

# Barnett Playbook



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## Barnett: *The Playbook*

From the editors of *Oil and Gas Investor*,  
*E&P*, and *PipeLine and Gas Technology*

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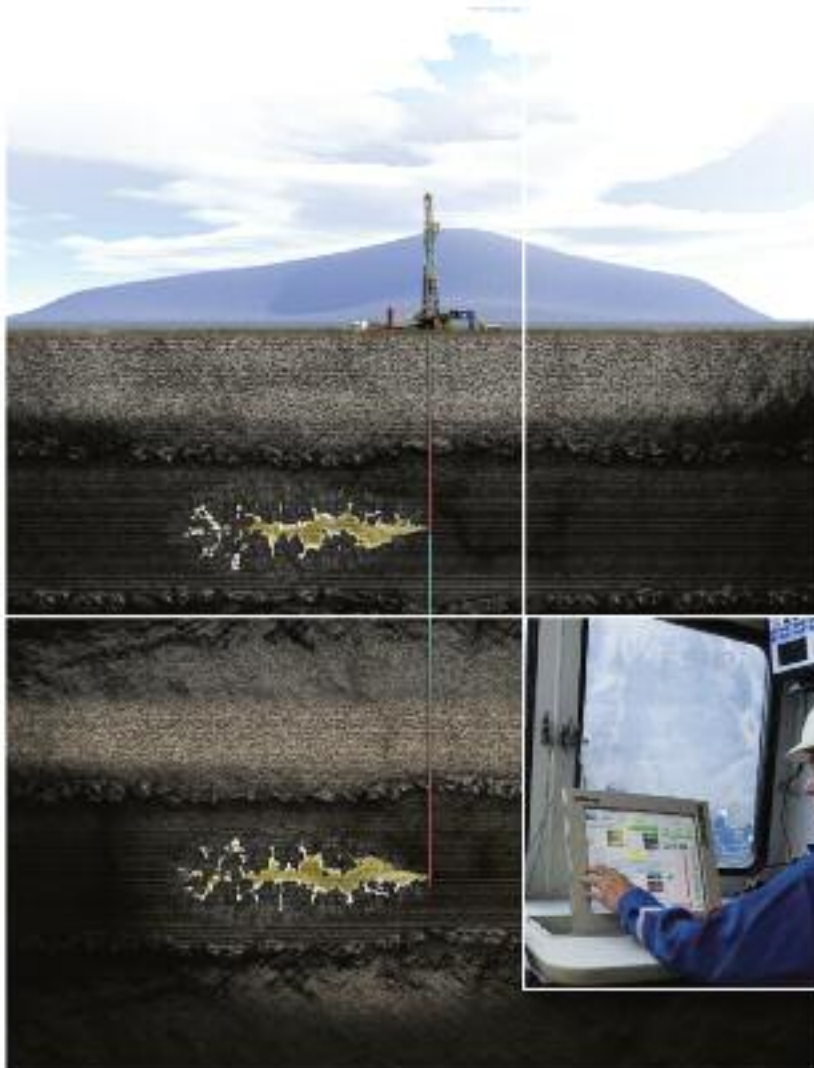
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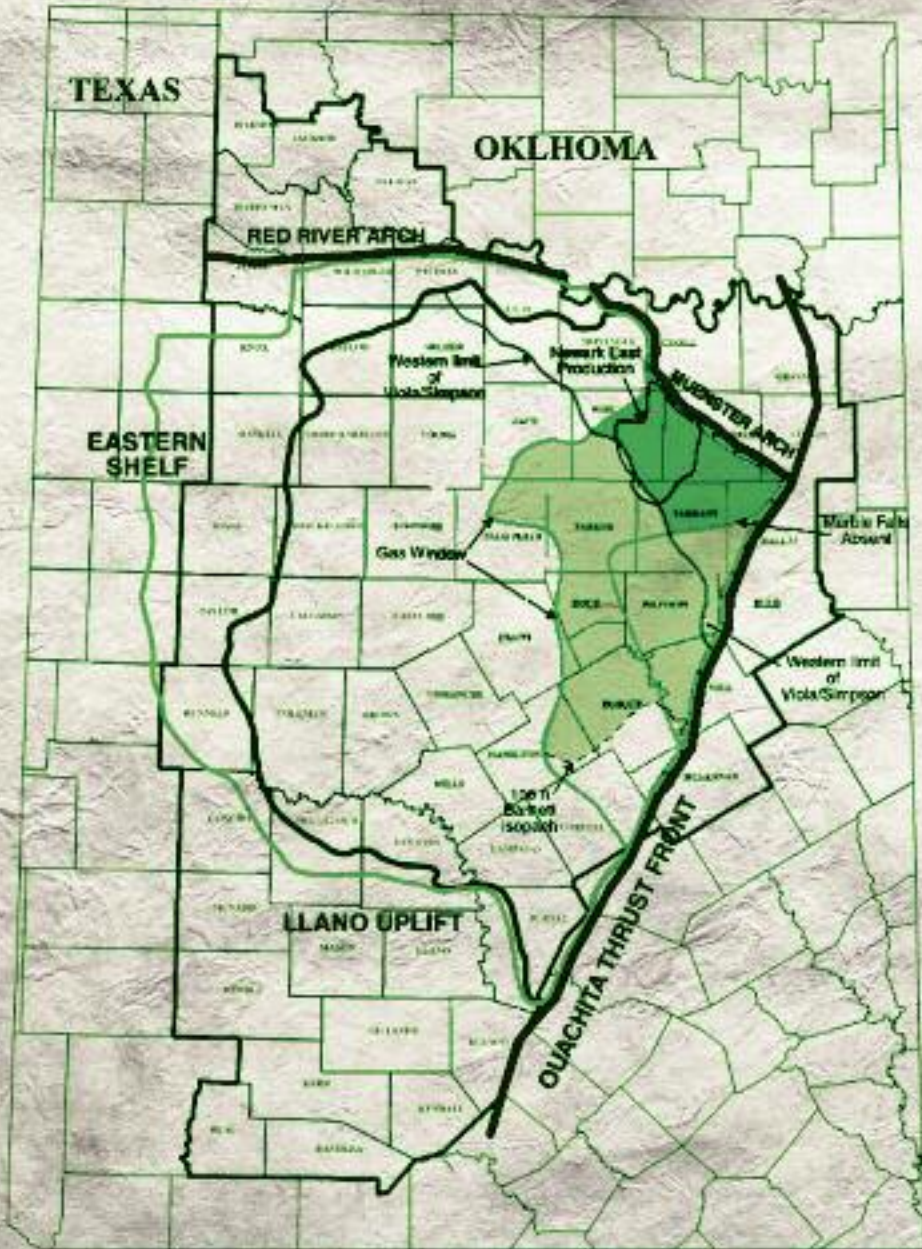
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-  USGS Province 40 Boundary - Band Arch-Fort Worth Basin
-  Barnett-Paleozoic Total Petroleum System
-  Geographic Eastern limit of Barnett Shale in Fort Worth Basin
-  Greater Newark East Frac-Barnett Continuous Barnett Shale Gas Assessment Unit
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## FORT WORTH BASIN

Source: USGS



# The Legendary Barnett

The technological advances and lessons learned during the growth of the Barnett will provide valuable insight into helping feed the global energy appetite.

**By Lisa Remington**

Geologist/Analyst, Drilling Info – Energy Strategy Partners and

**Jason Simmons**

Senior Research Analyst, Drilling Info – Energy Strategy Partners

The Barnett Shale is well known in the oil and gas industry. What once was an afterthought in domestic natural gas drilling is now one of the largest natural gas plays in North America. The facts are indisputable: 6 Tcf cumulative natural gas production, an estimated 26 to 39 Tcf of recoverable reserves, 11,000 producing wells, and a growing portion of the US natural gas supply. However, there is one more undeniable truth – the Barnett Shale now plays an important role in the development of other unconventional natural gas plays around the world. The technological advances and lessons learned during the growth of the Barnett will provide valuable insight into helping feed the global energy appetite.

## History

The Barnett Shale is named after John W. Barnett who, along with his family, settled in San Saba County during the 1870s. His family built a home near a creek, which, in turn, he named the Barnett Springs Creek. During the 20th century, geologists mapping the area noted thick black organic-rich shale in close proximity to the stream. The shale was consequently named the Barnett Shale. The Barnett Springs Ranch is currently on the original family settlement.

Production in the Fort Worth Basin began in the 1950s, but almost entirely in the shallower Boonsville Bend Conglomerate and the Strawn reservoirs. By the 1980s, production was beginning to decline, and George Mitchell, owner of Mitchell Energy (acquired by Devon in 2001), decided to

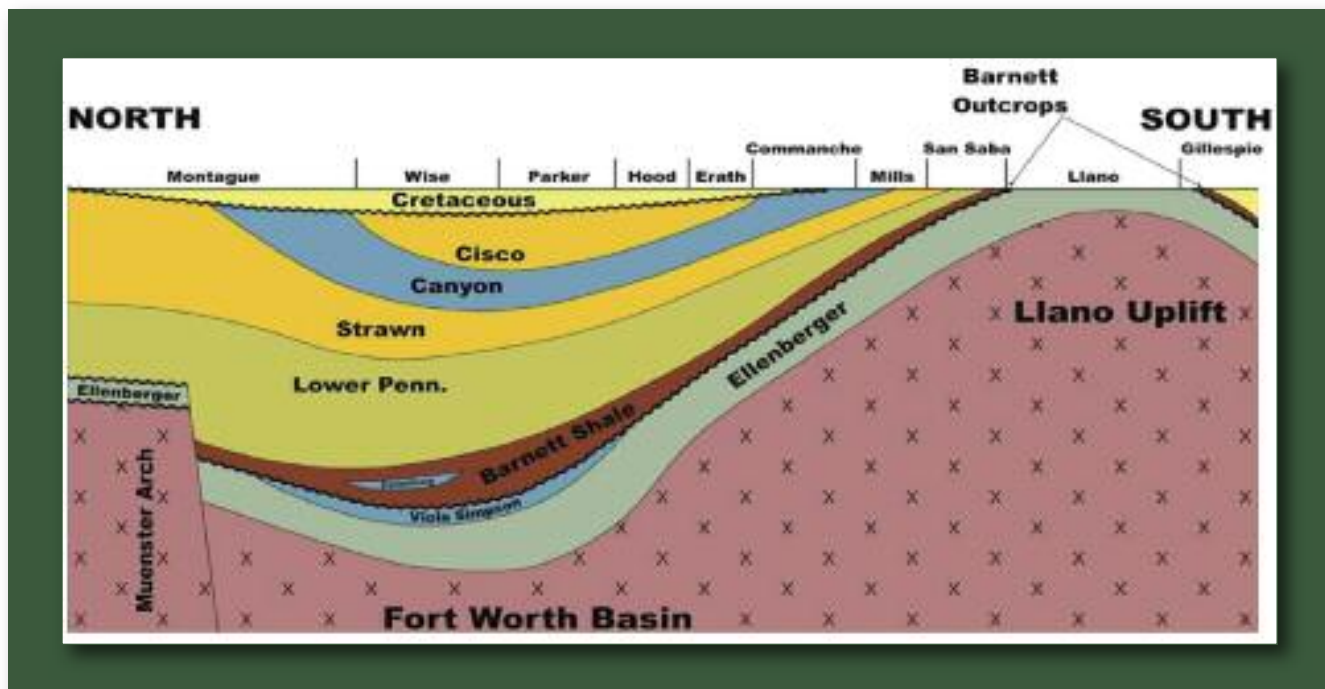
drill his first well into the Barnett Formation in 1981. With infrastructure in place and small incremental costs, Mitchell Energy began intensive studies of the geology and reservoir characteristics that make up the Barnett Shale.

By 1986, Mitchell Energy had completed an extensive analysis of the reservoir. Even with the advances in horizontal drilling and fracturing, significant drilling in the Barnett did not occur until the 1990s. By that time, natural gas prices had increased, light sand fracturing had been proven to be a successful stimulation technique, and Mitchell Energy discovered the Barnett had four times more gas in place than initially believed. By the end of the 1990s, after 18 years of experimentation and scientific study, the Barnett was a success. George Mitchell quickly became known as “The Father of the Barnett Shale.”

The large volumes and success of independent operators began to attract majors like ExxonMobil, and the amount of activity in the Barnett Shale quickly increased. Only 365 wells were drilled from 1995 through 1999, compared to 473 in 2002 and over 780 wells in 2003.

## Geology

The Barnett Shale play in the Fort Worth Basin is one of the 10 richest hydrocarbon systems in the world, and one of the largest onshore natural gas plays within the continental US, with an estimated 26 to 39 Tcf of recoverable reserves. Other estimates of the resource suggest 39 to 55 Tcf of recoverable reserves, however. The Barnett Shale



North-south cross-section showing the Barnett Shale overlying the Viola Limestone and Ellenberger Limestone.  
 Source: Pollastro, USGS

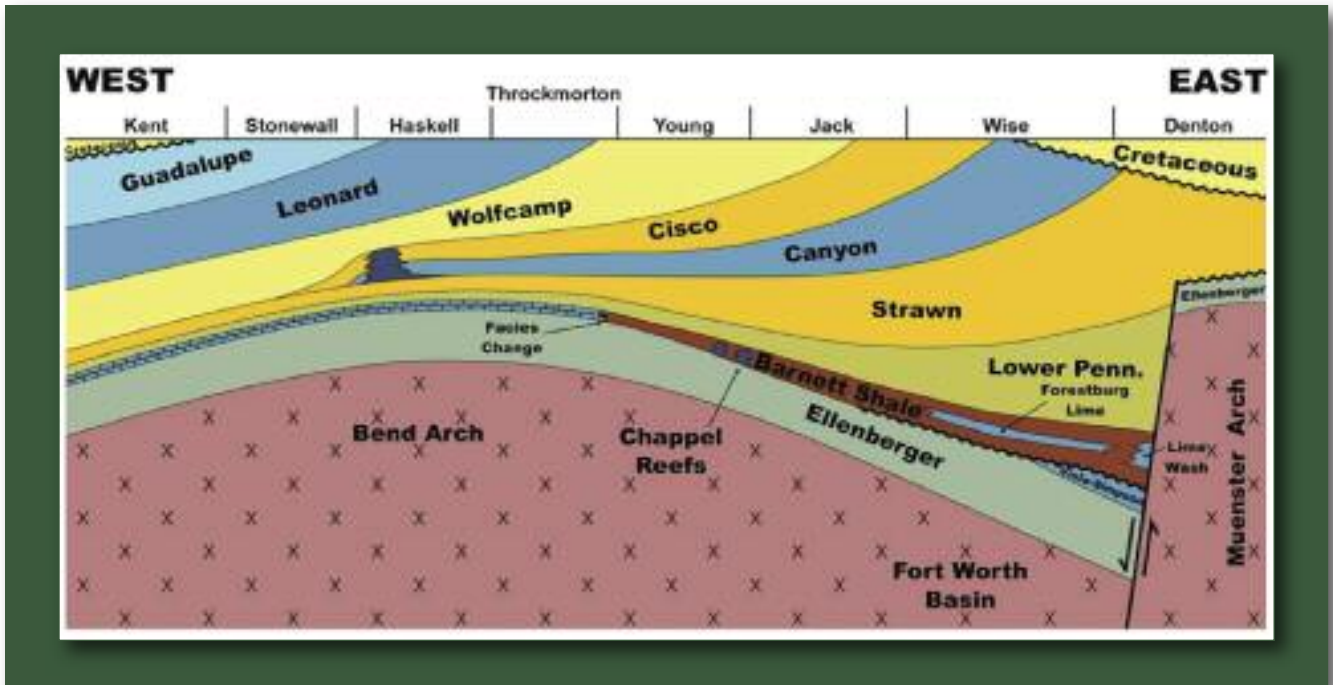
is also currently the most productive gas field in Texas in terms of daily production and continues to grow. The formation underlies the cities of Dallas and Fort Worth and comprises 5,000 sq miles and at least 17 counties. Technology, drilling, and exploration have all rapidly evolved in recent years as many geoscientists and engineers have made it their goal to understand the geology and geochemistry behind this play and their role in making drilling and completing as successful as possible.

The Mississippian-age Barnett Formation forms a complete hydrocarbon system in which the rock itself acts as the source, reservoir, and seal. It consists of a black, clay-mineral-poor, organically rich siliceous mudstone that was deposited in a deeper water foreland basin that was not in direct contact with the open ocean. The bottom of the basin went relatively undisturbed, which preserved the rich, organic matter that created the source rock. It is comprised mostly of fine-grained clay to silt-sized particles. There are four main lithofacies that comprise the Barnett: (1) laminated to nonlaminated siliceous mudstone, (2) laminated argillaceous lime mudstone (marl), (3) skeletal, argillaceous lime packstone, and (4) phosphatic-rich mudstone to grainstone. Each facies contains abundant

pyrite and phosphate (apatite). The phosphate formed in a slope environment and was transported into the deeper basin by gravity-flow processes. Carbonate concretions, a product of early diagenesis, are also common. The organic content that comprises the Barnett is derived from a variety of geological processes, including debris flow, turbidity current flow, contour currents, settling out of suspension, and mud plumes transported to the basin from the shelf. Limestone beds within the Barnett Formation are the product of debris flows that originated on a carbonate shelf to the north of the present basin center. The sediment is laminated and contains pyrite. It is estimated that the deposition of the Barnett may have taken place over a 25-Ma period with the sedimentation style remaining remarkably similar throughout this time span.

Stratigraphically, the Barnett lies between two prominent limestone units: the underlying Ordovician age Viola Limestone Formation and the overlying Pennsylvanian age Marble Falls Limestone Formation. These impermeable limestone barriers help confine induced fracturing during well production that has led to the success of maximized gas recovery over the years. The Fort Worth Basin is bounded on the east by the Ouachita





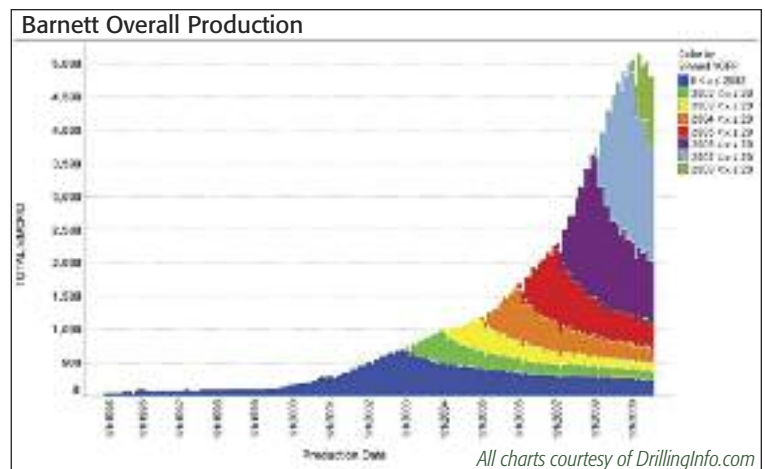
Thrust, on the north by the Muenster Arch, on the south by the Llano Uplift and on the west by the Bend Arch. The Barnett Shale is more than 1,000 ft thick adjacent to the Muenster Arch and is interbedded with thick limestones. Moving westward the Barnett thins rapidly over the Chappel Limestone to only a few tens of feet. Few exposures of the Barnett Shale exist in outcrop, and those that do are poorly preserved, making it difficult to conduct a detailed fracture analysis. The Marble Falls and Ellenberger formations contain the same major fracture sets and are better preserved in outcrop.

The Barnett's production is controlled by the play's thickness. The Barnett's thickness is controlled by the numerous karst-related collapse chimneys, or sinkholes related to Ellenberger karsting as evident through seismic horizons or time-slices. Gas production from the Barnett is enhanced by the complexity of its internal natural fracture networks. Wells are currently being hydraulically fractured and refractured, but in order for this stimulation practice to be successful, frac barriers must be present both above and below the Barnett. The unique thermal history of the Barnett is one of the important reasons for the economic success of the play. The thermal

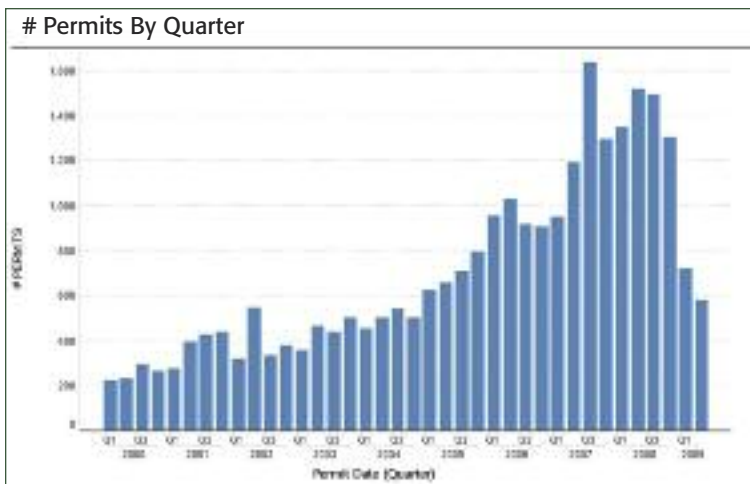
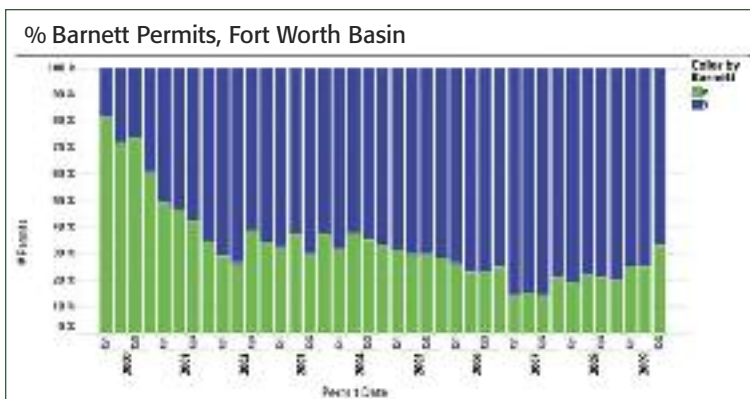
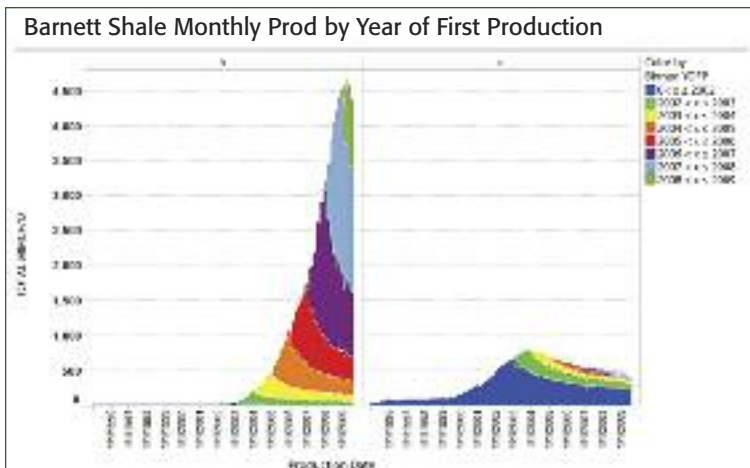
history of the Fort Worth Basin is directly related to the emplacement of the Ouachita system. Depth of burial is important in regard to the thermal maturity of the stratigraphic column within the basin, but the close proximity of the Ouachita belt greatly influenced the heat flow in the basin during the late Paleozoic. Sections of the Barnett bordering the Ouachita front have the highest thermal maturity and, hence, the lowest BTU-content of produced gas. There is an excellent correlation between %Ro (vitrinite reflectance) and BTU content of produced gas in individual wells.

West-east cross-section showing the Barnett Shale overlying the Viola Limestone and Ellenberger Limestone.

Source: Pollastro, USGS



All charts courtesy of DrillingInfo.com



The Barnett Shale has a very high total organic carbon that can range upwards of 10%. In addition to this, it also has exceptionally high silica content. This high silica content is what causes the Barnett to be relatively more brittle than the overlying and underlying formations, thus making it a perfect candidate for induced hydraulic fracturing.

Barnett gas production is poorer in areas near faults and structural flexures (anticlines and synclines). Fractures, which are most abundant in these structural settings, are detrimental to Barnett production. Gas production near faults and other structural features is much poorer and in worst case scenarios, these fractures can act as natural conduits to the water-bearing Ellenberger. However, these open natural fractures are rare in the Barnett. It should be noted that the reaction of these natural fractures are essential for creating complex fracture fairways when applying artificial fracturing techniques. In areas where the Barnett Shale is thermally mature with respect to gas generation, it is slightly overpressured (about 0.52 psi/ft [11.76 kPa/m]). It appears that the Barnett can be used as an exploration model for other basins, especially analogous basins of the Ouachita trend.

### Production

Overall, cumulative gas production from the Barnett Formation has totaled 6.2 Tcf of gas, or just over 1 billion boe, as of June 2009. The Barnett Formation has quickly grown from 500 MMcf/d in 2001 to 1,200 MMcf/d in 2005 to 5,000 MMcf/d in 2009 (from nearly 11,000 active wells).

The first vertical wells in the Barnett Shale were drilled in the early 1990s. Mitchell was drilling a few wells per year until third quarter of 1999, when drilling in the play began accelerating. Drilling rates peaked in late 2002 at 700 wells per year, and production from vertical wells peaked in mid 2003 at around 800 MMcf/d from 2,500 producing wells. Vertical drilling rates declined to around 550 wells in 2003, 490 in 2004, 250 in 2005, 100 in 2006, and 50 in 2007. Today, Barnett production from vertical wells is less than 500 MMcf/d from 3,500 wells and declining at a rate of less than 50 MMcf/d per year.

In order to extend the play into the area where Barnett Shale lies atop the water-producing Ellenburger Formation, and thus does not have Viola/Simpson rocks as an induced fracture barrier, the first horizontal wells were permitted in the first quarter of 2001 by WG Operating. Horizontal drilling began accelerating from a few test



horizontals to systemic drilling in third quarter 2003. Two hundred horizontal wells were brought on line in 2003, 400 in 2004, 773 in 2005, 1,328 in 2006, 2,100 in 2007, and 2,800 in 2008. Production has grown from 50 MMcfg/d in 2002 to 4,700 MMcfg/d by year end 2007 from 7,800 wells.

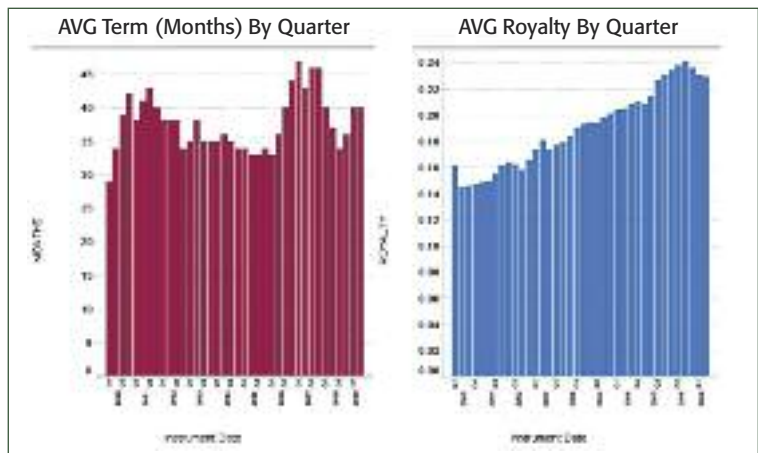
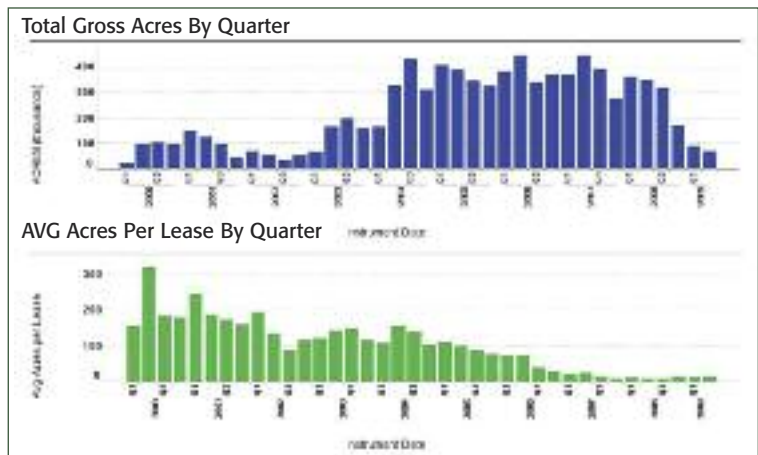
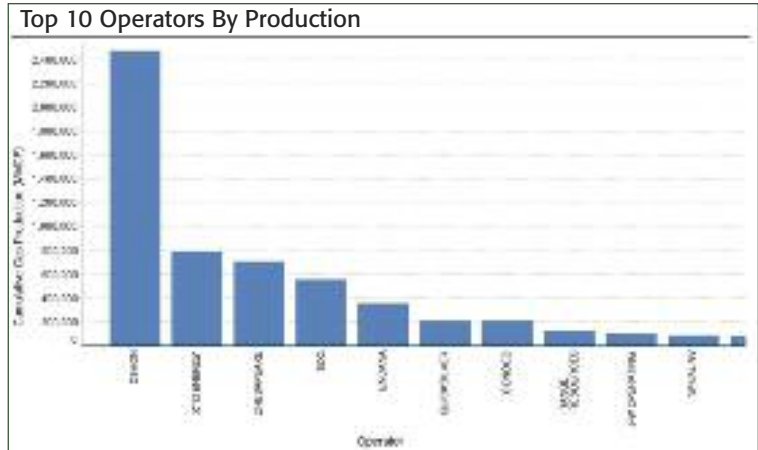
Liquids are an increasingly important contributor to the production mix of the Fort Worth Basin (FWB) Barnett Shale, to the point that several wells drilled recently are classified as “oil wells.” Liquids become an important contributor when the gas-oil ratio is less than 100. In 2001, the entire Barnett Formation was producing less than 1,000 b/d, but quickly grew to 5,000 b/d in 2005, and topped 14,000 b/d at the beginning of 2009. Currently, liquids production is around 11,000 b/d.

As expected, Devon is the largest operator in terms of cumulative production. Devon’s cumulative production has reached 2.4 Tcf, which represents almost 40% of the total production for the Barnett Shale. XTO and Chesapeake follow at 800 Bdf and 700 Bcf, respectively.

**Permitting**

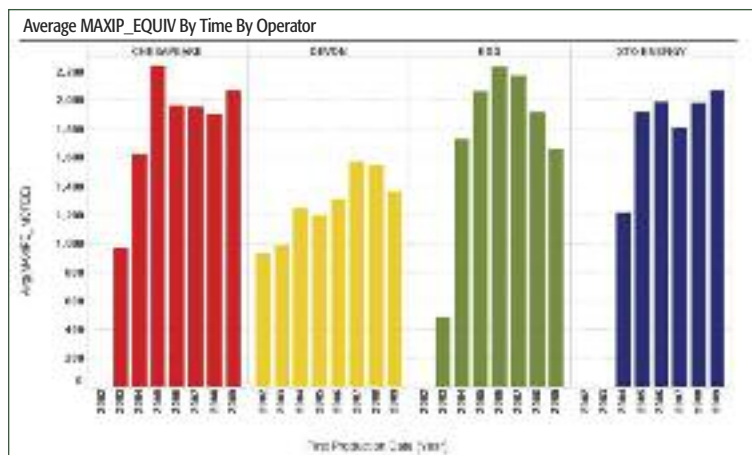
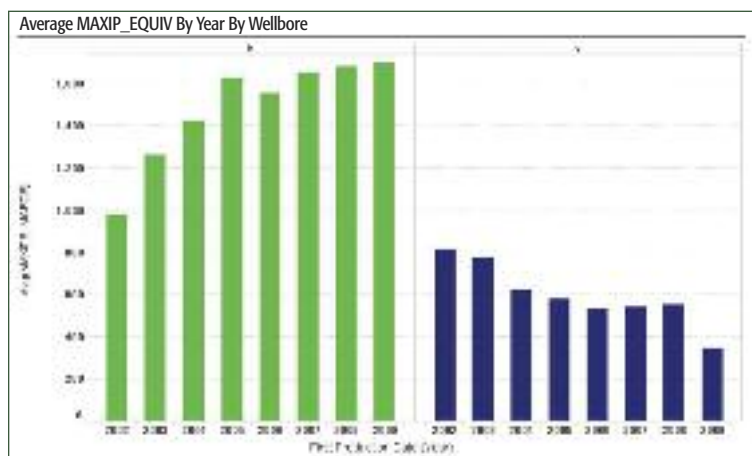
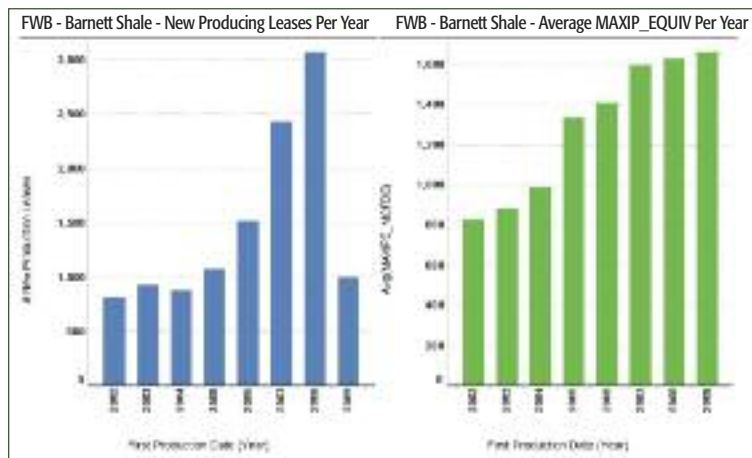
Permits to drill have steadily climbed for five years in the Barnett Shale, ranging from 300 per quarter in 2002 to a high of 1,600 in the third quarter of 2007. However, after the fall of natural gas price in 2008, there has been a precipitous decline in the number of permits to drill in the Barnett. In the second quarter of 2009, there were less than 600 permits to drill, representing a decline of 60% from the highs in 2007. In addition, 80% of Fort Worth Basin permits in 2000 were for non-Barnett wells. However, only 25% of permits in the Fort Worth Basin are non-Barnett today.

By type, FWB vertical well permits have fluctuated between 200 and 300 wells per quarter, while horizontal well permits show a horizontal boom taking place, from virtually none in early 2002 to a high of 1,356 in 2007. Currently, there are around 400 horizontal and directional permits in the Barnett. Approximately two-thirds of vertical permits in the FWB were for Barnett wells in early 2002 while today less than 10% of vertical permits in the basin are focused on Barnett. The opposite is true for



horizontal permits. Almost 100% of horizontal permits in the FWB since 2002 have been issued for the Barnett Formation.

In terms of depth, the average total depth from the drilling permits for vertical wells was 6,000 ft in 2002, but is currently at 4,000 ft for permits issued in 2009. For horizontal wells, the average total depth



has grown from 8,000 ft in 2002 to more than 9,000 ft in 2009. The most active operators in 2009 in terms of permitting have been Chesapeake, EOG, and XTO, with 324, 228, and 207, respectively.

### Leasing

Leasing activity has accelerated greatly since 2000.

Leases were taken at an average rate of 50,000 gross acres per quarter at the beginning of 2002, and didn't start to accelerate until mid 2003, when the economic viability of the play took off. Leasing reached a high of 450,000 gross acres in the second quarter of 2007. The first and second quarters of 2009, however, decreased over 75% from the 2007. Presently, leasing is in the 50,000 to 100,000 gross acres range.

The average numbers of acres per lease remained constant at approximately 120 acres until the third quarter of 2004, and it has progressively declined since then, now averaging less than 20 acres per instrument, where it has remained since the first quarter of 2007. This reflects an increasing focus on suburban and urban drilling in Tarrant and Johnson counties.

With the increase in leasing activity, there was also an expected increase in royalty percentages. Royalty interest gradually increased from 14% in 2000 to 24% in 2008 due to the high demand for Barnett acreage. However, royalty interest in the Barnett has dropped to 23% in 2009.

The same trend can be seen in the average lease term. From 2002 until 2006, the average term for leases was 3 years. But, the increased activity also brought scarcity in drilling rigs and equipment, causing the average term to increase to 4 years in 2007 and 2008.

The most active operator in terms of leasing since 2002 has been EOG, with Chesapeake and Quicksilver following.

Along with the recent decrease in royalty percentages, there has also been a decrease in royalty bonuses from 2008. In 2005, rumors indicated lease-signing bonuses up to \$10,000 per acre. However, bonuses reportedly reached a record of \$32,500 per acre in 2008. More recently, reports suggest that lease bonuses are currently in the range of \$2,500 to \$5,000 per acre, but those bonuses vary depending on neighborhood and quality of acreage.

### New producing leases and Max IP

Logically, maximum initial production (Max IP) rates for the basin improve as technology advances and operator learning curve matures. From 2002 through 2005, the Barnett Shale had an average of 200 new producing leases per quarter. During that same time frame, average Max IP rates varied between 800 and 1,000 Mcf/d. However, in 2005 there was a dramatic



shift in the production rates. The average Max IP in 2005 was 1,330 Mcf/d and continued to increase through 2009. Currently, new producing leases in 2009 are averaging over a 1,600 Mcf/d in 1,000 new

leases (note: data as of 7/1/2009).

When evaluating wellbore data, the same trend continues with horizontal wells. Since 2002, new horizontal leases and horizontal well Max IP have greatly increased. In 2002, there were 55 new horizontal producing leases and almost 3,000 in 2008. The average Max IP rate increased from 1,000 Mcf/d to over 1,600 Mcf/d in 2009. The opposite is true with the vertical wells. The number of vertical wells has decreased by 80% from 750 in 2002 to 157 in 2008 and Max IP rates decreased by 30% during that same time period. In 2009, new vertical wells are averaging 350 Mcf/d, while rates averaged 815 Mcf/d in 2002.

When evaluating that average Max IP of the top four producers in the Barnett, a general improvement over time is seen across the board. However, vast differences exist between the operators because of quality of acreage (core vs. non-core), operator learning curve, and technology.

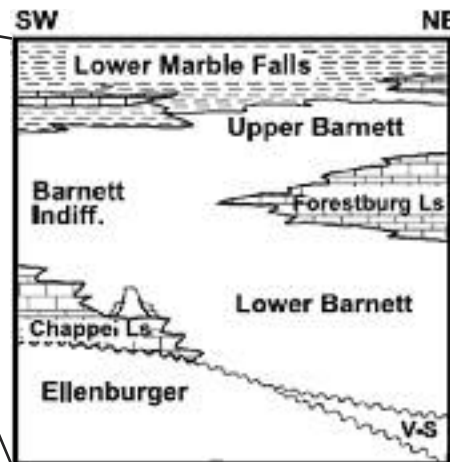
**Conclusion**

The Barnett Shale has been aggressively developed since the beginning of the decade and is currently the most prolific shale gas play in the US. It has become a significant contributor to the US gas supply, and the advent of horizontal drilling and hydraulic fracturing allowed the field to be rapidly developed as economic returns improved with the technology. Many factors determine the value of future reserve potential, including the price of natural gas, operational costs, and improvements in technology. The lessons learned from the Barnett will almost certainly pave the way for development of other shale gas developments.

*References available*

SYSTEM AND SERIES		STAGE	GROUP or FORMATION
CRETACEOUS	LOWER	COMANCHEAN	
		OCHOAN - GUADALUPIAN	
PERMIAN		LEONARDIAN	
		WOLFCAMPIAN	☀ CISCO GROUP
		VRGILIAN	●
PENNSYLVANIAN		MISSOURIAN	● CANYON GROUP
		DESMOINESIAN	● ● ● ● ☀ STRAWN GROUP
		ATOKAN	☀ ● BEND GROUP
		MORROWAN	● MARBLE FALLS LIMESTONE
		CHESTERIAN - MERAMECIAN	● ☀ BARNETT SHALE
		OSAGEAN	● CHAPPEL LIMESTONE
MISSISSIPPIAN			● VIOLA LIMESTONE
			● SIMPSON GROUP
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CARBONIFEROUS	UPPER		● WILBERNS - RILEY - HICKORY FORMATIONS
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PRE-CAMBRIAN		GRANITE - DIORITE - METASEDIMENTS	

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- ☀ Gas Reservoir



Stratigraphic column of the Fort Worth Basin  
Source: AAPG

# Barnett Blues

Transactions and valuations have waned for the Grand Dame of resource plays, but today's poor economics could shake loose locked-up acreage.

**By Steve Toon**  
Editor, *A&D Watch*

For now, all is quiet on the Barnett front. Once the epicenter of land grabs and asset deals, A&D activity in the venerable original resource play in the Texas Fort Worth Basin is largely silent, with only two significant deals completed in 2009.

"Right now, you've got a play that is almost at a dead stop," says Albrecht and Associates Managing director Harrison Williams. "At the current price strip, the economics of drilling it are very difficult."

Like with many gas plays in the US at present, the Barnett Shale is suffering from poor economics due to low natural gas prices. Combined with limited access to capital resulting from tight lending practices during the current nationwide economic malaise, E&Ps are simply not looking to acquire in the play.

"There is very little interest" [in the Barnett], said Jack Aydin, senior managing director with KeyBanc Capital Markets Inc. "People don't have the money, and with natural gas prices so depressed, very little property exchange is taking place."

Because of the poor economics in the play, Williams said potential acquirers can only pay for proved developed producing (PDP) reserves, with little value left over for proved undeveloped (PUD) reserves. "The economics might be good in the core of the core," he said, "but on the rest it is marginal, so you can't pay for anything but the best PUD."

It's tough to sell gas – period, Williams said. "The appetite is much more for oily properties than for gas right now. I don't see a lot of people interested in acquiring gas. Gas markets are still scaring people."

## Then and now

Before the downturn in fourth-quarter 2008, deal making in the Barnett was robust. In June, Okla-

homa City's Crusader Energy Group bought Barnett-focused Westside Energy Corp. in Dallas in a reverse merger for US \$956 million, gaining 66,400 net acres in Montague, Johnson, and Hill counties.

Still in its acquisitive mode, Fort Worth, Texas-based XTO Energy Corp. acquired 12,900 acres and 300 Bcfe proved in the play in July for \$800 million. And Fort Worth's Quicksilver Resources Inc. bought Barnett assets in the core Tarrant County from Chief Resources LLC and others in July, gaining 13,000 net acres and 350 Bcfe proved for \$1.27 billion.

The tide turned in 2009. Short on cash following a borrowing-base redetermination, Crusader subsequently filed bankruptcy and Austin, Texas-based Jones Energy Ltd. is picking up all of the company's assets, including its recently acquired Barnett holdings, for \$289 million, still pending court approval at press time.

In May, Dallas-based, privately held Talon Oil & Gas LLC acquired a 60% interest in Denbury Resources Inc.'s Barnett Shale assets for \$270 million. This followed a long marketing process in which Denbury looked to divest all of its Barnett holdings. KeyBanc Capital Markets Inc. vice president Mitchell Wurschmidt valued the deal at \$0.98 per proved Mcfe.

Grant Henderson, Talon Oil & Gas president and chief executive, speaking at A&D Watch's A&D Strategies and Opportunities conference, said that while other Barnett buyers were either in hunker-down mode or going after other shales when Denbury was marketing its assets, "we were looking for a big acquisition. We retained Denbury as a 40% non-operated partner to help us with their expert-

*Opposite page:* Patterson-UTI Rig #322, an Apex walking rig, drills Alliance Speedway A#1H south of Justin, Texas, to a total depth of 12,788 ft and with a 5,000 lateral into the Barnett Shale as part of the joint venture between Quicksilver Resources and Eni. Photo courtesy of Quicksilver





ise and still participate in the (predicted) gas-price rebound in 2010.” With 300 to 400 wells to drill, “it came down to direct access to the Denbury management team.”

Also burdened by debt, in May Quicksilver farmed out a 27.5% interest in the same Barnett assets it bought the previous year to European independent Eni SpA for \$280 million, representing 131 Bcf of proved reserves.

Aydin, in a report following the deal, said, “While the valuation metrics of this deal are well below the acquisition price tag Quicksilver paid for the entire...position, we believe the valuation was not too shabby given the depressed natural gas pricing environment and tight credit environment.” He estimated Quicksilver received approximately \$2.14 per proved Mcfe, compared to \$3.73 per proved Mcfe it paid at purchase.

Analysts at Tudor, Pickering, Holt & Co. Securities Inc. said the Eni deal defined core metrics of the Barnett at \$2 per Mcfe, with noncore metrics at \$1 per Mcfe based on the Denbury sale.

On average, Aydin says metrics in the play have

dropped by about half since 2007, when an average valuation might have been around \$2.50 per proved Mcfe. Now, an average transaction would sell for \$1.25 to \$1.50 for proved reserves.

### Acreage fallout

If not for cash flow crunches, companies today would be acquiring acreage at some 20% of what they paid at the peak, with core acreage available for as low as \$500 an acre in a few instances. But “there is no money,” said Aydin. “This year, very few transactions are taking place in the Barnett.” Companies are instead using what cash flow they have to maintain production and meet drilling commitments.”

While much of the acreage in the Barnett is locked up, lease terms are due to expire and some companies — due to poor economics — are choosing to let their leases expire, particularly outside of the core areas. “Based on this current pricing environment, there is no reason to renew and keep leases in noncore acreage,” Aydin said. This trend could place a lot of previously unavailable acreage back into play.

Announced	Buyer	Seller	Transaction Value (\$MM)	% Gas/Total Proved Reserves
08-Jul-09	EOG Resources	Undisclosed	\$134,100	NA
18-May-09	Eni SpA	Quicksilver Resources	\$280,000	NA
14-May-09	Talon Oil & Gas	Denbury Resources	\$270,000	77%
22-Jul-08	XTO Energy	Undisclosed	\$800,000	NA
21-Jul-08	Williams Cos.	Aspect Abundant Shale	\$166,000	NA
07-Jul-08	Quicksilver Resources	Collins & Young, Hillwood Energy	\$1,307,000	NA
10-Dec-07	Range Resources	DTE, Adexco	\$305,000	NA
06-Nov-07	Pioneer Natural Resources	Royal Dutch Shell	\$150,000	NA
23-Oct-07	XTO Energy	Undisclosed	\$550,000	NA
26-Feb-07	Undisclosed	Range Resources	\$82,000	93%
03-Aug-06	Chesapeake Energy	Cities of Dallas, Fort Worth	\$181,000	NA
05-Jun-06	Chesapeake Energy	Sinclair, Four Sevens Oil	\$845,000	100%
05-Jun-06	Chesapeake Energy	Undisclosed	\$87,000	NA
01-Jun-06	XTO Energy	Peak Energy	\$110,400	100%
02-May-06	Devon Energy	Chief Oil & Gas	\$2,200,000	100%
06-Feb-06	Stroud Energy	Joint Resources	\$61,000	97%
<b>Mean</b>			<b>\$470,531</b>	<b>95%</b>
<b>Mean (excl. high &amp; low)</b>			<b>\$376,250</b>	<b>98%</b>
<b>Median</b>			<b>\$225,500</b>	<b>99%</b>

Source: Scotia Waterous, John S. Herold Inc./IHS

By comparison at the current price strip, the Barnett is not as attractive as the Haynesville, Marcellus, and Eagle Ford shales, which are attracting E&Ps away from the North Texas play. RBC Richardson Barr director Craig Lande said, “People have lost focus on the Barnett. The economics are so much more compelling” [in these other plays].

Companies are redeploying assets, said Albrecht’s Williams. “If they have choices, they are going to drill in the other plays rather than the Barnett.”

Williams said Albrecht has had conversations with a number of small operators interested in selling out. “Most of them are disappointed in the price ranges that we tell them their production will bring.”

Outside of a distressed sale, Aydin does not see corporate consolidation taking place among Barnett players. Companies view their stock prices as too cheap, leaving little interest in pursuing a merger, and the acquirer would likely have to assume a large debt load in an environment where banks are not lending money readily.

“You’re not going to be able to borrow \$2 billion or \$3 billion to do an acquisition,” he said. “Cash is hard to come by and leverage is undesirable.”

Instead, joint ventures such as the Quicksilver/Eni deal are more likely to drive any near-term A&D activity in the play. Producers without the cash flow to develop leases and facing acreage expirations will seek partners to provide capital. “The company can keep operations and get carried to a certain point. It’s easier than acquiring the whole company,” Aydin said

He also anticipates private-equity-backed companies and firms getting more involved in the play. “A lot of money is sitting on the sidelines. Private-equity shops are trying to make deals.”

Going forward? “You’re going to see a lot of leases turned over and new smaller and private players come to the play,” Aydin projected. “It’s all going to depend on the price and the economics. If natural gas prices improve, the area is going to get active and attractive. If we remain at sub \$4 gas, it’s going to be very slow for the Barnett.”

% Gas/Production	PDP/Total Proved	Henry Hub NatGas (\$/MMBtu)	R/P Ratio (Years)	Reserve Value/Proved Reserves (\$/Mcf)	Reserve Value/Production (\$/Mcf/d)
0%	NA	\$3.20	NA	NA	\$9,092
100%	45%	\$4.02	21.8	\$1.88	\$14,933
77%	23%	\$4.08	16.2	\$1.00	\$5,908
100%	25%	\$10.16	23.5	\$1.73	\$14,857
0%	NA	\$10.58	NA	NA	\$18,444
100%	40%	\$12.96	21.3	\$2.99	\$23,267
100%	NA	\$6.98	NA	NA	\$21,786
100%	NA	\$7.20	14.8	\$1.61	\$8,670
100%	NA	\$6.30	21.9	\$2.75	\$22,000
97%	NA	\$7.73	6.5	\$1.94	\$4,587
NA	NA	\$7.60	NA	NA	NA
100%	NA	\$6.35	14.6	\$3.38	\$18,050
NA	NA	\$6.35	NA	NA	NA
100%	14%	\$6.25	17.5	\$1.33	\$8,500
100%	NA	\$6.68	19.9	\$2.78	\$20,188
98%	54%	\$8.24	19.2	\$2.18	\$15,292
<b>84%</b>	<b>33%</b>	<b>\$7.17</b>	<b>17.9</b>	<b>\$2.14</b>	<b>\$14,684</b>
<b>89%</b>	<b>33%</b>	<b>\$7.04</b>	<b>18.6</b>	<b>\$2.13</b>	<b>\$14,810</b>
<b>100%</b>	<b>33%</b>	<b>\$6.83</b>	<b>19.2</b>	<b>\$1.94</b>	<b>\$15,113</b>



# Barnett Numbers Tell the Tale

Profiles of key operators' activities in the play reveal opportunities remain.

**By Don Lyle**  
Contributing Editor

The crippled US economy chopped natural gas prices by some 70%, and some of the higher-cost shale plays took big hits.

That Barnett play in North Texas shared the pain, but that pain was selective as the core and some Tier 1 counties remained strong and activity slipped in the outlying Tier 2 counties.

Even the selective activity represented a lot of opportunity for operators, since the Fort Worth Basin Barnett play covers some 5,000 sq miles and parts or all of 18 counties.

The numbers tell the tale. According to the Baker Hughes rig count for the week ended Oct. 16, 2009, 26 rigs were working in Texas Railroad Commission (RRC) 9, the prime Barnett activity area. At the same time, six rigs were working in RRC 7B with much of the outlying Barnett production areas.

The week ended Oct. 17 a year earlier, 39 rigs were active in RRC and 28 were working RRC 7B.

Since Barnett rigs largely worked under term contracts in 2008, the October numbers weren't much different from the March 2008, figures, before the price collapse. In the week ended March 14, 2008, RRC 9 hosted 39 rigs and RRC 7B had 32 rigs at work.

At the same time, the US rig count stood at 1,040, a sharp decrease from the 2,031 rigs working at the 2008 peak.

In an April 2009 article in the *Fort Worth Star-Telegram*, Texas economist Ray Perryman, in his third annual report on the economic impact of the Barnett Shale, said he expected the impact of the shale in Tarrant County to fall about 40% in 2009 from US \$11 billion in 2008 to \$6.5 billion

According to a *Dallas Morning News* article, Perryman said, "Even in 2009, which is likely to be the trough of the current downturn in energy markets, the benefits are expected to include \$6.5 billion in output and about 70,000 jobs. That's money and jobs that wouldn't otherwise be here."



Barnett action continues to boost Fort Worth's economy. Photo courtesy of BJ Services

He added that estimated field resources have grown from some 12 Tcf several years ago to 55 Tcf in 2009.

Perryman's report said the Barnett Shale produced almost 1.4 Tcf of gas in 2008 and generated 111,131 jobs.

The Perryman report, commissioned by the Fort Worth Chamber of Commerce, said the Barnett supported 3,643 drilling permits in 2007. That number rose to 4,145 in 2008 and continued growth to 5,037 permits in March, 2009.

Another *Fort Worth Star-Telegram* article on Sept. 30, 2009, quoted Vello Kuuskraa, president of Advanced Resources International, who held up the Barnett as the poster child for gas shale development worldwide.

He said he expected end-of-2009 statistics to show the Barnett Shale was the biggest gas-producing area in the US, overcoming the San Juan

Basin in northwestern New Mexico and southwestern Colorado.

Among the more active companies still working the Barnett in October, according to the *Star-Telegram*, Carrizo, Chesapeake, Quicksilver, and XTO were working Tarrant County; Devon and Williams were active in Denton County; Quicksilver was drilling in Hood County; EOG Resources and XTO were working their operations in Johnson County, and Aruba Petroleum was working in Wise County.

An Oct. 16, 2009, drilling report from the *Kilgore News Herald* said EnCana Oil & Gas (USA) Inc. completed the Mercer Rand No. 304H well in the Fort Worth city limits in Newark East Field for an initial potential of 3.6 MMcfg/d.

At the same time, XTO completed seven wells in the field with potentials ranging from 1.1 MMcfg/d to nearly 5 MMcfg/d.

Range Resources, in its third quarter 2009 report to shareholders said its production rose 13% from the same quarter a year earlier, driven by increased production from the Barnett in Texas and the Marcellus Shale in Appalachia.

Those plays helped the company increase production even after the sale of a field in West Texas that produced 15 MMcfg/d.

Range's Barnett properties produced an average 123 MMcfge/d during the third quarter of 2009 and increased that number to 130 MMcfge/d by mid-October.

In spite of the economic doldrums, select areas of the Barnett Shale generate profits for its operators. ■

### North Texas Barnett Shale Counties

Tarrant	Johnson
Denton	Montague
Wise	Palo Pinto
Bosque	Parker
Comanche	Hamilton
Cooke	Hill
Ellis	Hood
Erath	Somervell
Jack	Clay

Source: Barnett Shale Energy Education Council

Key Players



## R.L. Adkins Corp.

Sweetwater, Texas-based R.L. Adkins Corp. started operations in the oil business in 1977 after R.L. “Bob” Adkins drilled his first well in 1973.

Since that time, the company has drilled and operated more than 400 wells as well as participated with other companies in operations through Texas and New Mexico.

Currently, the company generates prospects and drills and operates wells in the Permian Basin and the Ft. Worth Basin.

In 2009, according to the company’s Web site, it ranked among the top 5% of operators in Texas in both oil and natural gas, drilling wells from 4,000 ft to 13,500 ft.

## Aruba Petroleum Inc.

Aruba Petroleum Inc., a Plano, Texas, company with its operating center in the Dallas suburbs has operated for more than 20 years.

Currently, the company concentrates on gas shale plays, including the Barnett, Marcellus, and Haynesville shales. It also has deep operations along the southern Texas coast.

According to August 2009 oil and gas reports published in the Sept. 15 edition of the *Denton Record-Chronicle* online site, Aruba planned two wells in Wise County, Texas, both on its Wright lease 5 miles southwest of Sidell, Texas, and both scheduled to 9,000 ft in the Barnett Shale.

The company’s philosophy, built on long-term increases in oil and gas demand with an expanding world population, persuades it to look for the best fields with large reserves along with stable production and potential for growth.

That concept led the company to shale plays in North America.

## Braden Exploration LLC

Braden Exploration LLC developed from the acquisition of Stroud Energy by Range Resources in 2006 and continued Stroud’s work in the Barnett Shale.

The new company focused its efforts on the core areas of the Barnett and completed 10 producing wells in 2008 and planned to complete eight or more wells by the end of 2009.

It anticipated higher production from down-spacing potential on its properties and the use of simul-frac technology involving the simultaneous fracturing of parallel horizontal well bores to boost output on both wells.

The company held six Barnett shale wells, including the third and 13th best wells, in Denton County on more than 1,000 acres under lease or agreement.

It held more than 9,000 acres in Wise County with four Barnett producers and started slightly less than 20 sq miles of 3-D seismic acquisition. It planned to drill all eight of the new wells on this property in 2009.

An investment of \$70 million in growth capital from Lime Rock Partners in late 2008 helped fund the company’s drilling activity.

According to the company Web site, its 10 Barnett wells put it in the upper 20% in production among all operators in the field.

## Carrizo Oil & Gas Inc.

Carrizo Oil & Gas Inc. offers a shining example of the potential that gas shales can provide for a smaller oil and gas company.

Already an aggressive company, Carrizo claimed a foothold in the Barnett and used that as a stairway to other shale plays around the county.

Take a look at some of the numbers. In 2008, the company claimed a 71% success rate throughout its operations, helped a lot by a 100% success rate in the Barnett Shale in North Texas.

Carrizo rigs up for a massive gas shale frac job at its Barnett properties on the University of Texas properties at Arlington, Texas. Photo courtesy of Carrizo Oil & Gas Inc.





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RESOURCES

In early 2009, Carrizo had 75,000 net acres in the Barnett play, 21,000 in the core counties, where finding and development (F&D) costs average around \$1.25/Mcfge; 24,000 in the Tier 1 counties with a \$1.78/Mcfge F&D cost and 30,000 net acres in Tier 2 counties with F&D costs around \$2.27/Mcfge.

Leveraging its property position with a heavy reliance on 3-D seismic to choose drilling sites and avoid faults that could short-circuit production, Carrizo has identified 812 potential locations for both exploratory and development drilling with horizontal wells, based on 60-acre spacing.

According to the company's second quarter 2009 financial report, Carrizo's production volume rose 29%, to 789 Bcfge, from the same quarter a year earlier, primarily from Barnett additions.

It planned to keep three rigs running in 2009, all on the company's net 18,000 acres in Tarrant County in the Barnett core. Those rigs should raise production by 110 MMcfge/d by the end of the year, the company said.

In an early 2009 presentation, Carrizo executives said the company had the potential to drill 400 net wells to reach 1.2 Tcfge in reserves in that county.

At that time, it had drilled six wells on University of Texas properties at Arlington, Texas, and the wells produced at a combined 20 MMcfge/d. It has locations for another 18 wells on the university property.

Looking at Tarrant County economics, Carrizo said it bought 45 acres of land at \$8,000 an acre for a net \$400,000. Acquisition of 3-D seismic cost \$30,000 per well on top of the \$3.3 million well cost.

Those properties gave the company a 39% internal rate of return at a gas price of \$7/Mcf and an 18% return with gas at \$5. Although gas prices were lower as this article was produced, Carrizo, like many other companies, hedged production to lock in higher prices.

During 2008 and 2009, Carrizo cut the number of days its drilling rigs remain on station from 28 to 29 days in earlier wells to 23 to 24 days in more current wells. The company attributed its improved drilling time to Helmerich & Payne's Flex rigs and Schlumberger's rotary steerable drilling tools.

At the same time, well costs dropped to \$2.8 million to \$3.5 million in new wells from \$3 million to \$3.5 million in earlier wells.

## Chesapeake Energy Corp.

Chesapeake Energy Corp. is a compelling force in natural gas production. It was the fourth-largest gas producer in the US in the second quarter of 2009 and the third-largest gas producer among independent oil and gas companies.

The company ranks either first or second in the top four gas shale plays in the US, the Barnett, Haynesville, Fayetteville, and Marcellus.

The Barnett dominates Chesapeake's shale operations. It is the second-largest producer in the play and the most prolific driller and largest leaseholder in the core and Tier 1 counties — Tarrant, Johnson, and western Dallas counties.

### POSITION

Chesapeake finished the second quarter of 2009 with net Barnett production of 650 MMcfge/d, up approximately 40% from the same point in 2008, putting the play at the top of its unconventional gas resource heap. Gross production at the end of the second quarter of 2009 was 950 MMcfge/d, the company said.

Since gas prices dropped in the second half of 2008, Chesapeake lowered its rig count. It planned to operate an average of 17 rigs in the Barnett play in the second half of 2009 to drill 145 new wells and average 18 rigs in 2010 to drill another 310 wells.

When gas prices were higher, Chesapeake completed a Barnett well every 15 hours and had kicked its rig count in the play to 43 by mid-2008 to reach that goal. In response to lower gas prices, Chesapeake reduced its rig count in 2009 to 20.

If it finds a joint venture partner, it will substantially increase drilling, according to a company presentation.

Chesapeake controls 310,000 net acres in the Barnett play, and 280,000 net acres are in the core and Tier 1 areas of the play.

At the end of the second quarter of 2009, Chesapeake estimated 3.2 Tcfge of Barnett proved reserves and 4.7 Tcfge of risked unproved reserves, assuming continued development on 60-acre spacing.

It also had 2, 750 risked net undrilled wells with an estimated average of 2.65 Bcfge per well.

In August 2009, the average company well cost US \$2.6 million. The company paid a 25% royalty and its finding and development cost was \$1.31/Mcfe. At a New York Mercantile Exchange price of \$7/MMBtu, Chesapeake received a 36% rate of return on its average Barnett well.

During its Barnett campaign, Chesapeake drilled two of the three best wells ever drilled in the Barnett. Those wells, the Donna 1H and Donna 3H horizontal wells returned a 30-day average peak production of 9.6 MMcfge/d and 8.8 MMcfge/d, respectively. The top well, drilled by another operator, offered a peak production of more than 10 MMcfge/d. The Donna Ray 1H is the biggest well in the Barnett, based on a peak monthly rate, and Chesapeake expected to break that record with a new well producing at a rate of more than 15 MMcfge/d before it was shut in.

In the second quarter of 2009, Chesapeake continued to bring in good wells. The Arnet Dale Street 7H in Tarrant County peaked at 7.8 MMcfge/d and averaged 4.4 MMcfge/d in the best 30-day period.

Its Chevy 2H in Johnson County, peaked at 7.4 MMcfge/d with a 30-day average of 5.8 MMcfge/d, and the Gann 4H, also in Johnson County, peaked at 7 MMcfge/d with a 30-day average of 5.4 MMcfge/d.

That's an impressive record for a company that just entered the play in 2004 with the acquisition of 18,000 acres of land and wells that produced 25 MMcfge/d.

#### DALLAS-FT. WORTH AIRPORT

The company's Dallas-Ft. Worth Airport project demonstrates the scale of operations the large company can undertake. After acquiring rights to work the Barnett Shale play on airport properties in late 2006, it conducted the only 3-D seismic survey ever conducted on an airport in the US. Crews had to work at night under strict US Homeland Security and local airport security restrictions to avoid disrupting operations at one of the busiest airports in the country.

Using results from the 3-D shoot, it drilled 112 successful wells on the property during 2007 and produced 60 MMcfge/d from the property with peak production around 80 MMcfge/d.



A field engineer reads gauges on a Barnett wellhead. Photo courtesy of Chesapeake Energy

#### ACQUISITIONS

In May 2008, the company announced it signed an agreement with Sundance Square, owned by the Bass family, giving the Oklahoma City company mineral rights to 40 acres of land in downtown Ft. Worth, between First and Fifth avenues and Lamar and Elm streets. Conceivably, a horizontal well drilled from a surface location a half-mile or more away could reach minerals under that site.

It also acquired Paloma Barnett LLC's Barnett properties with 8,600 net lease acres in Tarrant and Johnson counties in Texas.

The company acquired two new acres for each acre it drilled in the first quarter of 2008. At that time, Chesapeake said it held 250,000 acres of leases in Tarrant, Johnson, and Dallas counties and planned to reach 280,000 acres by the end of 2009. It reached that goal.

Amassing land on that scale takes a lot more work than simply visiting the neighborhood real estate agents. Part of the Paloma acquisition called for Paloma to work exclusively for Chesapeake to acquire land in parts of Tarrant County.

In October 2008, Chesapeake acquired the Barnett assets for DDJET Ltd. LLC, a joint venture between Harding Energy Co. and Exxon Mobil Corp. The partnership was named for Denton, Dallas, Johnson, Ellis, and Tarrant counties, but it also included operations in Collin, Navarro and Hill counties, according to an article in the *Fort Worth Star-Telegram*. ExxonMobil subsidiary Metroplex Barnett Shale LLC was the operator of the properties and produced some 1 MMcfge/d at the time of the sale.



Chesapeake had similar arrangements with Dale Property Services, LLC; Four Sevens Oil Co., Ltd., and Western Production Co., working in other parts of Tarrant County.

Perhaps the best illustration of Chesapeake's dedication to the Ft. Worth Basin and the Barnett play showed in the work force dedicated just to land acquisition.

With the agreements in Tarrant County and Chesapeake's own landmen and land brokers, the company had more than 1,300 landmen and lease brokers looking for undeveloped acreage and researching titles in Tarrant, Johnson, and western Dallas counties in 2008.

#### RECOVERY TECHNIQUE

Seismic is not the only technological tool in the arsenal. Chesapeake also created a Reservoir Technology Center that analyzes shale cores in the Barnett and its other plays. That center determines quickly which shale prospects will be profitable and the ideal completion techniques to maximize recovery. The in-house laboratory also gives the company a faster time-to-first-production to improve profits.

Work continues to reduce costs and cut drilling times. The company drilled one well in 14 days, and has drilled several wells within a 10-day time period. Typical drilling times range from 18 to 20 days. That's a significant cut from the 25-day average in 2007 and 35-day average the previous year.

#### INFORMATION

A company with hundreds of drilled wells knows the impact the amount of water needed for hydraulic fracturing operations will create for the company and for public officials. To educate the public, Chesapeake contacted local water authorities to obtain accurate information concerning water use by consumers and industries and distributed that information through public presentations and speeches.

It also put together a comprehensive consumer education campaign in North Texas with portions including movie star Tommy Lee Jones.

The message told readers, viewers, and listeners that the benefits of developing the shale resources in the area far outweigh the temporary inconveniences.

## Citrus Energy Corp.

Citrus Energy Corp. started operations as a corporation in 1989 and grew through a series of acquisitions and by the drill bit.

It counts more than 20,000 acres of Barnett Shale properties in the Ft. Worth Basin among its properties. The company said it currently is developing those properties.

It also holds 40,000 acres of properties in the Marcellus Shale play in Pennsylvania, 70,000 acres in the Chehalis Basin coalbed methane play in Washington state, and 50,000 acres in McIntosh County, Okla.

## Cohort Energy Co.

Cohort Energy Co., the exploration and production arm of J-W Operating Co., concentrates its efforts on high-quality, multi-well development projects, a concentration that led the parent company to its position in the Barnett Shale in North Texas.

J-W Operating specializes in gas gathering, compression, exploration, production, well servicing and gas measurement through its subsidiary companies.

According to Gene Daley, president of Cohort, his company holds approximately 72,000 gross, 43,500 net, acres of properties in the Barnett play. Those properties are in Wise, Denton, Tarrant, Johnson, and Hill counties. Except for Hill County, those operations are in the Barnett core or Tier 1 areas.

It moved into the Barnett area early and with caution picking up most of its properties through the bankruptcy of another operating company.

Cohort prefers to work its own properties, but it does have participation interests some of its Barnett wells.

In September 2009, Cohort produced some 70 MMcfge/d gross, 45 MMcfge/d net, from its properties and was ranked No. 1 among the top private producers in the play in 2009 by the *Oil & Gas Financial Journal*. It also ranked No. 4 among private producers in the Haynesville Shale.

Cohort also is starting up operations in the Marcellus Shale in the Appalachian Basin and J-W Operating was an early member of the Appalachian Shale Water Conservation and Management Committee and the Marcellus Shale Committee. Both organizations were established to work with area organi-

zations for the improvement of government and community relations.

Right now, Daley said, the company has suspended drilling in the Barnett and probably will stay in that holding pattern until natural gas prices improve.

To date, the company has drilled about 110 gross horizontal wells in the play and has interests in more than 200 wells, including vertical completions.

## ConocoPhillips Inc.

ConocoPhillips entered the Barnett Shale play in the Ft. Worth Basin of northern Texas the same way many other large companies joined the fray: by acquisition.

In ConocoPhillips' case, its acquisition of Burlington Resources Inc. made it an instant top 10 player in the Barnett in 2006. ConocoPhillips doesn't release much information about specific plays in its worldwide inventory, but it's clear the major company considers the Barnett, along with other unconventional gas plays, an asset worth developing.

When ConocoPhillips bought its way into the play, Burlington Resources already had worked the play for several years. It has some 28,000 net acres in the core area and another 22,000 net acres southwest of the Barnett core in Palo Pinto County. It planned to expand its position there. It also held 70,000 acres in Parker, Hood, and Johnson counties.

In a 2009 presentation, ConocoPhillips executives said the company still held 110,000 net acres of land in the Barnett and produced approximately 100 MMcf/d of gas at the end of 2008.

For contrast, the company held 180,000 net acres in the Bakken oil shale play in North Dakota and 300,000 net acres in the emerging Eagle Ford gas shale play in south Texas. As it concentrated on unconventional resources, the company pointed to those three shales as key segments of its Lower 48 production plans for the future. ConocoPhillips is the biggest oil and gas producer in North America with daily production of 1.1 million boe.

Following the Burlington Resources acquisition, ConocoPhillips became the sixth-largest producer in the Barnett play with 13.2 Bcfge in production between January and May of 2007.

Altogether, ConocoPhillips had picked up 2 billion boe in the acquisition, with production from

coalbed methane wells in the San Juan Basin of Colorado and New Mexico, the Lobo Trend in south Texas, the Bossier play between Houston and Dallas in Texas, and the Woodford/Barnett shales in the Permian Basin.

In its 2004 annual report, Burlington noted the company focused operations in the Barnett in Denton and Wise counties in the core area. At that time, it had as many as five drilling rigs working and participated in 93 wells in the shale, including 11 horizontal wells. It invested US \$83 million in the play that year and finished with 33 MMcf of gas, 4,200 b/d of natural gas liquids and 1,000 bbl of oil a day.

ConocoPhillips also considers the play important. In 2006, it continued to develop its acreage in Denton, Wise, Johnson, Hood, Parker and Palo Pinto counties. At that time, it had added holdings, raising its acreage position to 127,000 net acres in the basin. Production increased to 42 MMcf of gas, more than 3,000 bbl of natural gas liquids and 1,000 bbl of oil a day, as it concentrated on the more gas-prone areas of the Barnett.

In both 2007 and early 2008 it stated its intention to continue developing its shale and coalbed methane plays.

## Cornerstone E&P Co.

Cornerstone E&P Co., formed in 2006, holds properties in the Arkoma and Maverick basins, East Texas and the Barnett Shale in North Texas.

The company operated more than 40,000 net acres of undeveloped leases, most of them in Hill County, and planned to use horizontal drilling techniques with multistage fracturing to produce gas from the popular shale.

Shales in that area range from 300 to 900 ft thick at depths from 8,000 to 10,000 ft.

According to the company's Web site in a 2008 report, Hill County was the fastest-growing expansion area in the Barnett play as EOG Resources, Range Resources, and Quicksilver Resources were all running multiple rigs.

At that time, Cornerstone had two rigs working in the county and planned to complete 20 wells by the end of 2008.

The company had no more recent updates on activity.

## Crusader Energy Group

A reverse merger converted two smaller operators with interests in the Barnett Shale play in the Ft. Worth Basin into a single operating company with the size to accelerate shale activities. At least that was the plan in early 2008 when gas prices reached double-digit levels.

As gas prices cratered in late 2008 and into 2009, those plans changed radically.

By February 2009, the company lowered its planned 2009 drilling budget to US \$43.6 million from a previously planned \$103.6 million. By that time, Barnett activities had halted as the company kept two rigs at work in the Cleveland tight gas sand. It's only non-operated rig was working the Anadarko Basin.

By March, Crusader fell behind on payments to lenders and was looking for alternatives up to the sale of the company. At the end of that month, the company sought US Bankruptcy Court protection from creditors under Chapter 11 as it tried to reorganize. That move led to the delisting of the company from the American Stock Exchange.

A month later, the company received bankruptcy court permission to pay debt and royalties as the company worked as debtor-in-possession on its properties.

Officially, in the 2008 transaction, Crusader Energy Group absorbed Westside Energy Corp.

Financially, the smaller Westside Energy acquired the Crusader group of companies in a reverse merger and Westside changed its name to Crusader Energy Group in a stock exchange with a value of some \$956 million.

The pre-merger Crusader companies included Knight Energy Group I Holding Co. LLC, Knight Energy Group II Holding Co. LLC, Hawk Energy Fund I Holding Co. LLC, and RCH Energy Opportunity Fund I LP.

Both the Crusader companies and Westside had focused on unconventional gas plays. While Westside was exclusively in the Barnett Shale, the original Crusader companies also worked in the Anadarko, Val Verde, Delaware, and Williston basins with a focus on shales and tight sands.

Pre-merger, Westside controlled 81,431 gross (66,435 net) acres in the Barnett Shale, and 77,161 gross (65,208 net) acres were undeveloped. It produced some 5.23 MMcfge/d and had working inter-

ests in 75 gross, or 20.6 net, producing wells in Montague, Johnson, and Hill counties in Texas.

"The business combination provides Crusader additional opportunities to transfer our horizontal expertise and horizontal multistage isolation stimulation assemblies to the Barnett Shale, Bakken Shale, Cleveland sands and other unconventional reservoirs," said David D. Le Norman, Crusader's president and chief executive officer.

Pro-forma figures for the combined Crusader after the merger put the company's Barnett position at 26 Bcfge in reserves from 78,850 gross (67,370 net) acres of leases.

Net production reached 8.465 MMcfge/d. The combined companies had drilled 10 wells in 2007 with a 100% success rate, and the new company planned 31 wells in the Barnett in 2008.

The companies estimated reserve life at 15.8 years.

Near-term activity focused in Hill and Ellis counties where Crusader and Forest Oil Corp. had two drilling rigs working.

Crusader had 167 potential drilling sites, but that didn't include a large block in the southwestern segment of the Barnett play.

That large block of properties is in the early stages of development and work includes partnership arrangements with Forest Oil, Devon Energy Corp., and Range Resources Inc.

## Dale Resources LLC

Dale Resources LLC works its Barnett Shale properties through its Dale Operating Co. subsidiary with a program that includes a heavy emphasis on urban leasing in the Ft. Worth area of Tarrant County and a strong dose of community service.

The company started work in the area in 2003 with an initial leasehold on the Trinity River flood plane where it drills from multi-well pads on sites selected from an urban-consciousness approach. The multi-well pads allow the company to drill and produce from multiple horizontal wells and conduct simo-frac treatments on two or more of those wells along parallel well bores.

Because it works in urban areas, it must assemble properties from numerous leaseholders with small tracts of land. In all, it has leased from more than 95,000 mineral rights owners entities that



include Texas Industries, the City of Arlington, Target, Wal-Mart, and the YMCA.

It currently holds 117 drill site locations on more than 35,000 acres of leases.

The parent company also conducts leasing activities in the area for Chesapeake Energy Corp.

Dale has made numerous contributions to community organizations and installed an education program to help leasing organizations and individuals understand the process.

## Devon Energy Corp.

Devon Energy Corp., through its purchase of two of the biggest players in the Barnett Shale play in North Texas and through its own efforts, is by far the top operator in the biggest gas play in North America. The company bought Mitchell Energy and Development Corp. in 2001 for \$3.5 million. Mitchell initiated the play and held a huge land position in the core area. Devon added Chief Oil & Gas LLC assets five years later. Its position in the core area of the play allowed it to drill most of the top-producing wells in the Barnett.

The company's Virginia Gled 1H horizontal well, with an estimated ultimate recovery of 8.805 Bcf, is one of the best wells in the Barnett play.

It owns most of the properties in the core area of Tarrant, Parker, and Wise counties in Texas and is expanding into other shale plays. It expanded into Wise and Denton counties in 2006.

By the end of 2006, Devon had drilled 2,040 wells in the play, produced 630 MMcfe/d and had 18 rigs on full-time work. Only four years after drilling its first horizontal well into the Barnett, the company completed is 1,000th horizontal well.

During the first quarter of 2008, Barnett production averaged 995 MMcfe/d, up 36% from production at the same time a year earlier. By the end of the quarter, the company's production reached and passed the 1 Bcfe/d mark. It reached that goal 21 months ahead of the originally planned point with the help of 34 drilling rigs working the play and some 3,300 working wells.

According to Chairman Larry Nichols in the company's 2007 annual report, "As first mover in the Barnett, we established the best acreage position in the play, by far. We have thousands of future drilling

locations in the best areas of the field, and we acquired this position at a fraction of the cost of late-comers. As a result, Devon's returns in the Barnett are far superior to that of the competition. Furthermore, we are positioned for continued growth in the Barnett Shale for many years to come."

## RECOVERY TECHNIQUE

When Devon bought Mitchell's position in the Barnett, Mitchell was drilling vertical wells in the most favorable area of the play. Devon began experimenting with horizontal drilling to get more exposure to the producing formation.

More than any other technique, horizontal drilling unlocked the potential of the Barnett and other shales and will be a cornerstone in getting maximum production from other existing and future shale plays.

Even with its substantial production and healthy production growth in the play, the company managed to increase its reserves in the Barnett by 19% in 2007. That's a replacement rate of more than three times its production for the year.

In the past three years Devon managed to slice per-well drilling time in half. In the past year alone it increased recoveries from new Barnett wells by 15%. Nearly all those wells were horizontal.

Devon also found that, in some areas of the Barnett, it can increase recovery with tighter spacing. For example, it drilled its first horizontal wells on 160-acre spacing. It later moved to 80-acre spacing, then to 40-acre spacing and now is trying 20-acre spacing to fine-tune both economics and recoveries.

The company emphasizes that the tighter spacing isn't applicable to all its acreage, but the spacing work will help production from all of its properties.

## ENVIRONMENTAL CONCERN

The massive fracture treatments required to crack the tight shales and reach natural fractures use a lot of water. As early as 2005, Devon began recycling the water it used for frac jobs. It started with two recycling units in 2005 and currently operates nine units that operate 24 hours a day and process more than 2,500 b/d of water each.

The units use heat to vaporize the wastewater recovered from fractured wells, condense the steam

into distilled water and re-use the water in subsequent wells. The units have recycled more than 5 million bbl of water since the program began.

The company's nearly exclusive use of horizontal wells for recovery allows it to drill fewer wells from fewer surface locations.

#### POSITION

The Barnett Shale is Devon's biggest and most important asset and shows no sign of giving up that position, even with the company's substantial commitment to ultra-deep water in the Gulf of Mexico and its work in international plays around the world.

According to the company's 2008 annual report, it provided 37% of Devon's total proved reserves and 28% of its oil and gas production.

Devon is the largest lease holder in the play with some 715,000 net acres. It produced about a fourth of all the gas from the Barnett with 90% of its leases in the most productive areas of the field.

During 2008, the company drilled a record 659 Barnett wells to reach more than 3,800 wells in its inventory. It had drilled 539 wells in 2007 and 383 in 2006. Net production climbed to nearly 1.2 Bcfge/d by the end of 2008 even though the company reduced its drilling budget to match lower gas prices.

At the end of 2008, Devon had some 7,500 undrilled locations, enough to increase production to 2 Bcfge/d. By that time, it had produced more than 1.5 Tcf from the Barnett.

By the end of the second quarter of 2009, Devon reported a record daily production of 719,000 boe/d from all company sources, up 12% from the same quarter a year earlier. At the time, it said "US onshore natural gas production, led by the Barnett Shale field in Texas, demonstrated significant growth."

#### MOVING FORWARD

During 2008, Devon said it planned to drill between 500 and 600 Barnett wells and increase its concentration on 40-acre spacing for infill horizontal wells. It already started experimenting with 20-acre spacing. It looked to the western counties in North Texas for expansion of the Barnett play. Those properties were projected to help the company reach its production goal of 1.6 Bcfe to 2 Bcfe per day.

It exceeded that drilling goal as it reached 659 wells, 559 operated. It also refractured 93 vertical wells.

For 2009, Devon planned to drill between 220 and 230 wells, 208 operated. As prices remain tight, it is selectively deferring completions for maximum economic benefit and will continue to develop its more viable areas with 1,000-ft and 500-ft offset infill programs.

### DTE Gas Resources

The DTE Gas Resource arm of Detroit, Michigan-based DTE Energy Co. works a production operation in the Barnett Shale in North Texas.

The parent company is a widely diversified energy organization with holdings that include

Devon's Bridgeport natural gas processing plant is one of the largest in the country, serving hundreds of gas wells in the Barnett Shale play in North Texas.

*Photo courtesy of Devon Energy*



the Detroit Edison electric utility and the Mich-Con gas utility.

The company currently holds some 60,000 acres of leases with 170 producing wells, and the company planned to increase its operations in the area to add to its 17 MMcfge/d of production. It planned to produce some 5 Bcfge of gas during all of 2009.

During 2008, the company sold a portion of its Barnett properties to another company for approximately US \$250 million. Those properties included some 153 Bcfge of proved and probable reserves on 11,000 net area in the core of the play.

At that time, it kept 44,000 acres in the western part of the play with 108 gross producing wells in Jack, Erath, and Parker counties. It added another 16,000 acres to its properties since that sale.

## EagleRidge Energy LLC

EagleRidge Energy LLC, Dallas-based independent oil and gas company working through its EagleRidge Operating LLC arm, focused its efforts on the Barnett Shale in the Ft. Worth Basin of North Texas.

The company held 2,200 net acres of Barnett properties in Denton and Wise counties.

The EagleRidge corporate vision calls for the company to exploit its existing asset in a disciplined growth strategy.

It also plans to add accretive acquisitions in the Barnett and looks for leases in other trends with potential.

In its North Texas acquisitions it looks for properties that belong to mostly private companies that are undercapitalized and lack operating efficiencies needed for profit.

## Endeavor Energy Resources LP

Endeavor Energy Resources LP has Barnett properties in North Texas, but the private company doesn't publish leasehold, reserves, or production information.

In 2008, the company held properties in the Windjammer Unit in Newark East Field in Denton County, Texas, and, between 2004 and 2009, it installed more than 100 miles of Barnett Shale gathering lines in Parker, Hood, Johnson, Denton, and Tarrant counties with more than 30,000 hp of gas compression. It also built a plant with some 220

MMcfge/d of dehydration capacity to prepare Barnett gas for pipeline transportation.

## Eni Spa

Italy's Eni took advantage of sharply lower gas prices and gas property values to farm in to a position in the Barnett Shale in Denton and Tarrant counties in Texas.

The Italian major aligned itself with a veteran shale gas operator when it bought 27.5% of Quicksilver Resources Inc.'s Alliance leasehold in the play for US \$280 million. That leasehold covers some 13,000 net acres of land, and the arrangement calls for the companies not only to work the properties but to form an alliance to acquire, develop and exploit unconventional gas in an area of approximately 270,000 acres surrounding the Alliance leasehold with the same 72.5% to 27.5% shares. Quicksilver will keep 100% of its gathering and processing facilities in the area and it will continue as operator of the properties.

According to Eni, the deal adds 23 million boe of proven reserves and 17 million boe of probable and possible reserves to the corporate inventory.

At the end of the second quarter of 2009, Quicksilver had three drilling rigs working the Alliance area where it claimed more than 1 Tcfge of resource potential.

At the same time, Quicksilver produced some 263 MMcfge/d from its Barnett Shale properties, including production from the Alliance area. It also claimed more than 3 Tcfge in unbooked reserves.

## EOG Resources Inc.

EOG Resources Inc. made a name for itself as one of the early entrants to the Barnett Shale play outside the core area.

It reinforced that advantage with shrewd adoption of technology and a focus on high production at low cost, and solidified its advantage with the strongest industry presence in the Barnett combo oil and gas play north of the gas trend.

The company focused its early gas recovery techniques on Johnson County, Texas, and helped make that county the most prolific producer outside the Barnett core.

In addition to Johnson County properties, EOG



holds gas-prone leases in Jack, Wise, Palo Pinto, Parker, Hood, Erath, Bosque, Hill, McClennan, Stephens, and Somervell counties. Oil-prone Barnett leases are in Archer, Clay, Montague, Cook, Jack, Wise, Stephens, and Palo Pinto counties north and west of the gas play

**MOVING FORWARD**

The company ended 2007 with production of 375 MMcfge/d from the Barnett and it raised that rate during 2008 with more than 400 new wells. It planned to produce 400 MMcfge/d from the gas-prone area by November 2012, slightly more than at the end of 2009, and approximately 310 MMcfge/d from the combo play by the same time, up from about 70 MMcfge/d at the end of 2009, according to a late September 2009 presentation to investors.

The company continued to report excellent well performance with a development cost of \$1.50/Mcfge in its Johnson and Hill county wells in the gas-prone play.

EOG estimated potential reserves from the gas portion of the Barnett play between 5 Tcfge and 7.2 Tcfge, but it had booked only 1.4 Tcfge by mid-2009

The combo play totaled 194,000 acres in Montague and Cooke counties and another 144,000 acres in Clay and Archer counties, in addition to the 650,000 acres in the gas play.

The combo play returned wells with initial production rates between 200 and 500 b/d of oil plus 130 b/d of natural gas liquids plus between 1 MMcfge/d and 2 MMcfge/d.

Eastern Montague County held some 33 million bbl of oil and 115 Bcfg of gas in place, and EOG planned to recover approximately 2% of the hydrocarbons in place.

EOG planned between 100 and 120 Barnett combo play wells in 2009, and counted 50 MMboe of proved reserves and a 50% after-tax rate of return at September, 2009, oil and liquids prices.

**RECOVERY TECHNIQUES**

EOG's application of technology showed results early in its history in eastern Johnson County. The company found the Viola seal helped keep large fracture treatments within the Barnett and helped prevent water encroachment from the Ellenberger. That seal wasn't nearly as effective in the western section of the county.

The difference showed up in production. Select wells in the eastern area showed an initial potential average of more than 5 MMcfge/d. EOG called those preliminary results evidence that its 35,000 acres in eastern Johnson County could be its single best acreage position in the play.

EOG was one of the earliest users of horizontal drilling to enhance well production. Its horizontal wells in Johnson County came in at higher rates than any other producer in the area, a result of more efficient drilling and better well results. It closed 2007 with production of 375 MMcfge/d from the Barnett.

At the end of that year, the company stepped up its use of automated rigs and more efficient frac jobs to lower well costs.

Perhaps the most innovative step taken by EOG extended its Barnett activity north into Montague, Cooke, Clay, and Archer counties in Texas. It put together 338,000 acres in those counties and turned that part of the Barnett into the combo play.

A full-time rig drills horizontal wells for EOG Resources in North Texas fields. Photo courtesy of EOG Resources Inc.



In eastern Montague County, each section holds 33 million bbl of liquids and 115 Bcfg in place. An average well should produce 45,000 bbl of oil, 75,000 bbl of natural gas liquids, and 540 MMcf of gas for a total of 210,000 boe.

In a 2008 presentation, the company said the breakdown for potential included 110 million to 230 million bbl of oil, 400 Bcf to 800 Bcf of gas, and 50 million to 100 million bbl of natural gas liquids.

EOG's wells and 60 wells by other operators have proved up a Barnett oil fairway 40 miles east to west and 20 miles north to south.

EOG's success in the combo play also displayed the company's technologic expertise. Its per-well net average reserve potential changed from 75,000 bbl of oil, 34,000 bbl of natural gas liquids, and 260 MMcf of gas, for a total of 152,000 boe in March, 2008, to 45,000 bbl of oil, 75,000 bbl of liquids, and 540 MMcf of gas, for a total of 210,000 boe in February 2009.

## Exterra Energy Inc.

Exterra Energy Inc holds working interests in more than 50 Barnett Shale wells producing more than 9 MMcfg/d and some condensate. It also holds rights to acquire working interests in seven wells awaiting frac treatments and another two Barnett wells ready to be drilled.

Overall, the company holds interests in some 17,500 gross acres of leases and more than 63 producing wells in Newark East Field

That includes working interests, carried through first sales, in 3,979 acres of proven undeveloped leases with Barnett potential in Parker and Hood counties in Texas. According to the company's internet site, six Barnett wells are producing on that property and Carrizo Oil & Gas and Sauder Management are conducting a continuous drilling program on the property.

Exterra has a 5% interest in an 80-mile long, eight-inch-diameter, intrastate gas pipeline through parts of Bosque, Hamilton, Erath, and McLennan counties in Texas.

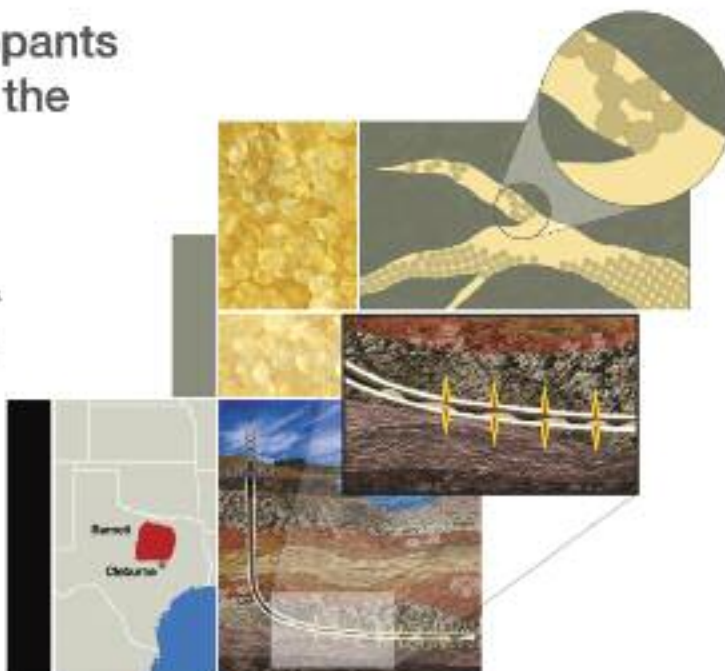
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In addition, the company acquired an overriding royalty interest in three Barnett wells in various stages of completion and a saltwater disposal well in Wise County.

## Fairway Resources LLC

Fairway Resources LLC set up business in 2006 as an oil and gas acquisition, development, and production company with its efforts aimed at the Ft. Worth and Permian basins.

Its Barnett properties lie in Wise, Palo Pinto, and Jack counties in North Texas, and its goal for shareholders is to create value through the drill bit.

Fairway acquired its Barnett properties in Wise County in early 2008 and followed up with Barnett Shale, Strawn, and Bend Conglomerate leases in Palo Pinto and Jack counties later that year.

The company now holds some 3,000 net acres in the Newark East Field segment of the Barnett. It started active operations in the area with a drilling and refracturing program in mid-2008, and the company operates 15 Barnett wells and 25 active Strawn and Bend Conglomerate wells.

## Fleet Oil and Gas Ltd.

Fleet Oil and Gas Ltd. carried out an active program to lease properties in the Ft. Worth area during the past few years.

In 2008, the company owned interests in more than 90 wells in Johnson, Tarrant, Hood, and Parker counties in North Texas and said it had completed agreements with three large public companies. Those agreements could lead to drilling 45 new wells in which the company would hold a participating interest.

Fleet said it had interests in more than 60 Barnett prospects.

The company also had interests in three drilling rigs and four workover rigs, along with interests in more than 150,000 acres of leases in four states.

## Frost Brothers Resources LLLP

The general partners of Frost Brothers Resources are the three brothers Robert, Edmund, and Harold Frost, children of Hildreth Frost Jr. and Doris Bowen Frost of Denver, Colo. The primary activity of the partnership is the development of

natural gas resources in the Barnett Shale underlying Fort Worth, Texas. The initial development has begun at Beach Street near the Trinity River on the land of Bowen Properties. Bowen Properties is the operating name for properties owned by the heirs of R.C. Bowen of Ft. Worth, Texas. Frost Brothers Resources also owns Frost Brothers Pipeline LLC, a public utility natural gas pipeline, with a line extending from the Bowen Prospect area north of the Trinity River into the Old Ocean line of Energy Transfer Partners L.P.

## Gulftex Operating Inc.

Gulftex Operating Inc. concentrated its efforts on the core area of the Barnett Shale and pulled together agreements with some of the largest and most active operators in the play.

In February 2009, Gulftex completed an agreement with Devon Energy, the largest operator in the Barnett for additional acreage in Denton County, the heart of the Barnett play, where Gulftex already had an active program in place. Earlier, the company signed a land acquisition agreement with The Williams Cos.

It also worked with Crusader Energy Group and XTO Energy on the McClendon #2-H, a horizontal Barnett Shale well.

Gulftex planned to complete five Barnett wells during 2009, including an offset to the successful Frenchtown #2-H well.

“A key factor in our agreements with companies like The Williams Companies and Devon Energy Corporation is our success record. By selecting top completion contractors, we can concentrate on providing the experienced oversight critical to insuring optimal production and economic drilling. With lower gas prices, experience can make all the difference in the outcome. We are working to be the lowest-cost producer with the best record in the field,” said Tim Burroughs, chief executive officer.

In early 2009, Gulftex had participated in more than 35 Barnett wells, including 20 in the core area.

## Halek Energy LLC

Halek Energy LLC places its efforts on premium Texas oil and gas projects with a current focus on the western portion of the Barnett Shale.



The company's operations team immerses itself in the full life cycle of its wells and works with industry experts to identify and acquire rights for properties. It currently holds 60 leases in production and designs its own drilling and production programs for each property.

Currently it is working on leases in Jack, Palo Pinto, and Erath counties on the western edge of the Barnett play.

## Hillwood International Energy

Hillwood International Energy, a Ross Perot company, sold a big segment of its properties in the core of the Barnett Shale, but the company retained some of its holdings and continued to work those properties.

Hillwood, Chief Resources LP and Collins and Young sold their Tarrant and Denton county Barnett properties to Quicksilver Resources in July 2008, for US \$1.3 billion.

According to the Pegasus News Wire, the company will retain a significant presence in the Barnett. It quoted Perot, who said, "We plan to continue the development of our Barnett position and remain in the area for a long time to come. The Barnett field development has a significant economic impact on the entire community, and having two strong local companies involved in this transaction enhances the impact for everyone."

The properties sold to Quicksilver included that company's Alliance development. Quicksilver later brought Italy's Eni into that play as a partner and potential partner in developing surrounding acreage.

The Alliance development covered some 17,000 acres in the two counties, but the Quicksilver acquisition involved 13,000 acres that produced some 45 MMcfge/d and estimated proved, probable, and possible reserves of 1 Tcfge.

## Infinity Energy Resources Inc.

Infinity Energy Resources Inc. got a good start in the Barnett Shale in 2004 as it acquired 27,105 gross (20,762 net) acres of leases in the Ft. Worth Basin.

A year later, its Infinity Oil and Gas of Texas Inc. subsidiary connected two of its initial five wells in Erath County, Texas, to a pipeline and seemed well on its way toward successful operations.

In all, the company had 75,000 gross (65,000 net) acres in Erath, Comanche, and Hamilton counties in Texas. It had drilled 16 horizontal and one vertical well in Erath County and three vertical Barnett wells in Comanche County by the end of 2006.

By the end of 2007, however, Infinity experienced liquidity problems and later farmed out properties in Erath County, Texas, to Forest Oil. Under that agreement, Forest Oil could earn a 75% interest in the spacing unit for each well in a 10-well program. If Forest completed the program, it could have earned a half interest in the remaining 25,000 acres of undeveloped leases and accompanying infrastructure owned by Infinity. It started drilling in April 2008, but the program faded with falling gas prices later in the year.

At that time, Renato Bernati, Infinity's chief operating officer, said, "Assuming drill results are favorable, we would expect to realize the benefits of initial production from these activities, which are being funded by Forest Oil, beginning in the third or fourth quarters of 2008. Forest has enjoyed notable success in the Barnett Shale, and the farm-out provides an opportunity for Infinity shareholders to benefit from Forest's operational experience in this regard. Meanwhile, our Infinity-Texas subsidiary anticipates that its 2008 capital expenditures will be limited to less than US \$1 million to potentially complete two vertical wells that were drilled last year."

At year end 2007, Infinity said it would try to continue operating its producing shale properties and could seek additional farm-out opportunities in the Ft. Worth and other basins.

The company said its 2008 capital expenditures would likely be less than the \$1 million required to complete two vertical wells that still awaited completion on March 31.

In August 2009, the company said production resumed at its Erath County properties after a double interruption. The company halted production to swap out compression units and an April 2009 lightning strike damaged a saltwater disposal well.

The wells came back online at a cumulative rate higher than the 2 MMcf/d of gas capacity of the compressor, and Infinity estimated production would stabilize at about 1.5 MMcf/d of gas.

## Infinity Oil & Gas Inc.

Infinity Oil & Gas Inc. celebrated the end of 2008 with the completion of its 220th development well on its Barnett Shale discovery in Johnson County, Texas.

Under the company's operating partner, Chesapeake Energy, the wells reached the best average per-well performance in the Barnett play, the company said.

The best well in the area tested for more than 11 MMcf/d of gas, a better rate than any well in Newark East Field, a field considered the sweet spot for Barnett production. The average production from wells on the company's property was more than 3.8 MMcf/d of gas.

Infinity has an additional advantage in the field. It acquired the property in 1999, just before large companies such as EOG Resources and Devon Energy recognized the potential.

That Barnett success persuaded Infinity to use it as a business model and to increase its involvement in other shale plays around the county.

The company also expanded its Barnett potential with the acquisition of 30,000 acres of a new sweet spot in the play in an area it calls the Rodeo Project. With 15 wells drilled in the area, it has confirmed the gas potential and the company's operating partner started honing completion techniques. That area alone could increase Infinity's Barnett reserves by another 500 Bcf of gas, the company said.

## Kornye-Tillman Co.

Kornye-Tillman Co. holds leases in Barnett Shale and has producing properties.

The Texas Railroad Commission set prorationing limits for the company on its fields in Railroad Commission District 9 in North Texas.

During October, the commission authorized the company to deliver 3.875 MMcf of gas from the Barnett in its Woodard Field. It authorized another 8.37 MMcf of gas from Little Field, another 7.626 MMcf from Crawford C Field, and another 9.548 MMcf from Crawford Field.

## Newark Energy LLC

Investors and industry veterans formed Newark

Energy LLC in 2008 to work the Barnett gas shale and other unconventional plays in the US.

Members of the company's management had worked the Barnett since 1999 and put that experience to work in the new company. By the fourth quarter of 2008, the company held more than 75,000 gross, 21,000 net, acres of Barnett Shale gas leases, mostly in Jack, Palo Pinto, Parker, and Wise counties in the Western Extension Area.

By 2009, the company had 17 horizontal wells and more than 100 identified drilling locations on its properties, and it produced 8 MMcf/d of gas from net proven reserves of 207 Bcfge.

Since early 2008, the company also acquired almost 60,000 gross acres in the Barnett oil play, generally north and west of the gas play in northern Texas, in Montague, Clay, and Archer counties.

Currently, some 8% of the company's production comes from Newark East Field.

Newark frequently partners with other industry companies, including XTO Energy, Quicksilver Resources, and Cohort Energy.

Among the company's other plays, it has more than 45,000 gross acres in the Marcellus Shale in Appalachia where it works with partners.

## Parallel Petroleum Corp.

Parallel Petroleum Corp. used its solid position in the Barnett Shale in Tarrant County, Texas, to assure itself of additional reserves at no cost to the company through a farm-out to Chesapeake Energy Corp.

Parallel made the deal early in 2009 and it, along with every other company in the industry, faced drilling obligations with plummeting gas prices.

At the end of the second quarter, the company had 25,600 gross, 9,300 net, acres operated by Chesapeake and another 8,000 gross, 1,000 net, acres operated by Dale Operating Co.

In 2009, it dedicated US \$10.2 million in capital expenditures to the Barnett play, more than any other project in the company's inventory. Those funds will complete wells that are drilling or being completed and will provide operating money for those wells.

On newer wells under the farm-out agreement, Chesapeake will carry all of Parallel's drilling, completion, and operating costs on wells through Dec.

31, 2016, in a series of projects. Each calendar year represents a separate project.

Payout to Parallel on each project begins when Chesapeake recovers 150% of its drilling, completion, and operating costs. After payout, Parallel can back in for half of its original interest in the wells. It also can participate for half of its original interest on all wells drilled after Jan. 1, 2017, but it must put up a proportionate share of the costs.

From Parallel's point of view, the deal eliminates all non-discretionary capital expenditures in the Chesapeake-Parallel properties through 2016 and frees up funds for other projects. It also gives Parallel cost-free reserve development and shifts leasehold preservation obligations to Chesapeake.

At the end of the second quarter of 2009, Parallel had 96 gross, 24.14 net, producing wells and another 25 gross, 7.82 net, work-in-progress wells. It also had 5 gross, 1.8 net, wells shut in because of water disposal problems. Those wells were scheduled to come back online in the third quarter.

It had 10.34 MMcfge/d in net production from the Barnett, down from 11.57 MMcfge/d in the first quarter. It claimed 19.5 Bcfge in proved reserves.

The company's Barnett Shale project lies in and around the Trinity River flood plain east and west of downtown Ft. Worth. The project controls 75 multi-well drilling pad sites, and the company anticipates development with horizontal wells on 40-acre spacing.

Larry C. Oldham, Parallel's president, said, "During 2009, our top priorities are to maximize liquidity and maintain financial flexibility by funding our \$29.1 million CAPEX budget out of operating cash flow, while positioning ourselves to capitalize on potential growth opportunities. In November 2008, we announced a \$118.8 million preliminary CAPEX budget for 2009, which included \$61.7 million for the non-operated Barnett Shale gas project. Because of our farm-out to Chesapeake, our 2009 capital requirements for the Barnett Shale gas project have dropped 80% to \$10.2 million for the estimated completion costs of the 31 gross (9.49 net) wells that were in progress at year-end 2008."

Parallel got into the core Barnett Shale producing area in Tarrant County and worked with knowledgeable and technologically active companies to increase its production from the play.

From a small start in 2003, the Midland, Texas, company added interests in 16 wells in the play in early 2006 to add an estimated 3.7 Bcf of gas reserves, net to Parallel. Of that, 56% was proved developed reserves. That purchase added 1.4 MMcf/d of gas production.

It purchased those interests from five unaffiliated companies and made arrangements to pay future costs to earn up to a half of those companies' interests in the properties.

In early March of 2006, the company had seven producing wells, two operated by Four Sevens Petroleum and five by Dale Resources LLC. Those wells produced 24 MMcf/e of gas, gross, or 1.16 MMcf/d of gas net to Parallel. Gross production from the wells ranged from 1 MMcf/d to 9.4 MMcf/d of gas.

Later that year, Chesapeake Energy Corp. took over the drilling and completion activities on the company's wells just east and west of downtown Ft. Worth. At the same time, Chesapeake acquired a 61% interest in the properties.

## RECOVERY TECHNIQUES

Even before Chesapeake entered the picture, Parallel and its partners initiated simo-frac treatments on its horizontal wells. Two of the simo-frac wells produced at a combined rate of about 15 MMcf/d of gas, gross.

That treatment involves complementary alternating fracturing of two nearby horizontal well bores usually drilled from the same pad. The fracture treatment in the first wellbore in the first stage creates a high-pressure stress zone around the fracture. That high-pressure zone directs the first fracture in the second well bore away from the first well bore and intensifies stresses around both wells. The result is more fractures with few opportunities for fractures to intersect and short-circuit production in either well bore.

The operation also saves time, since the fracturing equipment stays on the same pad.

## Pioneer Natural Resources Co.

Pioneer Natural Resources Co. put its Barnett Shale activities on the back burner as collapsing gas prices in the second half of 2008 moved the company toward projects with more potential and higher returns.



Pioneer continued to hold its Barnett properties but halted rig activity until higher gas prices made the play more attractive.

In a September 2009 presentation, the company said it had 24 million boe in proved reserves in the Barnett at the end of 2008, along with a multiyear inventory that included more than 450 proved and probable locations. In all, it estimated 90 million boe in addition net resource potential from the prolific Barnett.

The company also is evaluating participation in the liquids rich segment in the northern part of the Barnett play.

The Barnett wasn't the only company play to feel the bite of the budget axe. In its fourth quarter report, the company said it reduced activity from 29 rigs in the third quarter of 2008 to three rigs in February 2009. It terminated or stacked rigs working the Spraberry in West Texas, the Pierre Shale in southeastern Colorado, the Edwards Trend in south Texas, and the Barnett. It returned one rig to active status in the Wolfberry (Wolfcamp-Spraberry) play after the Texas Railroad Commission approved 20-acre spacing in the fifth-largest field in the country.

Pioneer bought into the Barnett play in late 2007, added a substantial position in mid-2008 and, before the price collapse, planned to build the popular shale play into a core area through future operations.

The Irving, Texas, company started its core construction program in November 2007 when it bought Royal Dutch Shell plc's entire position in the play for US \$150 million. Most of the Shell properties were covered by 3-D seismic data.

It's not that Shell couldn't make the play work. The company just wasn't willing to get into bidding wars on smaller pieces of property with independent companies. Getting the kind of substantial position the company wanted would have been expensive.

That \$150 million bought Pioneer 74,000 acres of leases with some active wells and with 81 Bcfge in net proved reserves. The properties had a net resource potential of 480 Bcfge. The wells produced about 15 MMcfge/d and the leases contained 300 additional drilling locations.

Most of the producing properties were on 37,000 gross acres of leases in Parker County, Texas, and Pioneer planned to operate those properties with a 70% interest.

That purchase increased the company's position substantially from the 13,000 acres it already held in the Barnett in Wise County and increased the number of drilling locations to 450. Pioneer formed a 50-50 partnership with Devon Energy on the Wise County properties.

The other 37,000 acres were in expansion areas of the Barnett play.

Pioneer drilled five wells on its property in early 2008, all successful, and planned to ramp up activity during 2008. With 20 wells planned on the partnership properties in 2008, it planned to increase its drilling program for 2009.

Pioneer's filings with the US Securities and Exchange Commission said the company spent almost \$2.6 million on acquisition of proved reserves in the Barnett in the first quarter of 2008 and another \$113,000 for unproved reserves. It spent \$3.3 million on exploration and \$2.16 million on development in the Barnett play.

In July 2008, Pioneer added to its Barnett position with properties in Denton and Wise counties purchased for \$41.5 million in cash from Dune Energy Inc.

At the end of 2007, the Dune properties consisted of 35 producing wells and six wells drilled but awaiting multistage fracture treatments. Those wells contained 19.3 Bcfge in proved developed reserves, and the company had another 13 proved developed locations with an estimated 14.1 Bcfge in net reserves.

During the first quarter of 2008, the properties returned \$7.64/Mcfge for Dune at a cost of \$4.36/Mcfge. Dune left the play, because its Gulf Coast operations gave it \$12.14/Mcfge at a cost of \$4.14/Mcfge, and executives felt the money would go further on the Gulf Coast.

During a presentation after the Shell acquisition, Timothy L. Dove, president and chief operating officer of Pioneer, said, "This is an important transaction as we continue to take steps to build our Barnett shales interest into the core area."

## Quicksilver Resources Inc.

While some other companies curtailed Barnett Shale operations as gas prices dropped in the last half of

2008, Quicksilver Resources Inc. continued strong growth in the company's core production area.

According to Quicksilver's Web site, "The Barnett Shale formation in the Ft. Worth Basin of North Texas is the foundation for the company's growth. The company has leased approximately 275,000 net acres in this world-class basin, including more than 173,000 net acres within the company's defined core fairway. With less than 40% of the acreage in the core fairway currently developed, the company expects to achieve continued growth in production and reserves in Texas, where more than 5 Tcf of total potential (gas equivalent) resources have been identified."

According to a September 2009 presentation, Quicksilver increased Barnett production 54% between the end of the second quarter of 2008 and the same date in 2009.

It claimed 192,000 net acres of Barnett holdings and a 10-year project inventory.

In June 2009, Quicksilver brought in a partner, Italian energy giant Eni. Eni acquired a 27.5% share in Quicksilver's Alliance leasehold in the Barnett Shale for \$280 million. The Alliance leasehold covers 13,000 acres, and the companies agreed to examine the 270,000 acres of properties surrounding that leasehold. If they find candidates with potential, they will jointly acquire, develop, and exploit unconventional gas in that area on a 72.5% to 27.5% basis.

Eni said the arrangement added 23 million boe of proven reserves and 17 million boe of probable and possible reserves to its corporate stockpile.

Quicksilver will retain all of its gathering and processing facilities in the area and will continue to operate the properties.

Quicksilver produced 263 MMcfge/d and had unbooked resources of more than 3 Tcfge from all of its Barnett properties at the halfway point of 2009.

The company continued development work its 175,000 net acres in its core fairway.

In the second quarter of 2009, it drilled 29 (22.9 net) wells and connected 27 (25.2 net) wells to sales and had five rigs working in the basin, including four rigs in the Lake Arlington and Alliance areas in Tarrant and Denton counties.

## BACKGROUND

Quicksilver Resources Inc. took a textbook approach to Barnett Shale development and choreographed triple-digit growth rates in the popular shale play in the Ft. Worth Basin of Texas.

In a presentation to analysts, Quicksilver outlined its timeline in the Barnett.

In 2002 and 2003 it identified the opportunity and started acquiring acreage. The following year, it started proving the commerciality of the play. It started defining the fairway and building infrastructure in 2005 with 45 net wells and hooked 39 of those wells into pipelines producing 10 MMcfge/d.

It started real development the following year with a cumulative 158 wells drilled and 98 wells place onstream producing at 35 MMcfge/d.

In 2007, it began optimizing spacing and doubled production again. By the end of the year, it produced 90 MMcfge/d, had drilled a cumulative 377 wells and produced from 261 of those wells.

It ramped-up development in 2008. By the end of that year, it planned to produce 193 MMcfge/d

## ACQUISITION

Most of Quicksilver's growth came from the drill bit, but it accelerated its growth potential in July 2008 with the US \$1.307 billion acquisition of Barnett Shale properties from a group of independents consisting of Chief Resources LLC, Hillwood Oil & Gas LP, and Collins and Young LLC.

The properties produced 45 MMcfge/d of gas and may cover more than 1 Tcf of recoverable gas resources, net to Quicksilver. That number includes 350 Bcf of proved reserves. Some 40% of those reserves are proved developed. It expects 650 Bcf of additional resource potential on the 13,000-acre Alliance Project in the acquisition.

The company's acreage lies in Hood, Parker, Johnson, Somervell, Denton, Erath, Bosque, Hill, Hamilton, and Tarrant counties in the southern part of the Barnett play.

Throughout its holdings, it drills horizontal wells from multi-well pads in broad "V" patterns.

At the end of 2008, the company had a 10-year development inventory, and 98% of the company's properties were covered with 3-D seismic.

## Ram Resources Inc.

Ram Resources Inc. held interests in some 27,000 gross, 7,000 net, acres of Tier 1 Barnett Shale properties in Jack and Wise counties in North Texas and another 17,000 gross, 13,000 net, acres in the Tier 2 Bosque and Hamilton counties.

Going forward, the company will continue to evaluate its Barnett Shale properties in North Texas, particularly in its Tier 1 properties.

Since the company was founded in 2006, it has drilled 19 gross, 7 net, Barnett wells with a success rate of 100%.

It drilled 7 gross, 3.2 net, wells in 2008 to get a net daily production rate of 515 boe/d, or about 7% of the company's total daily production for the year.

The company holds a participation agreement with Devon Energy Corp. giving Ram the right to participate with a 36% working interest in wells in its contract area. All 19 gross wells were drilled under that agreement.

Through 2008, Ram claimed 2.6 million boe in proved reserves in the Barnett Shale, or approximately 6% of the company's total proved reserves.

## Range Resources Corp.

Range Resources Corp. greeted lower gas prices with continued emphasis on cost controls and a sharp focus on its three primary plays, the Barnett Shale in Texas, the Nora/Haysi coalbed methane/shale field in western Virginia, and the Marcellus Shale in Appalachia.

The company increased production from its Barnett properties even as it cut the number of rigs working the play to two.

Overall, Range trimmed working rigs to 14 at the end of the second quarter of 2009 from 30 at the same time a year earlier. According to John Pinkerton, chairman and chief executive officer, "Given our excellent portfolio of drilling opportunities driven by the Marcellus, Nora, and the Barnett, coupled with our low cost structure and shallow decline property base, we are well positioned to continue our strategy of consistently growing production and reserves at low costs."

As part of its economizing strategy, Range chose not to renew some leases, "primarily those outside of our core area in the North Texas Barnett Shale play, given current low commodity prices," he added.

By the end of the second quarter, Range produced a net 120 MMcfge/d from its Barnett properties and had recently tested seven Denton County wells that produced at a combined rate of 17 MMcfge/d. It also completed two northeast Parker County wells with one reaching an initial production of 7.6 MMcfge/d. That could be the best well in the county.

By the time the company made a September 2009 presentation to analysts, Barnett production had climbed to 130 MMcfge/d.

At that time, Range offered a comparison of its three core plays.

The Barnett offered 1.8 Tcfge in resource potential with more than 1,000 additional drilling locations in the core area. The finding and development cost was \$1.14/Mcfge, and it provided the company a 23% return at a New York Mercantile Exchange gas price of \$4/MMBtu.

In contrast, the Nora/Haysi Field offered 2.3 Tcfge of potential with an additional 6,000 drilling locations. Finding and development costs in that area were 88 cents/Mcfge, and Range expected a 24% return at \$4 gas.

With those numbers as a base, it's easy to see why the company put the Marcellus Shale at the top of its development list. The Marcellus has 15 Tcfge to 22 Tcfge of resource potential, Pinkerton said during the presentation. Its finding and development cost was \$1.16/Mcfge/d, but Range anticipates a 34% return with \$4 gas.

Range's best Marcellus horizontal well reached an initial potential of 26 MMcfge/d and a 30-day average production rate of 10.8 MMcfge/d. Its best vertical well initially produced 6.8 MMcfge/d.

Range uses the simo-frac technique of simultaneously fracturing adjacent wells to get incremental gains in the fracture matrix on its Barnett wells.

In July 2008, the company held 109,000 net acres in the Barnett with 90 MMcfge/d of production. Some 42,000 net acres of that total were in Tarrant, Johnson, Denton, east Parker, east Hood, north-west Ellis, and southwest Dallas counties.

## Republic Energy Inc.

Privately held Republic Energy Inc. of Dallas worked the Bend conglomerate in the Ft. Worth Basin as



early as 1984 and watched while Mitchell Energy and Development spent money and thousands of hours of work trying to make the Barnett Shale pay off.

Mitchell achieved its goal and Republic engineers knew a good thing when they saw it. Republic was one of the first companies to enter the Barnett Shale play. It began accumulating leases in Newark East field in 1998. At the same time, it began its own fracture optimization program.

The company had been working low- to medium-risk prospects since 1984 with a primary focus in the Ft. Worth Basin. Since that start, it has drilled more than 350 Barnett and Bend conglomerate wells and has drilled more than 250 Barnett wells in the past 10 years with a 98% success rate.

It started its first multiyear Barnett development program in 1997 and sold out of the play in 2003 when Progress Energy purchased its properties for US \$148 million. That price bought Progress 195 Bcf in proven reserves with 30.1 MMcf/d of gas. That was a price of 76 cent/Mcf of proven reserves and \$4,911/MMcf/d of production, according to *Oil and Gas Investor*. Republic had permitted and drilled 92 wells in Wise and Denton counties in the core Barnett area between 2001 and 2003. Progress also contracted Republic to operate the properties for a year.

By that time, Republic had more experience than most companies in the shale, and it was getting high returns on the properties.

Republic rebuilt its Barnett operations with the help of a \$14 million lease acquisition program and drilling plan and sold out again to Burlington Resources in 2005 for \$140 million. During the two-year period, the company assembled 45,000 net acres in the Barnett. ConocoPhillips later picked up the properties when it acquired Burlington Resources later that year for \$35.6 billion.

Republic still is working the Barnett and used the Barnett experience to expand its reach to the Marcellus Shale in Appalachia.

For the future, Republic planned to continue its focus on the Barnett as the play moved to the south and west. It was rebuilding its lease position once more in areas with economic potential.

It also took its shale expertise to Wetzel County, W.Va., where it joined Trans Energy Inc. in a joint venture to test the Marcellus Shale.

According to James K. Abcouwer, president and chief executive officer of Trans Energy, “The Marcellus is looking more and more like a Barnett-style significant play, covering a large area of western Pennsylvania and northern West Virginia. We chose Republic because we didn’t want to climb a steep learning curve, as we see many other local operators now doing.”

## Roil Mineral & Land Co.

Dehryll Galloway, founder of Roil Mineral & Land Co., Roil Energy LP, and Roil Resources Inc. has raised money to drill wells in and around Wise County, Texas, since 1976.

Between 1976 and 1980, he raised US \$10 million for Crown Companies, or 20% of the cost of 109 wells, 69 successful.

In 1980 and 1981, he helped raise \$5 million for eight joint ventures, five operated by Crown and three by Roil Resources.

Since that time, he has been involved in funding, drilling, completing, and operating more than 200 wells.

More than 100 of those wells produced from the Barnett Shale, according to the company.

Roil’s latest venture attempted to raise money to drill the Clark #1 prospect in Montague County, Texas, about 6.5 miles west of the Wise County boundary line.

Under the proposal, the company offered 34 units at a cost of \$38,950 each to raise \$1.36 million for a 75% working interest (25% royalty).

The company broke down the cost of each unit into \$19,950 to drill and test the well, \$9,500 to complete and equip the well, and another \$9,500 to fracture, flow back, and start production.

## Ropa Exploration Corp.

Ropa Exploration Corp., a veteran North Texas operator, raises money by offering fractional interests in oil and gas wells in Jack County, Texas.

It currently is operating low-risk, infield development wells in the Booneville Bend Conglomerate Field and a field extension attempt in Risch Field in an area about 65 miles northwest of Ft. Worth, according to the company Web site.

Those prospects offer potential pay from up to 20 zones, including the Barnett Shale, which is the primary objective.

Once it raises the required funds, Ropa begins a joint operation with 3-R Production Inc. If the well is successful, Ropa and 3-R jointly operated the well. The production company has approximately 175 properties and owns and operates 100 wells in the area.

All of the programs are multiple-well, multiple-zone programs, and the wells are direct offsets to producing wells. Both Ropa and 3-R take a sizable interest in each program.

## Talon Oil & Gas LLC

Talon Oil & Gas LLC, newly formed in 2007, bought into the Barnett Shale play in mid-2009 as it purchased 60% of the Barnett properties owned by Denbury Resources Inc.

The purchase price totaled a net US \$259.8 million after adjustments and natural gas swaps for 2010, totaling 13 MMcf/d at an average price of \$5.65/MMBtu.

Production from the properties averaged some 45.7 MMcfge/d with 77% of the production in natural gas during 2008.

Although the companies didn't disclose the specific properties involved in the sale, Denbury held some 20,441 gross, 19,457 net, acres in the play in Parker, Wise, Tarrant, and Johnson counties with 458 Bcfge in proved reserves and 77 proved undeveloped drilling locations and another 64 probable undeveloped locations at the end of 2008.

In announcing the sale, Denbury Chief Executive Officer Phil Rykhoek said the company could make better returns on its Gulf Coast Tertiary oil assets and the sale would allow Denbury to accelerate that program.

Talon, a private company, was formed with investment backing from Encap Investments. It counts among its management people who have worked together for 15 years, including key senior positions at Coda Energy, Belco Oil and Gas, Westport Resources, and Kerr-McGee Corp.

## Titan Operating LLC

A group of Barnett experts, backed by Riverstone Holdings LLC, funded the start up of Titan Operating LLC in August 2008. The company dedicated itself to acquiring properties in the Barnett Shale.

Executives, led by Hollis Sullivan, chairman, include veteran Barnett players from EnCana Oil & Gas USA and Range Resources.

Sullivan was one of a number of operators that sold some 12,900 acres of Barnett properties to XTO Energy for US \$800 million.

"A partnership with a firm as well regarded as Riverstone is a milestone event for Titan. We believe that the opportunities in the Barnett, coupled with the sponsorship and support of a world-class private equity partner, have the potential to elevate Titan to become a significant player in the basin," Sullivan said in an article in the *Fort Worth Star-Telegram*.

The company started efforts by combining with the Caffey Group, a land company, to file more than 2,200 mineral-rights leases in Tarrant County. It acquired leases in the southwest and north Arlington areas and won the Colleyville Area Mineral Rights Association endorsement for a bid on properties under its members, but it later withdrew its offer in that area.

## Upham Oil & Gas Co. L.P.

Many companies boast long-time operations in Barnett Shale country, but few can match the 50 years of work in Palo Pinto, Parker, Jack, and Wise counties in North Texas tallied by Upham Oil & Gas.

The Upham family started business in the industry in the 1800s in Pennsylvania when David A. Upham owned one of the three drilling rigs in the world. The family moved to Palo Pinto County in 1914 and brought in its first gas well in the area in 1917, according to the company Web site.

The company now has gas-processing plants in Chico and Strawn, Texas, and several hundred wells in the four counties.

It drilled many of those wells for oil in the Conglomerate, Strawn, Marble Falls, and Big Saline formations.

The company did get in on the Barnett Shale play. Texas Railroad Commission records show the company had 18 Barnett wells in Newark East Field and another well in Wise County Regular Field.

## Vantage Energy LLC

Vantage Energy LLC, through its Vantage Fort Worth

Energy affiliate, started an aggressive leasing program in the Barnett Shale in the Ft. Worth area, but shifted to a lower gear as falling gas prices changed the economics of its near-record lease offers.

According to the *Fort Worth Star-Telegram*, the company, along with the Caffey Group, a land company, offered \$27,500 an acre to win the endorsement of the Southwest Fort Worth Alliance group representing more than 20,000 homeowners. Among publicly reported bids, only Chesapeake exceeded that offer with its \$30,000/acre bonus bid for properties in the Lake Worth area. The Vantage offer covered some 8,000 acres more than south of Interstate 20, about 10 times the area of the Chesapeake offer.

Vantage also undercut Chesapeake in its royalty proposal with plans to pay 23% in contrast to Chesapeake 25%.

As natural gas prices fell in 2008, however, Vantage cut its leasing activity in the area but said it would honor drafts previously issued.

Vantage also teamed with Titan Operators to win the leasing endorsement of a group of neighborhoods in the Grand Prairie area near Ft. Worth.

## The Williams Companies Inc.

The Williams Companies Inc. produced 1.2 Bcfge/d in the US from 4.3.Tcf of proved reserves in 2008, and it plans to grow with the help of its Barnett Shale assets in the Ft. Worth Basin.

The company specializes in natural gas from tight sands, coal seams, and shales.

At the end of 2008, the company produced 88 MMcfge/d from its Barnett Shale and Arkoma Basin properties combined.

By the end of March 2009, it produced 110 MMcfge/d gross, 81.5 MMcfge/d net, from the Barnett alone, according to an analyst presentation. The Barnett Shale, although much smaller than the company's Colorado properties, returned the highest growth.



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*Photo courtesy of  
Cohort Energy Co.*

Currently the company is high-grading its Barnett properties as it works some 250 drilling sites, based on 160-acre spacing.

In May, it held 35,000 net acres in the Barnett and 90% of that acreage was in the core and Tier 1 areas.

At the end of 2008, it claimed 190 Bcfge of proved reserves in the Barnett and 430 Bcfge of proved, probable, and possible reserves.

Williams has maintained a high growth rate in the popular shale play since it took over the properties.

During 2007, Williams' Barnett production grew 78% to 35 MMcfge/d with four rigs running full time. At that time, the company said it increased its growth potential with tighter spacing on its wells.

By the end of the first quarter of 2008, the company had Barnett doubled production from the previous year to 38 MMcfge/d, still with four rigs working. It produced from 100 wells roughly between Burseson and Bartonville, Texas.

Not a bad record for a company that didn't enter the Barnett play until the second quarter of 2005. It also anticipated 700 MMcf/d of gas production growth from its Ft. Worth Basin properties by 2017.

Williams' latest move will help it attain that goal. In August 2008, it acquired some 10,000 acres of Barnett properties for \$147 million from a group of companies that included Aspect Abundant Shale LP.

The properties in that purchase lie in Tarrant, Hood, and Johnson counties and include 41 wells producing a net 9 MMcfge/d. That's a significant addition to the 34,000 Barnett acres already held by the company. Even if the acquisition doesn't go through, Williams will hold 277 Bcfge in proved, probable, and possible reserves on its existing properties. If the deal goes through, it will add 175 Bcfge in proved, probable and possible reserves to that number.

Williams planned to contract two more rigs to work the new properties.

In its latest presentation, Williams said it could break even on Barnett core wells with a gas price of \$3.92/MMBtu, while properties in the western extension would require an \$8.94/MMBtu price to break even.

To get a 10% rate of return, it would need \$4.50/MMBtu in the core.

## R.P. Wilson Inc.

Richman Petroleum successfully drilled the 1H R.P. Wilson well in 2003 to mark the first Barnett Shale production in Erath County, Texas, according to Stephen Trammel, senior production manager of Current Activity Products at IHS Inc., writing for the October 2009 issue of the *Ft. Worth Basin Oil & Gas Magazine*.

Richman completed that horizontal well with fractured perforations between 4,350 and 4,570 ft to test at an initial potential of 33 b/d of oil, 199 Mcf/d of gas, and 361 b/d of water from a total depth of 5,048 ft.

R.P. Wilson Inc. owns the well now, and it has produced 2,430 bbl of oil, 22.5 MMcf of gas, and 24,857 bbl of water since it was drilled. That company, and others, continued to drill to the Barnett.

Since that time, the Erath County portion of Newark East Field hosted some 150 Barnett wells with a cumulative production of approximately 12.4 Bcf of gas and 64,547 bbl of condensate.

In September 2009, R.P. Wilson was drilling a wildcat on the western flank of the Ft. Worth Basin in central Erath County, Trammel said. It spudded the 1 Lane-Heady with a Cobra Drilling rig more than three miles west of the company's Stephenville headquarters with plans to drill to 4,000 ft, some 400 ft deeper than the Barnett Shale.

That location is southeast of a proposed 4,000-ft injection well permitted by the company earlier in 2009.

## XTO Energy Inc.

XTO Energy Inc. is a Barnett Shale powerhouse, producing some 631 MMcfge/d net from the Barnett Shale, and it maintained a high growth level in the Barnett and its other major shale plays.

At the end of 2008, it had 13.9 Tcfge in total reserves and was one of the top 10 gas producers in the country at 2.35 Bcfge/d.

More than 20% of its production came from the Barnett.

By the end of the second quarter of 2009, production climbed to 2.9 Bcfge/d, up from 2.2 Bcfge/d

a year earlier, and the Barnett accounted for 22% of the total, or 621 MMcfge/d.

Among its best core-area wells in the second quarter of 2009 were the Gafford C 1H with an initial potential of 5.5 MMcfge/d, the Arlington Surber

B 2H, at 5.1 MMcfge/d, and the Gafford D 1H at 4.6 MMcfge/d.

At the end of the period, the company held 277,000 net acres in the Barnett Shale and had 10 drilling rigs running. The rig total had been as high as 25 in 2007, according to a company report.

One reason for the company's phenomenal growth showed in its 2008 strategic acquisition program when it spent some US \$11 billion to get 1.7 million acres of leases in the nation's top five shale plays.

That program included Barnett reserves from a number of small sellers for \$1.5 billion.

Prices dropped sharply since the middle of 2008, but XTO believes they will return to higher levels. On June 2009, assuming a gas price on the New York Mercantile Exchange of \$7.50/MMBtu, it would get a 92% return. Even with \$5 gas, the return would come in at 47%.

XTO President Vaughn Vennerberg, in an *Oil and Gas Investor* article, said he was looking for additional Barnett reserves in 2009 and expected to find them, particularly from companies with expiring leases.

Among earlier acquisitions, in July 2008, XTO closed its acquisition of Bakken Shale oil-producing properties in North Dakota and Montana from Headington Oil Co. for \$1.8 billion in cash and stock.

Also, in July, the company signed a definitive agreement to acquire 12,900 net acres of Barnett Shale properties adjacent to its existing holdings for approximately \$800 million. It did not identify the seller. Those properties hold estimated proved reserves of more than 300 Bcfge. About 25% of that constitutes proved, developed reserves. The acquisition also will increase the company's production from the Barnett by 35 MMcfge/d.

"This bolt-on acquisition is perfectly situated in the fairway of our ongoing development in the area," said Keith A. Hutton, president. The company expects the acquisition to add more than 1 Tcf of gas to production over time. Closing is scheduled for early October 2008 with a July 1 effective date.

The company also is installed midstream infrastructure to accommodate planned growth. XTO currently has some 2,000 wells.



Cohort Energy Co. has drilled about 110 gross horizontal wells in the Barnett and has interests in more than 200 wells, including vertical completions.

*Photo courtesy of Cohort Energy Co.*



# Play Big in the Big Plays

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# The ‘Sleeping Giant’ Awakens

For more than 20 years, many scoffed at ‘Mitchell’s Folly’ as the intrepid wildcatter doggedly probed the inhospitable shale in the Fort Worth Basin — not anymore.

**By Dick Ghiselin**  
Contributing Editor

*Dawn lights the Barnett, and the silence is shattered by dozens of pump engines as they roar into life, waking the sleeping giant. Photo courtesy of Schlumberger*

Hailed as the largest unconventional gas play on the North American continent, the Barnett Shale was the harbinger of untold energy production that has spread across the US and Canada like wildfire. Names like Horn River, Haynesville, Marcellus, and Fayetteville were all but unheard of a decade ago until George Mitchell proved the possibility of producing commercial volumes of natural gas from the giant shale that today spans 21 counties of North Texas.

With predicted peak production pegged at 8 Bcf/d sometime around 2018, there’s still a lot of gas to be found and produced, and an equal amount of

challenges to be tackled in the Barnett. But no one likes challenges better than the technology providers in the service sector. They have applied their considerable experience and learnings gained from the activities of Mitchell and other early believers to develop better technology that improves recovery factors, enhances reservoir contact, and reduces well construction costs.

## **Variable reservoirs present variable challenges**

In shale plays, the traditional fracturing technique can be characterized as “perforate, pump, and pray.”

This reasoning seemed logical as many shale formations and traditional logs in shales lack character; however, one thing has become evident — not all shales are created equal, and not all sections of a lateral can be treated equally. With the massive geographical extent of the Barnett Shale, it is not surprising to see differences in reservoir characteristics from one part to another and differences in production from one well to another. In fact, it is also not surprising to learn that different fracturing stages in the same well behave differently. Schlumberger has developed the tools and expertise to understand this variability.

“Schlumberger has a more than 20-year history of experience in the Barnett, and there has been quite an evolution of technology in that time period,” said Shane Smith, Schlumberger technical sales manager for the Dallas-Ft. Worth area. “The first wells were all vertical, but now by far the majority of wells are horizontal because of the ability to contact more of the reservoir. To assist with the interpretation of all the data collected in this 20-year span, we opened a Regional Technology Center in Dallas in 2007, which focuses specifically on understanding shale gas.

“Completion technology has kept pace with the evolution to more horizontal completions. There has been a parallel evolution as well in fracture design. We base our designs on data acquisition and proper use of the data to impact the formation. The key to unlocking the full potential of shales is reservoir characterization and operating efficiency. Schlumberger has expertise in both.”

Following are a few technologies and services that have significantly improved operators’ ability to contact more of the right rock.

### Understanding goes back to ground truth

Core analysis performed by the Schlumberger geo-technical team at TerraTEK has been fundamental to gaining insights into the Barnett Shale. “We have acquired and analyzed thousands of core samples using tight rock analysis (TRA) to develop a clearer understanding of the geology, petrophysics, and geomechanics affecting the reservoir,” said Smith. TRA provides a detailed core measurement of rock permeability, porosity, and fluid saturation in chal-

lenging tight gas shales. “TRA helps to maximize recovery through expanded knowledge of vertical and lateral reservoir heterogeneity, reservoir quality, completion quality, fracture containment, fluid sensitivity, and retention of fracture conductivity.

### Finding the sweet spots is key

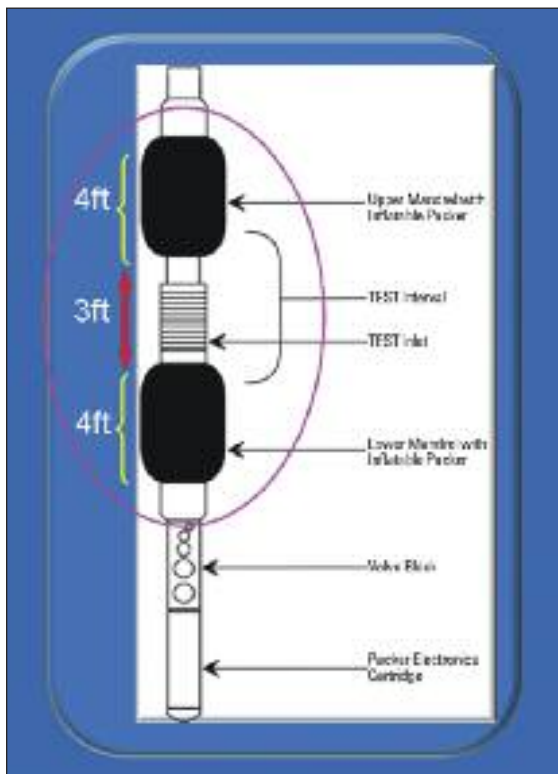
Like most shale play participants, Schlumberger recognizes that knowledge is power. Finding the gas and understanding how to recover it requires an integrated well evaluation process that draws on the experience of the company in gas shale development and its extensive suite of proven tools. The ECS\* Elemental Capture Spectroscopy tool is a geochemical tool that is the basis for resource evaluation. This tool classifies the types of rock in the reservoir and quantifies gas in place. The Sonic Scanner\* tool offers a better understanding of the distribution of stress and stress anisotropy along a well bore. Lastly, the FMI\* Fullbore Formation MicroImager device is used to determine the resistivity and clay content along the well bore as well as classify the natural and drilling induced fractures present. These tools are used to characterize the localized stress regime (called “states of stress”) that governs fracture propagation in shales. This information can be used to determine the best places to land new laterals, optimize perforation and staging strategy to contact more reservoir, and avoid potential trouble portions of the reservoir that may lead to undesired fracture results. All of these things help create better fracs and better production.

### Keeping the frac contained

As explained in SPE Paper 124147, one of the biggest challenges Barnett operators face when expanding their drilling activity to non-core areas is keeping their frac contained. Excessive height growth can introduce inefficiencies, driving up costs as well as reducing production and recovery. “You can place and land your well in the sweet spots, but if you don’t have fracture containment, you still may have water production issues,” said John Daniels, hydraulic fracture placement optimization product champion for Schlumberger. Predicting fracture containment, therefore, is a must, and the company has developed a three-step technique



Modular Dynamic Tester (MDT) tool configured for *in situ* stress testing. Image courtesy of Schlumberger



designed to place and orient fracture perforations in the best position every time. Key to this claim was the development of the *in situ* stress testing tool, which is a creative reverse-application of one of the company's most reliable services, the MDT\* modular formation dynamics tester.

At the core of the technique is the MDT Pump-Out Module, which is used to initiate a mini-frac while acquiring vital pressure measurements and transmitting them to surface in real time. Here's how it works:

The pump-out module is installed between two packer modules creating a very accurate mini-frac tool. The tool is positioned and mini-frac conducted opposite a zone of interest identified by the ECS, Sonic Scanner, and FMI. The stress required to break down the formation is measured by the MDT and is used to calibrate the logs' measurements as well as core measurements. These calibrated stress measurements can then be fed back into models, allowing operators to land their laterals in the right place as well as choose where and how to complete their wells for maximum reservoir contact.

The application of the three-step process takes the guesswork out of picking perforation zones

for multistage frac jobs. To prove the point, a client used this technique to choose a new landing point and determine perforations and staging for a well drilled in an area plagued with fracture containment issues and subsequent water production. StimMAP Live\* hydraulic fracture mapping was used to monitor this treatment in real time. Both the microseismic data and production information confirmed that the fracture stayed contained in the Barnett. This level of multi-measurement integration within a 3-D earth model illustrates the opportunity for step changes in shale gas development.

### Microseismic to simulation

Daniels acknowledged that the Barnett offers lots of stimulation challenges.

"Our expertise has been greatly enhanced by our ability to acquire relevant microseismic data and use it to drill and stimulate better wells for our customers," he said. "The value of having an integrated solution is three-fold. Firstly, microseismic imaging has allowed us to optimize our fracture treatments, literally on-the-fly, based on our real-time interpretations. With advanced processing algorithms delivering results every 15 seconds, we can use this data to help us understand when to deploy diverters or alter our pumping schedule to achieve the customer's objectives. Secondly, the integration of this data back into an earth model helps us truly understand the relationship between geomechanical and geophysical properties of the reservoir and hydraulic fracture placement. Lastly, the microseismic data can be used to simulate production and recovery from the well using all of the data contained in the 3-D earth model. At the end of the day, this information improves our ability to manage the asset and enhance recovery."

### Horizontal re-fracs grow in popularity

Based on information from SPE Paper 119636, Daniels offers the following: "Recently, we've seen a lot of Barnett Shale production logs that share a common trend. Of the perforation clusters in a typical horizontal, less than half are contributing to production. A few perforation clusters in each well deliver a majority of the gas. Both produc-

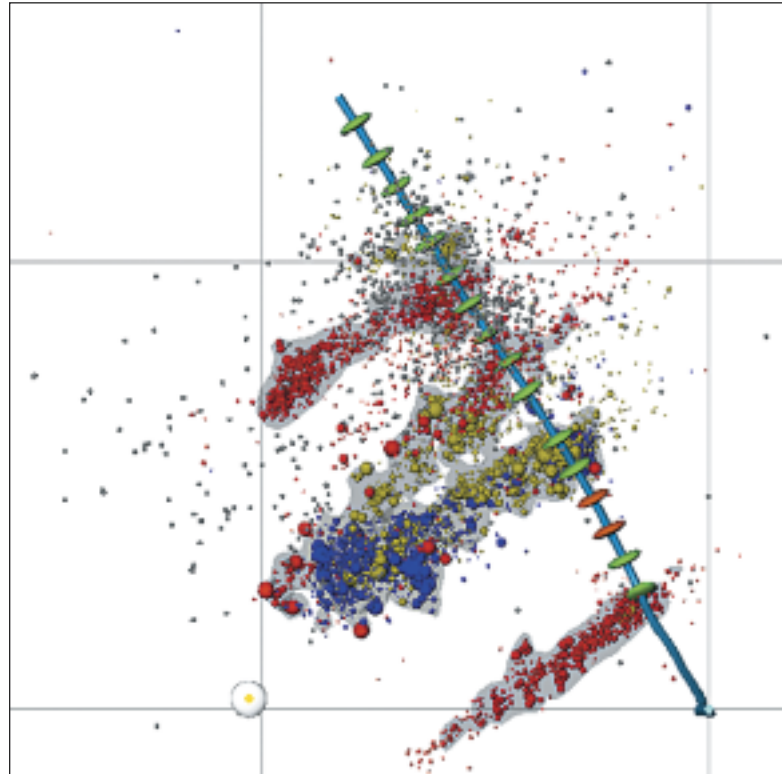
tion logs and microseismic data have clearly shown that we are not effectively contacting the reservoir.

“We’ve learned that there is a lot of gas left to be produced from the Barnett. So much so, in fact, that we have identified more than 8,000 Barnett wells that could benefit from re-treatment. This has led us to develop a rigorous candidate selection process whereby we classify wells based upon their potential for improved production as a result of re-fracing. Following candidate selection, we deploy key enabling technologies to identify the low-hanging fruit for our customers. As a result of these efforts, we have been able to lower finding and development costs for some of our clients by as much as 40%. The horizontal re-frac market is one I call a ‘sleeping giant’ in our industry, one that is starting to stir.”

### Turning data into decisions adds value

According to Daniels, for Schlumberger to take a leading role in the future of the Barnett Shale, the company will be working with this sleeping giant over the next few years. “Our goal is to help operators to quickly and efficiently add reserves while reducing their finding and development costs,” he said.

Daniels explained that unless the production logs tell them that a perforation cluster is making water there is no need to squeeze off old perforations before attempting a re-frac treatment. “When we go in for a re-frac, we add new perforation clusters in the zones we have picked based on relevant stress logs like the FMI or Sonic Scanner, production logs, and/or the previous StimMAP image if this data is available. We start pumping the re-frac, and if any of the old, open perforations start taking the treatment, we pump the diverter to move the treatment over to the new perforations. By observing the StimMAP



Microseismic events while refracturing a Barnett Shale horizontal well. MS events were detected before (yellow) and after fiber diversion cycles (blue and red). The aggressive diversion cycle (red) successfully stimulated new portions of the reservoir.  
*Image courtesy of Schlumberger*

image or distributed temperature profile (DTS), we know where the treatment is going and that governs our actions. Once we stop fracing new rock, we divert. No expensive and risky cement squeezing is required,” Daniels explained.

“We use the data to help our customers make better decisions on which wells to re-frac and which zones to re-frac within those wells,” he continued. “It allows us to use our ‘measure-control-optimize’ process to make decision on-the-fly that help place the fractures precisely where they can contact the most new reservoir rock. To do this we use our StimMore\* fiber diversion technology whereby degradable microfibers are pumped with the treatment to bridge over the fracs and shift the treatment force to the next point of least resistance. So we break new rock. We can observe this in real time using StimMAP Live or DTS and use the combination of pumping, observing, and diverting to contact more rock – which is the overall objective. The fibers bridging the early fractures degrade after a few days leaving all fractures open to contribute to production. Doing this, we have added on average 0.7 Bcf per re-fraced horizontal well.”

### Going green benefits the environment

In an effort to reduce the carbon footprint and impact on the environment, Schlumberger has developed state-of-the-art “green” chemistries, which are gaining popularity in the Barnett. The principle stimulation treatment is the “Slick-water Frac” and friction-reducing chemicals are used to lower the required frac horsepower. North America is increasingly focused on the environmental aspects of the chemicals used in hydraulic fracturing of shale reservoirs. Schlumberger is responding to this need by developing new non-hazardous fracturing fluids. The new green fluids will include friction reducers, bacteriacides, surfactants, and scale inhibitors. “These new products will enable our clients to use a wide range of water qualities such as flowback, produced, plant, or mine water. This will have a large beneficial effect on the operator’s environmental impact,” Daniels concluded.

### BJ Services: ‘Know your reservoir first’

BJ Services’ shale team practices what it preaches.

According to Chuck Bell, East Region technical manager, “The Barnett is a variable reservoir, and its variations are striking. There is no universal ‘Barnett solution’ so we must take the time to develop a clear understanding of all the factors affecting production in each Barnett area. Essentially our recommendations and designs are driven by the interplay of those factors. There are frac barriers, pressure changes, and fluid contacts and they all add up. The vertical wells typically produce less gas than the horizontal wells. However, horizontal wells that aren’t drilled and completed in an optimum fashion may not be as good as a vertical well. Starting every job with our Understand the Reservoir First™ process and knowing the principle stress direction helps operators drill the well in the direction of minimum stress to set up transverse fractures, thus contacting the maximum amount of reservoir rock,” Bell said.

According to Bell, microseismic imaging is critical to understanding where the fractures are going. “To that end, we recently commercialized the BJ

A BJ Services frac spread operates beside carefully hoarded frac water, which is exceedingly scarce despite the green appearance of the land. Photo courtesy of BJ Services





Services/Baker Hughes IntelliFrac™ process, which delivers microseismic interpretations during the job for improved fracturing treatment management,” Bell said. “From production simulations, we have come to believe that it’s much better to have several closely spaced short fractures than widely spaced deep fractures as far as efficient reservoir drainage is concerned. We start with reservoir quality parameters, followed by the well architecture parameters to build our frac model. Then we design the frac to get the best results given those over-riding parameters. Then we develop the perforating scheme, fluid type, and, finally, select the proppants.”

Unlike many of the other shale plays around the country, the Barnett has plenty of nearby observation wells to enable more usage of microseismic frac monitoring, and this is increasing, Bell said. “It has allowed us to get away from evenly spaced deep fractures that are far apart, to numerous optimally spaced shallow fractures. Instead of arbitrarily spacing fractures evenly along the lateral well section, we can actually pick the optimum location for each

perforation cluster based on our reservoir model, taking into account such features as faults that may act as frac barriers, and connections to the aquifers we want to avoid,” he continued. “We want to build a fracture network that does not intersect the previous stage fractures, but also doesn’t leave any untapped reservoir sections. It’s important to understand the limitations of microseismic imaging because depending on the location of the observation wells, there may be blind spots.”

“The Barnett doesn’t have particularly high closure stress, so we can use typical sand proppants — no ceramics for example. Proppant embedment is not much of an issue either. Brinell hardness varies, but the formations are generally hard enough to eliminate embedment as a potential problem. At the same time, proppant flowback is not an issue, so we don’t need to run resin-coated proppants. We pump 100-mesh sand, then follow with 40/70 mesh. So far we haven’t employed LiteProp™ proppant to fill in the tops of the fracture wings, but we expect there may be opportunities to use it in the future.”

Randy LaFollette, BJ Services’ shale gas technology manager, shared his views on the Barnett. “One of the most challenging aspects of the Barnett is its diversity. The play covers a large area of North Central Texas, and there is considerable variation in the composition of the Barnett itself as well as in the effects of structure, geohazards, and overlying and underlying strata. For example, generally west of Ft. Worth, the Viola Formation that separates the Barnett Shale from the Ellenberger pinches out. The Ellenberger is water-filled, and so it constitutes a major geohazard that must be avoided. To the northwest, the Barnett is oily and has some oil wells. Shale mineralogy varies from well to well and that affects its hardness and the way it fractures. Much of the Barnett Shale was cooked to pretty high temperatures so we don’t encounter swelling shales to the extent we find them elsewhere.”

Asked about future challenges, LaFollette explained, “Water issues are becoming increasingly important. We have to be smart about our treatment designs to make maximum effective use of frac water, and recover as much of it as possible. In addition, many of these wells may need to be re-fractured, and that presents additional challenges for



the future. The advantage is that now we have production history to add to our models.”

### No more ‘pump and pray’

Halliburton’s Bill Grieser has made understanding the Barnett a major objective in his extensive career with the company. “We believe we’re in the late stages of the development phase of the Barnett. There haven’t been a lot of real high-tech innovations, but now, thanks to the downturn, operators are going back and looking at how they did things and trying to find ways to do them better in the future. They are trying to evaluate whether the minor and major tweaks they’ve implemented have been economically successful or not.

“A lot of the analysis done in the past was only based on 30-day cumulative production. The real meat of the subject is finally coming into vision because now we’ve got 5 to 10 years of cumulative production on wells we’ve tried experimental stuff on. The requests we’re getting have to do with examining our learnings and using the information to plot a path for the future.”

Grieser enumerated the most frequent customer questions along with Halliburton’s analysis of the best ways to answer them:

*Where is production coming from?* The assumption has been that all the zones perforated and treated are producing, but that’s not entirely correct. Operators are asking us to determine which perforations are contributing to production and which are not—and why. Also, how do they get production from the areas that are not producing?

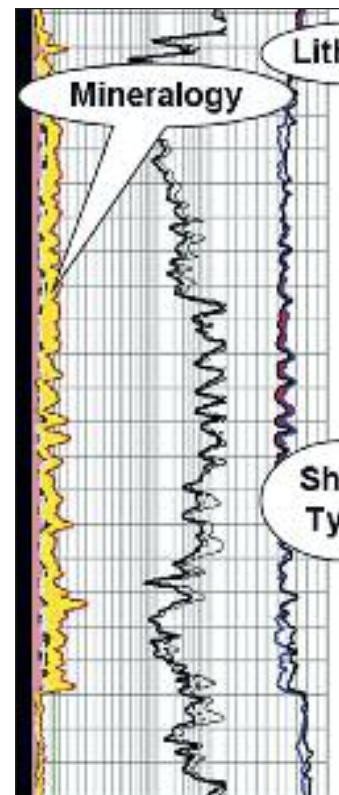
This brings up the subject of refracs, and there are 13,000 wells out there to choose from. Prior to the economic meltdown of last summer, the hot topic was re-completions. Oil company management is looking at net drainage of (optimistically) only 30 to 40% of the stimulated reservoir volume, and saying they want another 30 to 40%.

So how do we go about doing this? Our 2009 plan entailed developing technology to access the new rock in existing well bores. Halliburton has a number of proprietary technologies, and we’re working on different diverting materials hoping to change the direction of fracs in wells previously

fraced. Horizontal re-frac work programs began early in 2008 and continue today. However, it’s one of those subjects we can mention, but we can not publish details about results yet. We’re still experimenting with some techniques. Anything we can do to an existing well bore probably costs less than the alternative — drilling a new well. Operators are investigating the use of fiber optic cable which can detect temperature changes during injection or production through a distributed temperature sensing system. This allows us to visualize, locate, and quantify production or injection path.

*Can anyone predict how the reservoir will behave before drilling?* Operators need a simulator that can handle secondary porosity, absorption gas, and conventional Darcy flow. A solution has been documented in SPE 120271, and it accounts for injected fluids. It’s very useful in the Barnett. It predicts both gas and water flow. At last, we have a simulator that gives reasonable production estimates when input reservoir information is limited and isn’t labor intensive.

*What about frac water re-use and recycling?* We’re being asked about water and how to get the most mileage out of it. A major cost factor for the industry is getting, pumping, and then disposing of water. We’re actively looking at chemicals and chemical systems that allow us to pump fluids downhole using water that would not have previously been considered suitable for fracturing fluid. The most typical water frac chemical package consists of a friction reducer, usually a polyacrylamide, a biocide and scale inhibitor, and as water gets more and more loaded with dissolved solids like Ca and Mg, we’re trying to identify chemicals that will not negatively interact with that water. We now have more salt- and calcium-tolerant





additives. We found that biocides that worked on the surface got used up quickly at temperature. Now we have biocides that will withstand the formation heat, are long lasting, and less hazardous. We can't use the dirtiest of waters, but we mix brackish returned fluids with freshwater, which saves a lot of water. The days of pumping huge amounts of potable water downhole are gone forever.

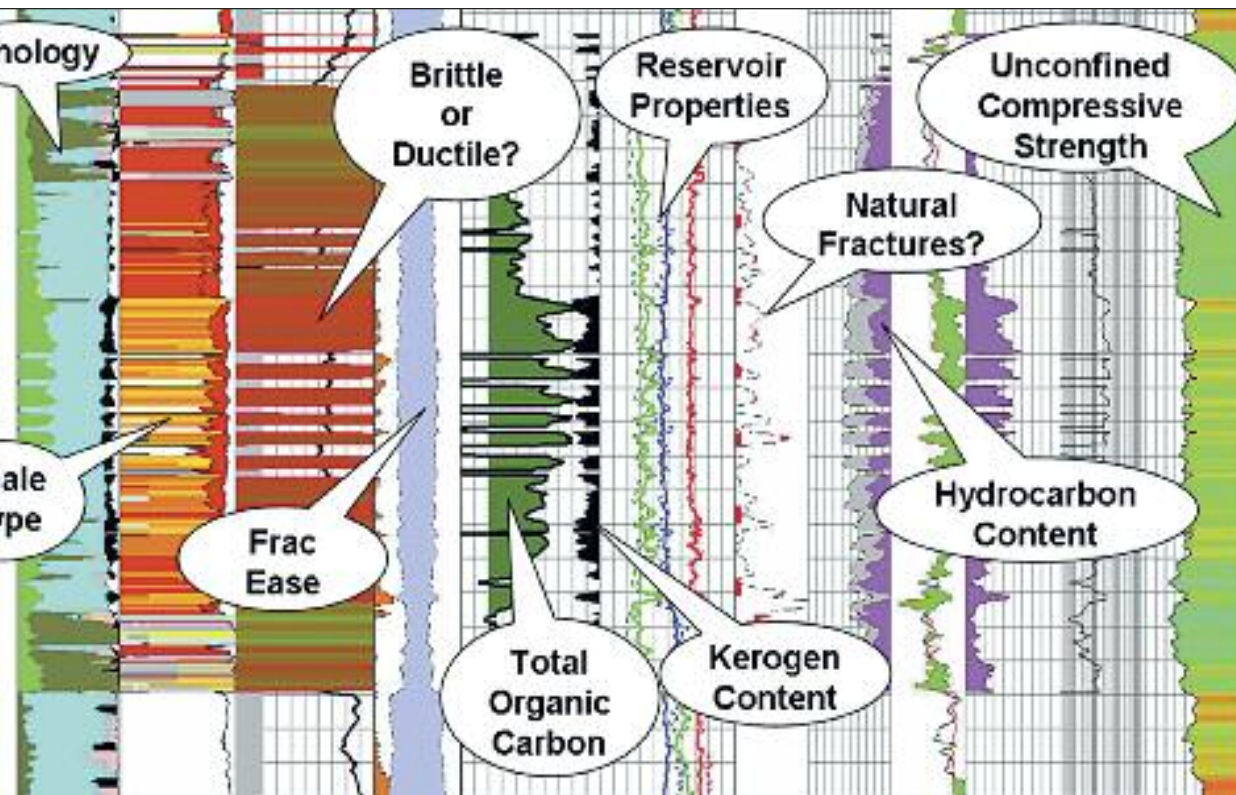
*Can we influence or control proppant flow-back?* The reason these questions are being asked now is that we're drawing the wells down harder now to get back more hydrocarbon. We have aqueous tackifiers and on-the-fly resin that we apply to proppant. It isn't particularly a new technology, but it is one that's getting reborn as we draw down the wells harder.

*Can water influx from surrounding strata be controlled?* We're pumping relative permeability modifiers to help reduce water influx. Using this material in very low permeability shale is relatively new. We think that putting water control material in the early proppant stages may be a good idea. We use little polymer strings that attach themselves to the surfaces of quartz and when water goes by them

they tend to expand and block, but when gas or oil goes by they tend to shrink.

*What about Barnett oil wells?* The lesser-known areas have an oil leg in northern Wise and Montague counties. Surfactant usage has been used experimentally in the gas shales of the Barnett. From our perspective, those trials have had mixed outcomes. As we move from gas to oil, all of the things that surfactants do get magnified because the hydrocarbon molecules are bigger. Things like wettability, surface tension and contact angle become very important because instead of moving a methane molecule of say 4 to 5 angstroms you're trying to move a large oil molecule that may contain a lot of dissolved gas. We believe mobility of oil through the matrix and the very narrow cracks in the fracture network can be increased with the proper surfactant selection.

*Can producing reservoir volume be measured?* The fact that the Barnett shatters can be a benefit, because instead of a typical bi-wing fracture, an interconnected complex network of fractures is created that contact more of the reservoir. One of the questions we're being asked is that because of the dendritic fracture networks, can we perform reservoir volume calculations? If you can imagine the



The shale log presentation provides an integrated, comprehensive, and correlated view of the reservoir with all the information needed for completion design. *Image courtesy of Halliburton.*



stimulated reservoir volume (SRV) as an ellipse, instead of a planar bi-wing fracture, that's often what we get. Quantifying gas or oil in place and estimated ultimate recovery (EUR) in such a regime is extremely difficult, and requires the combination of microseism mapping, decline curve analysis, and volumetric analysis.

*How does microseismic imaging contribute?* The microseismic images not only help in early phases of the shale life cycle, but also in the later phase of decline and maintenance as the planning for a re-frac program begins. You can go back and look at the original microseismic and it gives you a picture of what has been stimulated and where to go next to recover more reserves.

*Can we determine the so-called sweet spots in the vertical and horizontal portions of the well?* The reservoir changes dramatically from well to well. This is evident from the large distribution of production outcome observed in the Barnett. During the early decline and maintenance phase, the use of advanced logging and rock analysis tools become even more important. Tools like (InSite AFR™) azimuthal focused resistivity can be used to target the drill bit to specific pay sections. Elemental capture spectroscopy service (GEM™ Elemental Analysis Tool) and chemostratigraphy on drill cuttings (LaserStrat® Wellsite Chemostratigraphy Service) can provide detailed mineralogy and inorganic geochemical data to help classify the shales as we drill through them and identify the sweet spots.

*How can the thinner areas of the Barnett be exploited?* As the Barnett thins, the expected production outcome and eventual EUR is likely to be less than the core area. To be commercially viable, these areas require the cost to decrease and the efficiency to increase. The use of un cemented mechanical frac stage devices like Swellpacker® Isolation Tool and Delta Stim® Sleeves can make the frac completion a continuous single-day event.

*Can near-wellbore damage be remediated?* As the Barnett is produced, scale formation becomes a problem. We're looking at scale mitigation technology for both vertical and horizontal wells. Our Pulsonix® Acoustic Stimulation Tool is a jet pulse tool that actually removes scale with pressure pulses delivered from the tool. This

Customer questions	Halliburton solution applied in the Barnett	Halliburton solutions, field development projects (FDP) in other shale plays or in R&D
Where is production coming from?	Production logging	Fiber optics and pressure transducers on coiled tubing.
Can you model or predict production?	QuickLook® Reservoir Fluid Management Services -- 4-phase simulator.	Bio-Diverter FDP-903
How do I access new rock (re-frac)?	Diverter BioVert®, Pinpoint stimulation, SurgiFrac™ Fracturing Service, Cobra Frac® H Coiled Tubing Fracturing Service	CleanStream <sup>SM</sup>
Can we reuse frac water? Reduce water costs?	New friction reducer FR-66 New biocide BE-9	
Proppant flowback control as drawdown increases?	SandWedge® Conductivity Enhancement System, Expedite™ Fracturing Fluid	
Do you know stimulated reservoir volume (SRV)? What area am I draining?	Microseismic mapping, Production analysis	
Can you control or reduce water influx?	WaterWeb® Treatment Services, CW-FRac™ Fracturing Services	
Is surfactant chemistry important in oil shale?	Field surfactant tests.	Lab surfactant testing, Surfactant FDP-918
Where are the sweet spots vertical and horizontal?	ShaleLog® Logging Services, TMDL, WaveSonic® Diagnostic Service, XMRI InSite AFR™	LaserStrat® Wellsite Chemostratigraphy Service, MRIL™
Can we reduce drilling and completion days?	DatCI™ On site bit design, Swell Packer® Isolation System, Delta Stim® Sleeves, Cemented DSS	
Can we detect/remediate fracture/near wellbore damage?	DFIT, ShaleFrac RF™	Pulsonix® Acoustic Stimulation Service, Deep Wave® Stimulation Service, ShaleClean™
Can we collect, analyze review, and archive what we have done, and decide what works?	Relational data base analysis, Neural Networks.	The Digital Asset®

Source: Halliburton

tool used in conjunction with shale-specific reactive fluids, ShaleFrac-RF™ Treatment Service, has been used to remove wellbore skin.

*Can we analyze, review, and archive everything we've learned?* That's what we're doing now. We're integrating geology, drilling, and completion in a single package called The Digital Asset® from Halliburton. It will take everything into account from exploration, drilling, completing, and production and allow all to visualize the data in real time.

### Halliburton prescription explained

The North Texas Barnett Shale is well into its development phase and perhaps is entering the decline phase in the shale life cycle. While there are still unexplored areas of the 6,000 sq mile extent of the Barnett, the core area (Wise, Denton, Tarrant, Parker, and Johnson counties) are nearing the end of development mode and are in the early stages of the decline period. Operator needs and challenges are changing as the Barnett Shale lifecycle progresses. Areas of the Barnett reservoir that are thinner, less bounded, and more oil prone are currently being developed. The core dry gas area is reducing well spacing and is in re-completion/re-frac mode. During this economic slowdown in activity, customers have the opportunity to stop and ask questions about what they have done so far, what works, what does not work, and what does the future hold? The table on page 52 lists customer needs and challenges for the late development/early decline phase of the North Texas Barnett.

Customers' questions and challenges have a common theme. How can things be done faster, smarter, better? In the current economic environment and shale life cycle phase in which the industry is operating, the emphasis is on efficiency. That is not to say that operators are not concerned about production results. On the contrary, during this slowdown period, they are taking time to review production results and are asking hard questions about the spread of production outcome in this "continuous resource play." They are looking for technology advances that will increase their ability to find and produce more hydrocarbon from lesser-quality areas of the Barnett Shale or untapped rock in existing well bores.

During the Barnett early decline and maintenance phase, emphasis on technology advancement will become more important as engineers attempt to extend the decline curve to higher economic ultimate recovery. Long-term production results will support or change ideas and theories about the best drilling and completion methods, as Halliburton better understands the complex mix of Barnett geologic, geochemical, and geomechanical properties.

The North Texas Barnett will remain the standard by which all other shale plays are compared. The advantages are time and the talent and dedication of operators and service providers who have taken this reservoir from a curiosity to a major gas-producing basin.

### Weatherford drills ahead

By concentrating on drilling efficiency, Weatherford aims to reduce total rig costs for its customers. It recognizes that the keys to success are speed and reliability, and one way to make an impact on these is to perform detailed pre-job planning. Claiming the horizontal drilling speed record, the company pointed out that its success in this area is not a one-off feat. "We have completed more than 200 bottomhole assembly runs for Quicksilver Resources in the Barnett Alliance Airport Field this year," said Dennis Barrett, US drilling manager for the company. "We're averaging 10 days from surface to total depth," he said.

After introducing its even-rubber-thickness mud motor power sections, the resulting improved drilling efficiency more than compensated for the equipment's added cost, even in tight-margin environments. According to the company, one operator drilling from a pad and using the FrontLine ERT motors was able to improve its drilling performance from one and a half wells per month to three wells per month. Typically, Weatherford recommends drilling the vertical and build sections using FrontLine Plus mud lubricated directional drilling motors and EMPulse gamma ray sensors for depth correlation; then it switches to its Revolution rotary steerable systems to drill the lateral section. The technique has delivered the 10-day surface-to total depth cycle with 96% to 99% efficiency.

In one Johnson County well, the company demonstrated its “Turnizontal” drilling technique whereby the well is quickly built to 90° deviation, then turned to drill the lateral aligned with the principle horizontal stress plane using the minimum number of trips. The 10,355-ft 8 3/4-in. diameter borehole was completed in 13 days – 15 days less than the operator’s well plan. Key to this success was elimination of costly, time-consuming side tracks, and obtaining excellent wellbore quality throughout.

Commenting on Weatherford’s shale play approach, Rob Fulks, US projects manager said, “Our capabilities encompass the full shale service sequence of evaluation and planning to well operations and optimization.” Fulks went on to cite wireline services, cementing equipment, wellhead systems, frac flowback, artificial lift systems for dewatering, controlled pressure drilling, and multizone completions as key components of a total service offering. The company believes in risk reduction through increasing its geology and geomechanics knowledge prior to drilling. Augmenting thorough planning with real-time logging-while-drilling information helps the company optimize well placement while maximizing drilling efficiency. Importantly, with foreknowledge about the formations to be drilled, the company can identify zones of inadequate thermal maturity and organic content to provide economic production. Weatherford’s unique GC-TRACER surface gas detection service uses analysis of formation gas released while drilling to identify formation sweet spots, formation permeability barriers, reservoir connectivity, and compartmentalization.

Recognizing the diversity of the Barnett play, Barry Ekstrand, vice president, reservoir stimulation and pressure pumping, said, “We engineer the well design with an eye on localized characteristics. We can integrate data from many sources, including logs, cuttings, geomechanics, and seismic, and apply the results to all phases of the well’s life cycle, from drilling to evaluation, completion, production, and intervention.” As an example, Ekstrand elaborated on the company’s ability to align the lateral drainhole with the principle horizontal stress plane, thus enhancing the

ability to achieve transverse fractures with maximum reservoir contact. Then every aspect of the treatment is engineered from pumping schedule to fluids to proppant. Specialty chemicals, like the company’s ZetaFlow additive, are used to enhance fracture conductivity by changing the way proppants interact to increase porosity and permeability in the proppant pack.

### Innovations abound

The horizontal completions in the Barnett Shale have seen a transformation from the use of tubing conveyed perforating, to tractor conveyed perforating systems, coiled tubing conveyed systems, and now to pump down systems. These methods of deployment are being utilized with cost-savings measures in mind. In reality, the “Intelligent Perforating Systems” developed by Owen Oil Tools, have in large measure been major contributors to the enhancement of production and reduction of completion costs in the Barnett Shale. A marked improvement in breakdown pressures and improved injection rates due to the design of the shaped charge perforators have contributed to lower breakdown pressures required to frac these tight formations. Simply put, patented liner technology in Owen’s Hero and Super Hero Perforating Systems has made the difference, according to the company. This patented liner material eliminates the debris normally deposited in the perforation tunnel, therefore reducing the need for acid stimulation and other measures that raise the cost of the completion. More perforations open for flow, or treatment, are the result. These “High Efficiency Reservoir Optimization” perforating charges are providing the same results in all shale plays in the US and Canada.

As operators in the Barnett Shale start to develop programs for re-completions on existing assets, one hurdle will come into play – isolating existing perforation intervals.

A highly efficient and effective casing patch has been introduced by Owen Oil Tools division of CoreLab. Called X-SPAN® the tool consists of an expandable sealing element at both ends connected by an almost unlimited number of thin but very strong tubular extensions. The tool can be configured as it is run in the hole simply by adding extension sections until the patch spans the entire desired



interval. Applications include repair of damaged or corroded casing, sealing off unwanted perforations, or water shut-off. But it can also play a valuable role in re-fracturing jobs.

Successful fracturing and treatment of new production intervals will rely heavily on the ability to divert the frac fluids and pressures away from the original perforation intervals. Owen Oil Tools' X-SPAN Casing/Tubing Patch Systems provide a heavy-duty seal over perforations and can be used as an effective, inexpensive tool to divert the frac.

According to the company, X-SPAN burst and collapse pressure ratings are the highest in the industry; therefore, Barnett operators can rest assured that frac will go where intended.

### Chemistry and drill bit design shines in the Barnett

Baker Petrolite uses its considerable experience in developing effective oilfield chemistry to advantage in the Barnett. The company's AddFRAC measurement and control services work to prevent microbially induced corrosion failures that affect gathering system flowlines and produced water storage tanks. Even trailer-mounted frac tanks are attacked by aggressive corrosion media. The combination of these corrosion targets can create the risk of negative environmental impact and personal injury.

Instead of applying costly and potentially ineffective trial and error methods, the AddFRAC team works to determine the root cause of potentially damaging corrosion and develop a permanent solution. In one example, Petrolite's microbiologists and field technicians performed detailed measurements and diagnostic services of the fracturing process, tracking every drop of induced and produced fluid as it circulated through the system. They looked for potential combinations of fluids that could cause a corrosion cell to evolve.

The commonly used technique of re-using frac water may be an excellent way to conserve water, but it may be the mechanism that spreads a biological agent throughout the system like a virus through the human body. By understanding the actions and interactions of all the bio and chemical agents in the system, the bacterial loading of the entire system can be modeled. More importantly, once the agent is

identified, quantified, and modeled, an effective solution can be developed. The correct biocide, in the correct concentration, can then be applied to kill the cells and prevent their further proliferation. In addition to corrosives, dangerous concentrations of H<sub>2</sub>S can cumulate in frac tanks or field storage tanks. These, too, can be eliminated.

According to the company, in one Barnett project, 54 frac jobs, including 2,490 frac tanks were treated with Baker Petrolite XCide 575 microbiocide. As a result, gathering system flowline failures were reduced 80%. There was a substantial reduction in the number of produced water tanks with biogenic H<sub>2</sub>S production, and a 25% reduction in total program treatment costs due to early detection and rapid remediation.

Additional chemical treatments provided by Baker Petrolite to its Barnett Shale customers include scale control media, friction reducers, oxygen scavengers, and corrosion inhibitors. Scale control media can even be combined with formation treatments to inject scale inhibitors deep into the fracture networks where they can prevent scale buildup that can impair fracture conductivity.

Hughes Christensen has developed a bit line that has delivered enviable performance in drilling the Barnett. The company's Q507FX Quantec Force Series, polycrystalline diamond compact (PDC) bits optimize force distribution for added stability. In addition, they contain updated PDC cutter technology and feature additional structure design methodologies. Compared to eight other bits recommended for drilling surface and tangent sections of Barnett Shale horizontal wells, the Q507FX bit beat the average offset well penetration rate by nearly 37%. In one well, 4,315 ft were drilled at 94 fph, saving the operator 17 hours of rig time.

### Looking ahead

The Barnett play offers a rich mosaic of opportunities from exploration, to drilling, to completion and production, stimulating innovative minds to create new tools, chemicals and techniques specially designed for the shale as well as adaptations of existing tools to complement shale applications.

\* Mark of Schlumberger



Enbridge Energy Partners completed work a few years ago on its US \$530 million East Texas expansion project, which involved 252 miles of 36- and 24-in. pipe and the construction of a new gas-processing plant in Franklin County. *Photo courtesy of Enbridge Energy Partners*

# Takeaway Capacity in Place

With significant pipeline additions in recent years, Barnett Shale producers now have access to markets throughout the country.

**By Bruce Beaubouef, Ph.D.**

*Editor, Pipeline and Gas Technology*

Over the past few years, pipeline companies have been busy building hundreds of miles of transmission and gathering systems to move gas produced from the Barnett Shale to markets in the eastern, Midwestern, and southeastern US.

Many of the new pipeline systems have been built in the Upper Gulf Coast region, in northeast Texas and northwest Louisiana. This review highlights recent additions to the region's takeaway capacity, and examines proposals for new pipelines being built and planned.

## Facilities now in place

Enbridge Energy Partners is one of the key players in this market, and its East Texas natural gas pipeline is one of the key transportation systems in the region. It recently completed work on a US \$530 million expansion project that involved the construction of a 192-mile, 36-in. pipeline from Bethel to Orange County; and a 60-mile, 24-in. pipeline from Crockett to Franklin County. The project also included the construction of a number of upstream facilities, including gathering pipelines that will tie existing facilities into the new intrastate pipeline. To process the gas, a new plant was built near Marquez, in Franklin County.

Crosstex Energy is another key player in the region, and it has also added to the available Barnett Shale takeaway capacity in recent years. One of the key additions to the Crosstex network is the North Texas pipeline, a 140-mile, 24-in. pipeline that spans six North Texas counties to gather and transport gas out of the Barnett Shale. The company invested approximately \$115 million in the project, which now delivers Barnett Shale gas to major distributors like Coserv Energy and Atmos Energy for sale to local consumer and business markets. Delivery

points are planned for Natural Gas Pipeline Co. of America and Houston Pipe Line Co., which serve other markets in Texas as well as throughout the US. This line has the capacity to deliver 375 MMcf/d.

Other recently installed systems have also boosted takeaway capacity for Barnett Shale producers. One of these is CenterPoint Energy's \$425 million Carthage-to-Perryville natural gas pipeline. Completed in 2007, this pipeline now provides market access for production from East Texas and north Louisiana through interconnects with interstate and intrastate pipelines serving the East Coast, Midwest and southeastern US markets. The line runs with 172 miles of 42-in. pipe to move gas from Carthage, Texas, to the company's Perryville hub in northeast Louisiana. In April 2009, the FERC authorized CenterPoint to boost the capacity of the Carthage-to-Perryville pipeline to approximately 1.9 Bcf/d by building two turbine compressor units at the company's Westdale and Vernon compressor stations in Red River and Jackson parishes, Louisiana. This phase is projected to be placed in service in the second quarter of 2010.

There is also the Southeast Supply Header (SESH), completed by a CenterPoint Energy/Spectra Energy venture in 2008. It connects the Carthage-to-Perryville pipeline with southeastern markets. The SESH involved the construction of a 270-mile, 36- and 42-in. gas pipeline from the Perryville hub in Louisiana to the Gulfstream Natural Gas System near southern Mobile County, Alabama. The SESH now links gas supply from East Texas and north Louisiana basins to growing US southeast and northeast markets.

Energy Transfer has also been adding significant takeaway capacity for Barnett Shale producers, spending at least \$1.85 billion in recent years to



## Barnett Production Levels Cut into Processing Plans

While many midstream companies are maintaining a long-term commitment to the Barnett Shale, the formation has given up its status as the “hot play” to both the Haynesville and Marcellus in the eyes of many industry players.

Much of this, of course, has to do with the downturn in both natural gas prices and the overall US economy. However, the Barnett remains one of, if not the, largest natural gas plays in North America with over 22 Tcf in proved reserves.

The play has become known as the grandfather of unconventional gas shale plays with many companies first perfecting horizontal drilling techniques in North Texas earlier this decade. As such, much of the buildup for infrastructure, specifically gas-processing plants, occurred between 2003 and 2007.

There are currently about 13 natural gas-processing plants in the play with a fourteenth ready to be built by Crosstex Energy Services. The as-yet-built Bear Creek plant would be the company's fourth plant in the Barnett, but the current downturn has the plant off the company's radar.

“We own it, but have never installed due to the downturn in drilling activity and the economy,” said Scott Williams, the company's senior vice president of commercial. “It doesn't look like we'll need it for quite some time now. There are no plans to install it at this point. It's not even on the backburner right now. If we found somebody with the right price tag we would probably sell it.”

Crosstex is currently running the Silver Creek and Goforth plants and has its Azel plant idle due to the lower production levels. The Silver Creek plant has a capacity of 200 MMcf/d and has been averaging 150 MMcf/d recently while Goforth has a capacity of and has been operating at 35 MMcf/d. Azel has a capacity of 50 MMcf/d.

Since October 2007, drilling rigs in the play have gone from 200 to about 70. “It's pretty much come to a hard stop. There is no other way to explain it. We feel like there's still a tremendous amount of potential in the Barnett. It still has a lot of upside and we don't think it's peaked yet; it's just a cycle in the economy that we're having to weather through,” Williams said.

While prices have been increasing throughout 2009, he noted that these prices haven't helped the rig count rebound in the region. This is likely to continue until prices

hit the \$5 per MMBtu level, according to many reports. Williams anticipates 2010 production and processing levels in the play to be flat compared to 2009.

“Even if gas prices popped up to \$5 overnight, producers are still going to wonder if that is going to be real. The price has to prove it is there before drilling starts back up. You have a certain period of time to prove the price and a certain amount of time to ramp up production too,” he said.

Williams said that the company's plants pull from Parker, West Tarrant, and Hood counties with the strongest being Parker, which is where the bulk of the gathering system is located that supports the plants.

Devon Energy owns two of the larger plants in the play in the Bridgeport plant and West Johnson County plant. As of August 2009, Bridgeport was operating at 95% of its 620 MMcf/d capacity and the West Johnson County plant was operating at 65% of its 130 MMcf/d capacity.

Tony Thornton, a spokesperson for Devon, said that the Bridgeport plant processes gas for 113 producers from Wise, Denton, Parker, and Jack counties. Although there are no processing upgrades for the plant, Thornton said the company is adding 23 miles of expansion pipe next year.

The West Johnson County plant was completed in 2007 and processes gas for two producers from West Johnson County. There are no planned upgrades for the plant in 2010.

DCP Midstream, the largest gas processor in the country according to Gas Processors Report's rankings for 2007 and 2008, has two processing plants in the Barnett: Black Diamond and Tolar. Both of these plants are located in the southwest corner of the play, which is outside of the core area.

These plants are processing roughly 65 to 70 MMcf/d of natural gas. “We are built for growth at the moment, so we can take additional volumes as the region grows,” said Roz Elliott, a DCP Midstream spokesperson.

The downturn has not caused either DCP Midstream or Crosstex to lose faith in the Barnett though.

“We think that the Barnett, while brought to its knees a little bit because of the current economy and drilling activity, is still equally as important a core area for us as the Haynesville,” Williams said.

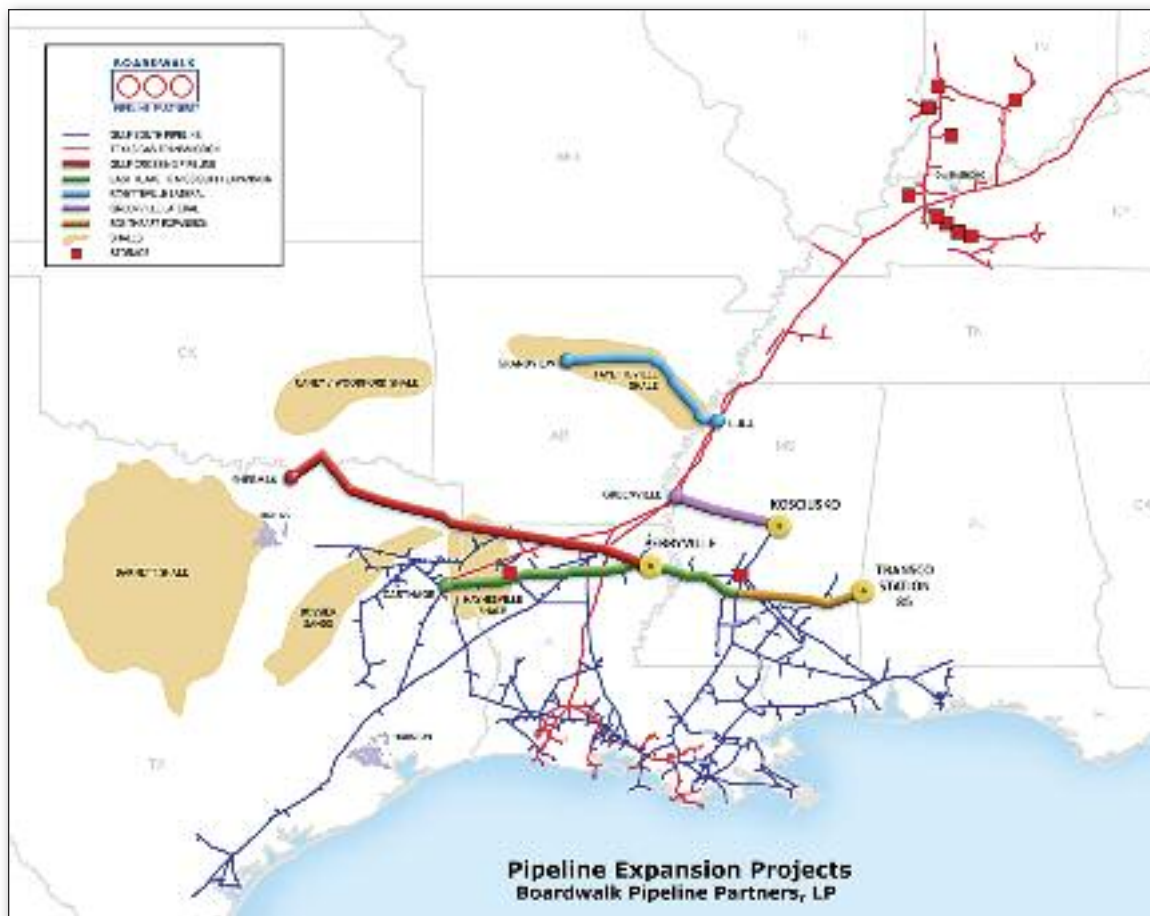
– Frank Nieto, Editor, Gas Processors Report

and 30-in. pipeline that connects the partnership’s ET fuel system with its HPL system, running from Cleburne, Texas, in Johnson County to a point near Reed, Texas, in central Freestone County; and from there to the Texoma pipeline at the Carthage, Texas, hub. Since placing that line in service, Energy Transfer has extended and expanded the system with 157 miles of 42-in. pipeline and 132,700 in additional compressor horsepower. The extension now provides natural gas service from Limestone County, running in a southeasterly direction to interconnect with the 30-in. Texoma system in Hardin County, Texas, northeast of Beaumont. Interconnects with several interstate pipelines are being planned.

And, Energy Transfer has continued to add take-away capacity. In 2009, the partnership announced the completion of its \$485 million natural Texas Independence Pipeline. This new 160-mile, 42-in. natural gas pipeline increases Energy Transfer’s takeaway capacity in Texas by an incremental 1.1

Bcf/d, and serves the Bossier and Barnett Shale natural gas resource plays in east and north central Texas. Originating just west of Maypearl, Texas, and ending near Henderson, Texas, the new system connects the partnership’s existing central and North Texas infrastructure to its East Texas pipeline network. With the addition of compression, the project may be expanded to transport natural gas volumes in excess of 1.75 Bcf/d.

Energy Transfer has also announced the completion of the 56-mile, 36-in. Katy Expansion project, which increased the capacity of the partnership’s existing ETC Katy natural gas pipeline in southeast Texas by more than 400 MMcfd. The expansion project also provided approximately 20,000 hp of compression to the 30-in. section of the ETC Katy pipeline, which extends from the partnership’s Grimes County compressor station to the Katy natural gas trading hub. The project increases the capacity of the pipeline from 700 MMcf/d to more than 1.1 Bcf/d, enhancing transportation service



Boardwalk Pipeline Partners has added significant take-away capacity for Barnett Shale producers in recent years, including the US \$1.1 billion Gulf Crossing pipeline project and the \$330 million Southeast expansion project. *Map courtesy of Boardwalk Pipeline Partners*

out of the Barnett Shale and Bossier Sands natural gas plays in Texas.

Elsewhere in the region, Falcon Gas Storage Co. has also added takeaway capacity for Barnett Shale producers. It did so most notably with the completion of a 63-mile, 24-in. gas pipeline that serves the company's Worsham-Steed gas storage facility, located in the western portion of the Barnett Shale gas play in North Texas. The pipeline runs southward from the Worsham-Steed facility through Jack, Parker, and Hood counties, where it interconnects with a number of existing gas transmission pipelines, including the North Texas pipeline, jointly owned by Enterprise Products Partners and Energy Transfer Partners, and the Atmos Energy Line "X" pipeline.

Kinder Morgan has also added takeaway capacity in the region with the completion of a \$69 million project designed to increase capacity on Natural Gas Pipeline Company of America's (NGPL) Gulf Coast and Louisiana mainlines. The project added some 31,000 hp in compression and also included

3 miles of 36-in. looping. The scope of work also included a reconfiguring of NGPL's compressor station 304 on the Gulf Coast mainline in Harrison County, Texas, to allow the flow of natural gas southward into the Louisiana line. The project was designed to provide takeaway capacity for the Barnett Shale and Fayetteville Shale fields, and enhance the ability of shippers to reach markets along the East Coast.

### Other recent additions

Boardwalk Pipeline Partners has also added significant takeaway capacity for Barnett Shale producers in recent years. Its subsidiary, Gulf South Pipeline Co., has completed work on the \$1.1 billion Gulf Crossing project, which involved the construction of a 355-mile, 42-in. interstate gas pipeline to move gas from Sherman, Texas, to the Perryville, Louisiana, area. This project was completed in 2008. Boardwalk has also completed work on the \$330 million Southeast expansion project, which expanded transmission capacity on the Gulf South pipeline system

Crosstex Energy has added to the available Barnett Shale takeaway capacity with the completion of its North Texas pipeline project. Photo courtesy of Crosstex Energy





between Harrisville, Mississippi, to Choctaw County, Alabama. This project, which was placed in service in February, added 111 miles of 42-in. pipe to the Gulf South system.

Elsewhere, Enterprise Products Partners and Duncan Energy Partners report that construction has been completed on the 174-mile, 36-in. Sherman Extension pipeline. This project expanded the Enterprise Texas Intrastate natural gas pipeline system, which extends through the heart of the Barnett Shale play of North Texas. The Sherman Extension begins at a delivery point on the partnership's Texas Intrastate natural gas pipeline system near Morgan Mill, Texas, southwest of Fort Worth, and extends northward to an interconnect with Boardwalk Pipeline Partners' Gulf Crossing pipeline near Sherman, Texas. Completed in March, the initial throughput on the Sherman Extension was approximately 360 MMcfd before ramping up to about 950 MMcfd over the summer. The capacity was expanded as the remainder of the system's 48,000 hp of compression was brought online.

The developers say that the completion of the Sherman Extension adds 1.1 Bcfd of incremental takeaway capacity from the region, while providing Barnett Shale producers with greater flexibility in accessing the most attractive markets, particularly those in the northeastern and southeastern areas of the country. Current natural gas production from the Barnett Shale is approximately 4 Bcf/d and is projected to surpass 6 Bcf/d by 2011. "Since we first announced this initiative a little more than two years ago, the production performance of the Barnett Shale has continued to exceed expectations," said Michael A. Creel, Enterprise president and chief executive officer. "Highlighted by the fact that there are currently more than 350 completed wells awaiting pipeline connections, the need for midstream infrastructure like the Sherman Extension has never been greater."

The Sherman Extension also laid the foundation for a separate but complementary project that the developers are planning to support emerging new areas of the Barnett Shale that are not adequately served by pipelines at present.



In particular, the partnerships are in the process of constructing a new 40-mile, 30- and 36-in. pipeline that will link producers in the Trinity River Basin to the Sherman Extension near Justin, Texas. This new pipeline will originate in Tarrant County, Texas, and have a capacity of 1 Bcf/d. And, the developers say that like the Sherman Extension project, this new pipeline is supported by long-term transportation agreements with major producers. The Trinity River lateral is on track to begin service in late 2009 or early 2010.

### Leveraging existing assets

Some production companies are leveraging their existing Barnett Shale pipeline assets to raise funds for other operations. One example is Oklahoma City-based Chesapeake Energy, which recently announced that it will raise \$588 million in cash by selling half its natural gas pipelines in the Barnett Shale play, as well as properties in other petroleum basins.

Chesapeake, a major Barnett gas producer, says it has entered into a definitive agreement to form a joint venture with Global Infrastructure Partners, a New York-based private equity fund. According to the Fort Worth Star Telegram, Chesapeake will contribute its Barnett Shale pipelines and processing facilities to the new Chesapeake Midstream Partners (CMP) venture. Global Infrastructure Partners will pay \$588 million for its 50% interest in CMP, and Chesapeake will retain the other half. The deal was not a major surprise, since Chesapeake had said in May that it was in talks with four potential bidders for a \$500 million stake in its Barnett Shale midstream properties.

Under the terms of the deal, Chesapeake will contribute substantially all of its midstream assets in the Barnett Shale as well as most of the company's non-shale midstream assets in the Arkoma, Anadarko, Delaware, and Permian basins. The deal will provide additional money for Chesapeake's operations, which include large lease holdings in major shale gas plays including the Barnett, the Haynesville in Louisiana, and the Marcellus in the Appalachian region.

Like other large independent gas producers, Chesapeake's revenue has been reduced by a deep

downturn in natural gas prices since the summer of 2008, although the company has offset the effect somewhat by hedging prices on the futures market. While natural gas prices rose above \$13 per thousand cubic feet last year, they have generally been in a range of \$2.50 to \$4 in recent months, with a subsequent deleterious effect on US drilling activity – including the Barnett.

### Major assets in place

The sharp slowdown in Barnett Shale drilling not only means that the big natural gas field will peak earlier than expected but also that most of the major pipelines aimed at moving gas out of the field are already in place, says Barry E. Davis, president and chief executive officer of Dallas-based Crosstex Energy. Davis recently told a Fort Worth audience that producers will still need to build the smaller-diameter gathering systems to carry gas from their wells to processing plants. But “probably 80% or 90% of the capital spending” on big transmission lines to distant trading hubs has been done, said Davis, who made his remarks at an energy investment conference sponsored by the Texas Christian University Energy Institute.

Davis estimated that the Barnett Shale's take-away capacity – the amount of natural gas that pipelines can carry – stands at 5.5 to 6 Bcf/d. Producer and analyst groups have estimated that production from the Barnett Shale field will be 4.6 to 5 Bcf/d by the end of the year – indicating that in the near term, at least, there will be excess take-away capacity. And these levels are far short of early predictions that the field could grow to 8 or 9 Bcf/d, Davis said, a level that would have required the industry to inject millions more into pipeline infrastructure. In retrospect, he said, the flattening of the Barnett's production rate will probably result in a more effective use of those pipelines. “So now the Barnett gets to 4.5 or 5 billion Bcf,” he said, and, as drilling stabilizes, “it just stays there forever.” Such projections are in line with comments from some producers in the field, who note that even if the field's daily production does not peak as high as it might have if the drilling frenzy continued, the field will still produce at a high level for decades. ■



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# Future Returns

Why the Barnett may be a good investment.

**By Ray Deacon**

Senior Research Analyst, Pritchard Capital Partners

The Barnett Shale has been the centerpiece for pioneering in American shale gas plays and the development of horizontal “unconventional” drilling technologies. Originally thought to hold an estimated 327 Tcf of gas in place, 44 Tcf of which was deemed recoverable, the play has a long future of production. Just how this future will look, however, is subject to the economics for natural gas, and especially the returns that the Barnett Shale can offer in comparison with its peers. An examination of the future of the Barnett from the vantage of an investor reveals why it may be a good investment in the future.

The Barnett is located in the Fort Worth Basin in Texas, spanning 10 counties for an area of approximately 5,000 sq miles. The Barnett Shale covers 10 counties in Central Texas and currently produces 3.85 Bcf/d, based on data from the Texas Railroad Commission, significantly off its peak of 4.45 Bcf/d in October 2008. As a result of the 59% decline in natural gas prices the rig count has declined to 57 currently from its peak of 174 in the second quarter of 2008. The core area (where economics of wells is the most rewarding) is now believed to be in Johnson and Tarrant counties with some areas of Denton and Wise counties believed to have similar economics. Tier 1, which

lies to the south and west of the core areas, is somewhat less economic (gas price sensitive) and generally lacks the Viola Limestone that separates the Barnett from the underlying waterbearing formations and can present more challenges.

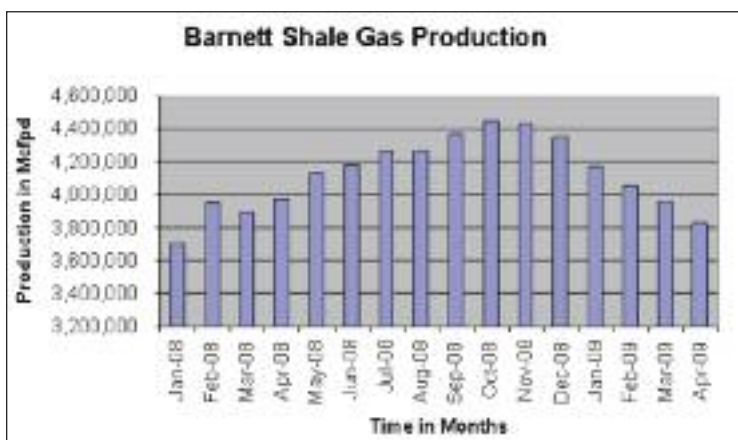
The Mississippian-age shale lies between the Marble Falls Limestone (6,500 ft depth) and the Chapel Limestone (8,500 ft depth), ranging in thickness from 100 to 600 ft. Within the formation, the Barnett has one of the highest gas contents, ranging from 300 to 350 scf/ton of rock. The best economics to be found in the play lie in the core, followed by the Tier 1 area, and then Tier 2 (which we do not expect to be developed in the next 5 years to a material degree). Tier 2 acreage is primarily located in Erath, Jack, and Palo Pinto counties. Well spacing ranges from 60 to 160 acres per well. Nearly 11,000 wells are currently producing from an average depth of 7,500 ft depth. This accounts for over 7% of total domestic gas production.

Barnett wells start being economic at US \$5.50/Mmbtu gas prices (prices are in the \$4 range as of press time), and we predict prices will reach the \$5 level in the first quarter of 2010. At \$6 gas, core horizontal wells generate returns of 43%, and verticals show returns of 19%. In Tier 1, horizontals can generate a return of 34%. Even at \$5, returns come

to 17%. What this means is that the Barnett can be a major player again in 2010. Now, what differentiates the Barnett from the other North American shale giants?

Key to making the economics of the play work was the introduction of large-scale hydraulic fracturing, a process first developed in Texas in the 1950s and first used in the Barnett in 1986. The first Barnett horizontal well was drilled in 1992.

Source:  
Pritchard Capital  
Partners

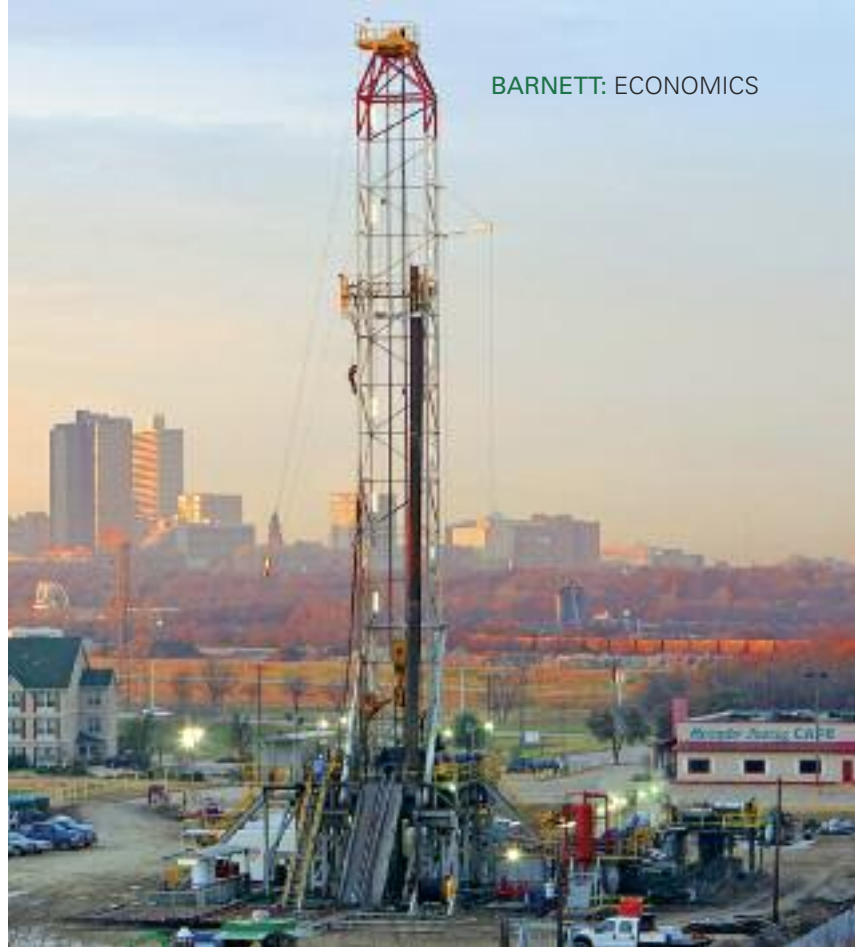


Through continued improvements in the techniques and technology of hydraulic fracturing, development of the Barnett Shale has accelerated. In the ensuing two decades, the science of shale gas extraction has matured into a sophisticated process that utilizes horizontal drilling and sequenced, multi-stage hydraulic fracturing technologies. The combination of sequenced hydraulic fracture treatments and horizontal well completions has been crucial in facilitating the expansion of the Barnett. Prior to the successful application of these two technologies in the Barnett Shale, shale gas resources in many basins had been overlooked because production was not viewed as economically feasible. The low natural permeability of shale has been the limiting factor to the production of shale gas resources because it only allows minor volumes of gas to flow naturally to a well bore. The characteristic of low matrix permeability represents a key difference between shale and other gas reservoirs. For gas shales to be economically produced, these restrictions must be overcome. The combination of challenging economics and low permeability of gas shale formations historically caused operators to bypass these formations and focus on other resources.

One recent development of interest is the increase in M&A activity as ENI, EOG, and others have sold properties in the play for between \$14,000 and \$70,000 an acre, illustrating the difference between core and non-core acreage as well as the value of the optionality underlying the basin once prices recover.

The Barnett's key competitive advantage as prices rise is its infrastructure in place and the high visibility of E&Ps in the play. Unlike the Marcellus Shale, where gas on gas competition will likely keep some players from expanding their footprint, the Barnett is locked and loaded for production. With over 100 operators in the play, production will flow seemingly overnight when gas prices rebound. Likewise, there is less to worry about in older plays like the Barnett than in the relatively new Haynesville and Marcellus, as operators have both data points and drilling experience to guide their development.

So which operators give the best upside exposure to the Barnett? Devon Energy Corp., following its purchase of Mitchell Energy, drove the play forward



more than anybody else and, importantly, has over 80% of its gas coming out of the play covered under firm transportation contracts. Devon holds acreage with approximately 5,750 undrilled risked locations, amounting to an approximate 8.4 Tcf of probable and possible risked resources and 41 Tcf of unrisked resources. What really puts Devon ahead of the game, though, is its gathering system, as it owns 3,100 miles of pipeline and 7 gas-processing plants in the area. Combined with Devon's improved economics (drilling days down to 15.8 in 2008 from 33.4 in 2004), the gathering system makes Devon a top pick for exposure to the Barnett. Its high net revenue interest (81%, on average) allows them to drill at lower gas prices relative to newcomers to the play. Their low average lease cost provides another boost to their economics.

Carrizo Oil and Gas Inc. holds a very attractive position in the Barnett, with 60,000 total acres, 21,000 of which are in the core. Carrizo has three rigs running in the core, and plans to ramp its program up over the next 12 months, with a 2009 exit rate of 100 MMcf/d likely. ■

*Editor's note: Pritchard Capital Partners LLC has not managed an investment banking services transaction for any of the companies mentioned herein within the past 12 months. The author nor Pritchard Capital Partners has positions in any securities mentioned in this report.*

Mercado drill site on Ft. Worth's Northside. Photo courtesy of Chesapeake Energy

## Additional Information on the Barnett

For more details on the Barnett Shale, consult the selected sources below.

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*By Ann Priestman, Executive Editor, Unconventional Natural Gas Report*

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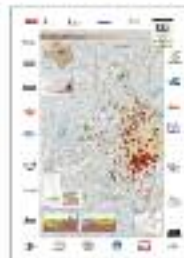
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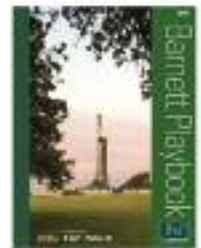
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