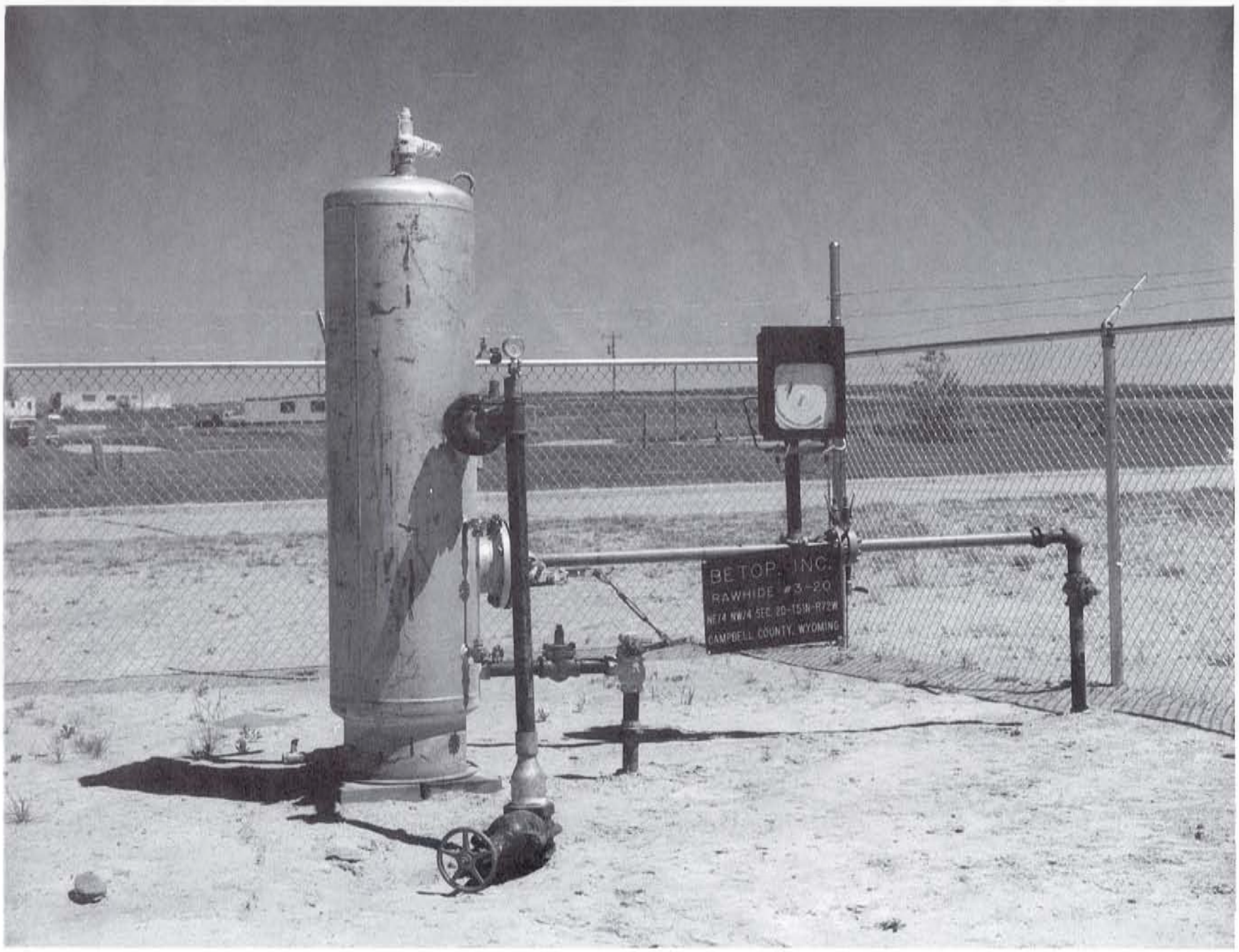
THE GEOLOGICAL SURVEY OF WYOMING
Gary B. Glass, State Geologist

COALBED METHANE IN WYOMING

by
Richard W. Jones and Rodney H. DeBruin



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Cover Photo: Surface production facilities at BETOP, Inc.'s 3-20 Betop Rawhide discovery well. This is the first commercial coalbed methane well completed in a coal bed in Wyoming. The well, located in SE NE NW sec. 20, T51N, R72W, was completed on September 4, 1988, at a total depth of 464 feet in the Paleocene Fort Union Formation. Production is from the Wyodak coal bed, which consists of a 34-foot-thick upper bed and an 88-foot-thick lower bed in the discovery well. Production began in April, 1989; cumulative production through April, 1990, was 71,791 MCF (thousand cubic feet) of gas and 10,924 barrels of water. Photo courtesy of BETOP, Inc., Carrollton, Texas.

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Abstract

Coalbed methane is a natural by-product of the coalification (thermal maturation) of humic materials that contain type III vitrinitic kerogen. Although a large percentage of the methane generated by the coalification process escapes to the surface or migrates into adjacent reservoir rocks, a portion is trapped within the coal itself, primarily adsorbed on or absorbed within micropores of the coal.

Although coalbed methane probably exists in all coal regions of Wyoming, many of the State's coal deposits are shallow and too thermally immature to have generated substantial amounts of gas. However, many of these shallow coals do have biogenic methane entrapped in them. The most significant quantity of biogenic methane exists in shallow coal beds in the Powder River Coal Field. While methane content per ton of coal is relatively low in this basin, the individual bed thicknesses as well as the aggregate thickness of shallow Tertiary coal beds account for the accumulation of large quantities of biogenic coalbed methane. In contrast, Cretaceous and some Tertiary coal beds buried in the structurally deep portions of many Wyoming basins are much more thermally mature and no doubt have generated large volumes of thermogenic methane.

BETOP, Inc., is the first company in Wyoming to commercially produce methane from wells completed in coal beds. BETOP is now producing coalbed methane from five wells in a subbituminous Fort Union Formation coal bed, located a few miles north of Gillette in Campbell County. Additional wells are projected to increase production from the field to 2.5 million cubic feet of gas per day. BETOP is also developing coalbed methane from Fort Union Formation coal beds in the Dead Horse Creek Field, located southwest of Gillette.

In addition, methane from sandstone units adjacent to coal beds in the Tongue River Member of the Paleocene Fort Union Formation is produced in the Recluse area of the northeastern Powder River Coal Field. The sandstone units are apparently charged with methane from the adjacent coal beds. Twenty-three wells were completed in this area through December, 1989. Each of these wells is producing from 3 to 453 thousand cubic feet (MCF) of gas per day; cumulative production is over 2.0 billion cubic feet for the 23 wells.

Using current estimates of the total coal resources in the major coal-bearing areas in Wyoming, and assuming that each ton of coal contains between 5 and 100 cubic feet of methane, Wyoming's estimated in-place resource of coalbed methane is from 7.25 to 145.0 trillion cubic feet. Even if only 50 percent of the lower number is recoverable, this is still a very significant amount of gas.

Introduction

Recent production of methane from coal beds in Wyoming has created much interest in the possibilities for further development of this resource. This article briefly summarizes the origin, occurrence, development, and resources of coalbed methane in Wyoming.

Acknowledgments

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Origin

During coalification of humic material through time, increased temperatures during burial drive off volatile matter. Methane is one of several major components in the volatile matter. In addition to methane, coalification also releases carbon dioxide, nitrogen, and water. Because most Rocky Mountain coals are classified as common or humic coals (derived primarily from the woody constituents of complex terrestrial plants) and contain dominantly type III vitrinitic kerogen, they are considered to be dry gas-generating source rocks when they reach thermal maturity (Meissner, 1984).

During the early stages of coalification of buried peat, biogenic methane is generated as a by-product of bacterial respiration. Aerobic bacteria first metabolize any free oxygen left in the plant remains and surrounding sediments. If sulfates are present, methane generation will not dominate until after sulfate-reducing species of anaerobic bacteria have metabolized the sulfates. In environments where waters are low in sulfates (such as brackish or fresh water), methane production begins immediately after the oxygen is depleted (Rice and Claypool, 1981). Other species of anaerobic bacteria then reduce carbon dioxide and produce methane ("methanogenesis") through anaerobic respiration (Rice and Claypool, 1981). When a coal has reached about 50° C, and after a sufficient amount of time, most of the biogenic methane will have been generated, about two-thirds of the original moisture will have been expelled, and the coal will have attained an approximate rank of subbituminous (Rightmire, 1984).

With additional time, and as the temperature increases above 50° C (through increased depth of burial or increased geothermal gradient) and thermogenic processes begin, additional water plus 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 100° C. Thermogenic generation of methane begins in the higher ranks of the high volatile bituminous coals, and at about 120° C (the approximate boundary between high volatile and medium volatile bituminous coals), generation of methane exceeds generation of carbon dioxide (Rightmire, 1984). Maximum generation of methane from coal occurs at about 150° C. This temperature corresponds to the approximate division between medium and low volatile bituminous coals. With even higher temperatures (and higher rank coals), methane is still generated, but at somewhat lower rates and volumes (Rightmire, 1984).

Mode of occurrence

The methane generated by coal beds may escape directly to the surface, migrate into adjacent reservoir rocks, or be retained within the coal. It is estimated that under some conditions, more than 9 million cubic feet of methane have been generated for each ton of coal that has matured from lignite to anthracite (Meissner, 1984). The actual amount of methane retained by coal can be less than 10 cubic feet per ton to more than 600 cubic feet per ton (D.K. Murray, personal communication, 1990). The methane can occur in coal as adsorbed or absorbed molecules on the surface of micropores in the coal, as free gas existing within fractures or pores, and as dissolved gas in formation waters (Rightmire, 1984). Ninety percent or more of the total methane retained by the coal is probably adsorbed on the coal micropore surfaces or absorbed within the molecular structure of the coal. Meissner (1984) believed that coals act more as molecular sieves or solid solvents that absorb, rather than adsorb, methane molecules.

Coalbed reservoirs typically have low matrix permeabilities (often less than 1 millidarcy), relying on cleats and(or) fractures for permeability. According to Petroleum Information (1986), desorption and gas flow through a water-saturated coalbed reservoir during production occurs in three stages:

(1) Single-phase flow. Gas is completely saturated in the water. The hydrostatic head that holds methane in an absorbed state is reduced through pumping or natural artesian flow.

(2) Unsaturated single-phase flow. Although methane desorption begins as reservoir pressure drops, only isolated gas bubbles form and no gas flow occurs.

(3) Two-phase flow. Gas and water are present and mobile, gas saturation increases (with pressure drop and desorption), and individual gas bubbles connect to form continuous pathways to a well bore. This stage of gas flow is characterized by the free-phase flow of gas through natural fractures (cleats) and macropores of the coal as well as diffusion flow of gas through the microporosity of the solid coal.

The volumes of methane present in coalbed reservoirs are dependent on the depth of the reservoir, coal rank, and hydrogeologic environment (Petroleum Information, 1986). The ability of gas to flow through a reservoir depends on such factors as structural setting (which controls fractures), depth, variations in coal maturation history, and water saturation. Depth is extremely important in the producibility of a coalbed methane reservoir because permeability decreases more rapidly with depth in coal reservoirs than in conventional sandstone and carbonate reservoirs (Petroleum Information, 1986). In addition, visco-elastic flow of the coal may occur at depth (Petroleum Information, 1986). On the positive side, coalbed methane reservoirs often exhibit negative decline curves as they are produced because as the coal is dewatered and reservoir pressure is lowered, gas flow (desorption) and permeability to gas increase (Petroleum Information, 1986).

Occurrences in Wyoming

Methane associated with coal beds has been observed in nearly all the coal-bearing areas in Wyoming (**Figure 1**). Evidence for its occurrence include 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**).

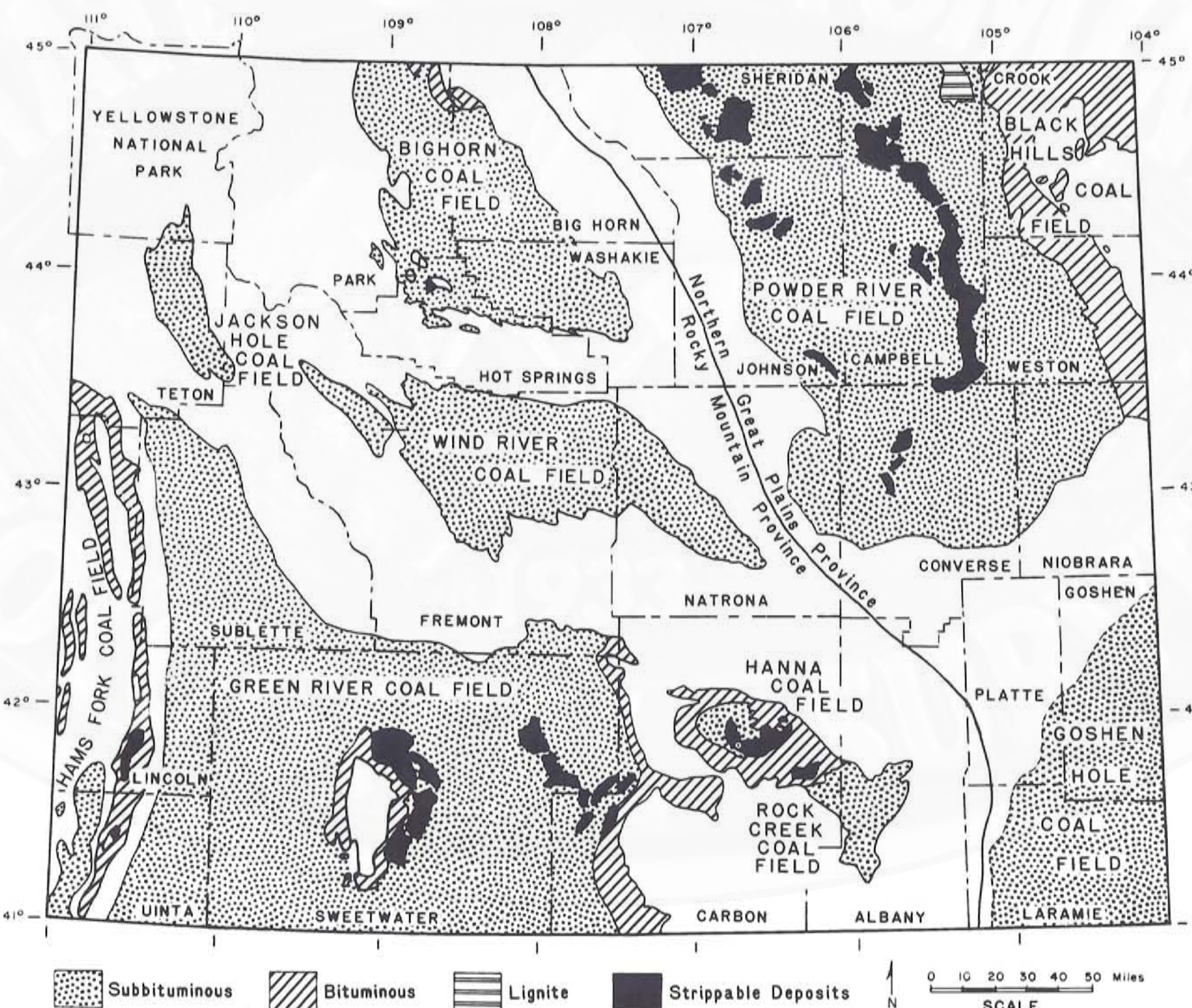

Figure 1. Wyoming coal fields.

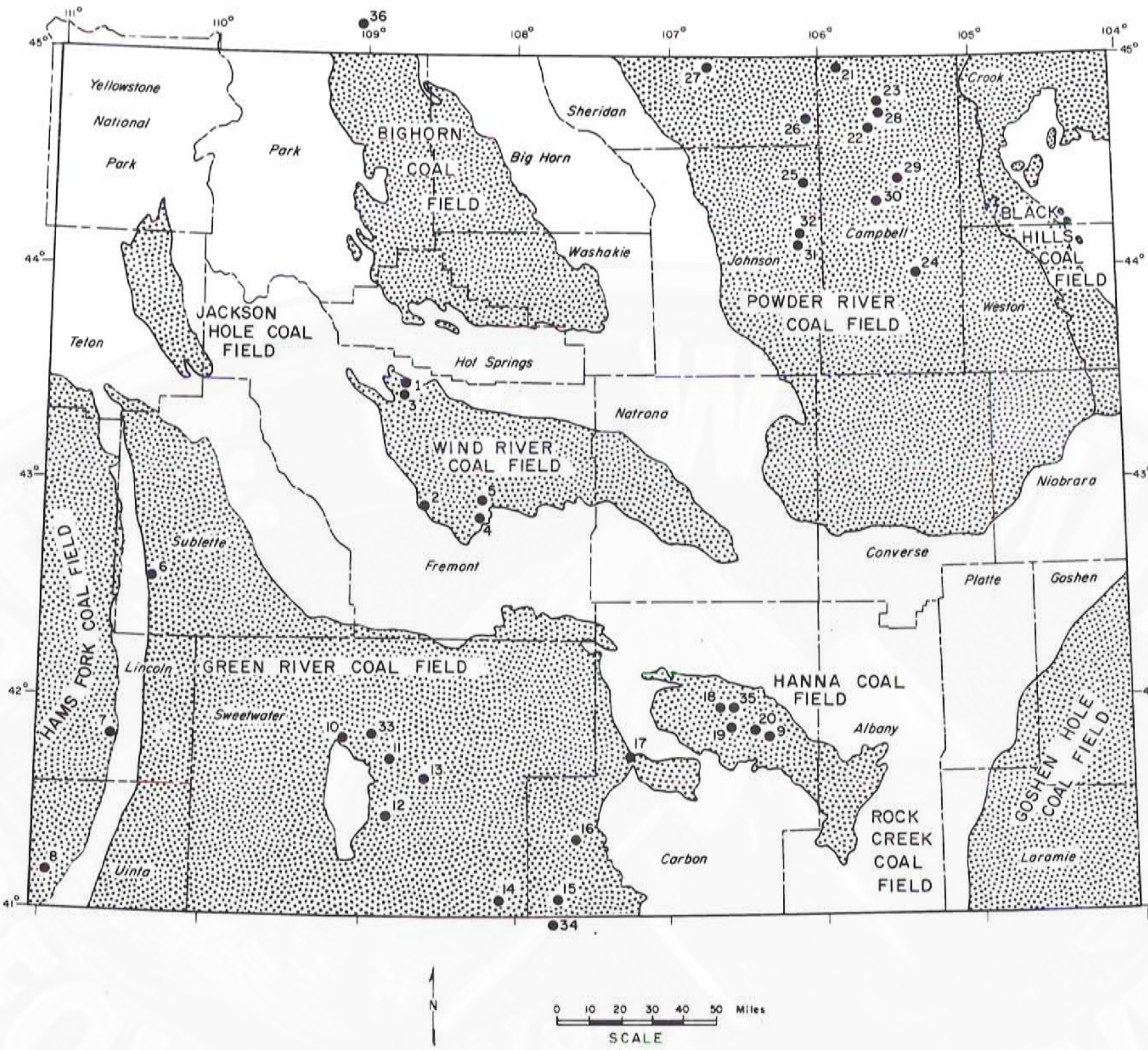

Figure 2. Coalbed methane occurrences and exploration activities.

Group) near the town of Rock Springs were not particularly gassy; however, coal exploration holes north of Rock Springs, in sec. 5, T21N, R103W (No. 10, **Figure 2**) did encounter methane in the Rock Springs Formation (Mesaverde Group) at depths between 300 and 320 feet (McCord, 1980). Exploration drilling for coal beds in the Almond Formation (Mesaverde Group) in the Leucite Hills, sec. 15, T20N, R101W (No. 11, **Figure 2**) and Salt Wells, secs. 9 and 16, T17N, R101W (No. 12, **Figure 2**) areas, as well as exploration drilling for Tertiary coal beds in sec. 16, T19N, R99W (No. 13, **Figure 2**), also encountered coalbed methane at shallow depths (McCord, 1980).

Using data compiled by Bradley (1945), McCord (1980) reported that shallow wells in the eastern part of the Green River Coal Field (southern and southeastern part of the Washakie Basin) encountered gas at depths of less than 1,000 feet (Nos. 14, 15, and 16, **Figure 2**). In addition, a main entry to the Dillon underground mine in sec. 36, T21N, R88W (No. 17, **Figure 2**) was abandoned in the late 1800s because of the quantity of methane gas encountered in the Mesaverde Group coal bed that was being mined (Ball and Stebinger, 1908).

In the Hanna Coal Field, occurrences of methane gas associated with coal beds are known from drill holes and underground mines. Logs of several oil and gas exploratory wells drilled in the central part of the basin in sec. 30, T24N, R83W and sec. 25, T24N, R84W (No. 18, **Figure 2**), show numerous "gas kicks" from coal beds in the Tertiary part of the Ferris Formation. Methane gas was also observed in entries to an underground coal mine located in sec. 7, T22N, R82W (No. 19, **Figure 2**) that operated in Tertiary Hanna Formation coal beds in the 1970s (Neil Parker, personal communication, 1989). Underground mines that operated in and near the town of Hanna (T22N, R81W) (No. 20, **Figure 2**) in the late 1800s and early 1900s were known to be gassy and posed a serious safety hazard to the miners. The presence of methane gas has been reported for the Hanna No. 1, Hanna No. 2, and Hanna No. 4 mines (Swann, 1940). Large gas (and related coal dust) explosions and resultant fires in the Hanna No. 1 mine in 1903 and 1908 killed 228 miners (including a rescue party) before the mine was permanently sealed. Underground coal mines at Carbon, located about 12 miles east of Hanna in sec. 26, T22N, R80W (No. 9, **Figure 2**), which operated from 1868 to 1900, may also have been gassy; in 1870 the Carbon No. 1 mine experienced a gas [or coal dust] explosion (Union Pacific Coal Company, 1940).

History of development

It has been known for many years that methane often vents from shallow water wells and coal exploration drill holes in the Powder River Coal Field. The gas occurs in sandstones and coal beds at different stratigraphic levels in the Tongue River Member of the Paleocene Fort Union Formation. Most documented historic occurrences are in the northern Powder River Coal Field (**Figure 2**). The first known well in the Powder River Coal Field that produced suspected coal-bed gas was in SE sec. 30, T58N, R75W (Olive, 1957). The gas from this well (No. 21, **Figure 2**) has been used at the Dobrenz ranch since 1916. Olive (1957) listed three additional wells in secs. 8 and 20, T54N, R73W and sec. 12, T54N, R74W (No. 22, **Figure 2**) that had initial potentials between 0.5 to 1.0 million cubic feet per day from shallow sandstone units in the Fort Union Formation. One of these wells, the 2 Rothwell Ranch, was drilled in 1934 (SE SW sec. 8, T54N, R73W) and is considered the discovery well for Hay Creek Field (Biggs and Espach, 1960). A second well drilled in Hay Creek Field in sec. 29, T54N, R73W (No. 22, **Figure 2**) had an estimated initial flow of 2.6 million cubic feet of gas per day. No commercial gas production has ever been reported from this field; however, gas from one of the wells was reportedly used at a nearby ranch (Biggs and Espach, 1960).

During 1975, the U.S. Geological Survey drilled seven shallow coal evaluation holes in T55N, R73W and T56N, Rs72-73W (No. 23, **Figure 2**) (Hobbs, 1978). Methane was encountered in every hole. The methane occurred in sandstone beds above the first coal, in the coal, and in sandstone and shale beds between coals. One of the holes drilled in sec. 24, T46N, R71W (No. 24, **Figure 2**) blew out when it encountered a large gas flow below 240 feet (U.S. Geological Survey and Montana Bureau of Mines and Geology, 1976).

Whitcomb and others (1966) published a gas analysis from a Fort Union Formation water well in sec. 20, T51N, R77W (No. 25, **Figure 2**) and Lowry and Cummings (1966) provided gas analyses from four other water wells. These wells are in sec. 5, T54N, R76W; sec. 5, T54N, R77W; sec. 20, T57N, R76W (No. 26, **Figure 2**); and sec. 30, T58N, R82W (No. 27, **Figure 2**) and were completed in the Fort Union Formation. All five wells showed high concentrations of methane in the gas. Whitcomb and others (1966) and Lowry and Cummings (1966) agree that several wells in Johnson and Sheridan Counties are artesian because of gas in the aquifer. Gas contained in an aquifer affects the height to which water will rise in a well and may provide a lifting action to bring water to the surface.

Commercial exploitation of methane related to coal beds started in the Powder River Coal Field in September, 1986, when Wyatt Petroleum completed a Fort Union well, the Oedekoven 83-6 in SW SE sec. 19, T55N, R73W, in Oedekoven Field. That well produced 24 MCF of gas daily in December of 1989 and its cumulative production through December 1989 is 284,308 MCF. Wyatt Petroleum and several other operators completed 23 wells through December of 1989 in the Tongue River Member of the Fort Union Formation in T54N, Rs73-75W and Ts55-56N, R73W in the Recluse area as shallow production in Carson, Chan, Oedekoven, and Spotted Horse fields (No. 28, **Figure 2**). Daily production ranged from 3 to 453 MCF and cumulative production through December, 1989, is over two billion cubic feet (Petroleum Information, 1990a). The main operators in this area are Wyatt Petroleum, Oilfield Salvage and Service, and Stewart Petroleum.

The first commercial venture to produce methane directly from coal beds in Wyoming is now operating.

BETOP, Inc. is producing the gas from five wells, the Rawhide 7-20, 3-20, and 6-20 and the DEQ 2002 and 2003, with average depths of about 400 feet. The wells are located in Rawhide Butte Field, sec. 20, T51N, R72W (No. 29, **Figure 2**) and production is from about 140 feet of subbituminous coal (the Wyodak coal bed) in the Fort Union Formation. This field was discovered after residents in a housing subdivision north of Gillette reported gas in their basements and under their streets. This surface venting of methane was highly publicized and ultimately resulted in the abandonment of most of the homes in the subdivision (Jones, and others, 1987; Glass and others, 1987; and Jones and Taucher, 1989).

As of January, 1990, BETOP had staked locations for four additional wells in the area; NCRA had completed one well and staked locations for three others; and Martens and Peck Operating had drilled one well and staked a location for another (Petroleum Information, 1990b). As of January, 1990, BETOP also had drilled four wells and staked locations for four other coalbed methane tests in T49N, R75W. The wells, the 11-29 BTP 4975 and the 5-29 BTP 4975 in sec. 29, the 1-31 BTP 4975 in sec. 31, and the 8-32 BTP 4975 in sec. 32, and the new locations are in Dead Horse Creek Field (No. 30, **Figure 2**) in the Fort Union Formation (Petroleum Information, 1990c). The Wyodak coal bed is 60 to 80 feet thick in this area (Ayers, 1986).

As of January, 1990, Coastal Oil and Gas had drilled four coalbed methane wells, the 3 Sasquatch Unit well in sec. 10, the 19 Sasquatch Unit well in sec. 20, the 1 Sasquatch Unit well in sec. 30, T48N, R77, and the 2 Sasquatch Unit well in sec. 26, T48N, R78W; Materi Exploration had drilled the 2-12 Federal coalbed methane well in sec. 12, T48N, R77W; and Gilmore Oil and Gas had staked six locations in T50N, R77W (No. 31, **Figure 2**) (Petroleum Information, 1990d) to test a thick Fort Union coal bed at depths between 1,240 and 1,620 feet. These tests are located near a coal exploration well drilled by the U.S. Geological Survey in sec. 7, T48N, R77W (No. 32, **Figure 2**). In this hole, a coal bed known as Seam 14 (Ayers, 1986) or "Big George" (Kent, 1986) was encountered at a depth of about 1,000 feet. The coal in this drill hole is as much as 200 feet thick (Boreck and Weaver, 1984), and its average thickness is 113 feet (Kent, 1986). Methane was desorbed from cores taken from the coal bed; gas contents ranged from 56 to 74 standard cubic feet per ton of coal (Boreck and Weaver, 1984).

In the Green River Coal Field, Triton Oil and Gas recently drilled two Mesaverde Formation coalbed methane tests, the 1 UPRC in sec. 9 and the 2 UPRC in sec. 1, T22N, R102W, Buttonwood Petroleum staked two locations for Mesaverde coalbed methane tests, and Eagle Oil and Gas drilled the 1-21 UPRC Mesaverde coalbed methane test in sec. 21, T22N, R104W and staked 3 additional tests in the Leucite Hills area (No. 33, **Figure 2**) (Petroleum Information, 1990e). No details on these wells are available.

In the southeastern part of the Green River Coal Field, Quintana Petroleum drilled two wells, the 1-20 and 3-20 Timberlake Unit wells in sec. 20, T12N, R91W, and staked three more locations to test Fort Union Formation coal beds in the Sand Wash Basin, Colorado. These three staked locations are less than 2 miles south of the Wyoming-Colorado border (No. 34, **Figure 2**) and about 4 miles southeast of Baggs, Wyoming (Petroleum Information, 1990f). Meridian Oil also drilled three Fort Union coalbed methane tests just a few miles south of the Quintana wells: the 11-23 State well in sec. 23, T12N, R92W, the 14-35 Federal well in sec. 33, T12N, R93W, and the 32-36 State well in sec. 36, T12N, R93W; however, no details are available (Petroleum Information, 1990f).

In the Hanna Coal Field, Conquest Oil recently drilled two coalbed methane tests in the Ferris Formation, the 2-23 Hanna-UPRC well in sec. 23, T23N, R83W and the 4-30 Seminoe-Federal well in sec. 30, T24N, R83W (Petroleum Information, 1990g) (No. 35, **Figure 2**). Again, no details are available.

In Golden Dome Field in the Montana portion of the Bighorn Basin, Montana Power completed a coalbed methane well, the 7X-14 Kuchinski, in sec. 14, T7S, R22E, in the Eagle Sandstone (Mesaverde) for an initial potential of 75 MCF of gas daily (Petroleum Information, 1990h). The well is approximately 15 miles north of the Wyoming-Montana border (No. 36, **Figure 2**).

In-place resources

To estimate in-place resources of coalbed methane, it is necessary to know the amount of gas present per unit volume of coal (from the desorption of coal cores). Unfortunately, desorption data for Wyoming coal beds are extremely scarce and an accurate estimate of coalbed methane resources is difficult. The data that exist suggest a ton of coal in Wyoming might contain an average of somewhere between 5 and 100 cubic feet of methane. To provide a very preliminary estimate of the in-place resources, current estimates of the total coal resources in seven of the coal fields of Wyoming (Wood and Bour, 1988) were multiplied by 5 and 100 cubic feet/ton, respectively (**Table 2**). This methodology indicates that Wyoming's in-place resources of coalbed methane are between 7.25 and 145.0 trillion cubic feet. If only 50 percent of the lower estimate is recoverable, it is a very significant amount of gas, considering that the cumulative production of "conventional gas" in Wyoming through 1989 was slightly more than 14 trillion cubic feet.

Table 2. Estimated in-place resources of coalbed methane in Wyoming.

Coal Fields	Coal resources[1] (in trillions of tons)	Methane[2] @ 5 cubic feet/ton	Methane[2] @ 100 cubic feet/ton
Powder River	1.031	5.155	103.1
Green River and Hams Fork	0.287	1.435	28.7
Wind River	0.081	0.405	8.1
Hanna and Rock Creek	0.027	0.135	2.7
Bighorn	0.024	0.120	2.4
Totals	1.450	7.250	145.0

[1] Modified from Wood and Bour (1988).
[2] In trillions of cubic feet.

Leasing and tax credits for coalbed methane

Coalbed methane presents special problems for ownership and leasing because the coal is both the source and the reservoir for the gas, as well as being a separate leasing entity in itself. Coal rights reserved for the Federal government do not include coalbed methane, but oil and gas rights reserved for the Federal government do. There are no clearly established rules or precedents for state-owned or privately owned coal and coalbed methane.

As an incentive to develop alternative fuel resources in the United States, the Crude Oil Windfall Profit Tax Act of 1980 contained provisions for the Internal Revenue Service (IRS) to give tax credits to producers of nonconventional fuels (including methane produced from coal beds). These tax credits were designed to help producers of nonconventional fuels remain competitive in times of low oil and natural gas prices. Calculation of the tax credit uses an inflation adjustment factor (based on the gross national product implicit price deflator as determined by the IRS) and a phase-out factor based on domestic crude oil prices (Soot, 1988). The tax credit is only applicable for production from new wells on new property and only applies to wells drilled after December 31, 1979, and before January 1, 1990 [now extended to January 1, 1991] (Soot, 1988). In addition, wells that produced coalbed gas before 1980 are ineligible for the tax credit. Coalbed methane production in 1986 was eligible for a tax credit of $0.7526 per million Btu of gas sold; in 1987, the tax credit was $0.78 per million Btu of gas sold (Soot, 1988). By 2000, the tax credit could be $1.34 per million Btu (Soot, 1988) depending upon the rate of inflation, among other factors.

Exploration targets

Exploration targets for coalbed methane can be defined by (but not limited to) the following criteria: (1) known, thick, abundant, and continuous coal beds (source rocks); (2) coal-bearing areas with coals of appropriate rank (determined directly from coal analyses or by inferences about probable subsurface coal rank); (3) adequate conditions for accumulation and preservation of coalbed methane (a favorable reservoir); (4) depth to the coalbed methane reservoir (places economic and mechanical limits on development); and (5) other evidence such as degree and location of fracturing and faulting, geothermal gradient, high pressure or overpressured areas in the subsurface, and the presence of gas fields producing from coal-bearing rocks. A preliminary delineation of exploration targets for coalbed methane in Wyoming (**Figure 3**) was based on the first four criteria plus identified occurrences of coalbed methane or methane in coal, data available from coalbed methane tests, and limited production of coalbed methane. McCord (1980) considered coal beds

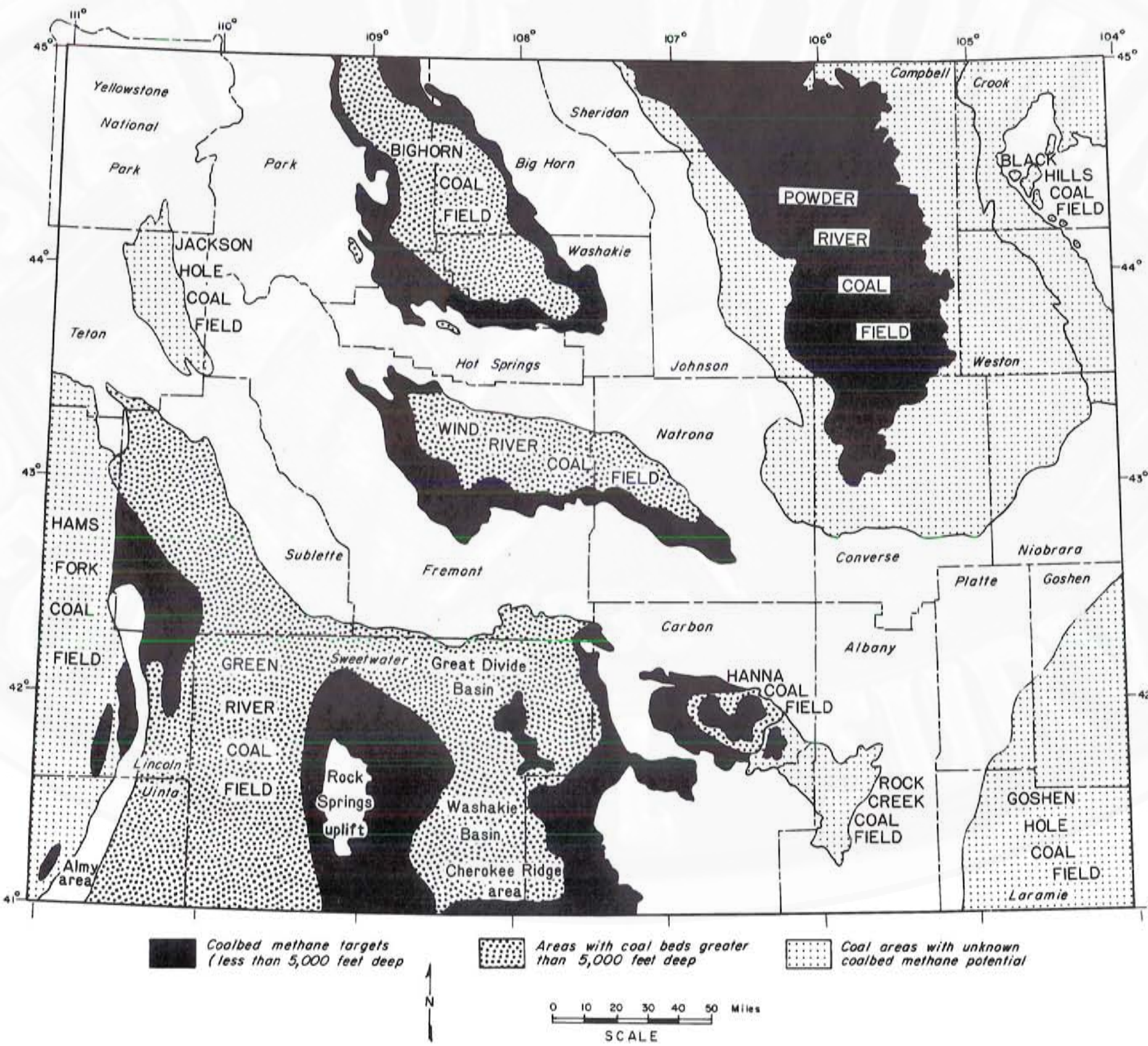

Figure 3. Exploration targets for relatively shallow coalbed methane (less than 5,000 feet deep).

less than 5,000 feet deep to be the primary targets for initial exploration in the Green River Coal Field; the present report applies this depth limit to other Wyoming coal fields as well. Below this depth limit, and possibly even below 3,500 feet (Eddy, 1980), viscoelastic properties of coal beds may inhibit effective production of methane directly from the coal beds.

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 Frontier, Adaville, and Mesaverde formations under less that 5,000 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. In the remainder of the Hams Fork Coal Field, the data are inadequate to define any additional exploration targets and therefore the potential for coalbed methane is unknown.

Cretaceous and Tertiary coal beds that crop out around the Rock Springs uplift are also considered to be exploration targets to a depth of 5,000 feet (McCord, 1980). Several areas that contain thick, shallow, subbituminous Tertiary coal beds in the south-central part of the Great Divide Basin and in the eastern and southern Washakie Basin may be exploration targets for biogenic coalbed methane. Coalbed methane targets are also located in the Almond Formation (uppermost part of the Mesaverde Group) to depths of 5,000 feet in the eastern Washakie and Great Divide Basins and along Cherokee Ridge in the southern Washakie/northern Sand Wash Basins. 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.

Exploration targets for coalbed methane in the Wind River and Bighorn coal fields are defined primarily by coal beds in the Mesaverde Formation that are under less than 5,000 feet of cover.

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 5,000 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 thick, numerous, laterally continuous, relatively shallow (less than 3,000 feet deep) Tertiary coal beds. The primary exploration targets for this basin 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) of the Wyodak and equivalent coal beds. 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.

Summary and conclusions

Coalbed methane is one of the major components of the volatile matter driven off during the coalfication of humic material through time. Methane is retained in coal beds as gas molecules absorbed in and adsorbed on coal particles, as free gas in fractures and pores of the coal, and as dissolved gas in formation water.

In Wyoming, methane found in coal beds and associated rocks is derived from both relatively shallow, low-temperature coalification dominated by biogenic processes and deeper, higher temperature coalification dominated by thermogenic processes. To date, the presence of coalbed methane in the State's coal fields has been documented directly in a small number of drill holes, coal cores, and producing coalbed methane wells. Inferences of the presence of coalbed methane in unexplored (undrilled) areas of Wyoming are based on indirect evidence such as surface venting, blowouts of shallow coal exploration holes, gas-related explosions and fires in underground coal mines, data on coal rank, and thermal histories of coal fields.

Biogenic coalbed methane is found at relatively shallow depths in coal beds and in sandstone reservoirs associated with coal beds. Although much of this methane occurs in low-rank coals with low gas yields (less than 100 cubic feet of gas per ton of coal), the great number of coals and the exceptional thicknesses of some coals in many of Wyoming's coal-bearing areas indicate a large in-place methane resource.

In addition, thermogenic coalbed methane probably exists in nearly all the coal fields of Wyoming. It is associated with higher rank coals that have been or are presently more deeply buried [and (or) have been more thermally metamorphosed] than low-rank coals. Although these coals are usually not as thick as the shallower lower rank coals, their methane content is probably higher (exceeding 500 cubic feet of gas per ton of coal in western Wyoming). The deeply buried coals that exist in some coal-bearing areas of Wyoming may be a source for coalbed methane that has been trapped either in the coal or in reservoir rocks associated with the coal.

Our estimate of in-place coalbed methane resources in Wyoming ranges from 7.25 to 145.0 trillion cubic feet. The wide range in this estimate reflects very limited data on the gas content of coal beds and is based on very conservative assumptions for regional or statewide gas contents per ton of coal. Hopefully, more accurate estimates of coalbed methane resources for Wyoming can be made as more exploration and research occurs in the State and the necessary basic data become available.

Active exploration for coalbed methane in Wyoming is now proceeding in the Powder River Coal Field, where exploration is occurring in thick Fort Union Formation coals and sandstones; in the Green River Coal Field, where exploration is concentrated on the flanks of the Rock Springs uplift and in the southern and southeastern Washakie Basin; and in the Hanna Coal Field. Commercial production of coalbed methane in the Powder River Coal Field indicates that at least part of Wyoming's vast resource of coalbed methane is currently economically viable.

The future development of coalbed methane in Wyoming depends on several factors: the price of and the demand for natural gas, the availability of transportation to markets, production tax credits, and the proper disposal of production waters. This resource has the potential to become a very significant part of Wyoming's energy industry.

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STATE OF WYOMING

1933

GEOLOGICAL SURVEY

Coalbed Methane in Wyoming

PIC 30

Geology -- Interpreting the past to provide for the future