.S. Geological Survey, 2000.)

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