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Drill Hole Data for Coal Beds in the Powder River Basin, Montana and Wyoming

Data Series 713

U.S. Department of the Interior
U.S. Geological Survey

Cover. Coalbed methane well in the Powder River Basin, Wyoming. Photograph by Margaret S. Ellis, U.S. Geological Survey, Denver, Colorado.

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Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NAVD 29).

Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD27).

Elevation, as used in this report, refers to distance above the vertical datum.

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Abstract

This report by the U.S. Geological Survey (USGS) of the Powder River Basin (PRB) of Montana and Wyoming is part of the U.S. Coal Resources and Reserves Assessment Project. Essential to that project was the creation of a comprehensive drill hole database that was used for coal bed correlation and for coal resource and reserve assessments in the PRB. This drill hole database was assembled using data from the USGS National Coal Resources Data System, several other Federal and State agencies, and selected mining companies. Additionally, USGS personnel manually entered lithologic picks into the database from geophysical logs of coalbed methane, oil, and gas wells. Of the 29,928 drill holes processed, records of 21,393 are in the public domain and are included in this report. The database contains location information, lithology, and coal bed names for each drill hole.

Introduction and Objectives

The PRB was previously assessed for coal resources and reserves by the USGS and other Federal and State agencies. These assessments generally involved studies that covered only limited geographic areas and (or) limited depths. The current U.S. Coal Resources and Reserves Assessment Project expanded the scope of past studies to include the entire PRB, all coal beds, and at all depths. For this purpose, the PRB was divided into four assessment areas to permit more timely publication of assessment results. These assessment areas (fig. 1) are (1) Gillette coal field (Luppens and others, 2008), (2) Northern Wyoming PRB (Scott and others, 2010) , (3) Southwestern PRB (Osmonson and others, 2011), and (4) Montana PRB (Haacke and others, 2012).

As a foundation for the PRB assessment, the largest possible drill hole database was assembled. The core of the digital database came from the U.S. Geological Survey National Coal Resources Data System (NCRDS, *http://energy.er.usgs.gov/products/databases/CoalQual/index.htm*). Additional digital data were supplied by the Wyoming State Geological Survey (WSGS, *http://www.wsgs.uwyo.edu/*), the Montana Bureau of Mines and Geology (MBMG, *http://www.mbmg.mtech.edu/*), the Bureau of Land Management (BLM, *http://www.blm.gov/wo/st/en.html*), and a commercial database created by Goolsby, Finley, and Associates, LLC (Goolsby and others, 2001) that was released to public domain. Confidential drill hole data were loaned to the USGS by several mining companies operating in the PRB. A substantial amount of new data is now available from the recent development of coalbed methane (CBM) in Wyoming and Montana. Geophysical logs of an additional 13,358 CBM, oil, and gas wells were examined and the lithology picks entered in the database using the StratiFact® (GRG Corporation, 1998) drill hole database and graphics program (table 1).

The correlation of all coal beds was determined using the StratiFact program, with some 250,000 cross-sections viewed in order to place 47 coal beds into a single stratigraphic system. The interpretations from this greatly expanded database provided a more accurate view of the coal resources and reserves in the PRB. The resulting correlated database contained 29,928 drill holes, of which 21,393 are public domain (fig. 1). Each of the four assessment area reports, listed above, using the correlated drill hole dataset, contains discussions on geology, coal resources, and reserves tonnages. The purpose of this report is to make the drill hole data available to the public.

Table 1. List of the contents of the location table LITH_BY field showing the organization that made the lithology picks, and the number of drill holes entered.

Number of holes	Field contents	Full name
697	GFA	Goolsby, Finley, and Associates, LLC
1,034	MBMG	The Montana Bureau of Mines and Geology
697	USBLM	The Bureau of Land Management
16,732	USGS	The U.S. Geological Survey
2,233	WSGS	The Wyoming State Geological Survey

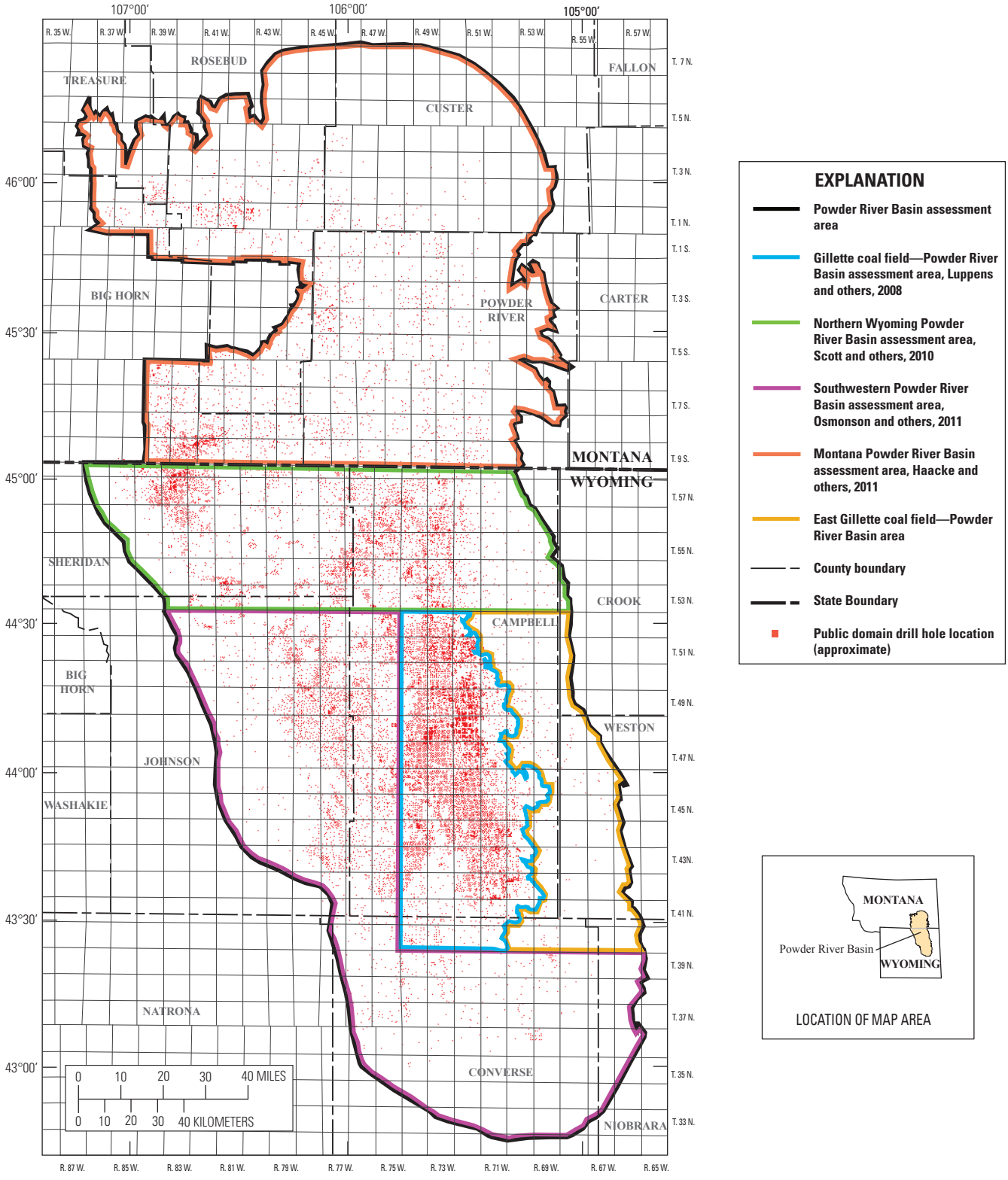

Figure 1. Map showing public domain drill hole locations for the Powder River Basin, Montana and Wyoming. Locations are approximate.

Study Methodology

Two steps were used in producing the completed drill hole database (1) data collection and (2) coal bed correlation. The assessment process is discussed in detail in the four individual assessment reports.

Data Collection

The first phase in data collection began with a search of the USGS NCRDS database that contains coal drill hole and measured section data for the United States collected by the USGS and various State agencies. The NCRDS data that came from WSGS and MBMG were later augmented by additional digital data supplied by those State agencies. Coal companies having activity in the PRB were approached with requests for use of their data in the assessments and several supplied digital data upon conditions of anonymity and data confidentiality.

The next phase involved entering data from CBM, oil, and gas wells. In the mid-1990s, CBM drilling in the Wyoming portion of the PRB increased rapidly, and by 1999 thousands of CBM wells were being drilled. By the time that the PRB assessment project began in 2004 the large number of new publically available CBM wells as well as thousands of older oil and gas wells allowed a more comprehensive evaluation of geology and coal resources than had been possible in previous studies. TIFF images of drill hole geophysical logs, selected for data entry into StratiFact, were downloaded from the Wyoming Oil and Gas Conservation Commission (WOGCC) web site as were drill hole coordinates for all Wyoming wells.

In Montana, CBM, oil, and gas drilling is limited. CBM development has been restricted to an area south and east of the town of Decker (which is about 75 miles southeast of Billings). Additionally, oil and gas exploration and development in the Montana PRB has been much less extensive than in Wyoming. The result is a significant lack of publicly available drill hole data in Montana as compared with Wyoming. Geophysical logs for Montana were purchased from MJ Systems (2009) and converted to TIFF format. Drill hole coordinates for all Montana wells were downloaded from the Montana Board of Oil and Gas (Montana Board of Oil and Gas, 2006).

The drill hole coordinates and elevations were derived from a variety of sources, accuracy of most of these data is unknown. A concentrated effort was made to check drill hole locations but, lacking access to much of the original data, locations of many drill hole could not be verified. The latitudes, longitudes and elevations of CBM, oil, and gas wells came from the respective oil and gas commissions of Montana and Wyoming, having been supplied by the operators of the wells. Both state commissions assume the coordinates and elevations to be in NAD 27 datum but it is not required. In addition, the state commissions only require that the well be in the permitted quarter-quarter of a section, so the coordinates may only be approximate. Overall, drill holes in this database are believed to have sufficiently accurate coordinates and elevations for regional coal correlations.

Other factors add to the variability in data consistency for entries in this database because (1) geophysical logs differ widely in type, quality, and resolution; (2) in a majority of CBM wells, only gamma ray logs were run and many of those were logged through drill pipe or casing; and (3) hundreds of wells were logged only to the top of the target coal. Oil and gas wells were logged primarily for detail in deep formations, and typically the upper (coal-bearing) intervals were either not logged or only gamma logged through the surface casing.

Lithology picks from geophysical logs were entered into the StratiFact program. The primary focus of the PRB assessment was to determine coal resources and reserves rather than to conduct a comprehensive geological study; therefore, no attempt was made to interpret non-coal lithologies and in cases where the lithology was not already described in detail, lithologies were coded as coal or rock. Partings within coal beds and interburden between coal beds were also coded as rock. An interval for which there was no geophysical logging, such as the shallower part of an oil or well or a CBM well that was not logged to the bottom of the well, was entered as "No Log." However, if the methane-producing interval of the CBM well was available from production records, that interval was entered as "Coal, CBM Perf." For some data supplied to the USGS, only coal picks were recorded and the non-reported intervals were entered as "Not Reported." In some cases, those non-reported intervals possibly had coals that were not considered significant. Therefore the "No Log" and "Not Reported" intervals should be considered as null information rather than as not having any coal for correlation and modeling purposes. In all, lithologic data from 9,565 CBM wells and 3,091 oil and gas wells in Wyoming, and 290 CBM wells and 412 oil and gas wells in Montana were entered in the database.

Coal Bed Correlations and Nomenclature

The second step in producing the database was the correlation of coal beds. Historically, correlation of individually named coal beds and coal zones across the entire PRB has been difficult, because the beds commonly split, merge, and pinch out (Flores and others, 1999). Also, distances between individual drill holes were often widely spaced, increasing the uncertainty of coal bed correlations from one drill hole to the next. However, with this greatly expanded database, the distance between drill holes was reduced resulting in a higher density of subsurface data and increased correlation reliability.

Many different names for individual coal beds and coal zones in the PRB have been used during the past 30 years. A report by Kent and others (1980), who described the northern part of the Gillette coal field that falls within the Spotted Horse coal field of Olive (1957), established a coal bed nomenclature system that has become the standard for much of the PRB in Wyoming. Kent and others (1980) retained certain existing coal bed nomenclature and revised

other nomenclature by introducing new coal bed names. Molnia and Pierce (1992) also described coal bed stratigraphy in the central PRB in Wyoming and Montana; their nomenclature followed the usage of Culbertson and others (1979), Law and others (1979), Kent and others (1980), and Culbertson and Saperstone (1987). Flores and others (1999) defined a coal zone in the PRB known as the Wyodak-Anderson, which includes many named coal beds in the upper part of the Tongue River Member of the Fort Union Formation. Five previously published regional cross sections were particularly instrumental in setting the framework for coal bed correlations in the PRB (1) McLellan and others (1990), (2) Pierce and others (1990), (3) Hardie (1991), (4) McLellan (1991), and (5) Molnia and Pierce (1992). Coal bed names used in this and previous reports are discussed in the four individual assessment reports mentioned earlier. The formation and bed names used in this report and the number of holes that encountered each coal bed are given in table 2.

The graphical interface of the StratiFact database was a critical tool for managing the interpretation of the large volume of information. On-screen cross sections were selected, edited, and correlated. Both linear and circular cross sections were constructed to correlate coal beds across the PRB assessment area. Circular cross sections that verify closure were especially valuable when coal beds either split or thinned adjacent to sand channels. In this process, the beginning and ending drill holes of the cross section are the same, assuring correlation accuracy.

Guidelines were established regarding how to handle situations in which two named beds merged into a single bed. The general guideline used in these cases was that two named beds were considered to have merged into a single named bed when an intervening parting was less than 2.0 ft thick. The following exceptions were made for modeling purposes:

- In individual holes, coal beds split by partings as much as 5.0 ft thick were considered to be merged if surrounding holes indicate the beds had merged into a single bed.
- In individual holes, coal beds with no partings or partings less than 2.0 ft thick were considered to be split into two beds if surrounding holes showed the coal has split into two beds.
- The upper bed's name was used for the merged-bed name, except in the case of a rider bed that merged into the main bed; for example, where the Anderson bed merged with the Upper Anderson Rider bed, the resulting bed was considered the Anderson bed.

Database

The database consists of two tables, the location table and the stratigraphy table. The data in the two tables are linked by unique id numbers assigned to each drill hole. Each table is supplied in two formats, containing identical data. The quote and comma delimited format files have a "CSV" extension; the dbase format files have a "DBF" extension.

The following section lists the fields in the database tables. Each field name is described as a Character, Integer, or Numeric field along with the size of the field. There is also a brief description of the purpose of each field and for some fields the specific contents of each field.

Location Fields (and Structure)

UNIQUE_ID (Integer)
Unique number assigned to each drill hole to relate data in the location table to those in the stratigraphy table. Numbered from 1 to the total number of drill holes in the database.

HOLE_ID (Character)
The drill hole identifier assigned by the company or agency who drilled the well, except for CBM, oil, and gas wells where the standard API number is used

LAT_NAD27 (Numeric, 5 decimals)
The Latitude coordinate, expressed in decimal degrees, in NAD 27 datum

LONG_NAD27 (Numeric, 5 decimals)
The Longitude coordinate, expressed in decimal degrees, in NAD 27 datum.

UTME_NAD27 (Numeric, 2 decimals)
Universal Transverse Mercator coordinates, expressed in meters, zone 13, in NAD 27 datum. Values were converted from the Latitude and Longitude coordinates using the Army Corps of Engineers Corpscon 6 software.

UTMN_NAD27 (Numeric, 2 decimals)
Universal Transverse Mercator coordinates, expressed in meters, zone 13, in NAD 27 datum. Values were converted from the Latitude and Longitude coordinates using the Army Corps of Engineers Corpscon 6 software.

ELEVATION (Numeric, 2 decimals)
Surface elevation of all drill holes, except for oil wells where the elevation is taken at the kelly bushing.

DH_DEPTH (Numeric, 2 decimals)
The drilled depth of the drill hole.

TOWNSHIP (Character)
Township within the 6th Principal Meridian.

RANGE (Character)
Range within the 6th Principal Meridian.

SECTION (Numeric, 2 decimals)
The Section within a township and a range.

QTR_QTR (Character)
The Quarter, Quarter within a Section.

STATE (Character)
Contents are either Montana or Wyoming. There are 2,925 holes in Montana and 18,469 holes in Wyoming.

COUNTY (Character)
Contains the county name.

TYPE (Character)
Type of drill hole (table 3).

DAT_SOURCE (Character)
Data source with original drill hole information from which lithology picks were made. Much of the original drill hole data is publically available from publications and online sources. A detailed list of the sources with comments is in table 4.

LITH_BY (Character)
Name of the agency, organization, or company that made the lithology picks (table 1). Where available, the field also contains the name of the individual who made the picks.

COMPANY (Character)
For CBM, oil, and gas wells, this field contains the name of the company for which the well was drilled. For holes drilled for coal, this field either contains the name of the mining company or the government agency. There are 1,014 different entries in this field.

WELL_NAME (Character)
Contains the common well name for CBM, oil, and gas wells.

QUAD_MAP (Character)
Contains the name of the USGS 7.5 minute quadrangle map.

Stratigraphy Fields (and Structure)

UNIQUE ID (Integer)
This is the unique number assigned to each drill hole to relate data in the stratigraphy table to the location table. Numbered from 1 to the total number of drill holes in the database.

HOLE_ID (Character)
The drill hole identifier assigned by the company or agency who drilled the well, except for CBM, oil, and gas wells where the standard API number is used

TOP_DEPTH (Numeric, 2 decimals)
This is the depth, in feet, from the surface to the top of each lithologic unit.

BOT_DEPTH (Numeric, 2 decimals)
This is the depth, in feet, from the surface to the bottom of each lithologic unit.

PRIME_LITH and LITH_MOD (Character)
These two fields contain the primary lithology and lithology modifier for every stratigraphic record (table 5).

FORMATION (Character, 16) and BED (Character)
These two fields contain the correlated formation and coal bed names (table 2).

ARC Map

Supplemental to the database are GIS data created using Esri ArcGIS 9.3.1 (Esri, 2000) that can be used to show the drill hole database in map view along with other pertinent data layers. These layers include surface geology, coal assessment study area boundaries, townships and ranges, generalized surface ownership, topography, and various cultural features that are also included in basemap GIS services provided by Esri, Inc. (Esri, 2010).

Downloadable Data and the Interactive Map

The GIS is available for interactive analysis as a map document (both MXD and PMF formats) that can be downloaded from the USGS website at *http://pubs.usgs.gov/ds/713*/. Because of the ability to toggle layers on and off and analyze attributes, data analysis can be achieved effectively with the interactive map. The publishing process uses the ArcMap document (MXD) and creates a special file called a published map file (PMF). ArcGIS Publisher (Esri, 2008a, *http://www.esri.com/software/arcgis/extensions/publisher/index.html*) is the extension used to create the PMF from the MXD and packages the required data with the PMF file for easy distribution. PMFs can be viewed or printed using any ArcGIS (Esri, 2000*, http://www.esri.com/software/arcgis/)* desktop product, including ArcMap and the no-cost ArcReader (Esri, 2008b, *http://www.esri.com/software/arcgis/arcreader/download.html*) application. Users can download and install the ArcReader software

Table 2. List of the contents of the stratigraphy table FORMATION and BED fields showing the 47 coal beds, in stratigraphic order from youngest to oldest, in the Powder River Basin of Montana and Wyoming, and the number of drill holes encountering each bed.

Number of holes	Formation	Bed
186	Wasatch	Upper Healy
658	Wasatch	Healy/Lower Ulm
785	Wasatch	Murray
591	Wasatch	Ucross
1,989	Wasatch	Upper Felix
4,444	Wasatch	Felix
4,109	Wasatch	Lower Felix
5,710	Fort Union	Upper Roland Rider
1,619	Fort Union	Lower Roland Rider
9,987	Fort Union	Roland (Baker)
953	Fort Union	Roland (Taff)
326	Fort Union	Upper Smith
9,334	Fort Union	Smith
343	Fort Union	Upper Anderson Rider
480	Fort Union	Lower Anderson Rider
11,775	Fort Union	Anderson
883	Fort Union	Lower Anderson
672	Fort Union	Dietz 1
930	Fort Union	Dietz 2
4,816	Fort Union	Dietz 3
624	Fort Union	Dietz 4
726	Fort Union	Upper Canyon/Cox
9,354	Fort Union	Canyon
4,374	Fort Union	Lower Canyon
145	Fort Union	Upper Ferry
744	Fort Union	Ferry
4,460	Fort Union	Werner/Cook
328	Fort Union	Upper Otter
3,642	Fort Union	Otter
3,412	Fort Union	Gates/Wall
1,368	Fort Union	Pawnee
110	Fort Union	Brewster-Arnold
1,052	Fort Union	Odell
247	Fort Union	Cache
24	Fort Union	A Zone
44	Fort Union	Upper Rosebud/S1
2,206	Fort Union	Rosebud/Knobloch
86	Fort Union	Calvert
2,499	Fort Union	Mckay/Nance
63	Fort Union	Lower Mckay/S2
2,752	Fort Union	Flowers-Goodale/Danner
1	Fort Union	Upper Witham
1,491	Fort Union	Robinson/Witham
1,768	Fort Union	Roberts/Terret
50	Fort Union	Burley
91	Fort Union	Upper Stag
8	Fort Union	Lower Stag

from Esri. *To access the MXD, users must have ArcGIS 9.3.1 or later software (*Esri, 2000, *http://www.esri.com/software/arcgis/eval-help/arcgis-931.html*).

The ArcMap project is a compilation of both published and unpublished coal geology data. For the published data, the accompanying metadata have been retained as published. For the ArcGIS.com web services (formerly ArcGIS Online; Esri, 2010, *http://www.esri.com/software/arcgis/arcgisonline/index.html*), data descriptions, sources, and credits are stored as layer properties.

The Data Package

The report, whether downloaded from a USGS web site or from the CD consists of the text of this report (the pamphlet), the drill hole database, and the GIS data. The Data folder contains the drill hole database in CSV and DBF formats. The GIS folder contains the PRB_drill_holes.MXD and PRB_drill_holes.PMF files. All GIS data are stored in a geodatabase using the GCS_North_American_1983 coordinate system and reside in the 'PRB_drill_holes.gdb' folder within the GIS folder.

Acknowledgments

We would like to thank the staff of the Wyoming State Geological Survey, and Jay Gunderson of the Montana Bureau of Mines and Geology for supplying drill-hole data. The outstanding efforts of Laura R.H. Biewick and Lee M. Osmonson (U.S. Geological Survey) in creating the GIS map were extremely appreciated. Ronald H. Affolter, Scott A. Kinney, William R. Keefer, and Margaret S. Ellis, all of the U.S. Geological Survey, provided technical reviews of the manuscript which greatly improved this report.

Table 3. List of the contents of the location table TYPE field showing the drill hole types and the number of drill holes of each type.

Number of holes	Field contents	Comment
12,553	CBM	Coalbed methane well
3,503	Coal test	Drilled for exploration and/or development of coal
5,003	Oil & gas	Oil and gas well
334	Water well	Originally drilled as a water well

Table 4. Federal and State publications and online sources with original drill hole logs in the Powder River Basin. The publication number is contained in the location table DAT_SOURCE field. The Comment column describes the drill hole number series and type of logs contained.

Source Publication	Comments
Babcock, R.N. and Hobbs, R.G., 1979, Geophysical logging of water wells for coal occurrences in northern Campbell County and eastern Sheridan County, Wyoming: U.S. Geological Survey Open-File Report 79–1213, 12 p.	Table listing of coal picks for holes numbered 76–BCR–1 through 76–BCR–11, 77–BCR–1 through 77–BCR–63, and 78–BCR–1 through 78-BCR–5. The published database contains 1 drill hole from this source publication.
Cathcart, J.D., 1984, Bibliography of U.S. Geological Survey reports on coal drilling and geophysical logging projects, and related reports on geologic uses, Powder River Basin, Montana and Wyoming, 1973–1983: U.S. Geological Survey Open-File Report 84–518, 16 p.	This publication lists most of the U.S. Geological Survey publications listed in this bibliography and well as many other publications.
Cathcart, J.D. and Roberts, S.B., 1982, Preliminary report of coal exploration drilling in the Broadus Area, Powder River County, Montana, during 1980: U.S. Geological Survey Open-File Report 82–828, 113 p.	Lithology logs and geophysical logs for holes numbered 80–MB–A1 through 80–MB–E9. The published database contains 18 drill holes from this source publication.
Cathcart, J.D., Babcock, R.N. and Hobbs, R.G., 1983, Geophysical logs of water wells logged for coal occurrences in northern Campbell and eastern Sheridan Counties, Wyoming: U.S. Geological Survey Open-File Report 83–411, 119 p.	Geophysical logs for holes numbered 76–BCR–1 through 76–BCR–11, 77–BCR–1 through 77–BCR–63, and 78–BCR–1 through 78–BCR–5. The published database contains 1 drill hole from this source publication.
Correia, G.A., 1980, Preliminary results of 1978 coal assessment drilling in northern and western Recluse Geologic Analysis Area, northern Campbell County and eastern Sheridan County, Wyoming: U.S. Geological Survey Open-File Report 80–80, 70 p.	Geophysical logs for holes numbered 78–1 through 78–31. The published database contains 15 drill holes from this source publication.
Culbertson, W.C., 1981, Coal exploratory holes drilled in 1980 in the Birney 1 degree × 2 degrees Quadrangle, Powder River and Big Horn Counties, Montana: U.S. Geological Survey Open-File Report 81–1329, 54 p.	Lithology logs and geophysical logs for holes numbered OTTER 1 through OTTER 10. The published database contains 9 drill holes from this source publication.
Culbertson, W.C., Gaffke, T.M., and Correia, G.A., 1980, Coal exploratory holes drilled in 1978–79 in the Birney 1 degree by .5 degrees Quadrangle, Big Horn and Rosebud Counties, Montana, for coal beds in the Tongue River Member of the Paleocene Fort Union Formation: U.S. Geological Survey Open-File Report 80–55, 68 p.	Lithology logs and geophysical logs for holes numbered BIRNEY 1 through BIRNEY 10. The published database contains 13 drill holes from this source publication.
Hardie, J.K., 1979, Preliminary report of coal exploration drilling in the Broadus area, Powder River County, Montana, during 1978: U.S. Geological Survey Open-File Report 79–965, 51 p.	Lithology logs and geophysical logs for holes numbered 78M–BCR2 through 78M–BCCR11. The published database contains 10 drill holes from this source publication.
Hansen, W.B. and Culbertson, W.C., 1985, Correlated lithologic logs and analyses of 1982 coal drilling in Big Horn, Prairie, Rosebud, and Treasure Counties, Montana: U.S. Geological Survey Open-File Report 85–738, 125 p.	Lithology logs for holes numbered B–82–1 thru B–82–28, PDC–13 and PDC–14, R–82–1 through R–82–20, CC–13–82, CC–14–2, CC–19–82, and CC–20–82. The published database contains 43 drill holes from this source publication.
Hobbs, R.G., 1980, 1976 coal exploratory drilling: core description, and coal analyses, Recluse Geologic Analysis Area, northern Campbell County, Wyoming: U.S. Geological Survey Open-File Report 80–1160, 53 p.	Lithology logs and coal quality for holes numbered 76–103, 76–105, and 76–108. The published database contains 2 drill holes from this source publication.
Hobbs, R.G., 1980, Analyses of coal and selected rock samples from the USGS 1975 drilling, Recluse Geologic Analysis area, northern Campbell County, Wyoming: U.S. Geological Survey Open-File Report 80–1161, 78 p.	Coal quality for holes numbered RM–1 through RM–7. See Open-File Report 77–717 for lithology logs. The published database contains no drill holes from this source publication.
Hobbs, R.G., 1982, Coal exploratory drilling 1980, Recluse and Sheridan .5 degree by 1 degree Quadrangles, Campbell, Johnson, and Sheridan Counties, Wyoming: U.S. Geological Survey Open-File Report 82–799, 158 p.	Lithology logs and geophysical logs for holes numbered 80–AU1 through 80–AU26. The published database contains 18 drill holes from this source publication.

Table 4. Federal and State publications and online sources with original drill hole logs in the Powder River Basin. The publication number is contained in the location table DAT_SOURCE field. The Comment column describes the drill hole number series and type of logs contained.—Continued

Source Publication	Comments
Hobbs, R.G., Malotte, D.C., Sanchez, J.D., and Windolph, J.F., Jr., 1977, Core description logs, 1975 USGS drilling, Recluse area, northern Campbell County, Wyoming: U.S. Geological Survey Open-File Report 77–717, 46 p.	Lithology logs for holes numbered RM-1 through RM-7. The associated coal quality data are in Open-File Report 80-1161. The published database contains 4 drill holes from this source publication.
Kepferle, R.C., 1954, Selected deposits of strippable coal in central Rosebud County, Montana: U.S. Geological Survey Bulletin 995–I, 49 p, 5 pls.	Contains numerous measured sections. The published database contains 1 drill hole from this source publication.
Kirschbaum, M. A., Correia, G. A., and McPhillips, M., 1982, Coal exploratory drilling during 1979 in western Powder River County, Montana: U.S. Geological Survey Open-File Report 82–748, 141 p.	Lithology logs and geophysical logs for holes numbered MB–1C through MB–36. The published database contains 36 drill holes from this source publication.
Kistner, F.B., 1977, Preliminary report on five coal drill holes in Converse County, Wyoming: U.S. Geological Survey Open-File Report 77–774, 25 p.	Lithology logs and geophysical logs for holes numbered GS–7601 through GS–7605. The published database contains 2 drill holes from this source publication.
Kistner, F.B., 1980, Geophysical and lithologic logs of 35 wells in Converse and Campbell Counties, Wyoming: U.S. Geological Survey Open-File Report 80–125, 69 p.	Lithology logs and geophysical logs for holes numbered WW–76001 through WW–76003, WW–77001 through WW–77020, WW–78001 through WW–78018, and OW–77001. The published database contains no drill holes from this source publication.
Kistner, F.B., Holloman, G.A., and Coppock, D.G., 1979, Lithologic and geophysical logs and coal analyses from test holes drilled during 1977 in Converse and Campbell Counties, Wyoming: U.S. Geological Survey Open-File Report 79–1173, 88 p.	Geophysical logs for holes numbered CD–77001 through CD–77028. The published database contains 22 drill holes from this source publication.
Kistner, F.B., Donatich, A.J., and Holloman, G.A., 1980, Geophysical and lithologic logs and coal analyses from test holes drilled during 1978 in Campbell and Converse Counties, Wyoming: U.S. Geological Survey Open-File Report 80–851, 183 p.	Lithology logs and geophysical logs for holes numbered CD–78001 through CD–78081. The published database contains 47 drill holes from this source publication.
Lonnie, T.P., Corley, H.E., and Noah, R.J., 1980, Geophysical and lithologic logs from coal test holes drilled during 1979 in Converse and Campbell Counties, Wyoming: U.S. Geological Survey Open-File Report 80–1041, 102 p.	Geophysical logs for holes numbered CD–79001 through CD–79056. The published database contains 56 drill holes from this source publication.
Lonnie, T.P., and Noah, R.J., 1981, Geophysical and lithologic logs from coal test holes drilled during 1980 in Campbell County, Wyoming: U.S. Geological Survey Open-File Report 81–714, 162 p.	Geophysical logs for holes numbered CD–80001 through CD–80097. The published database contains 64 drill holes from this source publication.
Matson, R.E., 1971, Strippable coal in the Moorhead Coal Field, Montana: Montana Bureau of Mines and Geology Bulletin 83, 18 p., 3 pls.	Lithology logs and location maps for drill holes numbered SM–1 through SM–19, SH–61 through SH–64, and SH–7041 through SH–7043. The published database contains 18 drill holes from this source publication.
Matson, R.E. and Blumer, J.E., 1973, Quality and reserves of strippable coal, selected deposits, southeastern Montana: Montana Bureau of Mines and Geology Bulletin 91, 135 p, 34 pls., 4 figures, 91 tables.	Lithology logs and location maps for drill holes numbered SH–1 through SH–121, SH–701 through SH–70102, and SH–711 through SH–7195. The published database contains 443 drill holes from this source publication.
Pierce, W.G., 1936, Contributions to economic geology (short papers and preliminary reports), 1934–36. The Rosebud coal field, Rosebud and Custer Counties, Montana: U.S. Geological Survey Bulletin 847–B, 78 pages, 17 pls.	Contains numerous measured sections. The published database contains 3 drill holes from this source publication.
Robinson, L.N. and Van Gosen, B.S., 1985, Maps and sections showing geology and coal resources of the northeastern part of the Crow Indian Reservation, Big Horn County, Montana: U.S. Geological Survey Miscellaneous Field Studies Map 1796, scale 1:24,000, 9 maps.	Contains numerous drill hole and measured section locations on maps with annotated coal intercepts. The published database contains 6 drill holes from this source publication.

Table 4. Federal and State publications and online sources with original drill hole logs in the Powder River Basin. The publication number is contained in the location table DAT_SOURCE field. The Comment column describes the drill hole number series and type of logs contained.—Continued

Source Publication	Comments
Robinson, L.N. and Van Gosen, B.S., 1986, Maps showing the coal geology of the Sarpy Creek area, Big Horn and Treasure Counties, Montana: U.S. Geological Survey Miscellaneous Field Studies Map 1859, scale 1:24,000.	Coal picks and location maps for drill holes numbered 1 through 49. The published database contains 57 drill holes from this source publication.
U.S. Geological Survey and Montana Bureau of Mines and Geology, 1973, Preliminary report of coal drill hole data and chemical analyses of coal beds in Sheridan and Campbell Counties, Wyoming, and Big Horn County, Montana: U.S. Geological Survey Open-File Report 73–351, 51 p.	Lithology logs and coal quality for holes numbered BME–721 through BME–7228. The published database contains 21 drill holes from this source publication.
U.S. Geological Survey and Montana Bureau of Mines and Geology, 1974, Preliminary report of coal drill hole data and chemical analyses of coal beds in Campbell County, Wyoming: U.S. Geological Survey Open-File Report 74–97, 241 p.	Lithology logs and geophysical logs for holes numbered US–731 through US–7363. The published database contains 21 drill holes from this source publication.
U.S. Geological Survey and Montana Bureau of Mines and Geology, 1976, Preliminary report of coal drill hole data and chemical analyses of coal beds in Campbell and Sheridan Counties, Wyoming; Custer, Prairie, and Garfield Counties, Montana; and Mercer County, North Dakota: U.S. Geological Survey Open-File Report 76–319, 377 p.	Lithology logs and coal quality for holes numbered US–741 through US–74115. The published database contains 59 drill holes from this source publication.
U.S. Geological Survey and Montana Bureau of Mines and Geology, 1976, Preliminary report of coal drill-hole data and chemical analyses of coal beds in Campbell, Converse, and Sheridan Counties, Wyoming; and Big Horn, Richland, and Dawson Counties, Montana: U.S. Geological Survey Open-File Report 76–450, 382 p.	Lithology logs, geophysical logs and coal quality for holes numbered US–751 through US–75124. The published database contains 35 drill holes from this source publication.
U.S. Geological Survey and Montana Bureau of Mines and Geology, 1977, Preliminary report of 1977 coal drilling in eastern Montana and Northeastern Wyoming: Geophysical logs for Big Horn County, Montana: U.S. Geological Survey Open-File Report 77–721–B, 126 p.	Geophysical logs for holes numbered US–7738 through US–7798. The published database contains 53 drill holes from this source publication.
U.S. Geological Survey and Montana Bureau of Mines and Geology, 1977, Preliminary report on 1976 drilling of coals in Campbell and Sheridan Counties, Wyoming, and Big Horn, Dawson, McCone, Richland, Roosevelt, Rosebud, Sheridan, and Wibaux Counties, Montana: U.S. Geological Survey Open-File Report 77–283, 403 p.	Lithology logs and geophysical logs for holes numbered US–761 through US–76191. The published database contains 47 drill holes from this source publication.
U.S. Geological Survey and Montana Bureau of Mines and Geology, 1978, Preliminary report of 1977 coal drilling in eastern Montana and northeastern Wyoming: Geophysical logs for Big Horn, Fallon, and Powder River Counties, Montana: U.S. Geological Survey Open-File Report 77–721–A, 77 p.	Geophysical logs for holes numbered US-771 through US–7737. The published database contains 26 drill holes from this source publication.
U.S. Geological Survey and Montana Bureau of Mines and Geology, 1978, Preliminary report of 1977 coal drilling in eastern Montana and Northeastern Wyoming: Geophysical logs for Powder River and Dawson Counties, Montana: U.S. Geological Survey Open-File Report 77–721–C, 79 p.	Geophysical logs for holes numbered US–7799 through US–77148. The published database contains 41 drill holes from this source publication.
U.S. Geological Survey and Montana Bureau of Mines and Geology, 1978, Preliminary report of 1977 coal drilling in eastern Montana and Northeastern Wyoming: Geophysical logs for Dawson, Garfield, McCone, and Prairie Counties, Montana: U.S. Geological Survey Open-File Report 77–721–D, 101 p.	Geophysical logs for holes numbered US–77149 through US–77199. The published database contains 6 drill holes from this source publication.

Table 4. Federal and State publications and online sources with original drill hole logs in the Powder River Basin. The publication number is contained in the location table DAT_SOURCE field. The Comment column describes the drill hole number series and type of logs contained.—Continued

Source Publication	Comments
U.S. Geological Survey and Montana Bureau of Mines and Geology, 1978, Preliminary report of 1977 coal drilling in eastern Montana and Northeastern Wyoming: Geophysical logs for Campbell and Converse Counties, Wyoming: U.S. Geological Survey Open-File Report 77–721–E, 202 p.	Geophysical logs for holes numbered US–77200 through US–77290. The published database contains 72 drill holes from this source publication.
U.S. Geological Survey and Montana Bureau of Mines and Geology, 1978, Preliminary report of 1977 coal drilling in eastern Montana and northeastern Wyoming: Geophysical logs for Dawson, McCone, Richland, and Rosebud Counties, Montana: U.S. Geological Survey Open-File Report 77–721–F, 74 p.	Geophysical logs for holes numbered US–77291 through US–77317. The published database contains 2 drill holes from this source publication.
U.S. Geological Survey and the Montana Bureau of Mines and Geology, 1980, Coal drilling during 1978 in Big Horn, Daniels, Dawson, Musselshell, Richland, Roosevelt, Rosebud, Valley, and Yellowstone Counties, Montana: U.S. Geological Survey Open-File Report 80–267, 273 p.	Lithology logs and geophysical logs for holes numbered US–781 through US–78196. The published database contains 12 drill holes from this source publication.
U.S. Geological Survey and Montana Bureau of Mines and Geology, 1981, Coal drilling during 1979 in Williams County, North Dakota, and in Beaverhead, Big Horn, Dawson, Fallon, Garfield, McCone, Musselshell, Powder River, Prairie, Roosevelt, Rosebud, and Wibaux Counties, Montana: U.S. Geological Survey Open-File Report 81–314, 615 p.	Lithology logs and geophysical logs for holes numbered US–791 through US–79235. Only holes US–798 through US–7966 are within the Powder River Basin. The published database contains 57 drill holes from this source publication.
U.S. Geological Survey and the Montana Bureau of Mines and Geology, 1981, Coal drilling during 1980 in Big Horn, Dawson, McCone, Powder River, Prairie, Richland, Rosebud, and Treasure Counties, Montana: U.S. Geological Survey Open-File Report 82–26, 258 p.	Geophysical logs for holes numbered US–80001 through US–80128. The published database contains 58 drill holes from this source publication.
Wyoming Oil and Gas Conservation Commission *http://wogcc.state.wy.us/*.	Web site contains scanned logs of all Oil and Gas and Coalbed Methane wells in Wyoming along with location information for all wells. The published database contains 16,716 drill holes downloaded from this source.

Table 5. List of the contents of the stratigraphy table PRIME_LITH and LITH_MOD fields and the number of occurrences of each combination.

Number of occurrences	Primary lithology	Lithology modifier
2	Chert	
10,972	Claystone	
12	Claystone	Bentonite
12	Claystone	Calcareous
116	Claystone	Carb/coaly
53	Claystone	Carb/silty
2,544	Claystone	Carbonaceous
189	Claystone	Coaly
50	Claystone	Root
1,442	Claystone	Sandy
15	Claystone	Shaley
475	Claystone	Silty
30	Claystone	Silty/carb
6	Claystone	Silty/sandy
122	Clinker	
130,478	Coal	
15	Coal	Boney
792	Coal	Cbm perf
3	Coal	Clayey
19,890	Coal	High ash
187	Coal	Mod ash
607	Coal	Shaley
106	Conglomerate	
153	Interbedded	
2	Ironstone	
253	Limestone	
16	Limestone	Shaley
4,229	Mudstone	
6	Mudstone	Bentonite
172	Mudstone	Carbonaceous
38	Mudstone	Coaly
157	Mudstone	Sandy
45	Mudstone	Silty
2	Mudstone	Silty/carb
6,469	No log	
25,319	Not recorded	

Table 5. List of the contents of the stratigraphy table PRIME_LITH and LITH_MOD fields and the number of occurrences of each combination.—Continued.

Number of occurrences	Primary lithology	Lithology modifier
2	Pyrite	
118,649	Rock	
6	Sand	
13,126	Sandstone	
340	Sandstone	Calcareous
272	Sandstone	Carbonaceous
239	Sandstone	Clayey
6	Sandstone	Coaly
2	Sandstone	Conglomeritic
2	Sandstone	Cross bedded
2	Sandstone	Fossiliferous
12	Sandstone	Muddy
72	Sandstone	Shaley
728	Sandstone	Silty
3,614	Shale	
7	Shale	Bentonite
4	Shale	Calcareous
92	Shale	Carb/coaley
4	Shale	Carb/silty
2,837	Shale	Carbonaceous
87	Shale	Coaly
318	Shale	Sandy
5,276	Siltstone	
6	Siltstone	Burrowed
48	Siltstone	Calcareous
544	Siltstone	Carbonaceous
200	Siltstone	Clayey
15	Siltstone	Muddy
6	Siltstone	Root
406	Siltstone	Sandy
176	Siltstone	Shaley
121	Soil	
3	Surface gravel	
282	Surface material	

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