Oklahoma Geological Survey
Open-File Report 4–98

Oklahoma Coalbed-Methane Completions, 1988 to 1996

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1998

Unedited preprint of manuscript submitted for publication in "Pennsylvanian and Permian Geology and Petroleum in the Southern Midcontinent, 1998 Symposium"

Abstract

The coalbed-methane (CBM) industry in Oklahoma has developed rapidly since the first production of methane from the Hartshorne coal in 1988. The CBM play began in the Hartshorne coal beds (Hartshorne, Lower Hartshorne, and Upper Hartshorne; Middle Pennsylvanian) in the Arkoma basin. Completions in the Mulky and Rowe coal beds (Middle Pennsylvanian) on the northeast Oklahoma shelf began in 1994. Through 1996, there were 312 CBM completions reported in Oklahoma, 203 in the basin and 109 on the shelf. The CBM completions, separated into the Arkoma basin and the northeast Oklahoma shelf, are evaluated by coal bed, depth, initial potential gas rate, and initial produced water rate.

Introduction

Coalbed methane (CBM) was considered a hazard until the commercial production of CBM began in the San Juan basin of Colorado and New Mexico in 1977 and the Black Warrior basin of Alabama in 1980. Gas explosions in underground coal mines and underground-coal-mine safety studies by the U.S. Bureau of Mines have demonstrated that Oklahoma coals contain large amounts of methane. Commercial production of CBM in Oklahoma began in 1988 with methane production from the Hartshorne coal (depth range of 611–716 ft; initial-potential gas rate of 41–45 thousand cubic feet of gas per day, MCFGPD) from seven wells in the Kinta anticline (sec. 27, T.8N., R.20E.) in Haskell County by Bear Production. Bear Production was the only CBM operator in Oklahoma until 1991.

The following discussion of Oklahoma CBM completions from 1988 to 1996 is based on information reported to the Oklahoma Corporation Commission. Since not all of the wells are reported as CBM gas wells, some interpretation was necessary. Dual completions, including coal beds, were perforated in some wells. Therefore, not all of the wells are exclusively CBM completions. This summary is incomplete since some wells may not have been known to be CBM wells or were not reported by the time of this compilation. CBM completion data from Osage County was not available. The data for this report were compiled in the coalbed-methane completions table of the Oklahoma Coal Database and is available at the Oklahoma Geological Survey.

The coalfield in eastern Oklahoma is divided into the northeast Oklahoma shelf ("shelf") and the Arkoma basin ("basin") (Fig. 1). The commercial coal belt contains coal beds of minable thickness; coal beds in the noncommercial coal-bearing region are too thin or too deep for mining. CBM exploration has occurred in both areas.

Through 1996, there were 312 CBM completions reported in Oklahoma, 203 in the basin and 109 on the shelf. Figure 2 summarizes the history of CBM completions by year and area. The CBM play began in the basin. There were 3 CBM completions on the shelf in 1994. In 1996, there were 27 CBM completions in the basin and 70 CBM completions on the shelf, signaling increased activity on the shelf. The peak years for CBM completions in Oklahoma by area from 1988 to 1996 were 1992 in the basin (67 completions) and 1996 on the shelf (70 completions).

Figure 3 shows the main areas of CBM completions in 1988 to 1996. There are several areas in the basin and one large area on the shelf.

Arkoma Basin

Figure 4 shows the locations of CBM completions in the basin to 1998. CBM completions in the basin have been reported in Coal, Haskell, Latimer, Le Flore, McIntosh, and Pittsburg Counties. In ascending order, the coal beds producing methane in the basin in 1988 to 1996 are the Lower Hartshorne (7 wells), Upper (and Lower) Hartshorne (9 wells), Hartshorne (undivided; 181 wells), McAlester (a CBM completion in Coal County reported to be in the "Lehigh" coal is equivalent to the McAlester coal; 5 wells), and "Savanna" (Cavanal?; 1 well) of Desmoinesian (Middle Pennsylvanian) age.

Figure 5 shows the depth range (in 200 ft increments) of CBM completions in the basin. Coal was perforated at depths-to-top of coal of 598–3,026 ft (average of 1,270 ft from 202 wells). Most of the wells produce methane from the Hartshorne coal beds at depths of 600–1,800 ft.

Initial-potential CBM rates range from 3–281 MCFGPD (average of 66 MCFGPD from 164 wells). Most of the wells produce 10–120 MCFGPD, with the mode at 40-49 MCFGPD (Fig. 6). The highest initial-potential gas rates are from the Hartshorne coal. Based on 164 completions with depth and initial potential pairs, Figure 7 shows that there is no relationship between initial-potential gas rate and depth in the basin. Low gas rates (< 50 MCFGPD) span the entire depth range. The highest gas rates (> 150 MCFGPD) are from depths of 1,000–2,500 ft, not associated with the deepest completions. Theoretically, gas content increases with increasing rank, depth, and reservoir pressure (Kim, 1977; Scott and others, 1995; Rice, 1996). However, gas production depends on many variables, including gas content, water volume, cleat mineralogy, permeability, porosity, and stimulation method.

Initial produced water ranged from 0–90 barrels of water per day (BWPD; average of 9 BWPD from 130 wells) in the basin. Most of the wells produced less than 20 BWPD (Fig. 8). Most Arkoma basin CBM completions are associated with anticlines and have relatively little produced water. An undisclosed amount of initial water production is frac water (introduced during fracture stimulation).

Northeast Oklahoma Shelf

Figure 9 shows the locations of CBM completions on the shelf to 1998. CBM completions on the shelf have been reported in Craig, Nowata, Osage, Rogers, Tulsa, and Washington Counties. In ascending order, the coal beds producing methane on the shelf in 1988 to 1996 are the Riverton (2 wells), Rowe (35 wells), Bluejacket (1 well), Croweburg (4 wells), and Mulky (67 wells) of Desmoinesian (Middle Pennsylvanian) age.

Figure 10 shows the depth range (in 200 ft increments) of CBM completions on the shelf. Coal was perforated at depths-to-top of coal of 346–1,388 ft (average of 829 ft from 109 wells). Most of the wells on the shelf are in the Mulky coal (mode at 600–800 ft). The Mulky coal is the uppermost coal bed in the Senora Formation and occurs at the base of the Excello Shale Member (Hemish, 1987). The Mulky coal is gradational from coal to carbonaceous shale.

Initial-potential CBM rates range from 5–100 MCFGPD (average of 28 MCFGPD from 107 wells; Figure 11). Figure 12 shows the relationship of depth and initial-potential gas rate for the shelf; the Mulky coal occurs at depths of 346–924 ft (5–100 MCFGPD) and the Rowe coal occurs at depths of 916–1,388 ft (5–70 MCFGPD).

Initial produced water ranged from 0–200 BWPD (average of 75 BWPD from 102 wells). Produced water follows a Gaussian distribution, with a mode at 90-99 BWPD (Figure 13). Most of the water is suspected to be formation water and not frac water.

Conclusions

The Oklahoma CBM industry began in the basin in 1988. The play spread to the shelf in 1994. Through 1996, excluding Osage County, there were 312 CBM completions reported in Oklahoma, 203 in the basin and 109 on the shelf. There were nearly twice as many completions in the basin as on the shelf. The primary CBM objectives were the Hartshorne coals (197 wells) in the basin and the Mulky (67 wells) and Rowe (35 wells) coals on the shelf. There were nearly twice as many completions in the Mulky coal as in the Rowe coal.

The range in depth of the CBM completions was 598–3,026 ft (average of 1,270 ft from 202 wells) in the basin, and 346–1,388 ft (average of 829 ft from 109 wells) on the shelf. The maximum depth reported on the shelf is near the average for the basin.

Initial-potential gas rates range from 3–281 MCFGPD (average of 66 MCFGPD from 164 wells) in the basin, and from 5–100 MCFGPD (average of 28 MCFGPD from 107 wells) on the shelf. The average initial-potential gas rate in the basin is more than twice the average on the shelf.

Produced water ranged from 0–90 BWPD (average of 9 BWPD from 130 wells) in the basin, and from 0–200 BWPD (average of 75 BWPD from 102 wells) on the shelf. Clearly, produced water is a bigger problem on the shelf than in the basin.

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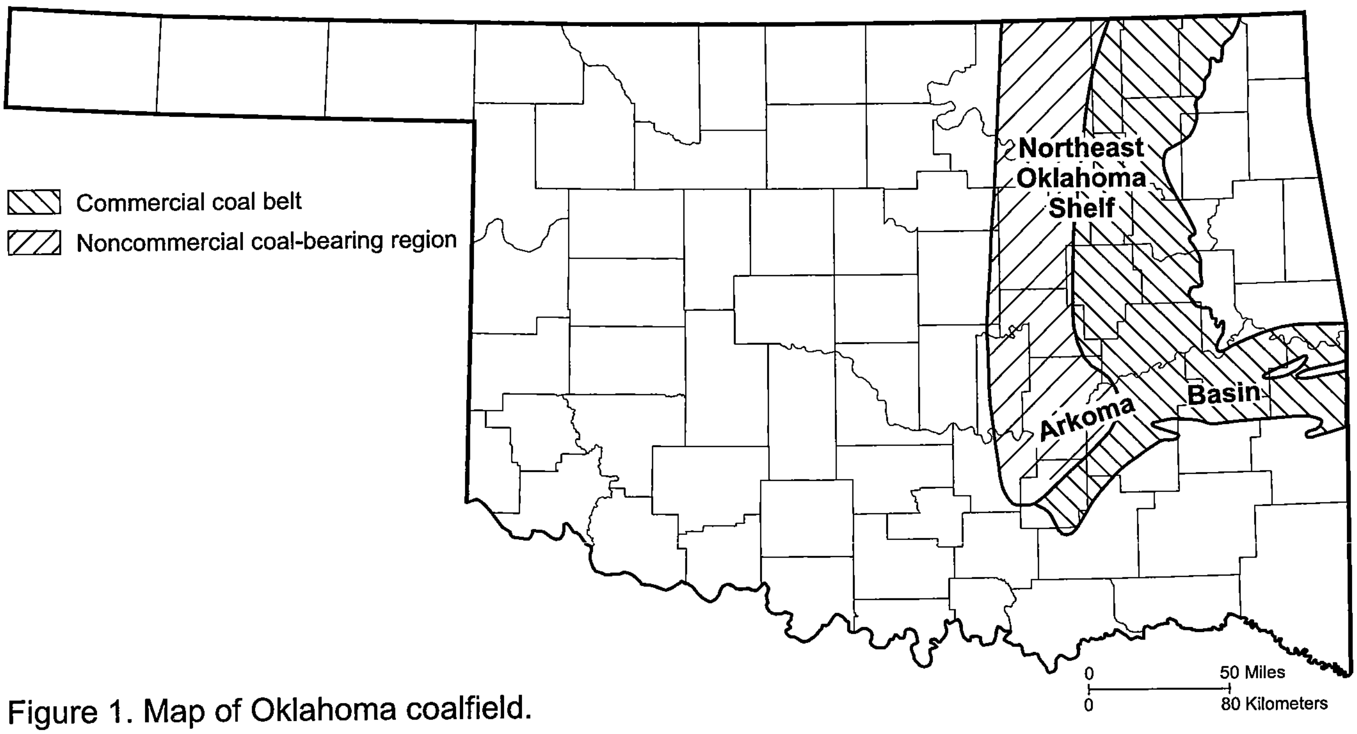

Figure 1. Map of Oklahoma coalfield.

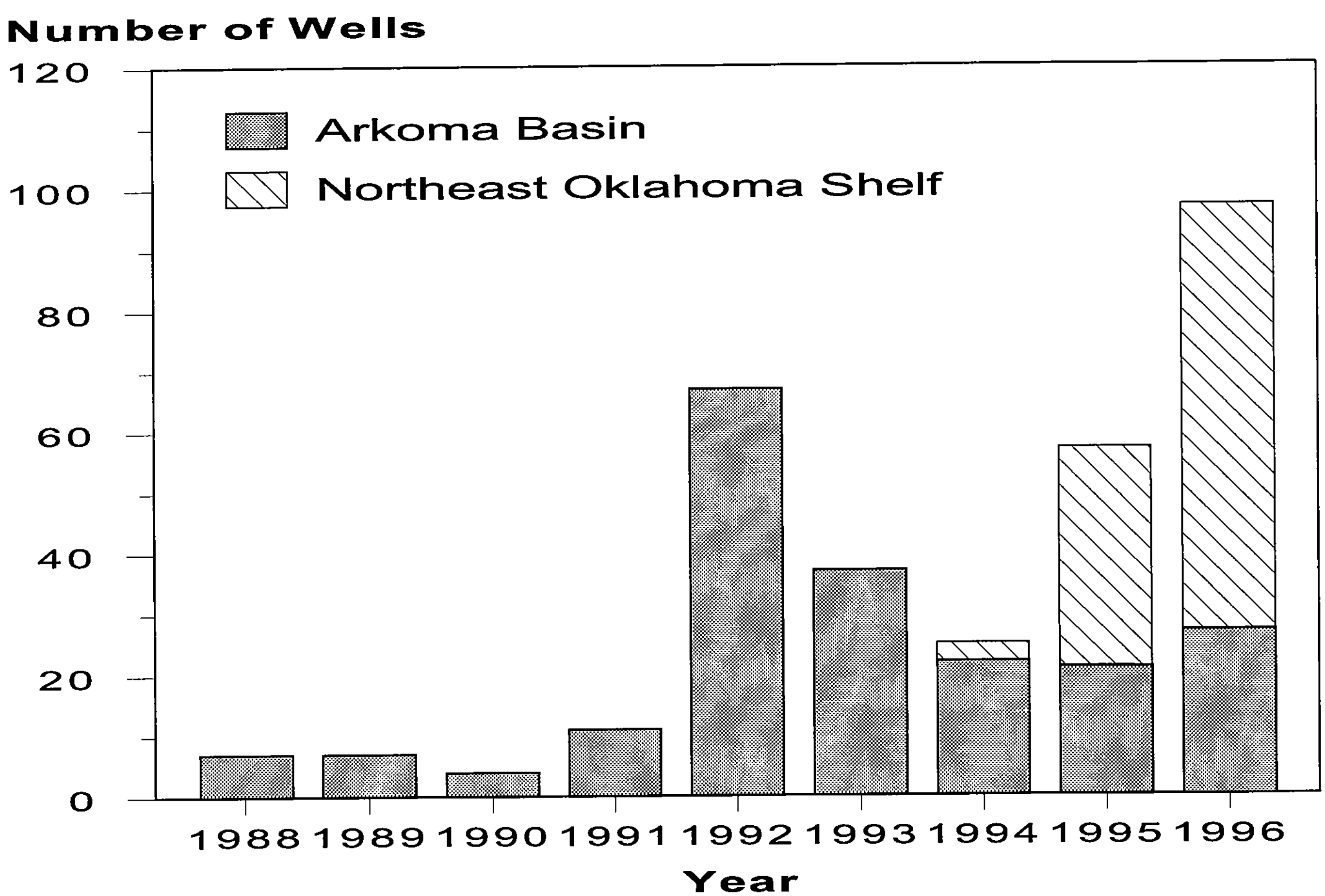

Figure 2. History of Oklahoma coalbed-methane completions, 1988 to 1996.

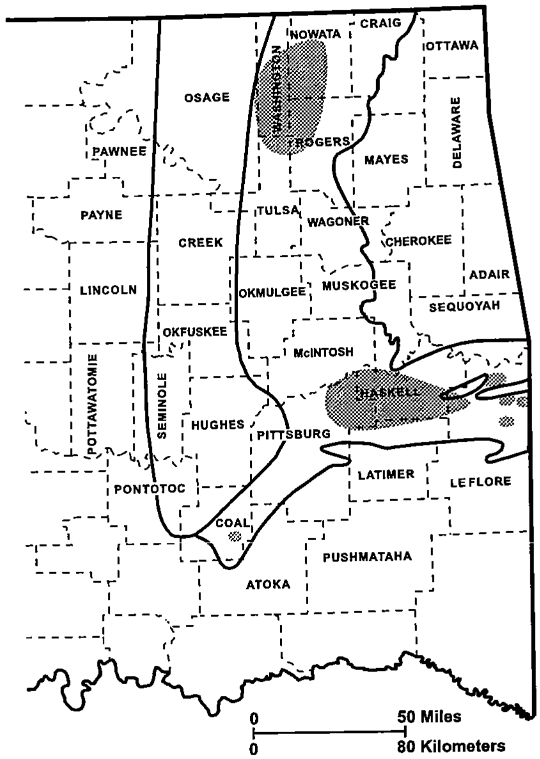

Figure 3. Map showing main areas of coalbed-methane completions, 1988 to 1996.

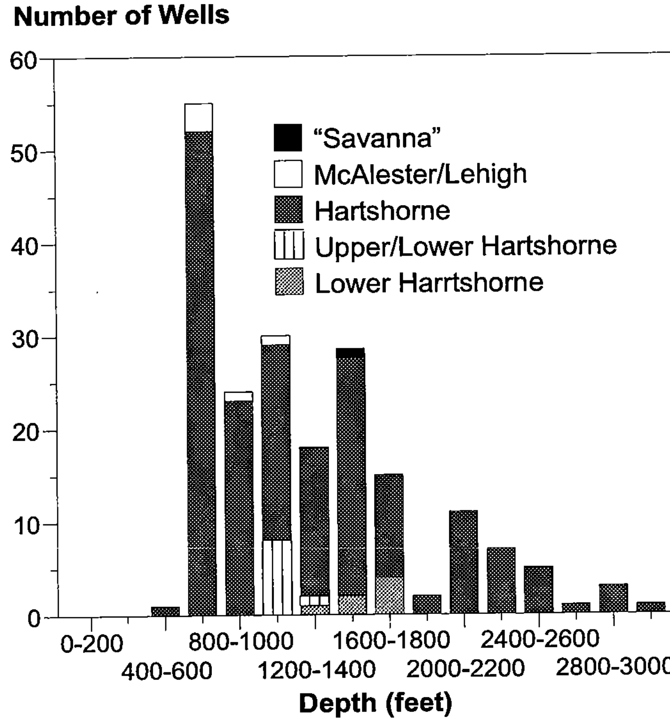

Figure 5. Histogram of coalbed-methane completions by depth and coal bed in the Arkoma basin

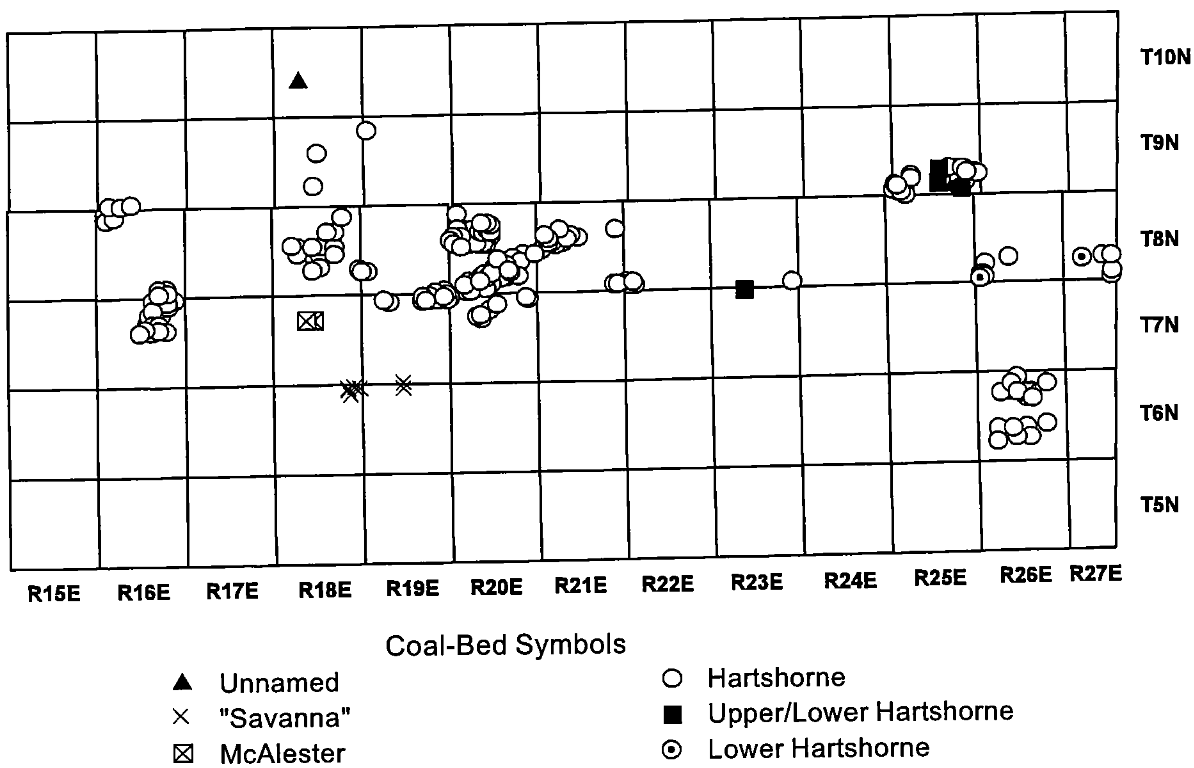

Figure 4. Map showing coalbed-methane completions in the Arkoma basin by coal bed (including completions from 1997-1998).

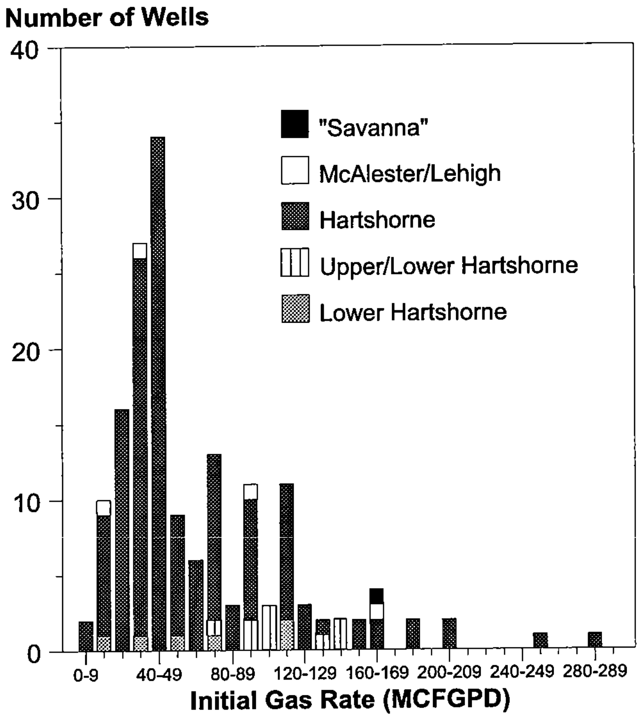

Figure 6. Histogram of coalbed-methane completions by initial potential gas rate and coal bed in the Arkoma basin.

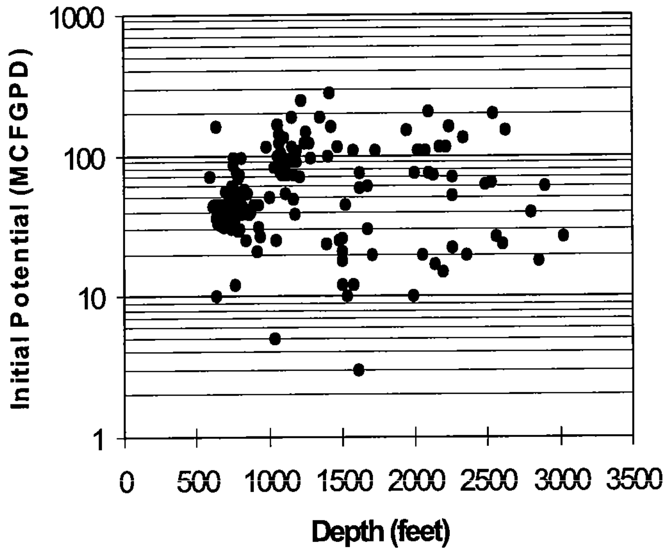

Figure 7. Scatter plot of initial potential gas rate and depth to top of coal in the Arkoma basin.

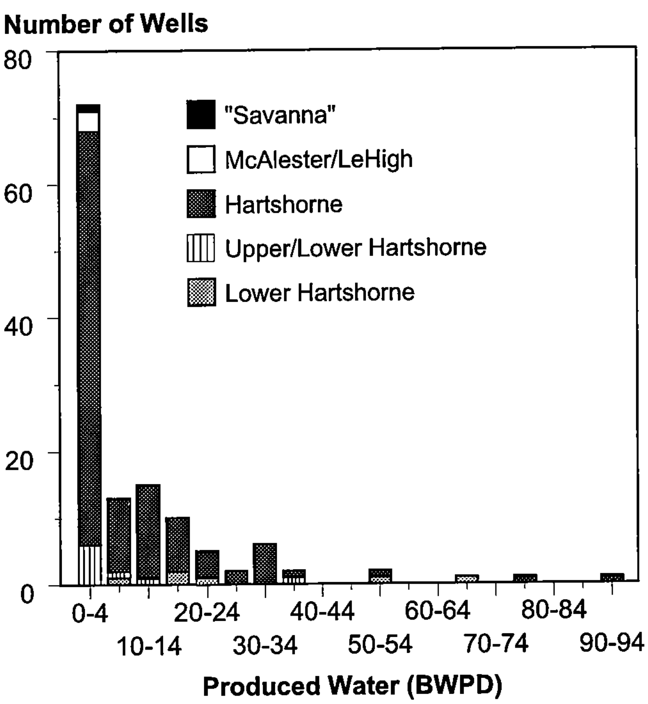

Figure 8. Histogram of coalbed-methane completions by produced water and coal bed in the Arkoma basin.

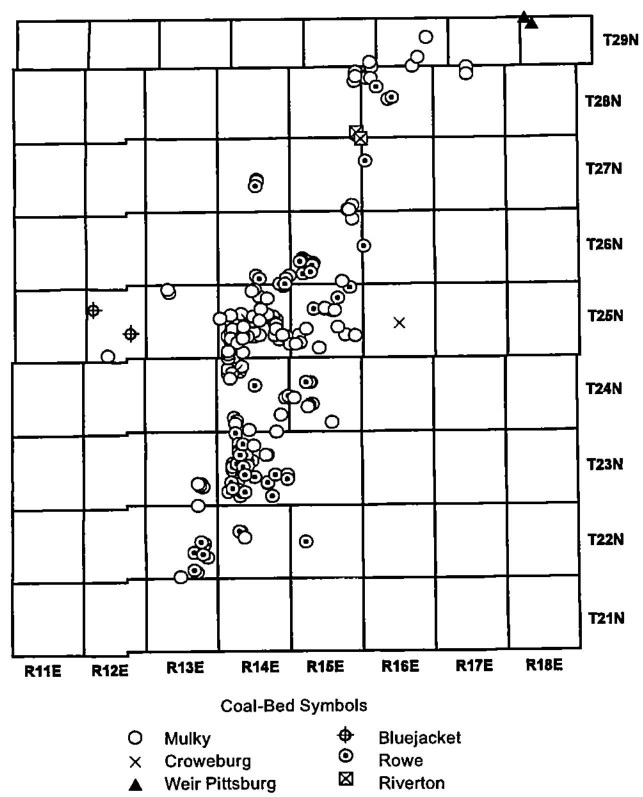

Figure 9. Map showing coalbed-methane completions in the northeast Oklahoma shelf by coal bed (including completions from 1997-1998).

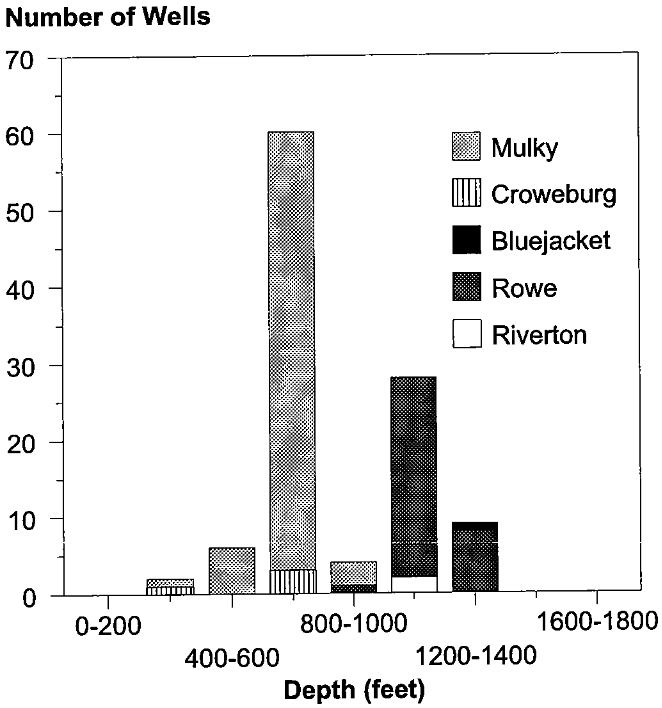

Figure 10. Histogram of coalbed-methane completions by depth and coal bed in the northeast Oklahoma shelf.

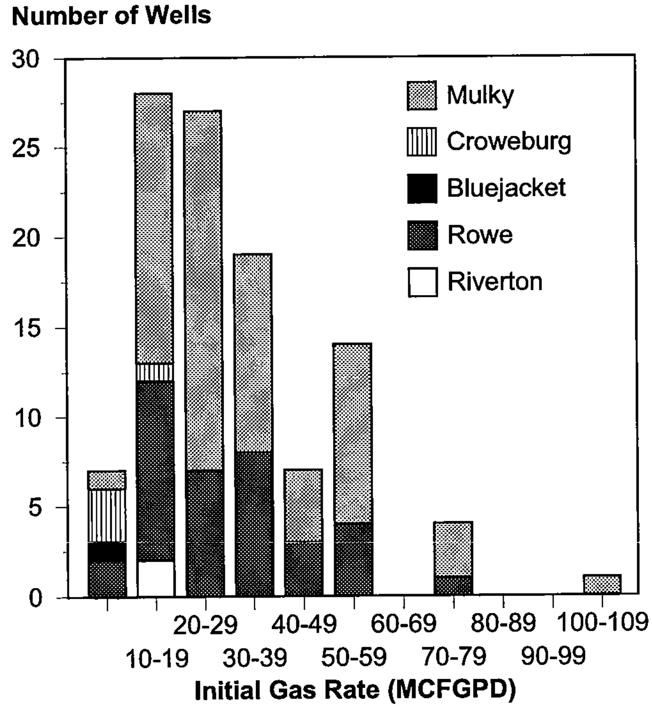

Figure 11. Histogram of coalbed-methane completions by initial potential gas rate and coal bed in the northeast Oklahoma shelf.

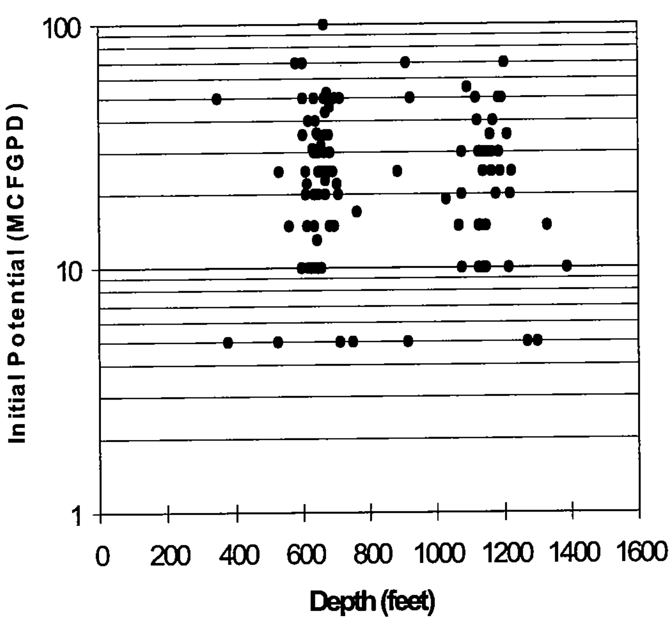

Figure 12. Scatter plot of initial potential gas rate and depth to top of coal in the northeast Oklahoma shelf.

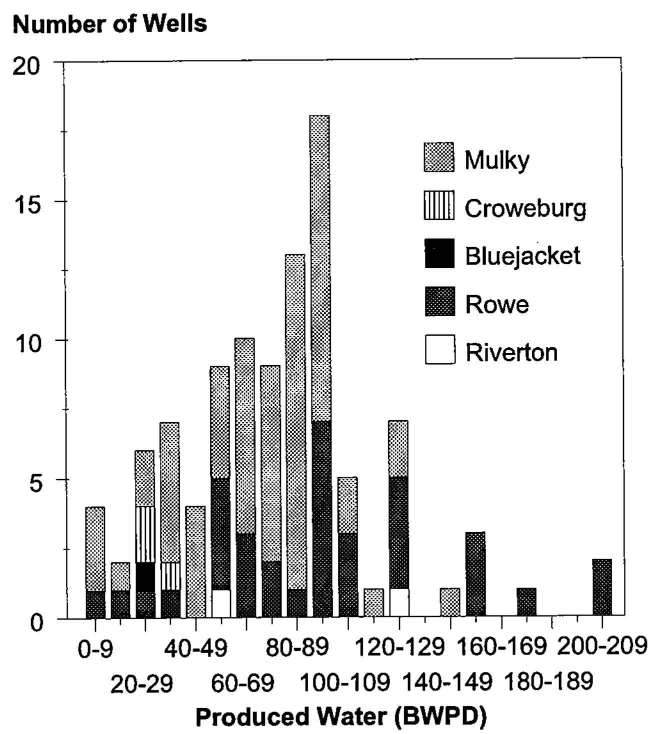

Figure 13. Histogram of CBM completions by produced water and coal bed in the northeast Oklahoma shelf.

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