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HART

# SHALLOW DJ GAS

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The eastern Denver-Julesburg Basin is classic prairie country. The high rolling plains of eastern Colorado, southwestern Nebraska and northwestern Kansas usually yield crops of corn, cattle and hogs. But these days, lots of shallow gas wells are sprouting up on the grass-covered hillsides.

The wells target gas in the Niobrara chalk. On the eastern flank of the basin, the Niobrara reservoir holds widespread biogenic gas deposits. The high-porosity, low-permeability chalk covers an extensive area, with commercial fields developed on sweet spots that are usually associated with structures. Since the 1970s, when development began in earnest, more than 2,900 wells have made some 470 billion cubic feet (Bcf) of gas from the Niobrara in the DJ Basin.

As in many other low-volume onshore gas plays, activity ebbed and flowed in the Niobrara in concert with gas prices. For years, modest flow rates and uninspired prices meant the wells usually could not make a grade of economic.

That book is open to a new page today. Gas prices are sturdy, and technological innovation has driven down well costs and raised success rates. Yuma County, Colorado, the heart of the play, has seen the addition of more than 800 producing wells during the past three years. The flow of gas from the county has climbed from some 62 million per day in January 2004 to more than 100 million at the close of 2006.

An active group of operators works the Niobrara, and lately the play has been in tumult as producing assets and acreage change hands.

## Colorado activity

Bakersfield, California-based Berry Petroleum Co. is one of the major operators in the shallow Niobrara. The company, which works the play from a regional office in Denver, holds three positions, says Bruce S. Kelso, Berry vice president of exploration, Rocky Mountain and Midcontinent regions.

Berry initially moved into the eastern DJ in early 2005 with a $105-million purchase of producing assets in Yuma County. Berry bought a 52% interest in 130,000 gross acres, including more than 650 producing wells, net production of 8.8 million cubic feet per day and 87 Bcf of proved reserves. It operates these properties, and has a number of partners, most notably Rosewood Resources, a private, Dallas-based independent.

Another Berry region lies in Phillips County, Colorado, immediately north of its Yuma County holdings. The properties are in a Berry-operated (50%) joint venture with Denver-based Chandler Energy (40%) and Bill Barrett Corp. (10%).

Additionally, Berry operates a joint venture with Bill Barrett Corp. that covers 368,000 gross acres, mainly in Kansas and Nebraska, with a small portion in Kiowa County, Colorado. The partners have drilled horizontal and vertical wells in their Tri-state joint venture, and shot 2-D and 3-D seismic. Barrett recently announced that the Tri-state project no longer fits its portfolio, and is pursuing strategic alternatives for its share of the venture.

Altogether, Berry holds 544,000 acres in the shallow Niobrara play and operates 915 wells, mainly in Yuma County. "Our assessment of the play is that, within Yuma County, it is a very economic, very solid play," says Kelso. Low well costs and repeatable drilling make the Niobrara almost a manufacturing play. But-and this is a considerable caveat-it's not a continuous-type play and certain areas yield far superior results than others.

One tool that has proven essential is 3-D seismic, for which Berry estimates it spends $35,000 to $40,000 per square mile. This is development-oriented 3-D: "Even if we are working an area where wells are drilled on 80-acre spacing, we'll still shoot 3-D seismic to place the 40-acre infills properly," says Kelso.

Beyond its obvious use for locating structural highs, the seismic highlights gas-charged areas in the high-porosity Beecher Island target zone in the Niobrara. Also, the reservoir is highly fractured, and seismic is used to identify fault positions. "We try to avoid intersecting faults where we would lose pay, and we also try to stay far enough away from faults so that we get good stimulations," he says.

In Berry's view, Yuma County is a development play, and areas beyond are exploratory. "We've had challenges with prospects outside of Yuma County," says Kelso. The seismic model that works so well in Yuma County doesn't translate as neatly into other areas.

Naturally, in a low-volume reservoir such as the Niobrara, strict cost control is mandatory. One method Berry prefers is the use of coiled-tubing rigs for drilling operations.

Last year, Berry drilled more than 200 wells in Yuma County with a coiled-tubing rig, and in 2005 it drilled more than 100. "It's a very efficient and appropriate application for this project," says Kelso. A coiled-tubing rig moves on location in the morning and drills a 2,500- to 2,800-foot well within six to eight hours. The wells are logged and cased, and the rig moves again the next morning. Berry drills 15 to 20 wells a month, and in 2007 it is anticipating a 165-well program.

The Yuma County wells usually encounter between 18 and 40 feet of prospective pay. Completions are single stage; the Beecher Island zone is perforated and fractured with a small stimulation of about 100,000 pounds of sand, cross-linked gels and CO2 or nitrogen.

Horizontal wells are another approach being tried in the chalk reservoir, particularly in Kansas. Results to date are mixed. Berry and Barrett jointly drilled a horizontal well in Sherman County, Kansas, but concluded that the incremental reserves did not justify the additional cost, which was three times that of a vertical well.

Initially, many of the Niobrara wells produce little or no water, but as they age, water production grows. Berry puts small rod pumps on its older wells, increasing daily production, often nearly back to initial levels. Produced water is injected into disposal wells.

All-in costs run $160,000 per well. In Berry's fairway in Yuma County, a typical well will ultimately produce up to 350 million cubic feet of gas. Occasionally, a well is quite stout and may make as much as 750 million. Clearly, the excellent finding and development costs are a fundamental attraction of the play.

A full house

Lots of companies are working throughout Yuma, Sedgwick and Phillips counties in northeastern Colorado.

In a $1.5-billion deal, Denver-based Forest Oil Corp. has committed to acquire Houston Exploration Co., a Houston-based independent with a broad position in the play. Post-merger, Forest will have 442,800 gross (329,100 net) acres in the Niobrara trend, and more than 1,890 drilling locations and 340 square miles of proprietary 3-D seismic. Separately, Forest acquired interests from Santos Ltd., a partner with Houston Exploration Co., on 145,000 gross acres.

As of May 2006, Houston Exploration was making 4.3 million cubic feet per day, gross, from 115 Niobrara wells, and had drilled more than 150 wells. A typical well had ultimate recovery of around 300 million cubic feet of gas. Production kicked off at an initial rate of 140,000 cubic feet per day and declined hyperbolically, for a well life of some 30 years. Cost per well was $230,000.

Development costs in the play are less than $1 per thousand cubic feet of gas, and Forest expects to increase activity in the area, it reported in a conference call.

"We can't really comment further on our plans until we close the transaction," says Pat Redmond, Forest director of investor relations. "We are excited-the play has very low finding and development costs and we can drill a large number of wells there."

Another hefty purchase in the Niobrara has been made by PRB Energy Inc., a Denver-based independent. At the close of 2006, the firm purchased 330,000 net acres, 12 gas wells and a water-disposal well that had belonged to Western Gas Resources for $11.7 million in cash. Western, prior to its acquisition by Anadarko Petroleum Corp. in mid-2006, had reported that 3-D seismic worked very well in identifying drilling locations in the Niobrara, but its wells encountered higher volumes of water than anticipated.

Now, PRB plans to optimize production on those wells, which lie in Phillips County, Colorado, right along the Phillips/Sedgwick county line in an area called Lone Duck Field. Nine of the wells are producing and three are awaiting pipeline hook-ups. Only three of the existing wells have artificial lift, however, and PRB plans to add artificial lift to all of the wells, says Bob Wright, chairman and chief executive.

This year, the company expects to drill some 80 Niobrara wells on its leases, which are mainly in Sedgwick and Phillips counties. It received licenses to 85 square miles of 3-D and 115 miles of 2-D seismic in the transaction, and it's putting the data to good use. "We've identified 159 locations on 3-D seismic and we're getting those locations ready. We hope to begin drilling in April," Wright says.

The company was attracted to the shallow play for several reasons. "We wanted to diversify from the

coalbed-methane play in the Powder River Basin, which has very short-lived wells that produce for seven or eight years. Niobrara wells produce for 25 to 30 years, so they provide a stable base of production."

Additionally, gas-marketing opportunities in the eastern DJ are excellent, and Kinder Morgan's Trailblazer and Pony Express lines and the proposed Rockies Express pipeline all traverse PRB's holdings.

Kansas potential

Kansas has two notable Niobrara shallow-gas producing areas, Goodland and Cherry Creek complex, in Sherman and Cheyenne counties, respectively. Well depths in Kansas are about 1,600 feet, considerably shallower than their Colorado cousins. The Kansas wells consequently cost less, but they also recover smaller volumes of gas.

Robbie Gries, president of Denver-based Priority Oil & Gas LLC, has been working in Cheyenne County on the Kansas side of the play since 1994.

The first purchases Gries made were several producing wells drilled on 640-acre spacing. "I figured if the price of gas ever went up, I could do some infill drilling," Gries says. At that time, wellhead prices were $0.68 per thousand cubic feet. "It was several years before we stopped losing money on the properties."

The tide finally turned in 1999, and Gries was able to raise funding for seismic and drilling. Priority drilled 40 wells that year, and another 35 in 2000. Only one was a dry hole. Gries credits Denver-based geophysicist Dean Lausten for the extraordinary success rate; the company uses 2-D swath seismic to site its wells.

Priority has since added another 55 wells, and opened up some new areas to development. Its wells range from 1,400 to 1,600 feet deep. The company started drilling with a conventional rig, and then switched to an adapted mining rig. For the past two years, it has used a coiled-tubing rig. "We really like the coiled-tubing rigs-they are fast and efficient and the footprints for the wells are very small," she says.

At present, Cheyenne County wells cost about $150,000, including stimulation. The wells come online at highly variable rates, from 100,000 to 300,000 cubic feet per day. Typical cumulative recoveries are 250 million cubic feet, although an occasional well will make 400 million.

"A lot of Colorado wells are put on pump, but we've chosen not to pump ours," she says. "For us, it's a huge amount of debt and expenditure to add pumps at this stage."

There's no spacing requirement in Kansas; Priority's wells average about one per 40 acres, nonetheless, on structures, based on where seismic interpretations show optimum prospects.

Priority has another 30 to 40 locations in inventory that it plans to drill at a rate of seven to 10 a year. "We still have some acreage that needs to be evaluated, so we could add to that," says Gries. "We have several more years of work out there."

An operator that has recently become quite active in the play is Bridgeport, West Virginia-based Petroleum Development Corp. The company has assembled almost 30,000 acres in Cheyenne County, Kansas, and Yuma County, Colorado, and currently operates 268 wells. Its 2006 exit rate was 10.7 million cubic feet per day, gross, and 8.5 million, net.

Currently, PDC is acquiring 50 square miles of 3-D seismic, and it has already defined eight structures on existing 3-D and swath seismic. This year, it plans to drill 141 wells. It has 107 proven undeveloped locations, 250 potential locations, and the possibility to add several hundred additional wellsites from the new 3-D shoot.

PDC reported that its shallow Niobrara wells make 280 million cubic feet of gas each, and cost $234,000 to drill and complete. Initial per-well production rates average 100,000 cubic feet per day, and decline to about 60,000 per day after a year.

Nebraska focus

Finally, several Nebraska counties are seeing activity. Denver-based Teton Energy Corp. and Houston -based Noble Energy Inc. have a joint venture that is focused in the Cornhusker State. Teton was carried by Noble for the first 20 wells drilled in the joint venture, which originally covered 182,000 gross acres. Noble has completed those wells and, going forward, Teton will have a 25% working interest and Noble will have 75%.

In addition, Teton recently purchased an additional 56,000 gross acres, about 80% of which lie within the area of mutual interest it shares with Noble. At present, Teton holds a total of 266,000 gross acres in the play.

Two Nebraska areas have been targeted by the partners: Chundy, in Chase and Dundy counties, and Grant, in Perkins County. Ten wells have been drilled in each of two pilots. The 2,000-foot wells target the Beecher Island zone and completed costs are about $200,000 each. At present, the companies are hooking the wells into pipeline sales to confirm commercial production.

If the play works, Teton has 1,200 potential locations on 160-acre spacing, although the pilots were drilled on 40s. The company expects a typical well in this area to ultimately make 200- to 300 million cubic feet of gas, and to produce at initial rates of 150,000 to 250,000 cubic feet per day.