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Assessment for undiscovered resources of coalbed methane in nine Wyoming BLM wilderness study areas

By

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards or with the North American Stratigraphic Code.

[1]Denver, Colorado

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ABSTRACT

Assessments of coalbed methane potential were made of the Adobe Town (WY-030-401/418), Buffalo Hump (WY-04-306), Cedar Mountain (WY-010-222), Devils Playground (WY-040-401), McCullough Peaks (WY-010-335), Oregon Buttes (WY-040-324), Raymond Mountain (WY-040-221), Sand Dunes Addition (WY-040-307), and Twin Buttes (WY-040-402) Wilderness Study Areas. The Sand Dunes Addition Wilderness Study Area has high potential for coalbed methane, the Buffalo Hump Wilderness Study Area has moderate potential, and the Raymond Mountain Wilderness Study Area has unknown potential. The Adobe Town, Cedar Mountain, Devils Playground, McCullough Peaks, Oregon Buttes, and Twin Buttes Wilderness Study Areas have low potential for coalbed methane.

INTRODUCTION

At the request of the Bureau of Land Management on August 13, 1991, an assessment was made for coalbed methane in nine wilderness study areas. This report presents these evaluations as a supplement to previously reported mineral and energy resource assessments made by the U.S. Geological Survey. Figure 1 shows the locations of the study areas and their relations to the coal fields of Wyoming. Table 1 is a list of the study areas showing the coalbed methane potential assessments, with their degrees of certainty, that resulted from the present study and referencing the original mineral resource assessments studies.

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ASSESSMENTS FOR COALBED METHANE

Character of the Resource

The presence of methane-rich gas in coal beds has long been recognized because of explosions that have occurred during underground mining. In addition, coal has been considered as a source of mainly nonassociated gas that has accumulated in adjacent reservoirs in many basins. Recently, coalbed gas has been recognized as a large, relatively untapped energy resource with the coal beds serving as both the source rock and reservoir rock. Active exploration for the coalbed gas has been encouraged by a federal tax credit given for the

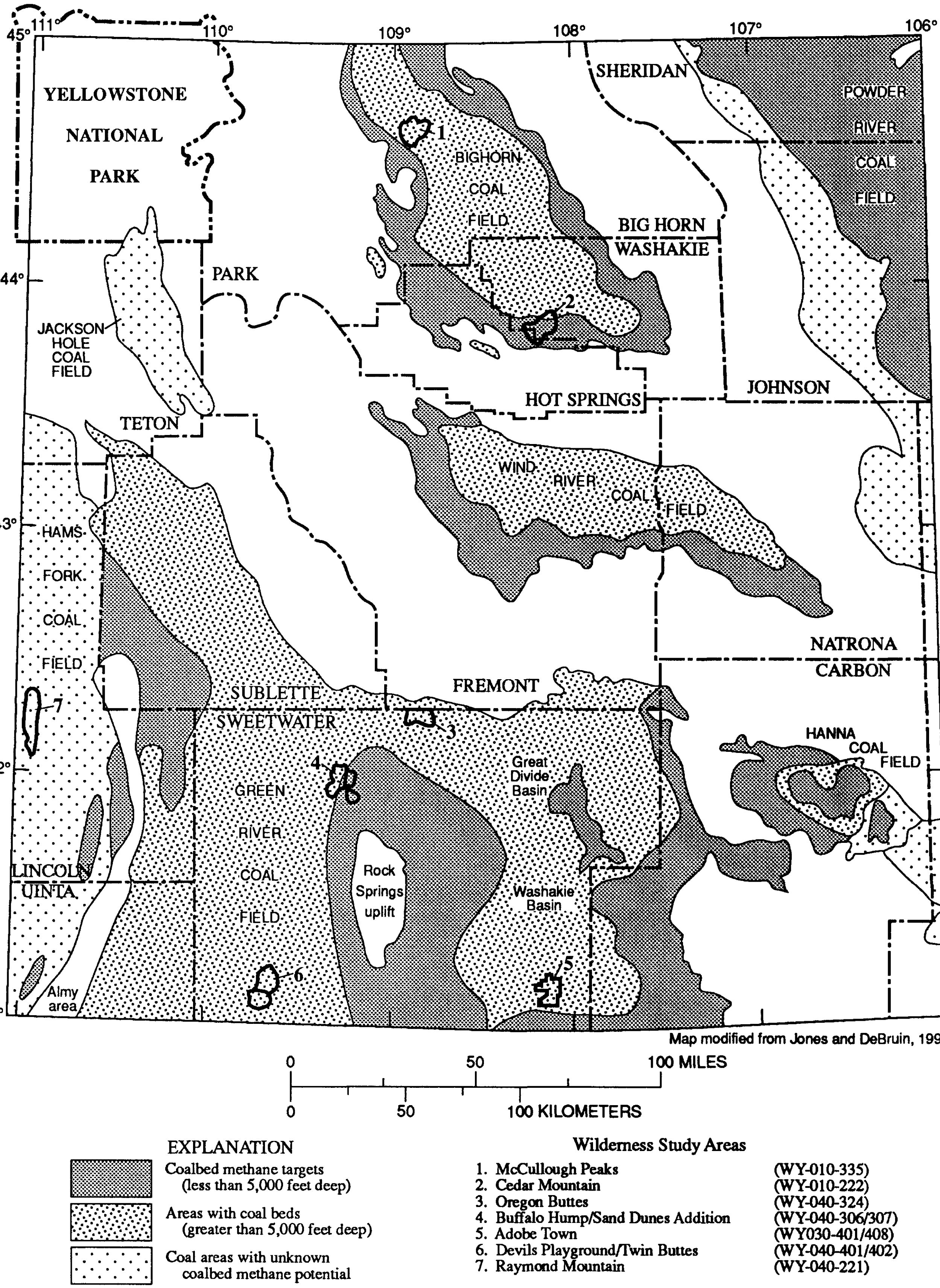

Figure 1.—Map of part of Wyoming showing the location of nine Wilderness Study Areas and major coal fields.

Table 1. *Coalbed methane potential, certainty ratings and references to previous studies for nine wilderness study areas in Wyoming*

Locality No. (fig. 1)	Area name	BLM No.	Resource potential	Level of certainty	Reference[1]
1	McCullough Peaks	WY-010-335	Low	C	Hadley and others, 1990, USGS Bulletin 1756-F.
2	Cedar Mountain	WY-010-222	Low	B	Larsen and others, 1988, USGS Bulletin 1756-B.
3	Oregon Buttes	WY-040-324	Low	C	Gibbons and others, 1990a, USGS Bulletin 1757-J.
4	Buffalo Hump	WY-040-306	Moderate	B	Gibbons and others, 1990b, USGS Bulletin 1757-G.
	Sand Dunes Addition	WY-040-307			Do.
	Northern part		High	B	
	Southern part		High	C	
5	Adobe Town	WY-030-401/408	Low	C	Van Loenen and others, 1990, USGS Bulletin 1757-H.
6	Devils Playground	WY-040-401	Low	C	Van Loenen and others, 1991, USGS Bulletin 1759-C.
	Twin Buttes	WY-040-402	Low	C	Do.
7	Raymond Mountain	WY-040-221	Unknown	A	Lund and others, 1990, USGS Bulletin 1757-I.

[1]Complete citation in References cited section.

production of gas from coal beds. Current estimates of in-place coalbed gas in the conterminous United States are as much as 400 trillion cubic feet (Tcf) (ICF Resources Inc., 1990) and a recent assessment of the recoverable resource is as much as 145 Tcf (Potential Gas Committee, 1991). A large part of the gas resource is in western U.S. basins where the coal beds are of Cretaceous and Tertiary age.

Some fundamentals of generation, storage, production, and assessment of coalbed gas are summarized below. More details are provided by Meissner (1984), Rightmire (1984), Petroleum Information, Inc. (1986), Ayers and Kelso (1989), and Kuuskraa and Brandenburg (1989).

Methane, carbon dioxide, and water are the main byproducts of the coalification process. The major stage of thermal methane generation by devolatilization of coal is estimated to begin with attainment of high-volatile bituminous rank. In addition, significant amounts of biogenic gas can be produced by the decomposition of organic matter in relatively low rank coals by anaerobic bacteria.

Most of the gas in coal beds is probably stored on the internal surfaces of the organic matter by molecular attraction (adsorbed) or within the molecular structure of the coal (absorbed). The volume of methane stored in coal is a function of rank, pressure, and temperature. In general, coals of increasing rank have higher sorptive capacities.

Reservoir properties of coal beds are complex and differ considerably from those of conventional reservoirs. Coal is essentially impermeable, except for the cleats (fractures), which provide the primary network for gas flow through the coal to the wellbore. The cleats in coal beds are thought to result from (1) dehydration and devolatilization and (2) tectonic stresses. The openness of the cleats, and hence the permeability of the coal, decrease with increasing pressure and depth of burial.

Primary targets for coalbed methane exploration should be within 5,000 ft of the surface (McCord, 1984; Jones and DeBruin, 1990). Below this depth and possibly at even shallower depths, permeability in coal beds decreases because of the sensitivity of the coal to pressure.

Gas stored in coal is generally held by the hydrostatic pressure of the water saturating the coal bed. The source of the water may be either inherent moisture or may be ground water, inasmuch as coal beds are generally good aquifers because of the well-developed cleats. Gas production is initiated by dewatering the coals, which results in reduction of hydrostatic pressure.

Methodology of Assessment of Potential

The assessment of coalbed gas potential of an area requires data, if available, on the correlation, areal extent, thickness, and rank of the coal, its gas content, and depth. The combination of these data forms the basis for identification of the areas with the best potential and for the assessment of the in-place coalbed gas resource. Knowledge of reservoir properties, pressure, temperature, ash content, hydrologic regime, tectonic setting, and depositional setting are also valuable in estimating the amount of the coalbed gas and its recoverability.

In the wilderness study areas whose coalbed methane potential was evaluated for this report, relevant information for each area included only data from a few sites on the rank, thickness, and depth of coal. In most cases, rank of coal had to be inferred from stratigraphic position. However, inasmuch as the rank of contained coal can be derived directly from the thermal maturity of the sedimentary section, rank of deeply buried coal was estimated from thermal maturity data wherever possible. Table 2 diagrams the way in which rank, thickness, and depth of burial of coal present in an area were used to evaluate the area's coalbed methane potential.

Coal Rank				
	≥ Low-volatile bituminous	very thin[a] <5[b]	thin 5-10	fairly thick >10
	High-med. volatile bituminous	very thin <10	thin 10-15	fairly thin >15
	≤ Subbituminous	fairly thin <20	fairly thick 20-40	very thick >40

gas generation ↓ gas generation ↓

Little Gas	Considerable Gas	Much Gas	Depth	Gas Extractability (In indicated depth-of-burial zones)
			500	
Low Potential	Moderate Potential	High Potential		Good
			5,000	
Low Potential	Low Potential	Moderate Potential		Fair
			10,000	
Low Potential	Low Potential	Low Potential		Poor
			15,000	

[a] -coal thickness in a single bed or close-spaced zone

[b] -all dimensions in this table are in feet

Table 2. Estimation of coalbed methane potential on the basis of gas abundance, indicated by rank and thickness of coal, and gas extractability, indicated by depth of burial. To estimate potential, begin at upper left with observed rank of coal, then read right to observed thickness of coal in order to place occurence in appropriate gas abundance column. Read down in that column through depth ranges to the range that includes observed burial depth of coal to find coalbed methane resource potential. Rank of coal is emphasized as a codeterminant of gas abundance because of the rapid increase in amount of gas generated with increasing rank. Emphasis on burial depth as prime determinant of gas extractability reflects progressive decrease in natural fractures in coal, through which contained gas can flow to a wellbore, as the depth of burial increases.

Assessments of Individual Study Areas

McCullough Peaks Wilderness Study Area (WY-010-335)

The geology and mineral resources of the McCullough Peaks Wilderness Study Area (Area 1 of figure 1) are discussed by Hadley and others (1990). The study area has a low potential for undiscovered resources of coalbed methane with a certainty level of C (see table 3 for explanation of terminology of resource potential and certainty levels). In the sedimentary section underlying the area, the uppermost 6,000 feet contains only low-rank coal in widely spaced beds five feet or less in thickness. Of the drill holes studied, Gulf Oil Company No. 1 Red Point, located in the northeast part of the study area, contains the most coal. It penetrates 17 coal beds in the uppermost 6,000 feet of section, but the aggregate thickness of coal in beds 30 inches or more thick is only about 55 feet (Robert T. Ryder, U.S. Geological Survey, oral communication, 1991). Indicated coals at 7,916-7,923 feet, 9,323-9,331 feet, 9,582-9587 feet, and 9,881-9,889 feet are in the Fort Union Formation of Tertiary age and the Lance Formation of Late Cretaceous age. Coals at these depths are probably high-volatile bituminous to medium-volatile bituminous in rank (Hadley and others, 1990). As such, they would have generated more gas than the shallower coals. However, as indicated on table 2, these coals represent only a low potential for coalbed methane because of their depth of burial.

Cedar Mountain Wilderness Study Area (WY-010-222)

The geology and mineral resources of the Cedar Mountain Wilderness Study Area (Area 2 of figure 1) are discussed by Larsen and others (1988). The study area has a low potential for coalbed methane with a certainty level of B. Resistivity and spontaneous potential logs of drill holes in and near the study area indicate as many as six coals from 7 to 15 feet thick in the upper 5,000 feet of section. These coals, in the Fort Union Formation of Tertiary age and the Lance and Meeteetse Formations of Late Cretaceous age, would be of subbituminous rank. Owing to their thinness, they would have generated little gas. A coal indicated at 7,770-7,780 feet depth in California Company drill hole Neiber Unit #3 in section 14 of T. 45 N., R. 93 W., is apparently in the Mesaverde Formation (Upper Cretaceous). At its depth of occurrence, this 10-foot coal might be bituminous in rank and could have generated considerable gas (table 2). However, this particular coal may not occur anywhere in the study area inasmuch as it was observed only in this drill hole, which is about 3 miles east of the study area. No Mesaverde coal is indicated on geophysical logs of drill hole Winchester Unit #1 of Sinclair Oil and Gas Company, located very near the east boundary of the study area in section 29, T. 45 N., R. 93 W. Thus what is known of the rank, thickness, and burial depth of coal in the study area indicates a low potential for coalbed methane (see table 2).

Oregon Buttes Wilderness Study Area (WY-040-324)

The geology and mineral resources of the Oregon Buttes Wilderness Study Area (Area 3 of figure 1) are discussed by Gibbons and others (1990a). The study area has a low potential for coalbed methane with a certainty level of C. Geophysical logs of the Davis Oil Company Musketeer Unit #1 well, located near the west boundary of the study area in section 8, T. 26 N., R. 101 W., indicate no coal above 5,000 feet depth. Thin coals at 5,478-5,482 feet and 5,536-5,539 feet depth are probably in the Fort Union Formation of Tertiary age. At these depths in this area, the coals are probably bituminous, to judge from thermal maturity data in Merewether and others (1987). Six coals in the thickness range 5 to 10 feet are indicated between 9,000 and 10,000 feet depth. These deep coals are probably in the Almond Formation of the Mesaverde Group (Upper Cretaceous) and, at this depth, are likely of high-volatile bituminous rank. However, this rank in coals of their thickness and depth is consistent only with a low potential for coalbed methane (table 2).

Buffalo Hump (WY-040-306) and Sand Dunes Addition (WY-040-307) Wilderness Study Areas

The geology and mineral resources of the Buffalo Hump and Sand Dunes Addition Wilderness Study Areas are discussed by Gibbons and others (1990b). The southern part of the two-part Sand Dunes Addition Wilderness Study Area (Southern part of Area 4 of figure 1) has a high potential for coalbed methane resources with a certainty level of C. The northern part of the Sand Dunes Addition Wilderness Study Area also has high potential, but with certainty level B. The Buffalo Hump Wilderness Study Area has a moderate potential for coalbed methane with a certainty level of B.

Near its eastern boundary, and possibly over most of its extent, the southern part of the Sand Dunes Addition Wilderness Study Area is underlain at depths of less than 5,000 feet by bituminous coal of the Rock Springs Formation (Upper Cretaceous) in beds 5 feet or more in thickness. On the basis of table 2, a high potential for coalbed methane is justified. Kelso and others (1991) detail an evaluation of a coalbed methane resource in the Rock Springs Formation at a location about 15 mi southeast of the study areas.

The block of acreage comprising the northern part of the Sand Dunes Addition Wilderness Study Area and the Buffalo Hump Wilderness Study Area is underlain by numerous coal beds at depths of less than 10,000 ft. The coal beds, which are apparently in the Fort Union and Almond Formations, include four coals ranging in thickness from 20 to 45 feet. Where penetrated by Davis Oil Company drill hole Grady Federal No. 1-Z in section 22, T. 24 N., R. 105 W., near the west boundary of the Buffalo Hump Wilderness Study Area, these thick coals occur in the depth range 5,800-7,500 feet. At this depth, Fort Union and Almond coals, normally subbituminous near the surface (McCord, 1984), are probably high-volatile bituminous in rank, as indicated by thermal maturity data in Merewether and others (1987). Updip to the east from the drill hole cited, at least the uppermost coal of the zone of thick coals should be within 5,000 ft of the surface over much of the northern part of the Sand Dunes Addition Wilderness Study Area. This area thus has a high potential for coalbed methane (table 2). The Buffalo Hump Wilderness Study Area, in which the zone of thick coals should lie between 5,000 and 10,000 ft depth, has moderate potential.

Adobe Town Wilderness Study Area (WY-030-401/408)

The geology and mineral resources of the Adobe Town Wilderness Study Area (Area 5 of figure 1) were discussed by Van Loenen and others (1990). In addition to the resources discussed in that report, the study area has low potential for undiscovered resources of coalbed methane. There are no coal-bearing strata exposed on the surface of the study area or within 5,000 ft of the surface. However, a thick sequence of Cretaceous and Tertiary sedimentary rock at depth is thought to be coal-bearing (McPeek, 1981). These rocks, where exposed around the outer edges of the Washakie basin, contain major amounts of coal, some of which has been mined (Root and others, 1973). The coal-bearing formations in this region are the Wasatch and Fort Union of Tertiary age and the Lance Formation and Mesaverde Group of Late Cretaceous age. The thickest and most extensive coals are in the Mesaverde Group and the Fort Union Formation. Most of the Tertiary-age coal and some of the Cretaceous coal is subbituminous, while that in the Rock Springs Formation of the Mesaverde Group is high-volatile bituminous coal (McCord, 1984, p. 280). Data from several drill holes adjacent to the study area indicate that the depth to the Wasatch beneath the study area is about 6,000 ft, to the Fort Union about 9,000 ft, and to the Lance about 12,000 ft (BLM files, Rawlins, Wyoming, 1989). These data show depth to the Mesaverde Group as about 16,000 ft, too deep for even a high-rank Mesaverde coal to represent anything more than a low coalbed gas potential (table 2). A geophysical log was examined, for this evaluation, from a hole drilled in sec. 28 of T. 14 N., R. 93 W. No thick beds of Tertiary-age subbituminous coal were identified between 5,000 and 10,000 ft. However, several thin beds (< 10 ft) that might be coal were noted at depths below 8,000 ft. On the basis of table 2, these coals, inferred to be low-rank, represent only a low potential for coalbed methane.

Little else is known about the nature of the coal beds beneath the study area except they contain gas because some of it has been expelled into sandstone reservoir rock overlying the coal beds. Much of the gas trapped in the Cretaceous and Tertiary sandstone reservoirs, which have a high potential for gas (Van Loenen and others, 1990), is probably derived from underlying coal beds. Due to the lack of permeability that would be expected in the deeply buried coal beds, and the lack of thick subbituminous coal at less than 10,000 ft (see table 2), the study area has low potential for undiscovered resources of coalbed methane with a certainty level of C.

Devils Playground (WY-040-401) and Twin Buttes (WY-040-402) Wilderness Study Areas

The geology and mineral resources of the Devils Playground and Twin Buttes Wilderness Study Areas are discussed by Van Loenen and others (1991). In addition, the study areas (Area 6 of figure 1) have low potential for undiscovered resources of coalbed methane with a certainty level of C. There are no coal-bearing strata on the surface or within 5,000 ft of the surface of the study areas. The study areas are located over the deepest parts of the Green River Basin, which may contain as much as 25,000 ft of Phanerozoic rock. The bulk of this rock is Cretaceous and Tertiary in age and contains coal beds throughout much of the Greater Green River Basin. However, little is known about these rocks beneath the study areas. Low rank coal occurs in the Ramsey Ranch Member of the Wasatch Formation at depths of about 5,000 ft, but the beds are thin, probably less than 10 ft thick (H.W. Roehler, U.S. Geological Survey, oral communication, 1991). If present, the high-rank Mesaverde Group coals would be at depths greater than 10,000 ft. The study areas are within a gas producing region and it is thought that much of the gas found in sandstone reservoirs is derived from the deeply buried coal (Law and others, 1989). The study areas have high potential for gas in Cretaceous and Tertiary sandstone reservoirs (Van Loenen and others, 1991). However, as indicated in table 2, the potential for coalbed methane is low because of the poor extractability, stemming from a lack of permeability, in the deeply buried coals and because of the low rank and thinness of coal beds at less than 10,000 ft depth.

Raymond Mountain Wilderness Study Area (WY-040-221)

The geology and mineral resources of the Raymond Mountain Wilderness Study Area (Area 7 of figure 1) are discussed in Lund and others (1990). The potential for undiscovered resources of coalbed methane in this study area is unknown. Coal-bearing rock of Cretaceous age crops out along the eastern edge of the study area. However, it does not extend at depth beneath the study area boundary (Lund and others, 1990). Little or nothing is known of other coals that may be present at depth. The study area is located within the Hams Fork coal field (fig. 1), characterized by Jones and DeBriun (1990) as having unknown coalbed methane potential.

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DEFINITION OF LEVELS OF MINERAL RESOURCE POTENTIAL AND CERTAINTY OF ASSESSMENT

Definitions of Mineral Resource Potential

LOW mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics define a geologic environment in which the existence of resources is unlikely. This broad category embraces areas with dispersed but insignificantly mineralized rock as well as areas with few or no indications of having been mineralized.

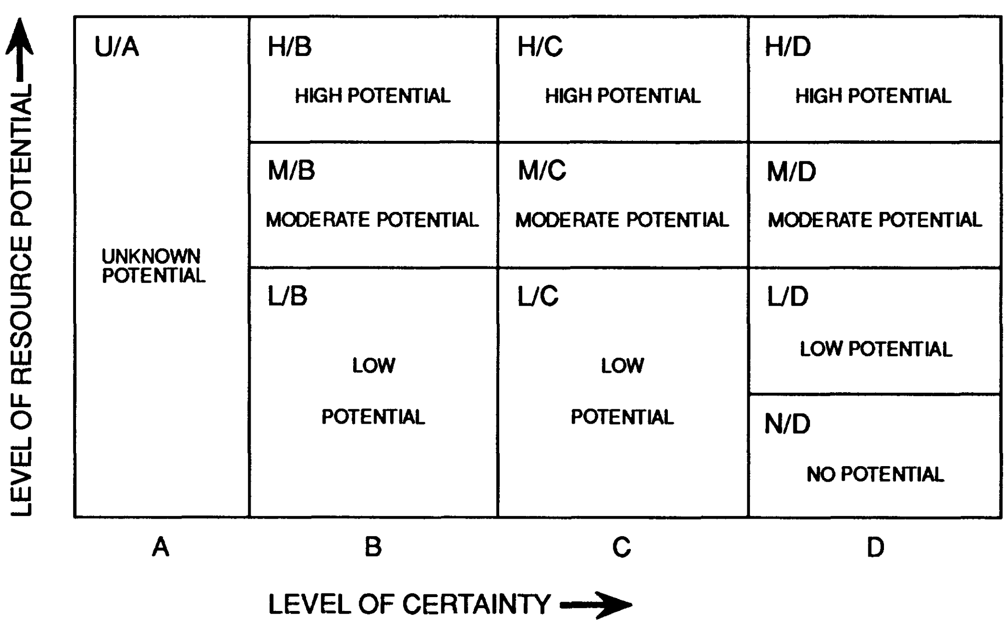
MODERATE mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a reasonable likelihood of resource accumulation, and (or) where an application of mineral-deposit models indicates favorable ground for the specified type(s) of deposits.

HIGH mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a high degree of likelihood for resource accumulation, where data support mineral-deposit models indicating presence of resources, and where evidence indicates that mineral concentration has taken place. Assignment of high resource potential to an area requires some positive knowledge that mineral-forming processes have been active in at least part of the area.

UNKNOWN mineral resource potential is assigned to areas where information is inadequate to assign low, moderate, or high levels of resource potential.

NO mineral resource potential is a category reserved for specific type of resource in a well-defined area.

Levels of Certainty



A. Available information is not adequate for determination of the level of mineral resource potential.
B. Available information suggests the level of mineral resource potential.
C. Available information gives a good indication of the level of mineral resource potential.
D. Available information clearly defines the level of mineral resource potential.