# COALBED METHANE IN WYOMING

by

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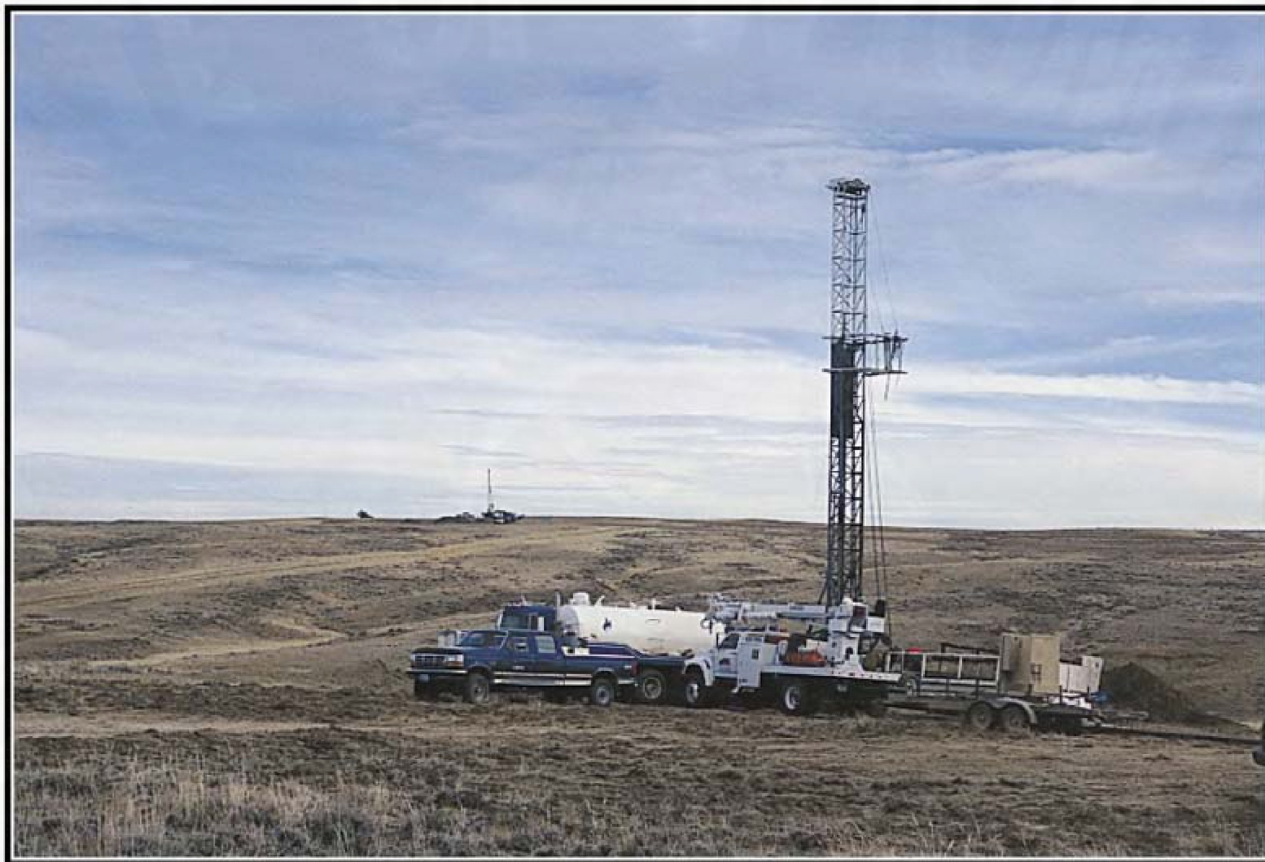

**WYOMING STATE GEOLOGICAL SURVEY**
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## *What is coalbed methane?*

Coalbed methane is natural gas or methane ($CH_4$) that occurs in coal beds and has been generated during the conversion of plant material to coal (the process known as coalification). Gas produced from low rank subbituminous coal in the Powder River Coal Field, Wyoming, is composed almost entirely of methane, with a minor amount (1.5 to 2%) of carbon dioxide ($CO_2$). Coalbed methane produced in other areas of the U.S. from higher rank bituminous coal may contain minor amounts (less than 3% each) of $CO_2$ and nitrogen ($N_2$), very minor to trace amounts of higher hydrocarbons (ethane, propane, butane, etc.), and sometimes a trace of hydrogen sulfide ($H_2S$) (Rightmire, 1984).

Methane produced from a typical coalbed methane well has a heating value of about 1000±25 British Thermal Units (Btus) per standard cubic foot. One million Btus (the energy equivalent of 1000 cubic feet of methane or one MCF) approximate the energy consumed by a person in the U.S. in about 1.2 days. A million Btus of fossil fuel can generate about 100 kilowatt-hours of electricity at an electric utility.

## *How does coalbed methane form?*

During coalification, plant material that accumulated and was preserved in ancient swamps and bogs at rates fast enough to prevent decay (oxidation) begins to compact upon burial. The material is first converted to peat as much of the water in the original material is expelled. Through time and as the temperature increases with further burial, ever-increasing ranks of coal form, starting with lignite, followed by subbituminous coal and bituminous coal. If the heat (and pressure) is great enough, anthracite (the highest rank of coal) forms.

At these different stages of coalification, various hydrocarbons (called volatile matter, including methane), along with carbon dioxide, nitrogen, and water, are released. Increased temperatures throughout burial drive off volatile matter. *Biogenic methane* (that attributed to bacterial activity) is first to form. When the temperature exceeds that in which bacteria can live, *thermogenic methane* (that attributed to heating) forms.

The coalification process can stop at any time, depending on geologic conditions, leaving what we see today as varying ranks of coal. Much of the methane generated by the coalification process escapes to the surface or migrates into adjacent reservoir or other rocks, but a portion is trapped within the coal itself, primarily adsorbed on or absorbed within micropores of the coal.

## *What are the two types of coalbed methane?*

During the early stages of coalification, biogenic methane is generated as a by-product of bacterial respiration. *Aerobic bacteria* (those that use oxygen in respiration) first metabolize any free oxygen left in the plant remains and surrounding sediments. In fresh water environments, methane production begins immediately after the oxygen is depleted (Rice and Claypool, 1981). Species of *anaerobic bacteria* (those that don't use oxygen) then reduce carbon dioxide and produce methane through anaerobic respiration (Rice and Claypool, 1981).

When a coal's temperature underground reaches about 122°F (*Figure 1*), and after a sufficient amount of time, most of the biogenic methane has been generated, about two-thirds of the original moisture has been expelled, and the coal attains an approximate rank of subbituminous (Rightmire, 1984). As the temperature increases above 122°F through increased

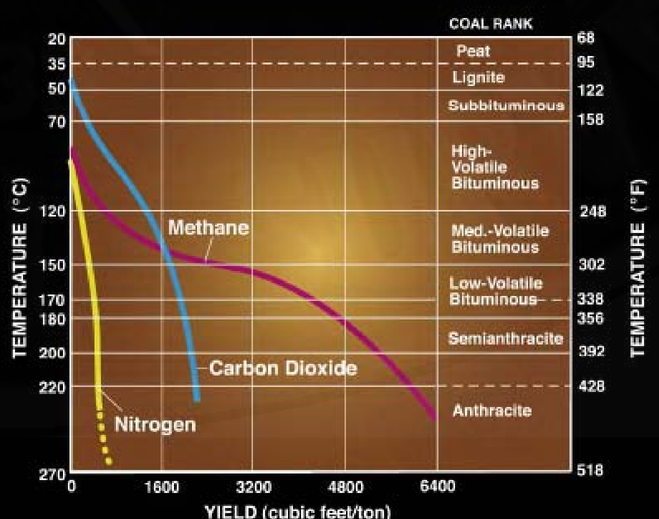



*Figure 1. Calculated curves of gases generated by thermogenesis from coal during coalification. Modified from Rightmire, 1984.*

burial or increased geothermal gradient, thermogenic processes begin and additional water, carbon dioxide, and nitrogen are generated as coalification proceeds to approximately the rank of high volatile bituminous (Rightmire, 1984). Maximum generation of carbon dioxide, with little methane generation occurs at about 210°F. Generation of thermogenic methane begins in the higher ranks of the high volatile bituminous coals, and at about 250°F, generation of methane exceeds generation of carbon dioxide. Maximum generation of methane from coal occurs at about 300°F. With even higher temperatures and higher rank coals, methane is still generated, but at somewhat lower volumes (Rightmire, 1984).

## *How does coalbed methane occur in the coal?*

Because coal beds serve as both the source rocks and the reservoir rocks, gas storage in coal beds is more complex than in most conventional reservoirs (e.g., carbonate and sandstone). Although coalbed methane can (and does) migrate to non-coal reservoir rocks, once the gas leaves the coal beds it is no longer considered coalbed methane. Coalbed methane reservoirs contain unique properties for gas storage that are not present in other reservoirs.

According to Yee and others (1993), coalbed methane can be stored in four ways: 1) as free gas within the *micropores* (pores with a diameter of less than .0025 inch) and *cleats* (sets of natural fractures in the coal); 2) as dissolved gas in water within the coal; 3) as adsorbed gas held by molecular attraction on surfaces of *macerals* (organic constituents that comprise the coal mass), micropores, and cleats in the coal; and 4) as absorbed gas within the molecular structure of the coal molecules.

The amount of methane present within a particular volume of coal can be very large. Coals at shallower depths with good cleat development contain significant amounts of free and dissolved gas while the percentage of adsorbed methane generally increases with increasing pressure (depth) and coal rank. For example, bituminous coals with high gas contents or yields, expressed as standard cubic feet of gas per short ton of coal (SCF/ton) contain as high as 500 SCF/ton. Low-yield subbituminous coals found in Wyoming that produce coalbed methane range from about 20 to 90 SCF/ton.

## *What types of coal and coalbed methane occur in Wyoming?*

Bituminous and subbituminous coal beds occur in all 10 coal fields of the state (*Figure 2*); these coal beds contain both biogenic and thermogenic coalbed methane. Wyoming's coal beds are Cretaceous and Tertiary in age and occur in a variety of structural and stratigraphic settings (Jones, 1990, 1991). [Much of the following discussion on Wyoming coal fields is extracted from Glass (1997). That report contains an excellent list of references for Wyoming coal quality, reserves, and coal bed descriptions.]

Cretaceous coals may attain the rank of high volatile A bituminous, but many Cretaceous coals are lower in rank and have not attained enough thermal maturity to have generated large amounts of thermogenic coalbed methane. However, some of these lower rank Cretaceous coals may contain biogenic coalbed methane. Deeply buried Cretaceous coals in the Bighorn, Wind River, and Green River coal fields have probably reached ranks that correspond to significant thermogenic methane generation.

Tertiary coal beds in Wyoming are generally lignite to subbituminous in rank. Some coals may be high volatile bituminous in rank where they have been deeply buried and have reached sufficient maturity for thermal generation of methane. These coal beds are located in the deeper parts of the Wind River, Bighorn, Hanna, and Green River coal fields. Less thermally mature Tertiary coal beds in the Wasatch and Fort Union formations of the Powder River Coal Field contain biogenic coalbed methane. Several individual Tertiary coal beds are 100 feet (or more) thick and contain large amounts of coalbed methane, even though the gas yield per ton of coal is relatively low.

## *Where is coalbed methane found in Wyoming?*

Methane associated with coal beds has been observed in nearly all the coal-bearing areas in Wyoming (*Figure 3*). Evidence for its occurrence includes direct measurements in wells and coal cores, surface venting of gas, gas-related explosions and fires in underground coal mines, inferences from the rank of coal, and thermal histories of coal fields (*Table 1*).

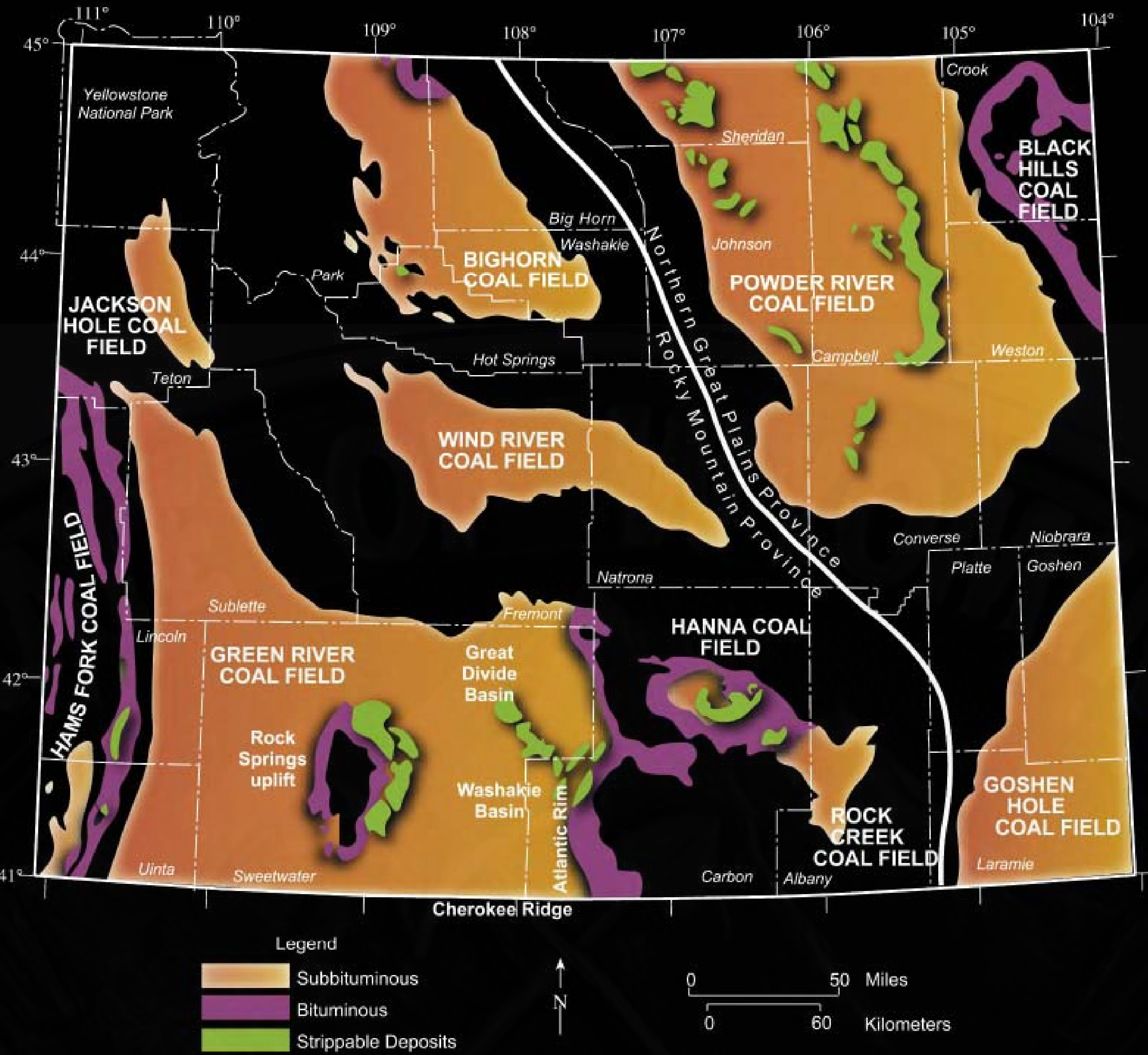



*Figure 2. Coal fields and rank of coal in Wyoming. Modified from Glass, 1997.*

Although coalbed methane exists in all coal regions of Wyoming, some of the state's coal deposits are shallow and too thermally immature to have generated substantial amounts of thermogenic gas. However, many of these shallow coals do have biogenic methane entrapped in them. The most significant quantity of biogenic methane in Wyoming exists in the relatively shallow, thick coal beds in the Powder River Coal Field. While methane content of coal beds is relatively low in this coal field, a number of thick, Tertiary coal beds (with large coal tonnages) account for the accumulation of large quantities of biogenic coalbed methane. In contrast, Cretaceous and some Tertiary coal beds deeply buried in many Wyoming basins are much more thermally mature and no doubt have generated and do contain large volumes of thermogenic gas.

## *Where are the best areas in Wyoming to look for coalbed methane?*

Exploration targets for coalbed methane can be defined by, but not limited to, the following criteria:

- known, thick, abundant, and laterally continuous coal beds;
- coal-bearing areas with coals of appropriate rank;
- adequate conditions for accumulation and preservation of coalbed methane (i.e., a favorable reservoir);
- depth to the coal bed, which influences economic and mechanical limits on development; and

*Table 1. Summary of historical evidence (direct and indirect) for coalbed methane occurrences. Numbers are those shown on Figure 3. Modified and adapted from Jones and De Bruin (1990) and De Bruin and Lyman (1999). See those papers for references to specific occurrences.*

| No. on Figure 3 | Evidence | Coal Field[2] | Formation or Group |
|---|---|---|---|
| 1 | Coal exploration well – blew out | WR | Frontier Formation |
| 2 | Underground coal mine – methane reported | WR | Mesaverde Formation |
| 3 | Desorption of coal cores – no desorbed gas | WR | Mesaverde Formation |
| 4 | Desorption of coal cores – no desorbed gas | WR | Mesaverde Formation |
| 5 | Desorption of coal cores – no desorbed gas | WR | Mesaverde Formation |
| 6 | Underground coal mines – explosions | HF | Frontier Formation |
| 7 | Underground coal mines – explosions | HF | Evanston Formation |
| 8 | Desorption of coal cores – 434 to 539 $ft_3$/ton | GR | Mesaverde Formation |
| 9 | Underground mines – closed due to gas build-up | HF | Frontier Formation |
| 10 | Coal exploration wells – encountered methane | GR | Wasatch Formation |
| 11 | Coal exploration wells – encountered methane | GR | Almond Formation |
| 12 | Coal exploration wells – encountered methane | GR | Almond Formation |
| 13 | Coal exploration wells – encountered methane | GR | Wasatch Formation |
| 14 | Coal exploration well – encountered methane | GR | Wasatch Formation |
| 15 | Coal exploration well – encountered methane | GR | Wasatch Formation |
| 16 | Coal exploration well – encountered methane | GR | Wasatch Formation |
| 17 | Underground coal mine – encountered methane | GR | Mesaverde Group |
| 18 | Oil and gas tests – "gas kicks" on mud logs | H | Ferris Formation |
| 19 | Underground coal mines – methane detected | H | Hanna Formation |
| 20 | Underground coal mines – explosions | H | Hanna Formation |
| 21 | Underground coal mines – explosions | H | Hanna Formation |
| 22 | Water well – methane used at ranch | PR | Fort Union Formation |
| 23 | Oil and gas tests – Ips of 0.5-2.6 MMCF/day[1] | PR | Fort Union Formation |
| 24 | Coal exploration wells – methane encountered | PR | Fort Union Formation |
| 25 | Coal exploration well – blew out | PR | Fort Union Formation |
| 26 | Water well – methane from analysis | PR | Fort Union Formation |
| 27 | Water wells – methane from analyses | PR | Fort Union Formation |
| 28 | Water well – methane from analysis | PR | Fort Union Formation |
| 29 | Gas wells – from sandstones adjacent to coal | PR | Fort Union Formation |

[1] IP = Initial potential; MMCF/day = million cubic feet per day.

[2] Abbreviations for coal fields: WR = Wind River, GR = Green River, H = Hanna, HF = Hams Fork, PR = Powder River.

- other evidence such as degree and location of fracturing (cleats) and faulting, geothermal gradient, high pressure or overpressured areas in the subsurface, and the presence of gas fields producing from known coal-bearing rocks.

Jones and De Bruin's (1990) map of exploration targets in Wyoming (*Figure 3*) is still valid. These targets were based on the first four criteria (above) plus identified occurrences of coalbed methane, data available from coalbed methane tests, and production of coalbed methane.

McCord (1980) considered coal beds less than 5000 feet deep to be the primary targets for initial exploration in the Green River Coal Field; this depth limit has been applied to other Wyoming coal fields as well. Visco-elastic properties of coal beds at depth may inhibit effective production of methane directly from coal beds. The shallow coal beds in the Powder River Coal Field are well above this depth limit.

Exploration targets in the Hams Fork Coal Field and the extreme western Green River Coal Field are those described by McCord (1980) for coal beds in the

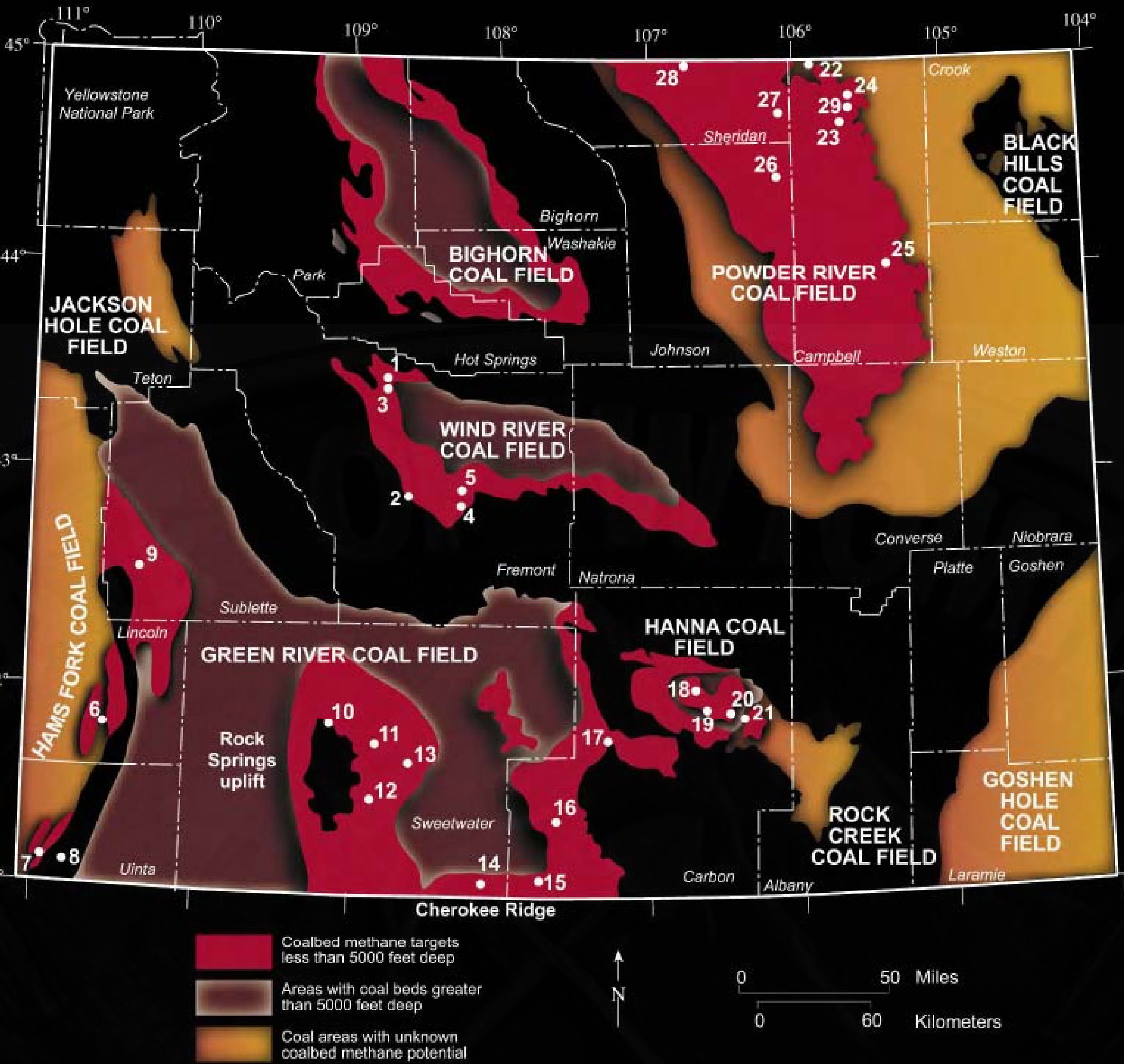



***Figure 3. Historical occurrences and exploration targets for coalbed methane in Wyoming. Modified and updated from Jones and De Bruin, 1990. Numbers are those listed on Table 1.***

Frontier, Adaville, and Mesaverde formations under less than 5000 feet of overburden. An additional target area is the Almy area near Evanston, Wyoming, where coal beds in the Evanston Formation may contain coalbed methane. Data are inadequate to define any additional exploration targets and therefore the potential for coalbed methane in the remainder of the coal field is unknown.

Cretaceous and Tertiary coal beds that crop out around the Rock Springs uplift are considered exploration targets to a depth of 5000 feet (McCord, 1980). Several areas that contain shallow, thick, subbituminous Tertiary coal beds in the eastern and southeastern parts of the Green River Coal Field may be exploration targets for biogenic coalbed methane. Coalbed methane targets are also located in the Almond Formation to depths of 5000 feet in the eastern Green River Coal Field and along Cherokee Ridge in the southeastern part of that coal field. The remainder of the Green River Coal Field may contain deep coal beds that have high enough rank to generate significant amounts of coalbed methane. A large part of this gas may have migrated to conventional Cretaceous reservoirs in this coal field.

Exploration targets for coalbed methane in the Wind River and Bighorn coal fields are defined primarily by coal beds in the Mesaverde Formation under less than 5000 feet of cover. Steeply-dipping

Lance and Meeteetse coal beds in the Waltman area of the Wind River Coal Field may present additional targets for coalbed methane development.

In the Hanna Coal Field, coalbed methane targets occur in the upper part of the Mesaverde Group and in the lower part of the Medicine Bow Formation to depths of 5000 feet. This target area is restricted to the western half of the coal field and is controlled primarily by the structure of the basin. In the interior of this coal field, coalbed methane targets occur in numerous coal beds of the Ferris and Hanna formations. Both biogenic and thermogenic methane probably exist in this coal field.

The Powder River Coal Field contains a large resource of biogenic coalbed methane associated with numerous relatively shallow (less than 3000 feet deep), thick, laterally continuous, Tertiary coal beds (*Figure 4*). The primary targets are confined to coal beds of the Tongue River Member of the Fort Union Formation and the Wasatch Formation. The eastern edge of the target area is defined as the outcrop or subcrop (behind the oxidized or "burned" coal)

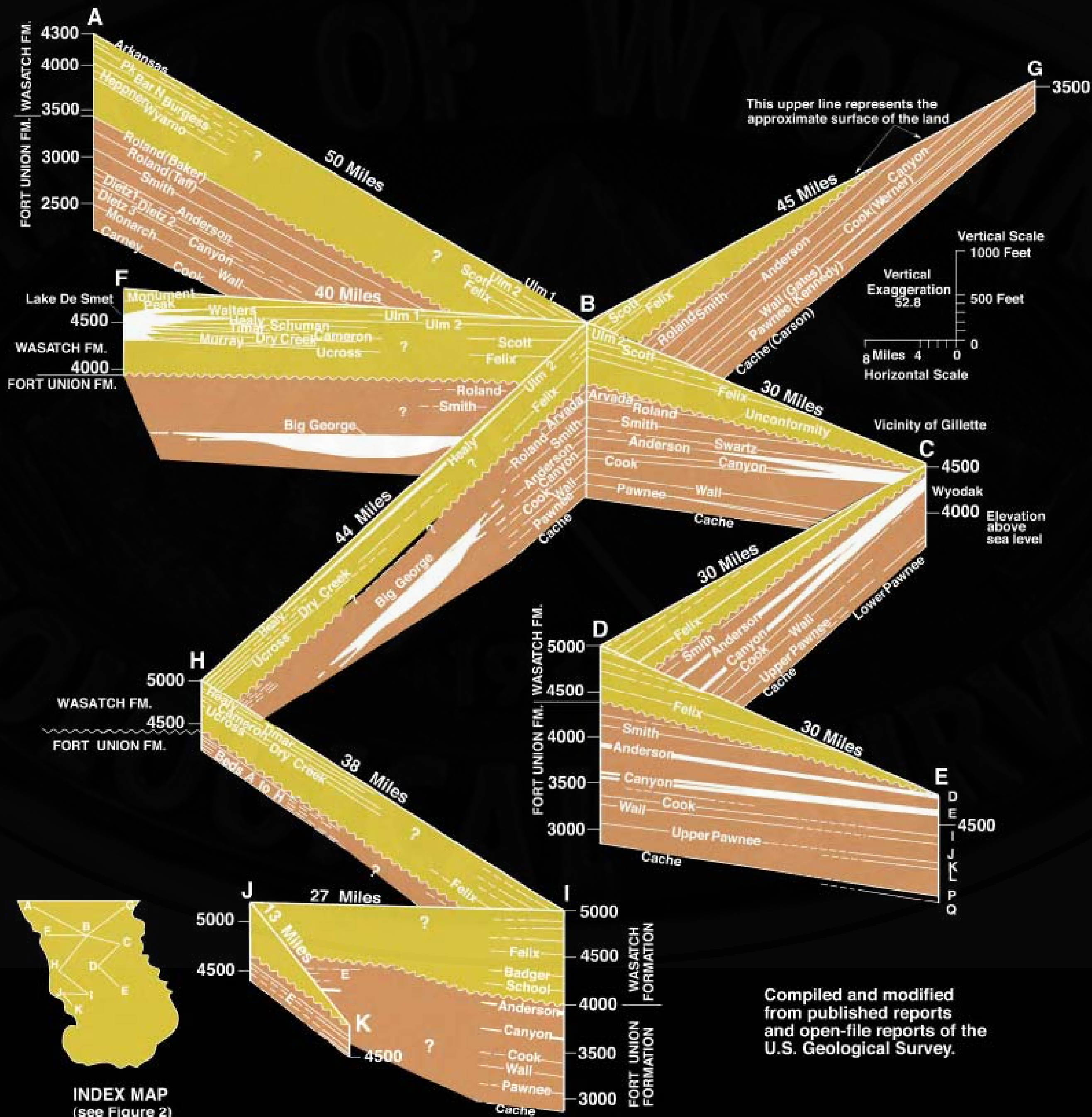



*Figure 4. Correlation diagram showing the main coal beds in the Powder River Coal Field. Modified from Glass, 1997.*

of the Wyodak and equivalent coal beds (*Figure 5*). The western edge of the target area is defined by the inferred subsurface extent of the "Big George" coal bed and/or the inferred subsurface extent of the Wyodak coal bed and its equivalents (*Figures 4 and 5*). Additional biogenic coalbed methane may be present in some of the thicker Wasatch Formation coal beds in the Buffalo and Sheridan areas (*Figures 4 and 5*), northwestern Powder River Coal Field, Wyoming.

## *How long have we known about coalbed methane?*

Occurrences of coalbed methane, either biogenically derived from shallow, lower rank coal beds or thermogenically derived from more deeply buried, higher rank coal beds, have been documented in many Wyoming coal areas (Jones and De Bruin, 1990). Coalbed methane has been observed in water wells in the Powder River Coal Field since the 1950s (Olive, 1957) and some of the historical ranches that have used coal beds for water sources have encountered coalbed methane since 1916 (Jones and De Bruin, 1990).

## *Why hasn't coalbed methane been produced before?*

Coals containing thermogenic coalbed methane in Wyoming are analogous to coals being produced in the San Juan Basin, New Mexico and the Black Warrior Basin, Alabama. The Wyoming coal beds are poorly documented and mostly unexplored. Before the current high level of activity, it appeared that many Wyoming coals were either too deep or not of sufficient thickness to be economically viable at the time.

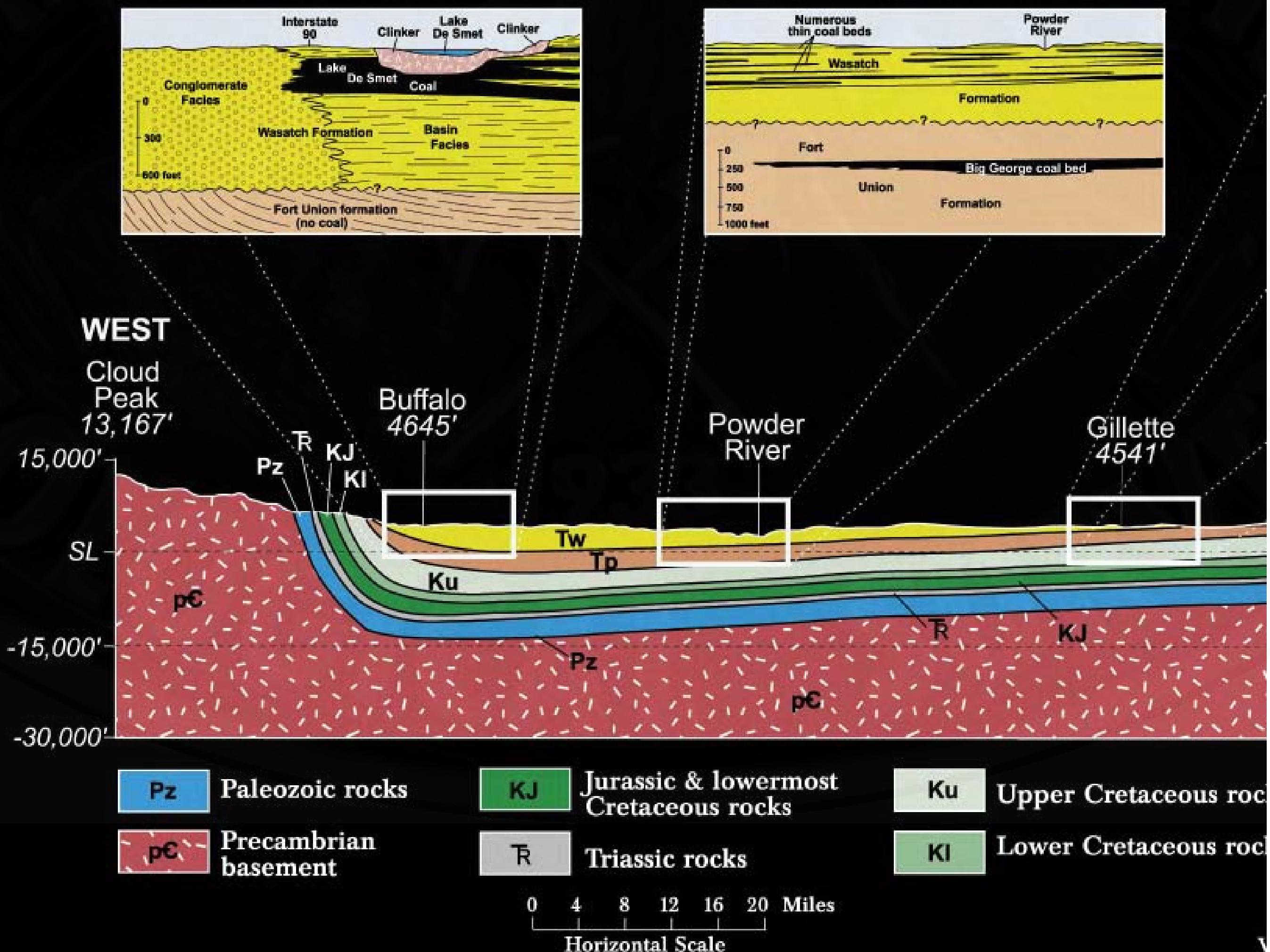



*Figure 5. Generalized east-west cross section across the Powder River Basin, Wyoming with enlargen eastern parts of the Powder River Coal Field. Base map and surface geology from Christiansen, 1991.*

Although Wyoming coal fields contain large coal resources in numerous thick beds, the shallow depths and immature (low rank) coals were once considered too low in gas content to be economically produced using conventional coalbed methane production methods. These methods had worked well in higher rank, higher yield coals (those with higher gas contents, e.g., on the order of 350 cubic feet of gas per ton of coal) but met with no success in the Powder River Coal Field (Shirley, 2000).

One of the main reasons for the acceleration in the number of wells and corresponding production in the Powder River Coal Field was the development of a new production technique in which wells are completed open hole (see section on production below).

Renewed interest in coalbed methane has expanded to most of the other Wyoming coal fields. This interest is mainly spillover from success in the Powder River Coal Field but also from increased exploration for more conventional (thermogenic) coalbed methane targets. For example, in the Atlantic Rim area on the southeastern flank of the Green River Coal Field, several pilot projects are assessing the economic potential of Mesaverde coal beds at depths approaching 2000 feet. There are currently 14 producing wells in this area with several companies completing additional wells. Larger rigs than those used in the Powder River Coal Field are required to drill these coalbed methane wells (*Figure 6*).

## *How is coalbed methane produced?*

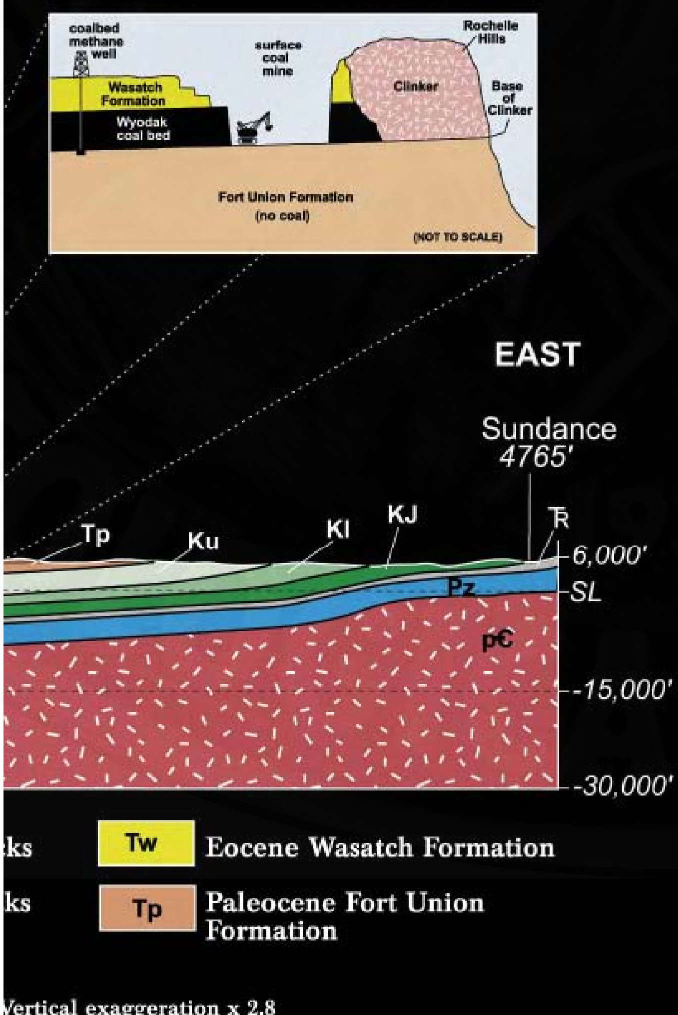
In the Powder River Coal Field, coalbed methane wells are completed open hole. Using this method, casing is set to the top of the target coal bed and the underlying target zone is under-reamed and cleaned out with a fresh-water flush. A downhole submersible pump produces water up the tubing; gas separates from the water and is produced up the annulus (*Figure 7*).

Natural gas and water produced at individual wells (*Figures 8 and 9*) are piped to a metering facility (*Figure 10*), where the amount of production from each well is recorded. The methane then flows

*Figure 6. Coalbed methane drilling rig on location, eastern Washakie Basin. Exploration is for coal beds in the Almond Formation, Mesaverde Group (Upper Cretaceous).*

to a compressor station (*Figure 11*), where the gas is compressed and then shipped via pipeline. The water goes to a central discharge point at a drainage or impoundment. Some produced water in the southeastern Green River Coal Field is now being reinjected into nearby aquifers (*Figure 12*).

In general, coalbed methane wells go through three stages during their production cycle (*Figure 13*). During the dewatering stage, the amount of water produced initially exceeds that of gas, but with continued production, the volume of water continues to decrease as the volume of methane increases. A stable production stage is reached when maximum methane is produced and water production becomes stable. During the decline stage, the amount of methane produced continues to decline until it becomes uneconomic to continue production.




nents of specific areas on the western, central, and

## *What is the current level of coalbed methane activity in Wyoming?*

In 2003, monthly production of coalbed methane in Wyoming averaged 29.0 billion cubic feet (BCF), with a total of 348.2 BCF produced for the year. This is almost 19% of the 1.83 trillion cubic feet of natural gas production from Wyoming in 2003. The coalbed methane production in 2003 came from over 12,000 producing wells, with another 4000 wells waiting to come on line. Wells in the Powder River Coal Field (*Figure 14*) accounted for all but 2.2 BCF of production (from 59 coalbed methane wells in the rest of the state).

Interest in coalbed methane is expanding to other Wyoming coal fields. In 2003, most activity appeared to be on the east flank of the Washakie Basin, southeastern Green River Coal Field (*Figure 2*). Several companies are exploring the Mesaverde Group for thermogenic coalbed methane in this area and several companies have placed wells into production. An Environmental Impact Statement (EIS) for the area will analyze the effects of a planned 1800 wells.

Two companies are showing interest in the Mesaverde and Tertiary coals in the Great Divide Basin. According to Cook and others (2002), Yates Petroleum has mapped fairly thick Tertiary (Fort Union Formation) coal beds in the north central Green River Coal Field (*Figure 15*).

Exploration is occurring for coalbed methane in Tertiary coal beds in the central part of the Hanna Coal Field and in Upper Cretaceous coal beds in the western part of the field. There are presently eight wells producing from depths around 5000 feet in the Mesaverde Group in the western Hanna Coal Field. Dewatering efforts are presently inconclusive. An EIS will analyze the effects of 1240 wells planned for this area.

Tertiary coal beds were explored for coalbed methane near Evanston in the Hams Fork Coal Field and Upper Cretaceous coal beds are being explored in the extreme western part of the Green River Coal Field. The latter activity is centered on Mesaverde Formation coal beds in the Riley Ridge area about 17 miles west of Big Piney in Sublette County. The coal beds near Evanston apparently never produced

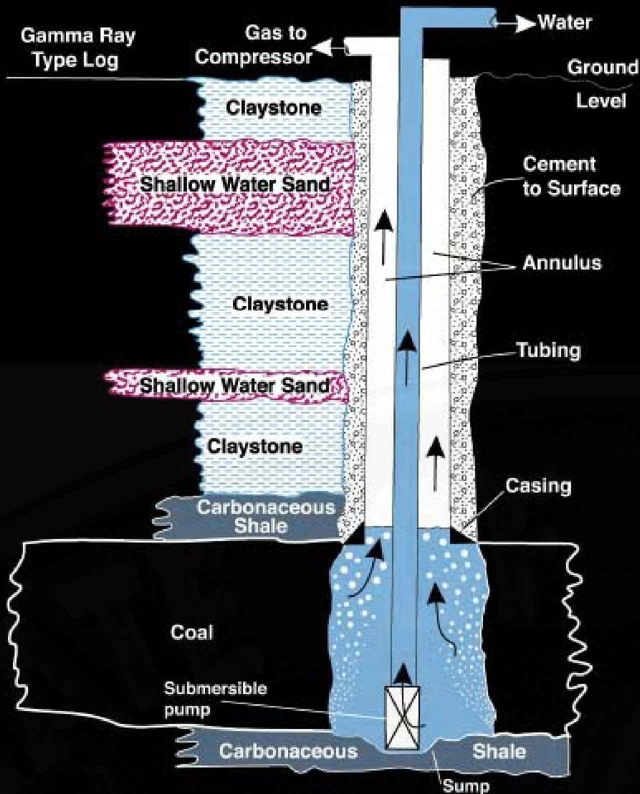



*Figure 7. Schematic diagram showing open-hole completion technique for a typical coalbed methane well. Modified from diagram furnished by the Wyoming State Engineer's Office.*

much gas and the company exploiting the coal beds in the Riley Ridge area recently declared the project uneconomic.

Two coalbed methane wells have been completed in the Mesaverde coal beds in Beaver Creek Field of the Wind River Coal Field. Another company has expressed an interest in the Mesaverde coal beds around Hudson.

After five years, production of coalbed methane from other coal fields in Wyoming is ahead of production for the first five years in the Powder River Coal Field. This production is from only half as many wells (*Table 2*). Only time will tell if this trend will continue.

## *Can Wyoming deliver coalbed methane to its markets?*

Until recently, natural gas production from the Powder River Basin (PRB) (which includes reservoirs older than, and outside of the coal field) was mainly associated with oil. When the coalbed methane play in the basin began accelerating in 1997, it became obvious that additional facilities such as gas pipelines and compressor stations were needed. As methane production from coal beds increased, companies began laying pipelines and converting some crude oil pipelines to carry gas.

Three major pipelines were laid in the basin in 1999 and 2000: Bighorn Gas Gathering, Fort Union, and Thunder Creek. The Medicine Bow Lateral was also constructed from Douglas to south of Cheyenne for transporting the coalbed methane to major pipelines that take gas to out-of-state markets.

Bighorn Gas Gathering recently completed and placed in service a 56-mile, 20-inch diameter extension of its gas gathering system in Sheridan County. This extension of Bighorn's existing 100-mile natural gas gathering system will help to serve the needs of coalbed methane producers.

Fort Union Gas Gathering boosted the capacity of its gas pipeline from Gillette to Glenrock by 45% in 2001. The expansion included a 20-inch diameter pipeline next to Fort Union's existing 24-inch, 106-mile pipeline. The new pipeline increased gathering capacity from 434 million cubic feet (MMCF) of gas per day to 634 MMCF of gas per day.

*Figure 8. Typical coalbed methane wellhead in the Powder River Coal Field with water and gas lines installed and a control box (red) in place. Photograph from Wyoming Coalbed Methane Clearinghouse web site, 2004.*

*Figure 9. A single coalbed methane well south of Gillette. As shown here, the surface equipment for many producing wells is enclosed in a small fiberglass or aluminum shell; other wells contain no structures and are simply wellheads enclosed by a fence.*

Medicine Bow Lateral has increased its capacity by looping its new line that carries gas from the southern PRB to south of Cheyenne. Looping a pipeline increases its capacity by constructing a parallel line to an existing pipeline and adding pumping capacity.

Grasslands Pipeline, owned by Williston Basin Interstate Pipeline was finished in late 2003. The pipeline began transporting 80 MMCF of coalbed methane per day from the northern PRB to the Northern Border Pipeline in North Dakota. The pipeline's capacity can be expanded with additional compression to handle up to 200 MMCF per day.

As of early 2004, over 0.9 BCF of coalbed methane per day is being transported out of the Powder River Coal Field. As production increases, new pipelines need to be built so that additional gas can reach markets. In the future, it may be necessary to limit coalbed methane production until these pipelines are completed.

In southern Wyoming, much of the additional interstate pipeline capacity that will be required for increased coalbed methane production already exists along the pipeline corridor that parallels the interstate highway (I-80) and the Union Pacific Railroad (*Figure 16*). Gathering systems in the newly developed coalbed methane areas will have to be constructed, compressor stations will be necessary (*Figure 17*), and feeder lines will be needed to transport coalbed methane north and south to meet pipelines along the southern Wyoming corridor.

## *How much coalbed methane is there?*

The amount of coalbed methane present in Wyoming coals depends upon the tonnage of coal and the amount of gas present in each ton of coal (gas content). After the total gas in place is estimated, recoverable resources are estimated based on geologic and economic factors. Total recoverable gas resources from coal beds in all Wyoming coal fields (*Table 3*) are now estimated at 31.7 trillion cubic feet (TCF). Compare this to 16.7 TCF estimated in the 2000 version of this pamphlet. This new estimate especially reflects the recent drilling activity in the Powder River Coal Field and the new data on both coal in place and the gas yields of the coals at various depths. To date (end of 2003), 1.2 TCF of coalbed methane has been produced in the Powder

*Table 2. Actual production and number of coalbed methane wells in the Powder River Coal Field (1989 through 2003) and other coal fields in Wyoming (1999 through 2003).*

| Year | Production (MCF) | Producing wells |
|---|---|---|
| Powder River Coal Field | | |
| 1989 | 987,792 | 22 |
| 1990 | 1,097,392 | 32 |
| 1991 | 966,239 | 48 |
| 1992 | 783,151 | 47 |
| 1993 | 1,101,700 | 113 |
| 1994 | 2,420,529 | 118 |
| 1995 | 4,769,933 | 158 |
| 1996 | 8,567,705 | 178 |
| 1997 | 14,048,488 | 360 |
| 1998 | 30,662,752 | 651 |
| 1999 | 58,188,993 | 1683 |
| 2000 | 150,760,808 | 4506 |
| 2001 | 255,731,538 | 8198 |
| 2002 | 327,059,468 | 10,728 |
| 2003 | 345,997,686 | 12,137 |
| Other Wyoming coal fields | | |
| 1999 | 83 | 2 |
| 2000 | 10,499 | 18 |
| 2001 | 76,312 | 19 |
| 2002 | 498,098 | 31 |
| 2003 | 2,176,744 | 59 |

River Coal Field and proved reserves in this field have reached nearly 2.4 TCF.

Gas contents of coal beds appear to be closely related to depth (and resultant pressure). Finley and Goolsby (2000) based their new resource estimates on a weighted average of 65 SCF/ton. This average included gas contents of 20 SCF/ton for coal beds between 200 and 500 feet deep, 45 SCF/ton for coal beds between 500 and 1000 feet, 70 SCF/ton for coal beds between 1000 and 1500 feet, and 90 SCF/ton for coal beds over 1500 feet deep. Coal beds less than 200 feet deep were not considered in their estimate because of the low gas content.

The new estimates of gas resources in this coal field are about 2.5 times greater than the earlier estimates (*Table 3*). The Powder River Coal Field accounts for nearly 80% of the state's total resources of coalbed methane. Recent results indicate that a higher recovery factor for coalbed methane in the Powder River Basin may raise that basin's recoverable gas resources above the 25.179 TCF shown on *Table 3*. From these comparisons, it is obvious that coalbed methane will be an important resource in Wyoming for many years.

## *How long can a coalbed methane well produce?*

The life of a coalbed methane well depends on the distance from its neighboring wells (spacing of the well field), how wells communicate with each other in the subsurface, and the amount of gas available to each well. These and other factors for Wyoming low rank coals are not entirely understood and are still being studied. Most of the producers in the Powder River Coal Field expect that a coalbed methane well can produce for as long as 10 years. As a coal bed in the original production zone is drained of its methane, the well often can be reworked to produce gas from lower coal beds. Depending on the situation, multiple coal beds could extend the life of a well site by 10 to 30 years. For thermogenic coalbed methane in Upper Cretaceous, higher rank coals in southern and central Wyoming, the production life of wells is somewhat longer, probably 12 to 15 years. This is based on similarities to coalbed methane being produced in the San Juan Basin from coal beds of similar age, origin, and thickness.

## *How much coalbed methane can be produced?*

Usually after several months of dewatering, coal beds in the Powder River Coal Field reach an average production rate of about 80 thousand cubic feet (or 80 MCF) of gas per day and 120 barrels (42 gallons per barrel) of water per day. Conservative estimates place the total amount of coalbed methane available per well at 400 MMCF. Wells in deeper, thicker coals may deliver more than this per well, while wells in shallower, thinner coals may produce less than this. Current production cycles have not continued long enough to construct adequate decline curves. In the newly developing southern and central Wyoming coalbed methane areas, even less is known about production cycles and decline curves, but the daily production rates and yields per well are expected to be substantially higher than those reported in northeastern Wyoming.

## *How thick should a coal bed be for a viable coalbed methane target?*

The coal thickness required for coalbed methane depends on the gas content which is related to the rank, thermal maturation, price of natural gas, and depth of the coal. Higher rank coals 10 feet thick have been exploited, but usually the target coals must be at least 20 feet thick. In the Powder River Coal Field, where the gas content per ton of coal is low, some wells produce from 30-foot-thick coals; most exploration targets are aimed at coals at least 40 feet thick. This extra thickness beyond 30 feet

***Figure 10. Coalbed methane facility, which houses equipment that measures production from a number of coalbed methane wells.***

*Figure 11. Compressor station where coalbed methane is compressed before transport through a pipeline.*

may be necessary to ensure economical operation of the coalbed methane well. Of course, natural gas prices help to determine the thickness required for a coal to be exploited. As prices rise, thinner coals may be targets and as prices fall, thicker coals may be needed for a producer to realize a profit. The difference in gas contents of biogenic versus thermogenic coals can be substantial, making much thinner and deeper coals in other parts of Wyoming economic to develop, whereas they would not be profitable in the Powder River Coal Field.

## Who owns the coalbed methane?

Both the land surface (surface estate) and the resources below the surface (mineral estate) can be owned and are considered property. The mineral estate can be owned in total (all minerals) or can be owned by specific mineral commodity (e.g., oil and gas estate, coal estate). Coalbed methane is considered natural gas and is part of the oil and gas estate.

Where one party owns both the surface and mineral estates, the land is said to be owned in fee simple. Homesteaders in Wyoming had the option of acquiring both estates, although many chose only to claim the surface estate (reserving the mineral estate to the federal government). To help finance construction of the transcontinental railroad, to give the builders of the railroad some financial incentives, and to assist in opening the developing nation to rail transportation, almost half of the mineral and surface estate was given to the railroads in select areas of Wyoming. In southern Wyoming, this area is called the Union Pacific land grant, and it includes a 20-mile-wide strip of land on both the north and south sides of the railroad route.

In much of Wyoming, the owner of the mineral rights is often different than the surface owner. It is common in Wyoming for the surface estate to be owned by private individuals and the mineral estate to be owned by the federal government (and leased to private individuals or companies). State lands are usually underlain by state-owned minerals. The U.S. Supreme Court ruled in 1999 that the owner of the oil and gas estate rather than the owner of the coal estate owns the coalbed methane. The mineral owner has rights to access and develop their minerals, and under the law, surface owners are entitled to compensation for damages to their property due to mineral extraction.

## Who owns the coal?

Coal in Wyoming is owned by the private, state, and federal sectors. In the early 1900s, the coal portion of the mineral estate was reserved over vast areas by the federal government. These areas can be leased by those wishing to develop the coal reserves. The State of Wyoming was given the coal under state lands ceded by the federal government.

## Which has priority, coal mining or coalbed methane development?

This depends on the owner of the mineral estate. A private mineral owner determines the priority of development, whereas for state-owned or federally owned coal, the one with the first lease (based on issuance date) generally has priority for development. Currently neither mining nor coalbed methane development has specific priority, and the State of Wyoming is encouraging joint cooperation between the two industries.

## How does the surface landowner keep his rights if he does not own or lease the minerals?

Landowner rights are preserved regardless of whether or not they participate in coalbed methane development of the mineral estate. Regulatory bodies are empowered to shut down coalbed methane operators and individual wells if their activities are irresponsible or damaging to the surface. The landowner can negotiate with the coalbed methane producer to be compensated for damage to or the loss of use of his land. Most of the coalbed methane operators are willing to work with the landowners to avoid conflicts, but when this fails, state and federal regulators can help resolve these matters.

## How does coalbed methane affect coal mining?

Coalbed methane operations can affect coal mining. Wells drilled ahead of an advancing mine must be removed or barriers must be left to protect the well in question. Leaving a barrier around the well would probably affect the well's performance: if the well were in the same coal that is being mined, the fluid and gas flow necessary for the well to produce may be destroyed or disrupted and the drainage area of the well may be restricted. Produced water discharged to the surface upstream from a mine could create water control and runoff problems not present or anticipated in the original mine plan. The mine operators may have to re-engineer their mine designs to handle the additional water and rework their reclamation plans to include new wetland areas. From a more positive standpoint, dewatering and degassing the coal in advance of underground mining eliminates the methane hazard and lessens the amount of water that would have to be pumped out of the mine. For surface mines, it would eliminate any possibility of coalbed methane seepage at the mine face and also lessen the amount of water that has to be removed from the mine.

Coal mining can affect the coalbed methane recovery by removing the coal and thus, the gas reservoir itself. Coal mining can also remove some of the water in the coal nearest the mine, thus stimulating more free gas production as coalbed methane operations approach the active mine areas.

## Can coalbed methane production lead to surface methane seeps or underground fires?

The possibility of either methane seeps or underground fires occurring as the result of coalbed methane development is extremely remote. Most coalbed methane development is in the deeper coal beds, usually more than 200 feet below the surface. Methane seeps usually occur where coal beds are extremely close to the surface; natural cracks or channels through which the gas must flow in a seep usually do not exist where the coal is deeper. Extraction of coalbed methane decreases the possibility of shallow gas seeps because it removes the gas from the coal before it flows into shallower areas. Production of coalbed methane also reduces the possibility of seeps developing because it provides much more efficient channelways for the gas to flow than might exist naturally. Coalbed methane production also lowers both the pressure of the gas in the coal and

*Figure 12. Water injection facilities operated by Petroleum Development Corporation north of Baggs. Tanks store water produced from several coalbed methane wells, which is then reinjected into the subsurface by pumps (housed in building behind stairway) powered by portable unit (on left).*

the hydrostatic pressure in the aquifer, so there is a lessened chance for seeps to develop.

Underground coal fires appear to have an even less chance of developing as a result of coalbed methane activities. A thorough discussion of spontaneous combustion of coal and underground mine fires (Lyman and Volkmer, 2001) concluded that even if a low-rank subbituminous coal bed were completely dewatered (which it isn't), the lack of fine particle sizes, the lack of access to an oxygen source, and the lack of large open voids underground would preclude both spontaneous combustion of coal and underground coal fires. The conditions necessary for pyrophoricity (spontaneous combustion of coal), which include primarily the temperature of oxidation and heat of wetting along with other factors such as airflow rate, particle size, temperature, pyrite content, and other geological factors simply do not exist in coalbed methane development in the Powder River Basin. The presence of water in the coal beds, which is needed for production of coalbed methane, serves to keep the coals from drying out, does not allow the introduction of air into the coal, and helps (along with the gas production) in dissipating any heat that could be generated within a coal bed.

## Can coalbed methane production cause surface subsidence?

Although withdrawal of fluids from subsurface aquifers is known to cause subsidence in many areas of the world (Edgar and Case, 2000), the geologic conditions in the Powder River Basin and in other parts of Wyoming are much different than those documented cases. For example, the bedrock in many of the documented cases is composed of unconsolidated clays overlying sands and gravels with extremely high porosity (pore space between the grains) in the clays, which are saturated with water. The water that is pumped from the sands and gravels is replaced by water from the saturated clays, which then compress significantly. The bedrock in Wyoming coalbed methane areas is composed of highly consolidated and compacted rocks like sandstone, siltstone, and shale with much less porosity. The effects of dewatering these consolidated rocks are much less.

Based on actual measurements of the different parameters involved, Case, Edgar, and De Bruin (2000) concluded that aquifer compression due to dewatering a coal bed in the Gillette area of the Powder River Basin could amount to slightly less than 1/2 inch and that only part, if any, of the compression would be observed at the surface. To date, no observable surface subsidence has been associated with equally significant water withdrawals from sandstones underlying the coals in the area around Gillette. If any subsidence occurred, it would distribute over a large uniform area and would not result in significant damage (Case, Edgar, and De Bruin, 2000).

## Who owns the produced water?

The operator of the well, who has obtained a water well permit with the State of Wyoming's Department

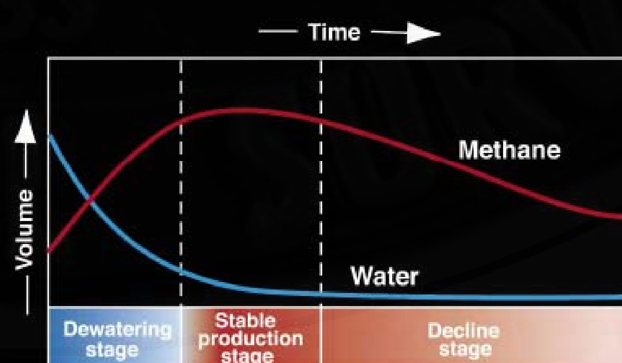



*Figure 13. Production history of a coalbed methane well. Modified from U.S. Geological Survey Energy Resource Surveys Program, 1999, Coalbed methane-an untapped energy resource and an environment concern: U.S. Geological Survey web site on coalbed methane.*

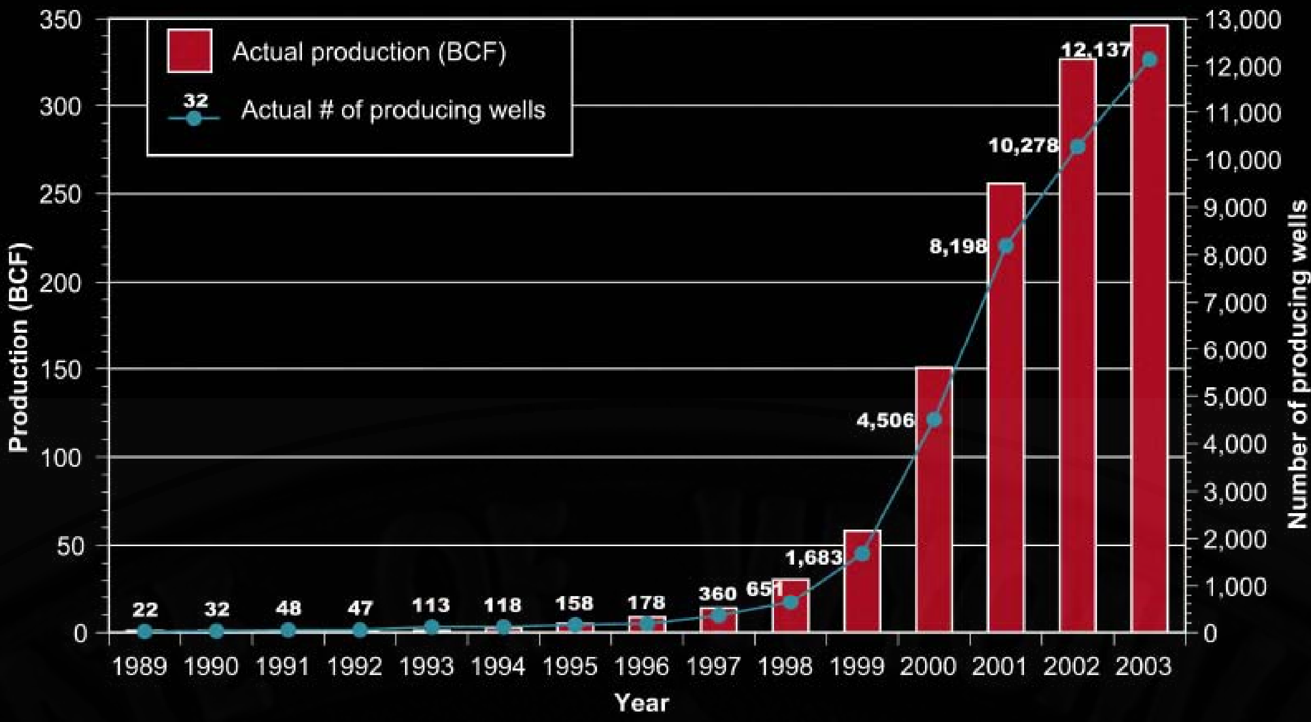



*Figure 14. Yearly production and number of producing wells for coalbed methane in the Powder River Coal Field, Wyoming, 1989 through 2003. Source: Wyoming Oil and Gas Conservation Commission production reports, 1989 through 2003.*

of Environmental Quality (DEQ), is responsible for the water. Each coalbed methane well must be permitted as both a gas well and a water well. At least three permits are required to operate a coalbed methane well: an application for permit to drill (APD), a water permit, and a water discharge permit.

## Where does the produced water go?

Most water produced from a coalbed methane well is currently discharged at the surface and runs off into surface drainages, or it flows into ponds where it seeps back into the soil or evaporates. Some produced water from coalbed methane wells in other Wyoming coal fields is now being reinjected into nearby aquifers that contain poorer quality water than the produced water.

## Is the produced water any good?

Much of the coalbed methane water being produced in the Powder River Coal Field, Wyoming generally meets drinking water standards. It is fresh, potable, and suitable for stock watering and human needs. For other areas being developed in the coal field and in other parts of Wyoming, this may not be the case. Water quality studies will be needed continuously to identify areas of concern and ensure that appropriate action and remedies are taken to protect the quality of the state's waters.

A new, interactive database has been developed that includes amongst its features the ability to retrieve water quality data from a variety of sources for specific areas, coal beds, or geologic formations in the northern Powder River Basin, Wyoming. The Wyoming State Geological Survey (WSGS) and the Wyoming Water Resource Data System (WRDS), in cooperation with a number of state and federal agencies, released in May, 2004 the *Interactive Geologic, Hydrologic, and Water Quality Database and Model for the Northern Powder River Basin (PRB), Wyoming* via an Internet Map Server (see http://ims.wrds.uwyo.edu/prb/prb.html).

This database utilizes a geologic model that enables a user to access data on bedrock geology, 32 coal bed horizons, and structural data for five formations in the PRB along with a ground water quality model. Concentrations of a number of individual water quality constituents can be accessed and mapped for specific coal beds, coal sequences, and geologic formations. This new and powerful tool will enable a variety of developers, water users, or regulators in the Powder River Coal Field to more

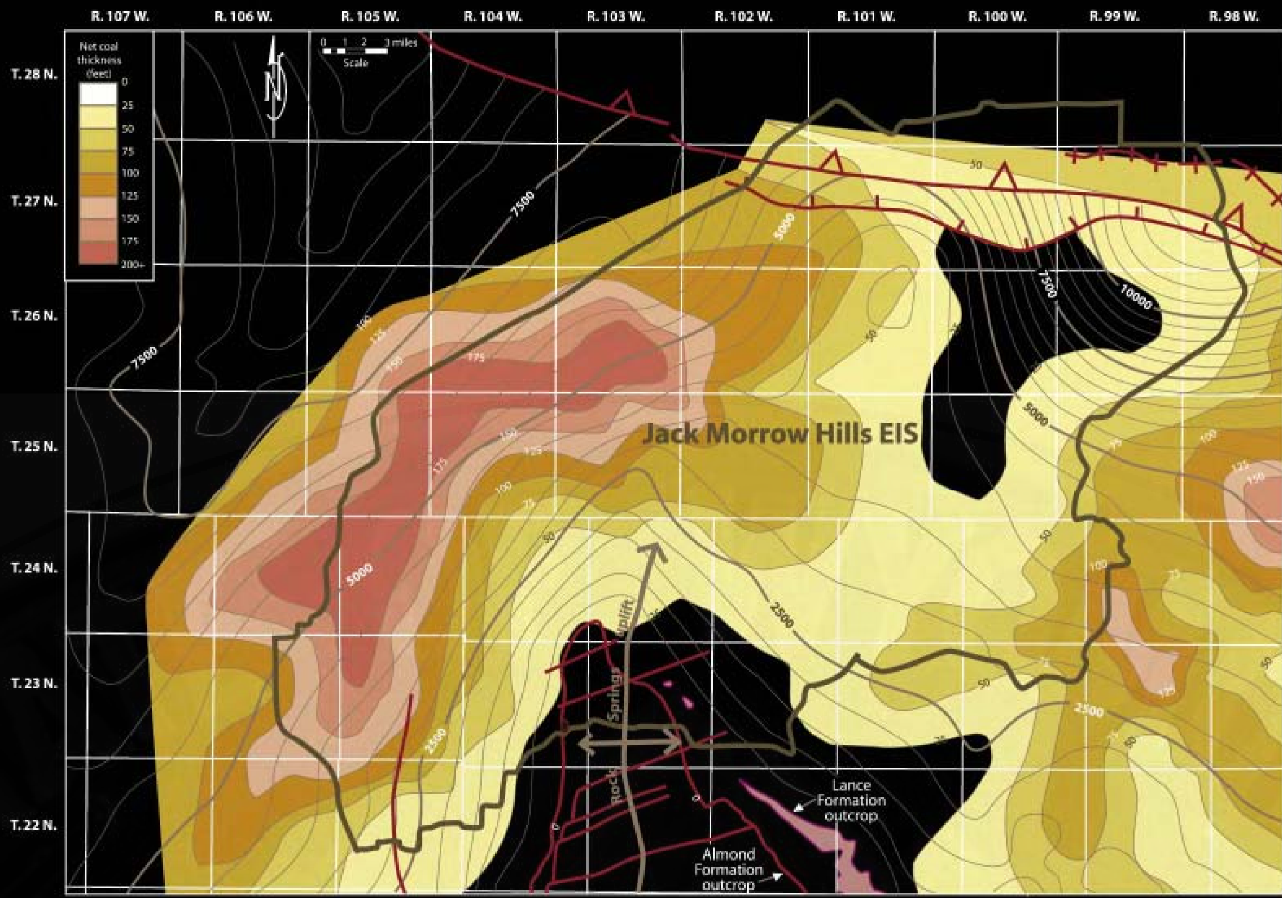



*Figure 15. Isopach map of net (total) coal thickness in the Fort Union Formation of the Jack Morrow Hills area, southwestern Wyoming. Depths to top of coal zone shown in 500-foot increments. Map modified and adapted from, and used with permission of Yates Petroleum Corporation (2002).*

effectively estimate the quality of water before it is produced.

## *What role does the SAR play in coalbed methane development and what do the numbers mean?*

SAR stands for Sodium Absorption Ratio. It is the ratio of the concentration of sodium to the combined concentration of calcium and magnesium in water. Since SAR is a ratio, it is possible to have very low sodium levels yet high SAR values due to the near-absence of calcium and magnesium in the water. SAR is used in conjunction with electrical conductivity measurements to predict how water will react with soil upon which it is applied. In general, high SAR values are indicative of potential problems in agricultural applications, while low SAR values suggest that water is suitable for agricultural use.

SAR values for water from coalbed methane wells in the Powder River Coal Field range from 3 to greater than 60. The suitability of the water can also be related to its electrical conductivity (a measure of the ions present), vegetation or crop type, and the soil type. In general, clay-rich soils are more susceptible to damage from high SAR values than are sandy, loamy soils. The U.S. Department of Agriculture Handbook No. 60 explains SAR values in more detail.

SAR values are variable in the Powder River Coal Field. Generally, SAR values for wells in the Cheyenne River and Belle Fourche drainages (southeastern part of the basin) are low, in the range of 3 to 8. High SAR values are encountered in the northern and western parts of the basin. In Montana, the groundwater is generally of lower quality (higher SAR) than in Wyoming. In general, shallower coals have lower SAR values than deeper coals at a given location. Development in Wyoming's Powder River Coal Field has moved westward to the deeper "Big George" coal bed and the water quality is not as good as on the eastern side of the coal basin.


*Figure 16. This compressor station, operated by Colorado Interstate Gas west of Laramie, is one of several along the pipeline corridor in southern Wyoming.*

## What if the water produced from a coalbed methane well is of poor quality?

State and federal standards for produced water force producers to maintain proper water quality. For example, if the produced water is of poor quality, it cannot be discharged into drainages. Options such as lined impoundments (evaporation ponds), chemical treatment, or re-injection of the water into other aquifers (*Figure 12*) can be considered in isolated areas of poor water quality. Atomization uses a sprinkler system that sprays the water as a fine mist to promote evaporation. Monitoring wells are continually being put in place to measure flows, drawdown, and quality; other studies, such as the PRB study discussed above, will be undertaken to determine areas of water quality concern.

Industry estimates that more than half of the recoverable coalbed methane produced in the Powder River Coal Field will come from the "Big George" coal bed near the center of the basin (*Figure 4*). Since the water from this coal bed is not as high in quality as water from coal beds on the east side of the basin, innovative approaches are being tried to reduce SAR. In some places, sulfur burners are being used to oxidize sulfur and produce acid that helps to lower the SAR of water passing through the burner. Ion exchange introduces resin into produced water, which removes sodium. Both the resin and sodium are removed from the water in the form of a briny solution and the treated water has a lower SAR. Both of these methods can add substantial costs to coalbed methane production.

## Who can use the produced water and how can it be used?

Because most of the water currently being produced in the Powder River Coal Field is of good quality, it is suitable for many uses. Ranching and farming uses include livestock watering, field irrigation, and drinking water. It has been proposed as a separate or supplemental source for municipal water in some areas and its use in a coal slurry pipeline is even being considered. Wildlife management groups see the creation of new wetlands as a plus for many wildlife species; fisheries groups have proposed reservoirs for fishing and other recreational uses of the waters. Additional uses proposed for the water include various industrial purposes such as cooling water for coal-fired power plants, synfuels, and even coal gasification. Some of the water is used to control dust on high-traffic gravel roads.

## *What if the landowner doesn't want the produced water?*

The State of Wyoming encourages the coalbed methane operator and the surface landowner to cooperate with each other and to explore suitable ways to handle produced coalbed methane water in a mutually beneficial way. It may be possible to pipe the water off a property or send it down stream to those that would like the additional water.

## *How does coalbed methane production affect the shallow aquifers?*

In some cases local water wells may be obtaining water from or near a coal bed being used to generate coalbed methane. In these special circumstances, water levels can be lowered and gas could flow from local water wells. This means that some water wells in the coal can be adversely affected. Water regulatory officials encourage ranchers and other landowners to register their water wells so that if a water well is damaged, it can be remedied by the responsible coalbed methane operator.

Many landowners negotiating with coalbed methane operators are now signing letters of understanding, which specify what will be done if their wells are damaged by the coalbed methane activity. Copies of these sorts of agreements can be obtained through the Wyoming State Engineer's Office, upon request.

## *Is the water produced offset by recharge elsewhere?*

Recharge back into subsurface aquifers is constantly taking place, but it is not known how fast or into what aquifers the recharge is occurring. A few studies have shown that some shallow aquifers are being recharged with water produced during coalbed

*Figure 17. In-field coalbed methane compressor facilities (under construction) in the southeastern part of the Green River Coal Field. A natural gas powered unit (center, with cooling fans) provides power to the facility.*

methane operations and production. However, it may take hundreds of years to fully recharge the producing coal beds. As deeper coal beds are tapped for methane in multiple coal zones, it may be possible to re-inject water produced from the deep beds into the gas-depleted shallow coal beds, thus accelerating the natural recharge process.

## What is the anticipated growth in Wyoming's coalbed methane industry?

Industry has shown that it can drill as many as 100 coalbed methane wells per week, which translates to about 5000 wells per year. However, there was a definite slowdown in drilling and coalbed methane well completions in 2003 mainly because very few federal permits were issued by the U.S. Bureau of Land Management (BLM). Although the BLM is now issuing permits faster, we do not expect more than 2500 wells will be drilled each year. If the number of wells drilled is discounted to allow for production declines associated with older wells, if only 1250 new wells are assumed to begin production each year, and if each well can produce at a rate of about 880 MCF of gas per day, forecasts can be made (*Figure 18*). We suggest that by the year 2010, production of 610 BCF/year (or about 1.7 BCF/day) from 20,900 wells is possible from coal beds in the Powder River Coal Field, Wyoming. This figure is very conservative and can increase substantially if the "Big George" wells perform much better than the shallow wells in the eastern part of the coal field.

## What factors will affect the growth of Wyoming's coalbed methane industry?

A number of factors will affect the projected growth of the coalbed methane industry in Wyoming. Some of these are: NEPA (the National Environmental Policy Act, which is the federal environmental planning process) and the federal permitting process; water discharge permits from the Wyoming DEQ; development of technology allowing completion of multiple coal seams from a single well bore; development of technology to reduce the SAR of produced water to acceptable levels without destroying the coalbed methane play's economics; inter-state negotiations on how to handle water quality issues; limitations imposed by infrastructure (e.g., building enough pipelines to transport gas out of the producing areas and the state); and price uncertainties in natural gas markets.

## How much money will state and local interests receive from development?

The State of Wyoming receives revenue from several taxes and sources, depending on the individual lease. Revenues are based on the value of the gas produced, which is related to its selling price. The

*Table 3. Estimated resources of coalbed methane in Wyoming1. Estimate by the Wyoming State Geological Survey, September, 2000.*

| Coal field | In place coal resources (millions of short tons) | Coal rank[2] | Gas content (cubic feet per ton) | Gas in place (trillion cubic feet) | Recoverable gas resources (trillion cubic feet) |
|---|---|---|---|---|---|
| Powder River[3] | 578,162 | Sb | 65 | 37.581 | 25.179 |
| Green River | 236,589 | Sb-Hvb | 275 | 65.062 | 3.253 |
| Wind River | 81,007 | Lig-Hvb | 59 | 4.779 | 0.956 |
| Hanna/Rock Creek | 26,390 | Sb-Hvb | 323 | 8.524 | 1.279 |
| Bighorn | 23,491 | Lig-Hvb | 107 | 2.514 | 0.628 |
| Hams Fork | 21,888 | Sb-Hvb | 84 | 1.839 | 0.276 |
| Other misc. | 10,720 | Sb-Hvb | 80 | 0.858 | 0.086 |
| Total | 978,247 | | | 121.157 | 31.657 |

[1]Modified from Gas Research Institute (1999) and Finley and Goolsby (2000).

[2]Lig=Lignite, Sb=Subbituminous, Hvb=high-volatile Bituminous.

[3]For this coal field only, in place resources are for coal beds greater than 20 feet thick; recoverable resources are based on a 67% recovery factor.

final revenue amounts are in turn related to whether the gas was produced from private, state, or federal leases. Revenues are received from: severance taxes of 6% of the value on all gas produced, which goes to the State's General Fund; royalties from gas produced from State leases (about 16.67% royalty rate) and lease bonuses which go to the State's Permanent Mineral Trust Fund; half of the lease bonus when federal lands are leased; half the royalty from gas produced from federal lands (half of 12.5% royalty rate); and sales and use taxes from purchase of equipment associated with development.

In summary, the State of Wyoming receives an average of about 10% of the gross revenue stream from all gas produced. Local government collects ad valorem taxes on produced gas (at a rate of about 6%, depending on the county) and sales and use taxes from other development activities. Mineral owners receive lease bonus payments and production royalties. Surface owners are entitled to receive damage payments. The local economies are boosted through sales of equipment, supplies, and services, as well as the impact on the non-industry-related services and businesses (home and auto sales, groceries, insurance, restaurants, motels, etc.).

## *Who do I contact about coalbed methane?*

- Wyoming Oil and Gas Conservation Commission: drilling permits (APDs) and production permits;
- Wyoming State Engineer's Office: water well drilling and completion permits;
- Wyoming Department of Environmental Quality: water discharge permits and drainage (Wyoming Department of Environmental Quality, 2000);
- Wyoming State Geological Survey: technical assistance and information; oil and gas and coalbed methane maps (see De Bruin, 2002 and De Bruin and others, 2004a, 2004b); the Internet (see the web sites under State of Wyoming agencies, p. 23); and Interactive database at http://ims.wrds.uwyo.edu/prb/prb.html);
- Coalbed Methane Coordinator: technical assistance and information; facilitates communication between all participants and parties interested in coalbed methane; and
- Federal government agencies, including:
- U.S. Bureau of Land Management (BLM),
- U.S. Forest Service (FS),
- Environmental Protection Agency (EPA), and
- U.S. Geological Survey (USGS).

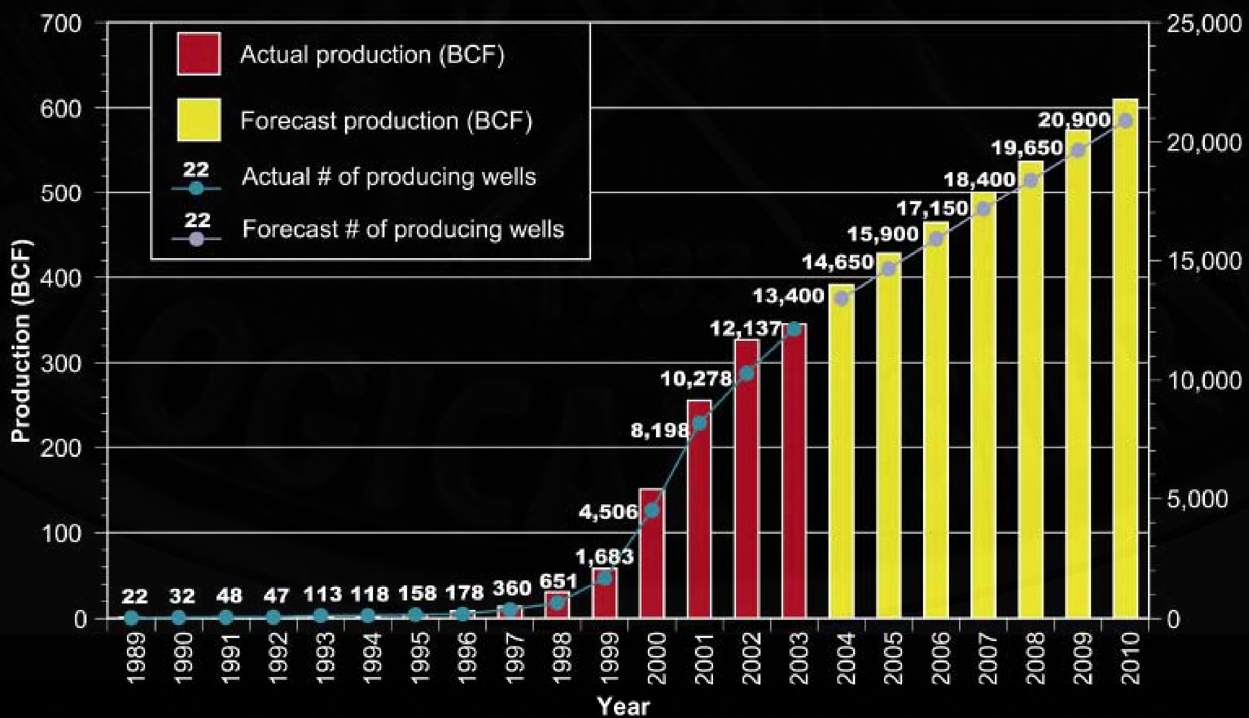



*Figure 18. Yearly production and number of producing wells for coalbed methane in the Powder River Coal Field, Wyoming, 1989 through 2003, with forecasts to 2010. Source: Wyoming Oil and Gas Conservation Commission production reports, 1989 through 2003; Wyoming State Geological Survey, 2004 through 2010.*

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## *State of Wyoming agencies to contact about coalbed methane:*

**Department of Environmental Quality**
122 West 25th Street, Herschler Bldg.
Cheyenne, Wyoming 82002
General phone number: (307) 777-7937
Fax: (307) 777-7682
Email: deqwyo@state.wy.us
Land Quality Division: (307) 777-7756
Water Quality Division: (307) 777-7781
Web site: http://deq.state.wy.us

**Wyoming State Engineer's Office**
122 West 25th Street,
Herschler Bldg., 4th Floor East
Cheyenne, Wyoming 82002
General phone number: (307) 777-7354
Fax: (307) 777-5451
Email: seoleg@state.wy.us
State Engineer: (307) 777-6150
Groundwater Division: (307) 777-6163
Surface Water and Engineering Division: (307) 777-6168
Web site: http://seo.state.wy.us

**Wyoming Oil and Gas Conservation Commission**
P.O. Box 2640
2211 King Boulevard
Casper, Wyoming 82602-2640
Phone: (307) 234-7147
Fax: (307) 234-5306
Web site: http://wogcc.state.wy.us

**Wyoming State Geological Survey**
P.O. Box 1347
Laramie, Wyoming 82073-1347
Phone: (307) 766-2286
Fax: (307) 766-2605
Email: wsgs@wsgs.uwyo.edu
Web site: http://wsgsweb.uwyo.edu
Interactive database:
http://ims.wrds.uwyo.edu/prb/prb.html

**Coalbed Methane Coordination Coalition**
760 West Fetterman
Buffalo, Wyoming 82834
Phone: (307) 684-7614
Email: cbmcc@vcn.com
Web site: http://www.cbmcc.vcn.com

## *Others to contact about coalbed methane:*

**Powder River CBM Information Council**
P.O. Box 6752
Sheridan, Wyoming 82801
Phone: (307) 673-7161
Email: info@cbmwyo.org
Web site: http://www.cbmwyo.org

**U.S. Bureau of Land Management**
Buffalo Field Office
1425 Fort Street
Buffalo, Wyoming 82834-2436
Phone: (307) 684-1100
Fax: (307) 684-1122
Email: buffalo_wymail@blm.gov
Web site: http://www.wy.blm.gov

**Wyoming CBM Clearinghouse**
University of Wyoming,
WilliamD. Ruckelshaus Institute of Environment and Natural Resources
Department 3971
1000 E. University Avenue
Laramie, WY 82071
Phone: (307) 766-5150
Email: ienr@uwyo.edu
Web site: http://www.cbmclearinghouse.info

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***Cover photograph: Coalbed methane drilling rig in Hawk Point oil field about 20 miles south of Gillette. A second rig is working in the background.***