U.S. Geological Survey resource assessment of selected Tertiary coal zones in Wyoming, Montana and North Dakota

Introduction

The U.S. Geological Survey (USGS) assessed selected coal resources in the contiguous United States to determine the quantity, quality and minability of the coal that is likely to be produced within the next 20 to 30 years. The National Coal Resource Assessment (NCRA) project includes studies of coal in the following 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 that is now being produced, and the region contains additional coal resources with a high potential for future production. In 1999, more than 37% of the nation’s coal production was from Wyoming, Montana and North Dakota (Table 1). Coal in the Powder River Basin of Wyoming and Montana is generally low in total sulfur and ash content and is compliant with Clean Air Act standards for use in coal-fired power plants. Most of the coal assessed is also low in other contaminants (trace elements of environmental concern).

Abstract

In 1999, 1 Gt (1.1 billion st) of coal was produced in the United States. Of this total, 37% was produced in Wyoming, Montana and North Dakota. Coals of Tertiary age from these states typically have low ash contents. Most of these coals have sulfur contents that are in compliance with Clean Air Act standards and most have low concentrations of the trace elements that are of environmental concern.

The U.S. Geological Survey (USGS) National Coal Resource Assessment for these states includes geologic, stratigraphic, palynologic and geochemical studies and resource calculations for major Tertiary coal zones in the Powder River, Williston, Greater Green River, Hanna and Carbon Basins. Calculated resources are 595 Gt (655 billion st). Results of the study are available in a USGS Professional Paper and a USGS Open-File Report, both in CD-ROM format.
The objectives of the NCRA were to compile all pertinent information on the selected coal beds or coal zones, to identify compliant coal in the region, to compile a publicly available digital database and to publish spatial digital products in a variety of interpretative and interactive forms. The coal assessment in Wyoming, Montana and North Dakota focused on ten producing coal zones designated as priority “assessment units” in five coal basins (Fig. 2). The assessment included local and regional geologic, stratigraphic, palynological and coal-geochemical studies, in addition to resource calculations.

Final products for the assessment in the Northern Rocky Mountains and Great Plains region include publications in CD-ROM format (Flores et al., 1999; Fort Union Coal Assessment Team, 1999) that present the results of the study in a variety of formats. These CD-ROM’s contain software for viewing, printing, querying and downloading text, graphics, spatial layers and raw data.

Coal assessed

Coal assessment units the Northern Rocky Mountains and Great Plains region included the Wyodak-Anderson, Anderson-Canyon, Rosebud-Robinson and Knobloch coal zones in the Powder River Basin of Wyoming; the Harmon, Hansen, Beulah-Zap and Hagel coal zones in the Williston Basin in North Dakota; the Deadman coal zone in the Greater Green River Basin in Wyoming; selected coal beds in the Ferris and Hanna Formations in the Hanna Basin in Wyoming; and the Johnson-107 coal zones in the Carbon Basin in Wyoming (Table 2; Fig. 2).

Coals in the Bighorn, Bull Mountain, Denver, North Park, Raton and Wind River basins (Fig. 2) were not assessed in detail for this study because they have lower potentials for development. These basins are summarized in the final report by the Fort Union Coal Assessment Team (1999).

Geology and age

Coal assessed in Wyoming, Montana and North Dakota is present in basins of early Tertiary (Paleocene) age. The coal formed from peat that accumulated in swamps adjacent to fluvial drainages within tectonically subsiding basins bordered by low mountain ranges or, in the case of the Williston Basin, the coastal plain of an inland seaway. The thickness of the peat deposits varied according to local conditions in the depositional environments, including subsidence rate, rainfall and the susceptibility of the peat swamp to flooding. In the Powder River Basin, peat deposits of exceptional thickness, but with limited lateral extent, accumulated. The coal beds that developed from the peat deposits tend to be lenticular in form, and they tend to be discontinuous and variable in thickness. Coal of Paleocene age is present from the surface down to a depth of about 1,800 m (6,000 ft) in the Powder River, Williston and Greater Green River Basins and from the surface to a depth of 3,600 m (12,000 ft) in the Hanna Basin.

The geological age of the coal was determined using palynology (the branch of science concerned with the study of pollens and spores) (Figs. 3 and 4). Palynological biozones were identified on the basis of fossil pollen that is found only in certain intervals in Paleocene rocks (for example, Nichols, 1999). The palynological biozones were used to establish the age of individual coal zones.

### Table 1

<table>
<thead>
<tr>
<th>Area of production</th>
<th>Coal production Mt</th>
<th>million st</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wyoming</td>
<td>304</td>
<td>335</td>
</tr>
<tr>
<td>Montana</td>
<td>37</td>
<td>41</td>
</tr>
<tr>
<td>North Dakota</td>
<td>27</td>
<td>30</td>
</tr>
<tr>
<td>Total of above states</td>
<td>368</td>
<td>406</td>
</tr>
<tr>
<td>Total U.S. production</td>
<td>992</td>
<td>1,094</td>
</tr>
</tbody>
</table>

![FIGURE 2](image) Coal basins in the Northern Rocky Mountains and Great Plains region. Basins indicated in bold type contain coal beds or coal zones studied in detail for the USGS coal assessment (modified from Fort Union Coal Assessment Team, 1999, Chapter IN, Fig. IN-1).
and other lithologic units for stratigraphic correlation and to aid in determining which beds were to be included in the assessment units.

Coal quality

Most of the coal produced in the Northern Rocky Mountains and Great Plains region comes from the Wyodak-Anderson coal zone in the Powder River Basin, which has the lowest mean content of pounds of SO₂ per million Btu of any of the coal assessed in the region (Table 3). This coal is compliant with Phase II Clean Air Act emission standards for acceptable levels of pounds of sulfur dioxide/million Btu (U.S. Statutes at Large, 1990). Current standards require that no more than the equivalent of 1.24 lb of SO₂/million Btu be released in flue emissions from coal-fired power plants. Standards for acceptable levels of trace elements of environmental concern (such as arsenic, mercury and selenium) are not yet in place, but compared with coal from other coal-producing regions in the United States, Tertiary coals from Wyoming, Montana and North Dakota have low concentrations of such contaminants.

Coal beds in the Powder River Basin are thick, and they contain little ash (Table 3). The assessed coal in this basin is subbituminous in apparent rank (as defined by American Society for Testing and Materials, 1999). The Williston Basin coal beds are relatively thin, and they contain large quantities of ash (Table 3). The assessed

TABLE 2
Coal basins, study areas, assessment units and coal beds included in the Northern Rocky Mountains and Great Plains region coal resource assessment.
coal in this basin is of lower apparent rank than coal in the other basins — lignite. Deep burial of the coal in the Hanna and Carbon Basins led to the development of coal that is of higher apparent rank than that in the other basins — subbituminous to bituminous. Assessed coal in the Greater Green River Basin is subbituminous in apparent rank and is moderately high in ash content (Table 3). More detailed descriptions of coal quality for coal beds and coal zones assessed are provided in Fort Union Coal Assessment Team (1999, Chapters PQ, WQ, HQ and GQ).

Resources and methodology
Data for this study were acquired through cooperation with the U.S. Bureau of Land Management (BLM), state geological surveys, U.S. Office of Surface Mining (OSM) and coal companies. The USGS National Coal Resource Data System (NCRDS) and WCHEM databases (unpublished) were also sources of digital data. The NCRDS database includes proprietary and nonproprietary stratigraphic and lithologic information from drill holes and measured sections at more than 18,900 locations. The WCHEM database contains coal quality and coal geochemistry information from about 1,000 locations.

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

The assessment was organized by study areas or coalfields (Fig. 6). Data on coal beds, coal zones and related rocks were collated in a relational database. The data were downloaded from the relational database and run through a custom program to define partings and to determine the thickness of coal beds for calculation of total, net coal thickness in each coal zone at each data point location.
FIGURE 6

Coalfields studied in detail for the National Coal Resource Assessment in the Northern Rocky Mountains and Great Plains region (modified from U.S. Geological Survey Fact Sheet, 2000).

EXPLANATION

Coalfields

- Powder River Basin
  - Wyodak-Anderson study area
  - Ashland
  - Colstrip

- Williston Basin
  - Bowman-Dickinsen
  - Beulah
  - Center-Falkirk

- Greater Green River Basin
  - Black Butte-Point of Rocks

- Hanna and Carbon Basins
  - Ferris
  - Hanna
  - South Carbon

- Tertiary coal basins

TABLE 3

Average total sulfur and ash contents, pounds of SO₂/million Btu and calorific value of assessed coal. Values for the Powder River Basin include only coal analyses from the Wyodak-Anderson coal zone.

<table>
<thead>
<tr>
<th>Coal basin</th>
<th>Total sulfur %</th>
<th>Ash %</th>
<th>lbSO₂ per mmBtu</th>
<th>Calorific value, Btu/lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Powder River</td>
<td>0.48</td>
<td>6.44</td>
<td>1.24</td>
<td>8,220</td>
</tr>
<tr>
<td>Williston</td>
<td>0.84</td>
<td>7.96</td>
<td>2.54</td>
<td>6,510</td>
</tr>
<tr>
<td>Greater Green River</td>
<td>0.56</td>
<td>11.18</td>
<td>1.27</td>
<td>9,000</td>
</tr>
<tr>
<td>Hanna and Carbon</td>
<td>0.96</td>
<td>12.48</td>
<td>2.07</td>
<td>10,090</td>
</tr>
</tbody>
</table>

Coal resources were reported by study area or coalfield are shown in Table 4. The total resources for the coal assessed in each basin are 516.5 Gt (569.3 billion st) in the Powder River Basin, 68.5 Gt (75.5 billion st) in the Williston Basin, 2.4 Gt (2.7 billion st) in the Greater Green River Basin and 6.4 Gt (7.1 billion st) in the Hanna and Carbon Basins. These calculations do not take into consideration many of the economic, technological, cultural and environmental restrictions to coal development.

Federal and nonfederal surface management and ownership of Tertiary coal resources in Wyoming, Montana and North Dakota are summarized in Fig. 7. About 85% of the coal is under Federal surface management, and about 80% is federally owned.

Conclusions

The National Coal Resource Assessment in the Northern Rocky Mountains and Great Plains region included detailed studies of selected coal zones in Wyoming, Montana and North Dakota. The total coal resources in these coal zones are about 594 Gt (655 billion st), with 80% of this coal federally owned.

The coal is generally low in trace-element contaminants and is compliant with Clean Air Act emissions requirements.
TABLE 4

Coal resources reported by study area of coalfield. Resources do not include coal in mine or lease areas, coal less than 0.76-m (2.5-ft) thick or coal in clinker areas.

<table>
<thead>
<tr>
<th>Study area or coalfield</th>
<th>Basin</th>
<th>State</th>
<th>Coal resources</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Powder River</td>
<td>Wyoming</td>
<td>461,300</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>508,500</td>
</tr>
<tr>
<td></td>
<td>Powder River</td>
<td>Montana</td>
<td>38,300</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>42,200</td>
</tr>
<tr>
<td></td>
<td>Williston</td>
<td>North Dakota</td>
<td>60,100</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>66,300</td>
</tr>
<tr>
<td></td>
<td>Greater Green River</td>
<td>Wyoming</td>
<td>2,400</td>
</tr>
<tr>
<td></td>
<td>Hanna and Carbon</td>
<td>Wyoming</td>
<td>2,700</td>
</tr>
</tbody>
</table>

standards. Given the quantity and quality of coal in this region, the potential for coal development, particularly in the Powder River Basin, is very high.

References


