Coalbed gas systems, resources, and production and a review of contrasting cases from the San Juan and Powder River basins

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ABSTRACT

Coalbed gas has been produced commercially from the northern Appalachian basin since the 1930s and from the San Juan basin since the early 1950s. However, the magnitude and economic significance of coalbed gas resources were realized only in the 1970s and early 1980s when the U.S. Bureau of Mines, U.S. Department of Energy, the Gas Research Institute, and oil and gas operators made a concerted effort to demonstrate commercial production of coalbed gas from vertical wells. Exploration and development expanded in the late 1980s and early 1990s, due partly to an unconventional fuels tax credit. By 2000, coalbed gas accounted for 8.8% of the reserves (15.7 tcf [0.44 Tm^3]) and 9.2% of the annual production (1.38 tcf [40 Gm^3]) of dry gas in the United States. From 1989 through 2000, cumulative United States coalbed gas production was 9.63 tcf (272 Gm^3). Today, coalbed gas development has spread to about a dozen basins in the United States, and exploration is progressing worldwide.

Coal beds are self-sourcing reservoirs that can contain thermogenic, migrated thermogenic, biogenic, or mixed gas. Coalbed gas is stored primarily within micropores of the coal matrix in an adsorbed state and secondarily in micropores and fractures as free gas or solution gas in water. The key parameters that control gas resources and producibility are thermal maturity, maceral composition, gas content, coal thickness, fracture density, in-situ stress, permeability, burial history, and hydrologic setting. These parameters vary greatly in the producing fields of the United States and the world.

In 2000, the San Juan basin accounted for more than 80% of the United States coalbed gas production. This basin contains a giant coalbed gas play, the Fruitland fairway, which has produced more than 7 tcf (0.2 Tm^3) of gas. The Fruitland coalbed gas system and its key elements contrast with the Fort Union coalbed gas play in the Powder River basin. The Fort Union coalbed play is one of

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Table 1. Comparison of Coalbed Gas Reservoir Parameters and Production Characteristics, San Juan and Powder River Basins

Properties/Characteristics	Fruitland Coalbed Gas System, San Juan Basin				Fort Union Coalbed Gas System, Powder River Basin East and North Rims
	Trend 1a	Trends 1b and 1c	Trend 2	Trend 3	
Net coal thickness in belts	50–70 ft (15–21 m)	30–60 ft (10–20 m)	30–50 ft (9–15 m)	30–50 ft (9–15 m)	50 to >215 ft (15 to >65 m)
Coal thermal maturity and gas origin	High-volatile A to medium-volatile bituminous; thermogenic gas with high biogenic component	High-volatile B to low-volatile bituminous; thermogenic gas with high biogenic component	High-volatile B bituminous or lower; early stage and migrated thermogenic gas?	Mostly high-volatile B bituminous or lower; some high volatile A in north; early stage and migrated thermogenic gas	Subbituminous C–B; biogenic gas
Gas content (saturation)	Commonly >500 scf/t (mostly saturated; some undersaturated)	200–400 scf/t (undersaturated)	Mostly <150 scf/t (undersaturated)	Mostly <150 scf/t; higher in north (undersaturated)	16–76 scf/t; increase with depth (undersaturated)
Gas resources (original gas in place)	15–30 (bcf/mi^2)	15–25 (bcf/mi^2)	3–15 (bcf/mi^2)	3–15 (bcf/mi^2)	1.6–19.8 (bcf/mi^2)
Gas dryness	C_1/C_1-C_5 > 0.97	C_1/C_1-C_5 > 0.97	C_1/C_1-C_5 > 0.89–0.98	C_1/C_1-C_5 > 0.89–0.95? (limited data)	C_1/C_1-C_5 > 0.98
CO_2 content	3–13%	1–6%	<1.5%	<1.5%	Desorbed from core = 8%; production stream <2%?
Hydrologic setting	Artesian overpressure; potential for upward flow	Artesian overpressure; potential for downward flow	Underpressured	Underpressured	Normal to artesian overpressure
Water quality and disposal (San Juan basin water disposal is by injection or evaporation)	Predominantly sodium bicarbonate, low chloride, moderate to high TDS	Sodium bicarbonate type water; fresh-to-brackish; low chloride near outcrop, TDS chloride increase basinward	Sodium chloride type water; similar to seawater; TDS 14,400–42,000 mg/L	Sodium chloride type water; similar to seawater; TDS 14,400–42,000 mg/L	Fresh water; TDS 370–1940 mg/L; surface application and ranch use
Face cleat orientation	Northwest and northeast?	Northwest, into basin	Northeast, into basin	North and northeast, into basin	East-northeast on east rim; into the basin
Permeability (md)	15–60 md	10–35 md	5–25 md	< 5 md (limited data)	10 to >1000 md

Typical peak gas production rates (mcf/day);(range and median cumulative production after 5 yr)	1–6 mmcf/day (.04–8 bcf; 2.4 bcf)	50–500 mcf/day (50–700 mmcf; 200 mmcf)	30–500 mcf/day (50–700 mmcf; 200 mmcf)	<50 mcf/day? (limited data?)	130–350 mcf/day EUR 300–400 mmcf/well on 80 ac spacing
Typical peak water production rates (bbl/day)	100–300 bbl/day; higher locally	100–300 bbl/day; higher locally	0–100 bbl/day	0–25 bbl/day?	200–500 bbl/day; >1000 bbl/day in deep, thick coal
Well completions	Average depth 2600 ft Highest rate wells are open-hole cavity completions; some fracture stimulation; 320 ac spacing	750–2500 ft deep Fracture stimulation is most effective; some open-hole cavity completions; 320 ac spacing; down spacing to 160 ac	1100–1800 ft deep Fracture stimulation; 320 ac spacing	Few wells; fracture stimulation; tight; horizontal wells will be tried along southeastern margin	200–2000 ft deep; most <750 ft deep; open hole; light water fracture stimulation; no additives or proppant; most commonly 80 ac spacing; some 40 ac spacing