

## Executive Summary

# TERTIARY COAL RESOURCES IN THE NORTHERN ROCKY MOUNTAINS AND GREAT PLAINS REGION—A CLEAN AND COMPLIANT FOSSIL FUEL BEYOND 2000

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## INTRODUCTION

The U.S. Geological Survey (USGS) is assessing coal resources in five regions within the conterminous United States (fig. ES-1) to determine the quantity, quality, and minability of coal likely to be used within the next 20-30 years. This assessment is critical because the utilization of coal has been rising in the U.S., primarily because it is the least expensive fuel for generation of electrical power that is essential to the goals and infrastructure of the Nation. Previous coal resource assessments attempted to assess the total amount of coal in the ground in the U.S., but those estimates tended to be high and socially irrelevant because they included coal deposits that are not available (coal that is in beds too thin or too deep underground to be mined efficiently, or that is too close to urban areas to be mined practically), or coal that is not of sufficient quality to serve as a fuel resource into the next century. A new assessment was required that focuses on those coal resources likely to be utilized in the next 20-30 years, resources that for the most part are currently being developed in existing mines.

This current National Coal Resource Assessment (NCRA) covers selected coal beds or zones in each of the five regions (fig. ES-1). Other coal deposits are either unassessed or have been reviewed in summary fashion rather than in detail. Data on the selected coal beds or zones that have been assessed include estimates of quantity, quality, and, in some cases, availability. The assessments of regions other than the Northern Rocky Mountains and Great Plains may be found in the other sets of CD-ROM's that are part of the NCRA series.

The Northern Rocky Mountains and Great Plains region (fig. ES-2) contains considerable resources of some of the cleanest coal in the U.S. Much of this coal is

compliant with emission regulations for trace elements of environmental concern set by the Clean Air Act and administered by the U.S. Environmental Protection Agency (EPA). Production of clean and compliant coal from the region, especially from the Powder River Basin of Wyoming, has been increasing in recent years, a trend that is expected to continue beyond the year 2000. In this Executive Summary, (1) the coal included in the current assessment in the Northern Rocky Mountains and Great Plains region is discussed, including those coal basins that were studied in detail in the current assessment and those that are only summarized from past literature (unassessed basins); (2) the provisions of the EPA Clean Air Act are reviewed; (3) the nature of coal resources in the region is described, with special reference to its clean and compliant qualities; and (4) the contents and organization of the CD-ROM publications are outlined.

## **COAL INCLUDED IN THIS ASSESSMENT**

The current coal resource assessment investigations in the Northern Rocky Mountains and Great Plains region concentrated on selected coal beds and zones in rocks of Tertiary age in four basins—coal resources that are most likely to be utilized in the next 20-30 years. These coal deposits are described in detail and estimates of quantity and quality are made for the Powder River Basin in Wyoming and Montana, the Williston Basin in North Dakota, the Greater Green River Basin in Wyoming, and the Hanna-Carbon Basin in Wyoming. Coal availability and recoverability for selected areas in the Powder River Basin are assessed, as well. **Table ES-1** summarizes the total resources in millions of short tons in each of the four assessed basins. In other basins in the region, Tertiary coal resources that are less likely to be utilized in the next 20-30 years are summarized but were not assessed. These unassessed areas include the Bighorn Basin, Wyoming; Bull

Mountain Basin, Montana; Wind River Basin, Wyoming; Denver Basin, Colorado; North Park Basin, Colorado; and Raton Basin, Colorado and New Mexico. Coal of other geologic ages that may exist within any of these assessed or unassessed basins, such as coal of Cretaceous age, is not discussed.

Table ES-1. Summaries of coal resources calculated for coal assessed in the Northern Rocky Mountains and Great Plains assessment region, by basin, and for deposits in-place. Resources are shown in millions of short tons with two significant figures for strippable coal. The resource area does not include mine or lease areas. Resources were not calculated for coal beds less than 2.5 ft thick

<b>Basin</b>	<b>State</b>	<b>Coalfields</b>	<b>Millions of short tons</b>
Powder River	Wyoming and Montana	Wyodak-Anderson area, Ashland, and Colstrip	570,000
Williston	North Dakota	Bowman-Dickinson, Beulah, and Center-Falkirk	76,000
Greater Green River	Wyoming	Point of Rocks-Black Butte	2,700
Hanna-Carbon	Wyoming	Ferris, Hanna, and South Carbon	7,200

Previous and present USGS and U.S. Bureau of Mines investigations in the central and northern Appalachian Basin and in the Illinois Basin indicated that of the original in-place coal resources, only 50-60 percent is available for mining after land-use restrictions and technological restrictions are applied, and only 11-38 percent is recoverable by modern mining techniques. After application of clean-air compliance restrictions and mine planning studies, only 4-13 percent of this recoverable coal can be mined economically. The current coal resource assessment considers these factors in order to present data of use to National officials, planners, mining companies, scientists, and the general public.

Data on thickness, lateral extent, nature of continuity, geometry, distribution, quality, and geochemical properties of coal has been collected and digitally analyzed to permit classification of in-place coal resources by surface and subsurface ownership (Federal, State, and private). Resource calculations include categories of measured, indicated, inferred, and hypothetical resources as defined by the USGS. Each category is statistically analyzed for levels of uncertainty. In selected areas, the in-place coal resources are analyzed for their availability and recoverability based on land-use, technologic, and mining restrictions. Land-use restrictions applying to building sites, infrastructure, streams, and wildlife habitats follow Federal, State, and local guidelines.

For ease of use, information in this USGS Professional Paper is presented digitally on two CD-ROM's. The data are reproduced as running text, bulleted text, graphic displays, tables, subsurface cross sections, and maps in a geographic information system (GIS) format.

The in-depth assessments of the coal that may be used in the next 20-30 years are necessarily limited by the availability of certain data, such as proprietary data; no data of a proprietary nature are released in this document. In addition, coal-bearing areas within National Parks are not subject to mining, and this assessment does not include coal in Tribal lands.

## **CLEAN AIR ACT REQUIREMENTS**

By the year 2000, in order to mitigate the environmental impact of coal utilization in the United States, coal-fired power plants are required by the Clean Air Act and EPA emission standards to use low-sulfur coal, which is defined as coal containing 0.6 pounds or less of sulfur per million Btu, or 1.2 pounds or less of SO<sub>2</sub> per million Btu (lbs/mmBtu). Present SO<sub>2</sub> emission standards allow a maximum of 2.5 lbs/mmBtu. In addition, the coal-fired power plants may be required by the EPA to reduce emissions of trace elements of environmental concern (for example, arsenic, mercury, and selenium) as defined in the 1990 Clean Air Act Amendments. Thus, an increased demand for clean, compliant coal (coal low in sulfur, ash or fine particulates, and trace elements of environmental concern) by power plants will be driven by these regulations. The resulting increased production of clean, compliant coal will continue to deplete low cost, minable reserves of this coal. Depletion of these reserves will lead to intense pressure to develop similar deposits of coal at greater depths and at greater cost.

## **CLEAN, COMPLIANT COAL—A FINITE RESOURCE**

Coal containing low amounts of sulfur, ash, and trace elements of environmental concern is found in many of the coal-bearing rocks of Tertiary age in the Northern Rocky Mountains and Great Plains region. About a dozen coal beds and zones of the Fort Union Formation and equivalent Tertiary rocks in this region yielded more than 38 percent of the 1998 total coal production in the U.S. For the past 25 years, production of this coal has increased from about 25 to about 383 million short tons, a more than fifteenfold increase. Production is mostly from surface mines whose strip ratio (ratio of the amount of waste removed to the amount of coal recovered) has changed from about 1:1 to as much as 3:1. This high-quality coal has been increasingly utilized by electric power generating plants in States in the western, midwestern, southern, and southeastern U.S. and foreign countries. The high production of this coal has reduced the amount of remaining low-cost, clean, and compliant coal. Such coal serves as the main combustible fuel, or as a blend with non-compliant coal, in many of these power plants.

## **TERTIARY COAL MEETS EMISSION STANDARDS**

Most Tertiary coal is considered a clean, low-contaminant, compliant coal resource. Coal in the Powder River Basin contains less sulfur and less ash than coal from other regions in the conterminous U.S. For example, coal produced from the Powder River Basin has one of the lowest mean values of SO<sub>2</sub> of any coal in the U.S. The extensively mined Wyodak-Anderson coal zone has the lowest mean sulfur and ash yield in the Powder River Basin (arithmetic mean for sulfur is 0.48 percent and ash yield is 6.44 percent, as-received basis, 279 samples). The quantity of trace elements of environmental concern named in the 1990 Clean Air Act

Amendments is of increasing importance in meeting compliance standards. These trace elements include antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, manganese, mercury, nickel, selenium, and uranium. Tertiary coal from the Powder River and Williston Basins has the lowest contents of these elements when compared to other coal within the Northern Rocky Mountains and Great Plains region and coal from other coal-producing regions in the conterminous U.S.

## **TERTIARY COAL FOR THE FUTURE**

The Northern Rocky Mountains and Great Plains region of Wyoming, Montana, and North Dakota contains a vast expanse of coal-bearing rocks of Tertiary age. These coal-bearing rocks exist from the surface to a depth of about 6,000 ft in certain basins (the Powder River, Williston, and Greater Green River Basins) and from the surface to a depth of 12,000 ft in the Hanna-Carbon Basin. The apparent rank of Tertiary coal ranges from lignite to subbituminous in the shallower strata and from subbituminous to bituminous in the deeper strata. Major production in the Powder River Basin is from the Wyoak-Anderson and Rosebud coal zones ([fig. ES-3](#)). In 1998 these coal zones, which range in thickness from 25 to 140 ft, produced more than 340 million short tons from 25 mines and made up more than 34 percent of the total U.S. coal production in that year. These coal deposits are projected to produce 416 million short tons per year by 2015, based on the projected increase per year of U.S. production, as forecast by the U.S. Department of Energy's Energy Information Agency in 1996. Coal resources in the Williston Basin are produced from the Beulah-Zap, Hagel, Harmon, and Hansen coal zones ([fig. ES-3](#)). These coal zones range in thickness from 20 to 40 ft. In the Hanna-Carbon Basin, coal production is from the Ferris and Hanna Formations (which are in part stratigraphically equivalent to the Fort Union Formation), from the Ferris

Nos. 23, 25, 31, 50, 65, and Hanna Nos. 77, 78, 79, and 81 coal beds (fig. ES-3). These beds are each as much as 30 ft thick. In the Greater Green River Basin, coal production is primarily from the Deadman coal zone and the equivalent coal seams (fig. ES-3). These beds range in thickness from 2 to 25 ft.

## **CONTENTS OF THE CD-ROM PUBLICATIONS**

USGS Professional Paper 1625-A comprises the first and second of a set of three CD-ROM's for the Northern Rocky Mountains and Great Plains region. The first contains text and graphics for this Executive Summary and for 39 separate chapters of the assessment study (as summarized below). Each chapter is assigned a unique two-letter code that is used to designate figures and tables throughout each chapter. Graphics are viewed using Adobe Acrobat software included on this CD-ROM. The second CD-ROM of Professional Paper 1625-A contains data, maps, and cross sections produced as GIS coverages; metadata for the GIS coverages are also included. A read-only version of the ArcView software required is included on that CD-ROM to enable the user to query the data and to interactively create and print maps. The third CD-ROM, which is USGS Open-File Report 99-376, contains Excel files of the non-proprietary stratigraphic data on which the cross sections are based and the non-proprietary geochemical data for coal quality.

The first chapter on the first CD-ROM of Professional Paper 1625-A is an Introduction that includes a section entitled Perspectives; it is a series of graphics to be viewed as a slide show. These graphic displays summarize the rationale for the assessment study in the Northern Rocky Mountains and Great Plains region, explain the “why,” “how,” and “where” of the assessment, and note the benefits to society. Following this is bulleted text that presents some background for the study and lists

the objectives and strategy. Next, the geologic setting of the region is described, and then the depositional setting and its influence on the coal resources is discussed. Finally, coal quality is summarized. Graphic displays accompany each of these sections.

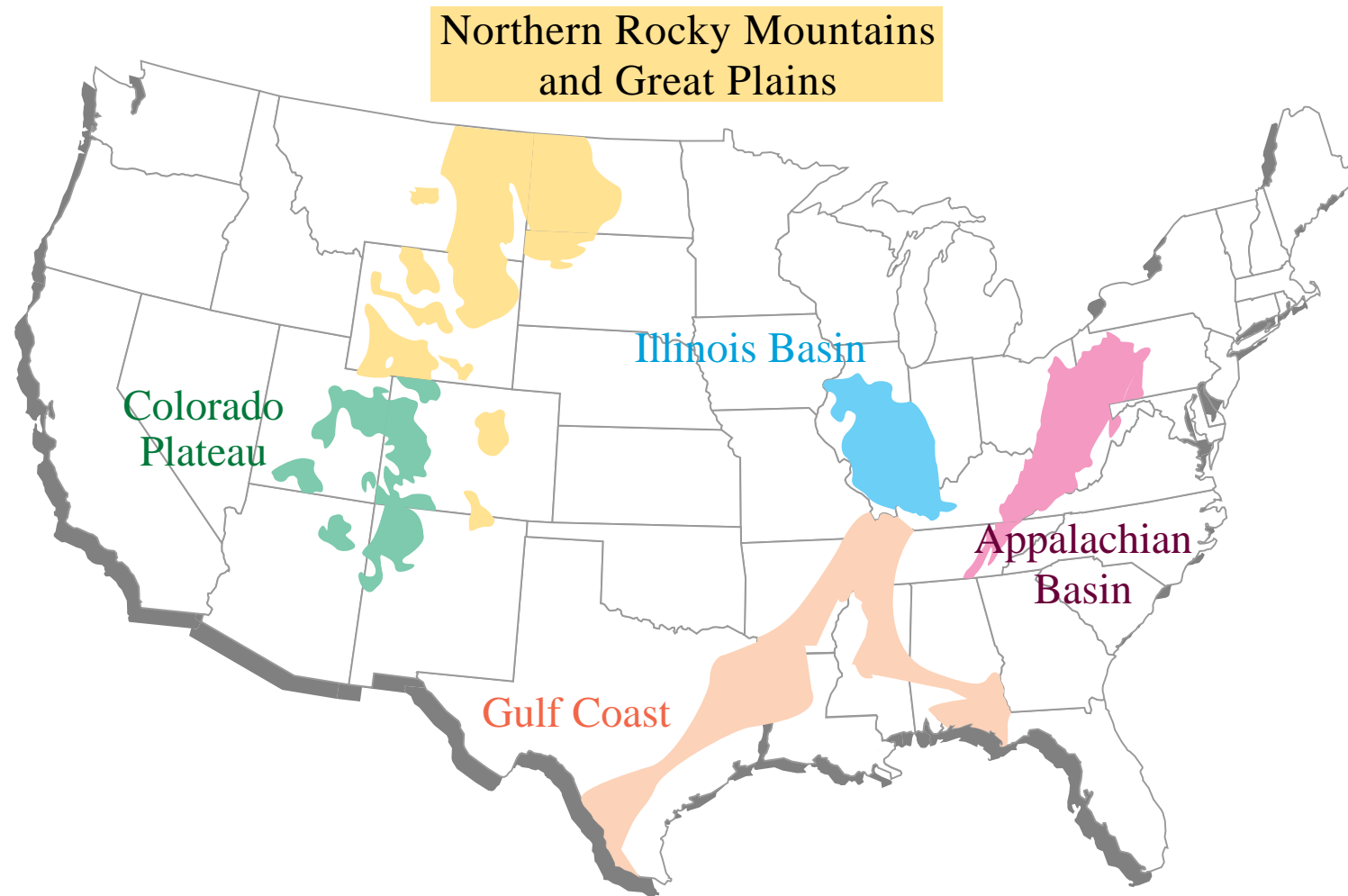
The second chapter describes database creation and resource evaluation methodology. Chapters following are grouped into Parts I-V, which contain detailed descriptions of each of the basins studied.

Part I covers the Powder River Basin, Part II the Williston Basin, Part III the Hanna-Carbon Basin, and Part IV covers the Greater Green River Basin. Topics discussed for each of these basins include a synthesis of coal deposits, framework geology, biostratigraphy, land-use and ownership, coal resources, and coal quality and geochemistry. Part I on the Powder River Basin also includes chapters on five individual coalfields and on coal availability and coal recoverability studies in the basin. Part V groups the summaries of the unassessed basins that include Tertiary coal deposits in the Bighorn, Bull Mountain, Wind River, Denver, North Park, and Raton Basins. The final chapter on the first CD-ROM is a slide show with photographs and Quicktime movies about surface mining and reclamation operations in the Northern Rocky Mountains and Great Plains region.

The GIS projects on the second CD-ROM of Professional Paper 1625-A and the non-proprietary stratigraphic and geochemical data in the third CD-ROM, Open-File Report 99-376, cover the Powder River, Williston, Hanna-Carbon, and Greater Green River Basins only. The maps, cross sections, and tables are grouped by basin. Users are urged to refer to the “readme” file on the second CD-ROM to learn how to navigate within and utilize the GIS projects.

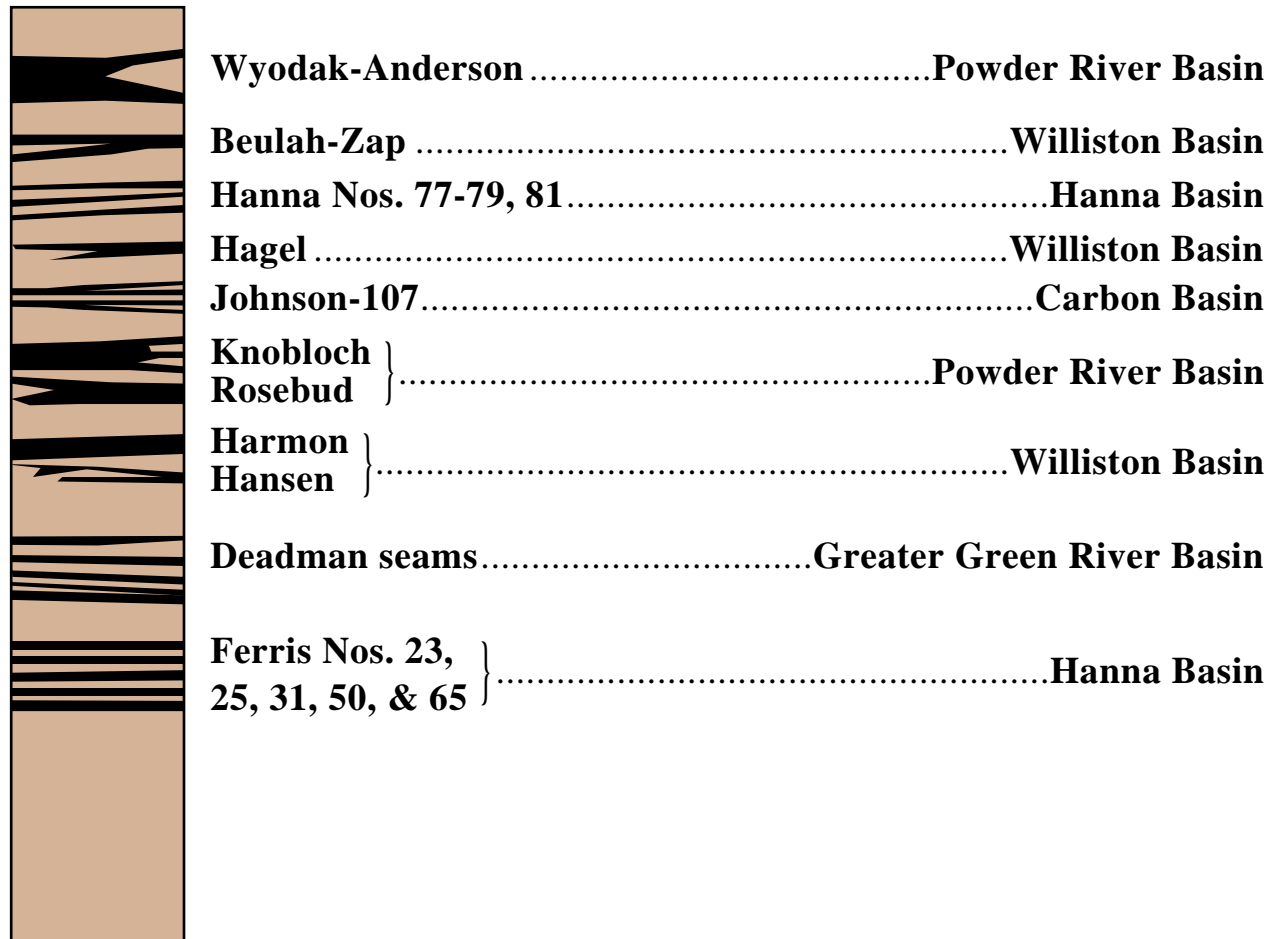
As noted, letter codes are assigned to each chapter as shown in the Contents for this CD-ROM, and most illustrations (figures) are numbered using these letter codes as prefixes for ease of reference. However, some Acrobat graphics (such as those in the Perspectives section) are not numbered as figures. They are accessed by clicking on “hot links” (words shown in red in the text) or by clicking on the directional arrows that appear on these displays. In all chapters included on this CD-ROM, text that appears in red is hot-linked to a figure or a table. In the Contents sections of each chapter, pages on which sections within the chapter begin are hot-linked by page numbers shown in red.

USGS Professional Paper 1625-A and Open File Report 99-376 in CD-ROM format represent the combined efforts of a team of geologists, computer specialists, and others, both within USGS and in collaborating agencies, who have compiled and interpreted the data and prepared the report over a period of five years. Refer to the credits and authorship in the first CD-ROM for a complete list.



**Figure ES-1. Coal basins under study in the current resource assessment, by region.**





**Figure ES-3. Composite stratigraphic section of coal-bearing Tertiary rocks in the four major basins studied in the Northern Rocky Mountains and Great Plains assessment region. The coal beds and zones named are those covered in detail in this assessment.**