Analysis of Production and Reservoir Characteristics from the Drunkards Wash Gas Field, Utah; Identification of Parameters Favoring High-Performance Gas Wells.

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Abstract

Drunkards Wash field is Utah's largest coalbed gas field, and the field has grown since its discovery in 1992 to become the largest producing gas field in the state. Parts of the field now have a mature production history of covering at least 10 years, allowing analysis of well production characteristics to help determine key parameters that might identify high-performance well locations in the greater Ferron coalbed gas fairway. Decline curve analysis was used to determine months to peak production, peak production of gas and water, estimated ultimate recoverable gas reserves, and well life for the study wells. The average exponential decline rate after peak production is achieved was found to be 19 percent, the average well life will be 18 years, and the average estimated ultimate recoverable gas reserve is estimated to be 1.75 billion cubic feet, on a per well basis. Wells with high water production tend to have correspondingly high gas production. Additional factors such as net coal thickness, average coalbed thickness, number of coalbeds, and depth to the coalbed reservoirs were compiled and analyzed; higher average coalbed thickness shows a correlation to higher ultimate recoverable reserves. In addition to tabular and graphical study of these parameters and their interrelationships, a number of these factors were mapped to examine their spatial distribution in the Drunkards Wash field.

Conclusions

Tabular, graphical, and spatial distribution studies of factors affecting gas production rates in the Drunkards Wash field led to the following conclusions:

1 - The average exponential decline rate for coal bed methane gas wells in the Drunkards Wash field is 19 % with a standard deviation of 7%;

2 - The approximate time from well completion to peak production was highly variable, but was commonly found to be three years;

3 - Wells that show high initial water production can be predicted to ultimately be good gas producers in the Drunkards Wash area;

4 - The average estimated ultimate recoverable reserves per well were calculated to be 1.75 bcf with a standard deviation of 1.43 bcf;

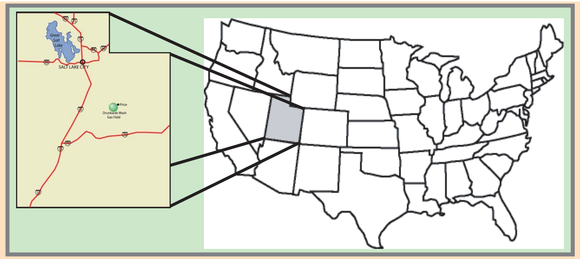
5 - Gas and water production rates for the selected wells experienced a rapid increase between 1998 and 2000, an increase believed to be due to changes in stimulation practices;

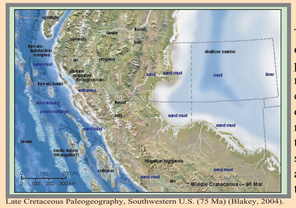
6 - Areas near local dikes and faults in the Drunkards Wash field are likely to have greater fracturing and permeability, resulting in better gas and water producibility.

7 - The Ferron coalbed gas deposit has some structural trapping component to its location. Structurally high areas have better gas producibility because of conventional trapping of migrated gas.

General Field Information

In 1991, coalbed methane drilling commenced at the Drunkards Wash unit near Price, Utah. River Gas Corporation initially operated the field with Texaco and Dominion Energy-Utah as partners (Burns and Lamarre, 1997). Located 3-5 miles from the town of Price, it is the largest coalbed methane producer and also the largest gas field in the state of Utah. The productive coals occur in the Upper Cretaceous Ferron Sandstone Member of the Mancos Shale.





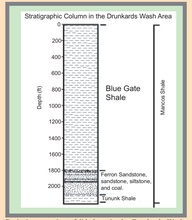
Late Cretaceous Paleogeography, Southwestern U.S. (75 Ma) (Blakey, 2004).

Geology of the Ferron Sandstone

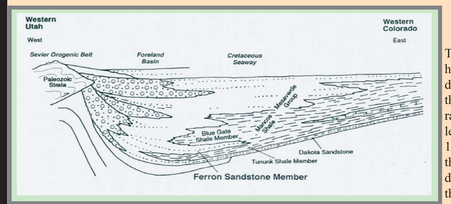
The Ferron Sandstone was mainly deposited in a river-dominated, deltaic system during late Turonian time (90 Ma). Hale and Van de Graff (1964) studied the paleogeographic setting of the Ferron and identified two deltaic systems: a northern Vernal delta and a southern Last Chance delta. The depositional character of the 100- to 400-foot-thick Ferron consists of stacked, fluvial-deltaic deposits included within a foreland sequence of alternating marine, marginal marine, and nonmarine sediments (see cross section below) shed eastward from the Cretaceous Tertiary Sevier orogenic belt (Gardner and Cross, 1994). At least seven cycles of deltaic sedimentation, each containing one coal zone or coalbed, are present in the Ferron (Ryer, 1981). The Drunkards Wash Unit occurs along the southwest margin of the Vernal delta (Burns and Lamarre, 1997).

Drunkards Wash Field and Production History

The current play was opened in 1991, when River Gas Corporation took a 92,000 ac farmout from Texaco and drilled a corehole in what later became the Drunkards Wash unit. Desorption tests on 37 ft of net coal from this well, the River Gas unit 1 (Sec. 36, T 14S, R9E), confirmed the high gas content found by Texaco and led to the drilling of several producers in the ensuing months (Montgomery et al., 2000). Three years later, a total of 89 producing wells existed in Drunkards Wash unit, and yearly production (for 1995) stood at 11.1 bcf and 5.7 million bbl water. Continued de-watering of these wells had raised the average daily gas flow per well from 310 mcf to 428 mcf during 1995, and to 491 mcf by 1997 (Burns and Lamarre, 1997). Following approval of the BLM, drilling within Drunkards Wash increased significantly, and well counts increased from around 95 wells in mid-1997 to 259 by November 1999 (Montgomery et al., 2000). As of December 2003, ConocoPhillips operated the main part of the field (487 wells), with minor holdings operated by Anadarko Petroleum (45 wells) and Marathon Oil (17 wells); cumulative production from the three parts of the field was over 438 bcf of gas.



Basic interpretation of lithology in the Drunkards Wash area. Column modified from Willis (1995).

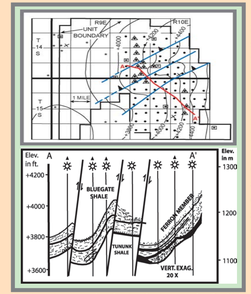


Generalized regional cross section, Cretaceous strata, central and eastern Utah. The Ferron Sandstone occurs in the lower part of the thick marine shales of the Mancos interval. Cross section modified from Armstrong (1968).

Well Completion Practices

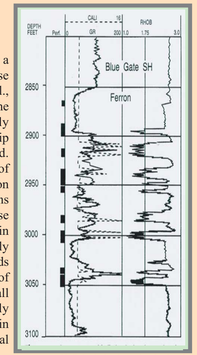
The majority of the wells are drilled with 7 7/8-in bits and 6-in air hammers (Burns and Lamarre, 1997). Air drilling is used to minimize damage to the coalbed reservoirs and to reduce overall costs. Because the overlying Blue Gate Shale is stable, drilling can proceed at high rates, for example, up to 130 ft per hour, allowing wells to be drilled in less than two days after surface casing has been set (Burns and Lamarre, 1997). The typical procedure is to drill at least 200 ft below the base of the lowest coals to facilitate logging, provide a "trap" for coal fines during production, and allow installation of pumping equipment below the productive zones (Montgomery et al., 2000). Once drilling has completed, the wells are logged, cased, perforated, and hydraulically stimulated.

Ferron Coal Structure and Characteristics

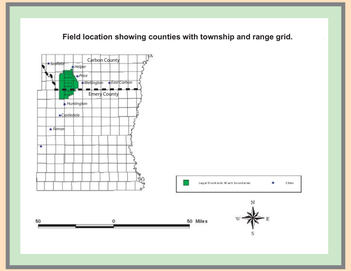


Structure contour map and northwest-southeast cross section, Drunkards Wash unit. Map is drawn using contour interval of 200 ft. Modified from Lamarre and Burns (1997).

Structurally, Ferron coals in the Drunkards Wash unit are deformed by a southwest-plunging anticline cut by several northeast-striking reverse faults that have up to 150 ft of vertical displacement (Montgomery et al., 2000). Cretaceous sediments were uplifted and tilted to the west by the Laramide-age San Rafael Uplift, which trends approximately north-south, parallel to the strike of the Ferron sediments. Beds dip monoclinally away from the uplift throughout most of the field. However, a southwest-plunging nose can be mapped near the center of the field. The reverse faults are aligned parallel to this nose. Production data suggest that these faults may compartmentalize the reservoir (Burns and Lamarre, 1997). Coalbeds in the Ferron Sandstone differ from those commonly targeted for coalbed methane exploration in that although thin and of relatively low rank, they are very high in gas content, particularly compared to other units in Rocky Mountain basins. Wells in Drunkards Wash unit commonly show 3-6 coalbeds over a stratigraphic unit of 150-200 ft. A few wells contain up to 10 or more coals, however, not all of which are productive. Isopach trends are oriented largely northeast-southwest. This orientation is orthogonal to paleoshorelines in the Last Chance delta and parallel to subparallel with those of the Vernal delta.



Gamma ray and bulk density log data and perforations for River Gas 19-151 Telonis well, a good producer (>1mmcf/day) in Drunkards Wash unit. Modified from Conway et al. (1997).



The Ferron play is one of the most successful and profitable examples of coalbed methane development in North America. Shallow target depths, low drilling and pumping costs, and existing infrastructure, coupled with gas flow rates, have made for favorable economics (Montgomery et al., 2000).

Still, many questions remain in terms of geologic controls on production in the Drunkards Wash field. Based on current production data, what production levels can be predicted on a per well basis for CBM wells in the Drunkards Wash field? What areas of the field are experiencing elevated gas production (i.e. are there any "sweet spots")? How have gas production levels changed with time? Are there geological factors that can be related to areas of high producibility?

Parts of the field now have a mature production history covering at least 10 years, allowing analysis of well production characteristics to help determine key parameters that might identify high-performance well locations in the Drunkards Wash field area.

The scope of our project was to try to answer questions in the following three specific areas:

1 - Analyze production data to determine characteristics of producing wells in the Drunkards Wash field.

2 - Graphically process the production data to identify correlations between production parameters.

3 - Observe spatial distributions of processed production data to classify field characteristics and general trends.

Our investigation results are presented in the remaining two panels.